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Membrane Cholesterol Prediction from Human Receptor using Rough Set based Mean-Shift Approach

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Abstract

In human physiology, cholesterol plays an imperative part in membrane cells which regulates the function of G-protein-coupled receptors (GPCR) family. Cholesterol is an individual type of lipid structure and about 90 percent of cellular cholesterol is present at plasma membrane region. Cholesterol Recognition/interaction Amino acid Consensus (CRAC) sequence, generally referred as the CRAC (L/V)-X1−5-(Y)-X1−5-(K/R) and the new cholesterol-binding domain is similar to the CRAC sequence, but exhibits the inverse orientation along the polypeptide chain i.e. CARC (K/R)-X1−5-(Y/F)-X1−5-(L/V). GPCR is treated as a biggest super family in human physiology and probably more than 900 protein genes included in this family. Among all membrane proteins GPCR is responsible for novel drug discovery in all pharmaceuticals industry. In earlier researches the researchers did not find the required number of valid motifs in terms of helices and motif types so they were lacking clinical relevance. The research gap here is that they were not able to predict the motifs effectively which are belonging to multiple motif types. To find out better motif sequences from human GPCR, we explored a hybrid computational model consisting of hybridization of Rough Set with Mean-Shift algorithm. In this paper we made comparison among our resulted output with other techniques such as fuzzy C-means (FCM), FCM with spectral clustering and we concluded that our proposed method targeted well on CRAC region in comparison to CARC region which have higher biological relevance in medicine industry and drug discovery.

Keywords: GPCR; CRAC; CARC; ANN; Decision Tree; Rough Set; Mean Shift.

1- Introduction

In cell biology, cholesterol acts as a major component in cell membrane and has a modulatory role in integral membrane protein like GPCRs. Cholesterol is an individual type of lipid structure and about 90 percent of cellular cholesterol is present at plasma membrane region. GPCR is treated as a biggest super family in human physiology and probably more than 900 protein genes included in this family. As GPCR super family is responsible for novel drug discovery in pharmaceuticals area, so it is an emerging field for all researchers. Normally, GPCR family is arranged by lengthy protein sequences which include three basic regions like N-terminus known as external portion, C- terminus is known as internal portion and another middle segment is their which containing seven transmembrane domains shown in figure 1. A long protein sequence is the combination of amino acid which starting from extracellular part to intracellular region through the cell membrane surface. Once a GPCR binds a ligand in the meantime ligand triggers a conformational varies in the 7-TM region of the receptor. These things stimulate the C-terminus, which subsequently recruits a substance that in order activates the G protein linked with the GPCR.

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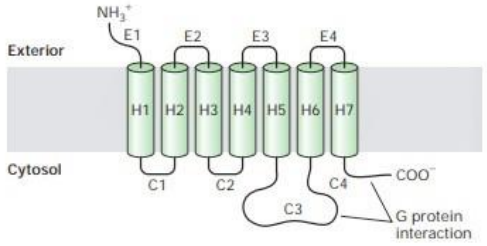

Fig. 1 Structure of GPCR Receptor

GPCRs contain seven helices such as H1-H7. Each helix contains individual protein chain which is the combination of all amino acids. Generally 20 amino acids are named as A, R,N, D, C, E, Q, G, H, I, L, K, M, F, P, S, T, W, Y, V have used for protein strain construction which is shown in Table 1. GPCRs family is a superfamily comprising of various subfamilies, including Class A rhodopsin-like, Class B secretin-like, Class C metabotropic glutamate/pheromone, Class F frizzled (FZD), Taste receptors, Vomeronasal receptors and 7TM orphan receptors. They are categorized into 7 subfamily based on the character of stimuli that stimulates the GPCRs and sequence similarity. Cholesterol is a 27 carbon compound with a distinctive structure with a hydrocarbon tail, a central sterol nucleus made of four hydrocarbon rings, and a hydroxyl group. The center sterol nucleus or ring is a feature of all steroid hormones. The hydrocarbon tail and the central ring are non-polar and therefore do not mix with water. Therefore cholesterol (lipid) is packaged together with apoproteins (protein) in order to be carried through the blood circulation as a lipoprotein. Lipid satisfies numerous biological functions and its presence is very essential for successful cellular homeostasis.

Table 1: List of Amino acid

Amino Acid	ABBREVIATION 3-Letter	1-Letter	Amino Acid	ABBREVIATION 3-Letter	1-Letter
Alanine	Ala	A	Leucine	Leu	L
Arginine	Arg	R	Lysine	Lys	K
Asparagine	Asn	N	Methionine	Met	M
Aspartic acid	Asp	D	Phenylalanine	Phe	F
Cysteine	Cys	C	Proline	Pro	P
Glutamic acid	Glu	E	Serine	Ser	S
Glutamine	Gln	Q	Threonine	Thr	T
Glycine	Gly	G	Tryptophan	Trp	W
Histidine	His	H	Tyrosine	Tyr	Y
Isoleucine	Ile	I	Valine	Val	V

Cholesterol is known as organic molecules and is biosynthesized by every animal cells and also very much essential structural component of animal cell membrane. Cholesterol plays a pivotal function in vitamin D production, bile secretion and hormone production. Cell membrane cholesterol acts as a significant role in modulating the function of numerous membrane proteins and from these proteins a special cholesterol binding motif is reported to which the membrane cholesterol binds and modulates their movement. This consensus motif is either seen as CRAC or CARC, [1-10] which correspond to the mixture of amino acid and its structure is shown in figure 2.

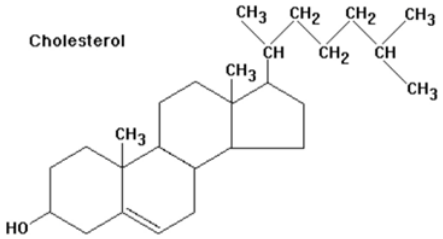

Fig. 2 Structure of Cholesterol

This work we highlights on prediction of membrane cholesterol from human integral protein such as GPCR family. Due to much more involvement of GPCR in cell biology it is very much important to identify novel signature motifs which have biological significance in the entire medical area. In modern times, many relevance areas in biomedical science and bioinformatics are introduced where most advanced soft computing techniques were applied successively. Main intention is to boost the correctness of clustering algorithms with least number of iterations. So a lot of scientists have explored diversity of classifiers algorithm like artificial neural network (ANN), logistic regression, fuzzy C-means and decision tree etc. to forecast the cholesterol signature motifs [11-19].

To investigate the signature motif of cholesterol using the dataset is our focal objectives. The research gap in earlier researches is that they were not able to predict the motifs which were belonging to multiple motif types. This dilemma can be removed by introducing rough set method which classifies the motif types to one or more regions based on their belongingness. Subsequently mean shift clustering algorithm gets the valid clusters which exhibits our proposed rough set based mean shift algorithm as prominent. Therefore, our present work is concentrating to uncover valid cholesterol motif signature from large helical protein sequences of human GPCR.

Gao, Q et al. [20] presented an ensemble method for G-protein coupled receptors classification in four stages to discuss about GPCRs and non-GPCRs. Gu, Q et al. [21] introduced a prediction model of Adaboost using a data base of low homology based on pseudo amino acid composition with close entropy and property of

hydrophobic forms to guess GPCR classes and this gave best consequence of the whole experiment. Furthermore Peng, Z et al. [22] gave a broad view of an improved classification model for prediction of GPCRs based on different characteristics.

The draft of the paper is as follows: in section 2, materials and methods, the results and discussion is instanced in section 3 plus in last section conclusion part is portrayed.

2- Research Method

All helical files namely H1 to H7 of GPCR family contains totals of 900 protein sequences. Generally, Protein dataset is the combination of unlike amino acid sequences retrieved sequentially from uniprot database using text (.txt) format [23]. The primary aim of our present work is to obtain and discover the valid cholesterol signature motif using different window size using the formula of CRAC/CARC. CRAC is a tiny linear motif which carries out a very simple algorithm, which is N-terminus to C-terminus direction and the formula is used here is (L/V)-X1−5-(Y)-X1−5-(K/R). Similarly CARC is the opposite orientation of CRAC which is formulated by (K/R)-X1−5-(Y/F)-X1−5-(L/V).

Table 2 shows that L is length of cholesterol motif. The length of window size range varies from minimum five to maximum thirteen for both forward and backward pattern recognition methods. A cholesterol dictionary d is constructed according to their motif type and window size. For example, considering $d9$ having length $L = 9$ can have motif types MT={15, 24, 34, 42, 51} and cholesterol motif signatures can be in the form of Leu/Val-X1-Y-X5-Lys/Arg, Leu/Val-X2-Y-X4-Lys/Arg, Leu/Val-X3-Y-X4-Lys/Arg, Leu/Val-X4-Y-X2-Lys/Arg and Leu/Val-X5-Y-X1-Lys/Arg, Lys/Arg-X1-Y/F-X5-Leu/Val, Lys/Arg-X2-Y/F-X4-Leu/Val, Lys/Arg-X3-Y/F-X4-Leu/Val, Lys/Arg-X4-Y/F- X2-Leu/Val and Lys/Arg-X5-Y/F-X1-Leu/Val for both CRAC and CARC algorithms respectively. And also X position can be varying from any residue among 20 amino acids. From above cholesterol formula, it is revealed that motif length remains stable but membrane cholesterol motif sequences fluctuate depending upon the 'Y and F' positions.

The probable combination of cholesterol sequence found in Table 3 and Table 4 for different motif lengths is show below. Whole numbers of uncovered cholesterol subsequence for CRAC (forward) and CARC (backward) after mapping are 2003 and 4013 respectively. From the result, it is perceptible that the combination backward sequence has more targets over forward. The combinations of N-terminus to C-terminus and vice versa are calculated for both CRAC and CARC. The motif sequence combination of CARC are calculated using{Arg-X(1-5)-Y/F-X(1-5)-Leu=1799, Lys-X(1-5)-Y/F-X(1-5)-Leu = 978, Arg-X(1-5)-Y/F-X(1-5)-Val = 779, Lys-X(1-5)-Y/F-X(1-5)-Val= 457} are to be found for unlike motif types. Likewise, for forward (CRAC) motif sequence combinations are {Leu-X(1-5)-Y-X(1-5)-Arg = 764, Leu-X(1-5)-Y-X(1-5)-Lys= 527, Val-X(1-5)-Y-X(1-5)-Arg =330, Val-X(1-5)-Y-X(1-5)-Lys = 382} are to be found.

Table 2. Depiction of all possible motif types with different combination using 20 amino acids

CHOLESTEROL DICTIONARY FORMULA	MOTIF TYPE/ CHOLESTEROL MOTIF LENGTH	SIGNATURE MOTIF SEQUENCE
BACKWARD (CARC) (R/K-$X_{(1-5)}$-Y/F-$X_{(1-5)}$-L/V)	11, ...15, =5,6,7,8,9 21,... 25 = 6,7,8,9,10 31,... 35 = 7,8,9,10,11 41.... 45 = 8,9,10,11,12 51,... 55 = 9,10,11,12,13	K/R-X1-Y/F-X1-L/V, ...K/R-X1-Y/F-X5-L/V K/R-X2-Y/F-X1-L/V, ...K/R-X2-Y/F-X5-L/V K/R-X3-Y/F-X1-L/V, ...K/R-X3-Y/F-X5-L/V K/R-X4-Y/F-X1-L/V, ...K/R-X4-Y/F-X5-L/V K/R-X5-Y/F-X1-L/V... .....K/R-X5-Y/F-X5-L/V
FORWARD (CRAC) (L/V-$X_{(1-5)}$-Y-$X_{(1-5)}$-R/K)	11, ...15, =5,6,7,8,9 21,... 25 = 6,7,8,9,10 31,... 35 = 7,8,9,10,11 41.... 45 = 8,9,10,11,12 51,... 55 = 9,10,11,12,13	L/V-X1-Y-X1-K/R.....L/V-X1-Y-X5-K/R L/V-X2-Y-X1-K/R.....L/V-X2-Y-X5-K/R L/V-X3-Y-X1-K/R.....L/V-X3-Y-X5-K/R L/V-X4-Y-X1-K/R.....L/V-X4-Y-X5-K/R L/V-X5-Y-X1-K/R.....L/V-X5-Y-X5-K/R

Table 3. Dissimilar Motif Types (MT) detected in GPCRs for Backward (CARC) cholesterol sequences

Motif-Length	Arg-$_{(1-5)}$-Y/F-$X_{(1-5)}$-Leu	Lys-$X_{(1-5)}$-Y/F-$X_{(1-5)}$-Leu	Arg-$X_{(1-5)}$-Y/F-$X_{(1-5)}$-Val	Lys-$X_{(1-5)}$-Y/F-$X_{(1-5)}$-Val	Total
5	49	25	35	23	**132**
6	249	56	177	27	**509**
7	79	46	94	45	**264**
8	377	219	100	95	**791**
9	630	112	146	89	**977**

10	191	70	91	63	**415**
11	125	297	56	50	**528**
12	65	122	62	54	**303**
13	34	31	18	11	**94**
Total	**1799**	**978**	**779**	**457**	**4013**

Table 4.Dissimilar Motif Types (MT) detected in GPCRs for forward (CRAC) cholesterol sequences

Motif-Length	**Leu- $X_{(1-5)}$-Y- $X_{(1-5)}$-Arg**	**Leu- $X_{(1-5)}$-Y- $X_{(1-5)}$-Lys**	**Val- $X_{(1-5)}$-Y- $X_{(1-5)}$-Arg**	**Val- $X_{(1-5)}$-Y- $X_{(1-5)}$-Lys**	**Total**
5	29	21	19	11	**71**
6	51	35	38	26	**150**
7	80	52	33	22	**187**
8	107	57	48	28	**240**
9	126	87	70	112	**395**
10	160	107	56	98	**421**
11	70	63	26	29	**188**
12	38	29	17	27	**111**
13	103	76	23	29	**231**
Total	**764**	**527**	**330**	**382**	**2003**

Figure 3 which is given below depicts about the architecture of proposed model which stores all helical files in text format and also stores cholesterol dictionary whose data are retrieved utilizing the technique known as sliding window which has considered the length of motif and it is denoted as $L = \{5, 6, 7, 8, 9, 10, 11, 12, 13\}$. Dictionary of cholesterol can be calculated using motif length/ number of sequence.

Our aim is to investigate the signature motif of cholesterol using above dataset. In the first stage of our proposed model entire helical data are retrieved sequentially and cholesterol data are retrieved according to their motif type from dictionary. Then we are mapping our two datasets. Once mapping is over we go for next step for calculation of CRAC and CARC motif. Then we apply our hybrid technique Rough set with Mean-Shift algorithm for computing all cluster centers. After finding the cluster centers we can sort, merge the motifs using weight value. We have a cut-off on calculation of motif according to their weight. Finally we reconstruct the data points and obtained our motifs which have biological relevance.

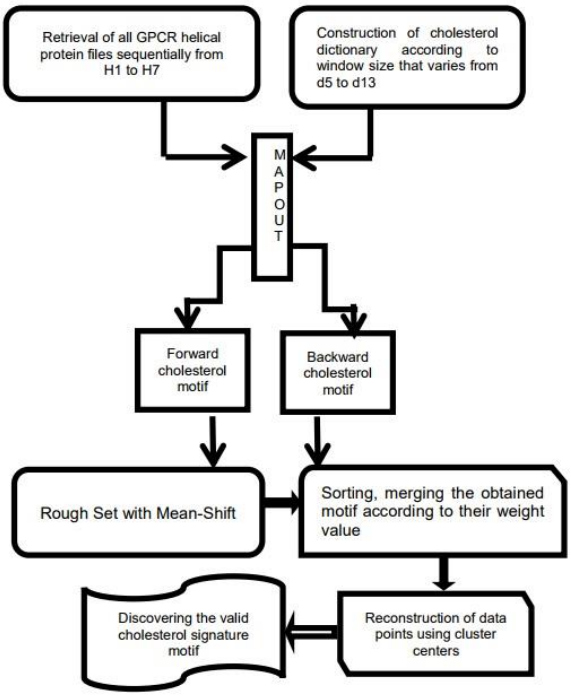

Fig.3Architecture of proposed Rough Set with Mean-Shift cholesterol model for identification of valid motif signature

2-1- Rough Set Theory (RS)

Rough set theory is a technique for dealing with imperfect knowledge, in particular with vague concepts. Rough set theory has gained interest of many researchers and practitioners from all over the world. This theory has been implemented in many areas like Bioinformatics, acoustics, business and finance, chemistry, computer engineering and electrical engineering decision analysis and systems, economics, digital image processing, informatics, medicine, molecular biology, neurology, robotics, social science, software engineering, spatial visualization, Web engineering, and Web mining. That's why we are motivated to implement this theory within our paper for prediction purpose. Generally, biological data are very

complex and sensitive. To handle this complex data set and to discover structural relationship within expected imprecise and noisy data, rough set approach is used here.
Our both data such as cholesterol and GPCR protein were taken for prediction purpose. After mapping is over we have categorized the forward motif and backward motif. We have proposed a hybrid approach Rough set with Mean shift for prediction of valid motif sequences. Basically this procedure clearly dealt with finding hidden pattern motif sequences and evaluation of significance of motifs without any overlapping.
RS theory is characterized as a system S = < U , V, R, F>by Z. Pawlak, with R = D∪C, [24] at which U be a non-void bounded collection of items and R be a non-void bounded collection of properties, D and C be the subsets known as decision and condition feature collection. Where V = $\bigcup_{a \in R} Va$, Vais represented as a gathering of feature values of a, also cardinality of (Va)>1 and f: R → V is a fact or characterization mapping. Indiscernible relation [24]: For a known subclass of feature collection B⊆R, an imperceptible relationship imp(B) in the space of discussion U which could be characterized in equation (1) as below,

$$imp(B) = \{(m,n) \mid (m,n) \in U^2, \forall_{b \in B}(b(m) = b(n))\} \quad (1)$$

So similarity relationship here is nothing but an imperceptible relationship. [n]imp(B) or [n]B and [n] refers equality family unit of an piece. And then (U, [n]imp(B)) pair off is addressed as an guesstimate space. Lower and Upper approximation sets [25]: For a given system S = <U, V, R, F>,Considering Y⊆ U where Y is a subset, upper and lower bound sets respectively be determined in equation (2) plus (3) by

$$\overline{appr}(Y) = \{n \in U \mid [n] \cap Y \neq \phi\}, \quad (2)$$

$$\underline{appr}(Y) = \{n \in U \mid [n] \subseteq Y\}, \quad (3)$$

Where [n] refers equality family of n.
So collection of every equality families is received as the ratio collection of U, and U/R = {[n] | n∈U} refers it. Here three disjoint parts of space are like the negative, positive plus boundary approximation sets are given in equations (4-6) below [24-28].

$$P(Y) = \underline{appr}(Y), \quad (4)$$

$$B(Y) = \overline{appr}(Y) - \underline{appr}(Y), \quad (5)$$

$$N(Y) = U - \overline{appr}(Y), \quad (6)$$

When object n∈ P(Y), then, it is counted on target set Y positively. When object n∈ B(Y), then, it would not be counted as goal set Y positively. When n∈ N(Y), so it is not easy to decide whether n would be a part of goal set Y.

2-2- Mean-Shift Approach

In human pathogen every amino acid sequence has some biological significance. To compute valid cholesterol motif from human GPCR we implemented Mean-Shift algorithm which cluster each data points employing window across it and calculates the average of the data point. Then it shifts the center of the window to the average and reiterates the algorithm till it converges. After each iteration, the window shifts to a denser region of the dataset. In case of time and space complexity Rough Set with Mean-Shift does well on GPCR data [29-34]. Now the steps of Rough Set with Mean-shift algorithm for a collection of different amino acid sequences S are given below:

Rough Set with Mean-Shift Algorithm:

Step-1: Construct cholesterol dictionary according to window size that varies from $d_5$to d_{13}.

Step-2: Apply Rough Set based method over the targeted motif sequences from constructed dataset consisting of sequence of amino acids.

Step-3: For each amino acid sequence $s \in S$, discover the neighboring points *N(s)* of *s*.

Step-4: For each amino acid sequence $s \in S$, calculate the *mean shift m(s)* from the equation (7):

$$m(s) = \frac{\sum_{s_i \in N(s)} K(s_i - s) s_i}{\sum_{s_i \in N(s)} K(s_i - s) s_i} \quad (7)$$

Step-5: For each amino acid sequence $s \in S$, update $s \leftarrow m(s)$.

Step-6: Iterate Step-1 for *n times* or until *m(s)* converges.

Here N(s) represents the function to evaluate the neighbors of a data sequence s ∈ S. The distances of neighboring points are calculated by the Euclidean distance metric [35]. Again K(d) represents the kernel used in Mean-Shift, where K denotes a Gaussian Kernel [36-37] and d denotes the distance between the two data sequences. The algorithm runs with time complexity $O(KN^2)$. Clustering results are depicted in Figure 4 where prediction of both membrane cholesterol and GPCRs are done.

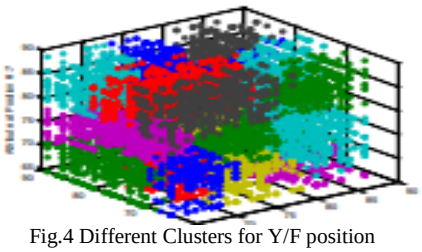

Fig.4 Different Clusters for Y/F position

3- Results and Discussion

All the transmembrane proteins data were collected from uniprot database and cholesterol dictionary is constructed using CARC /CRAC algorithm. According to helix number protein sequences are maintained. Each helix includes ~820 proteins. The most important objective of this work is to identify and fetch the entire cholesterol consensus motif available in the protein primary sequences and develop a signature motif for receptors belonging to GPCR superfamily. Dissimilar motif types are considered using parameters. For example motif sequence for forward region is LAAMAYDR. It means first position is L/V and last position is combination of K/R and Y position is fixed. Here motif type is 41, i.e. L4Y1R and the window size is 8. Using CRAC algorithm we have calculated the motif types.

The main intention of this paper is to uncover the most important motif signatures utilizing both forward plus backward formula from human GPCR. After mapping a large volume of data set, we are looking for an enhanced data mining method for obtaining effective signature motif of cholesterol. Through one example we explain this as; a given motif: K/RXY/FXL/V of length 9 can be in more than one motif types like {15, 24, 34, 42, 51} given in Table 1. We found Rough Set technique [24-28] is better to handle the data belonging to more than one class and Mean-Shift technique [29-34] as an efficient one to find the cluster centers. Hence, to mine this category of information wherever data can fit in to more than one cluster, we employed Rough set with Mean-Shift algorithm in our projected model.

Table 5 expressed about the signature motifs of cholesterol for GPCRs using the forward (CRAC) and backward formula CARC. In these tables we have elaborated helix number, motif types plus its valid signature. Among all helices like H1-H7 only targeted helix for forward region is h3, h5, h6 and h7 and similarly for backward region the targeted helices are h2, h7. Each helix target includes both motif types with corresponding valid signature.

Table 5. Signature motifs of cholesterol for GPCRs using the forward formula (CRAC) and backward formula (CARC)

CRAC			CARC		
HELIX	**CRAC MOTIF TYPE**	**SIGNATURE**	**HELIX**	**CARC MOTIF TYPE**	**SIGNATURE**
H3	L4Y1R	LAAMAYDR	H2	R2F2L	RPMFFLL
H3	L5Y1R	LLAVMAYDR	H2	R5F1L	RLHTPMFFL
H3	L3Y2K	LSIFYCLK	H2	R5Y2L	RLHTPMYFFL
H3	V3Y1R	VLMAYDR	H2	R4Y4L	RTVTNYFILNL
H5	L4Y4R	LNPFIYSLRNR	H2	R5Y5L	RLHTPMYFFLSNL
H5	L5Y4K	LLNPIIYSLRMK	H2	R4Y2V	RTVTNYFIV
H5	V4Y4K	VNPLVYTLRMK	H2	K2Y2L	KPMYIFL
H6	L2Y1R	LMSYDR	H2	K3Y1L	KAMYYFL
H6	L3Y1R	LVFMYLR	H2	K5Y1L	KTASVFYTL
H6	V5Y1R	VPCIYAYLR	H2	K2Y5L	KPMYFFLSML
H7	L1Y4R	LSYTRINR	H2	K5Y2L	KLHTPMYFFL
H7	L4Y2R	LNPLIYSL	H2	K5F3L	KTATNIFLLNL
H7	L5Y2R	LLNPFIYSLR	H2	K5Y5L	KLLTPMYFFLTPL
H7	L4Y4R	LNPLIYTLRNR	H7	K5Y1V	KVASVFYTV
H7	L3Y2K	LSIFYLLK	H7	K5Y2V	KVASVFYTVV
H7	L4Y2K	LNPLIYSLK	H7	K5Y1L	KLLTVIYSL
H7	L4Y4K	LNPLIYSLRNK	H7	K5Y2L	KLHTPMYTFL
H7	L4Y5K	LNPILYFLRNEK	H7	K5Y5L	KLLTLFYFFLTPL
H7	L5Y4K	LLNPFIYTLRNK			
H7	V4Y2R	VNPLIYSLR			
H7	V5Y2R	VLNPLIYSLR			
H7	V1Y4K	VIYTLRNK			
H7	V4Y4K	VNPLVYSLRNK			

In our present work Rough Set deals data with uncertainty as very well and Mean-Shift being a non-parametric clustering technique with the strengths of capable of handling arbitrary feature spaces with no pre-specified number of clusters analyzes the real GPCR data in a fair manner.

3-1- Comparison among the Methods

Table 6 shows the contrast among all methods with respect to helix name and motif type for both forward

with backward region. Helix name means it represented the targeted helix name of GPCR. Each time, membrane cholesterol is bound with N-C terminus region of membrane proteins and also with their corresponding helix. Another important part is the motif type which is denoted as forward and backward position. With the help of algorithm CRAC and CARC we choose motif type. If motif type is written as 55 means for forward position the formula as: L/V-X5-Y-X5-K/R. Here X5 is any combination of five amino acid which is residing in between L/V and Y and in next part X5 is represented as any five amino acid combination reside within Y and K/R. Likewise it is represented for 11,12,--15, 21---25, 31…35, 41…45, 51…55 etc. From comparison table (Table 6) we conclude that our proposed model Rough with mean shift target on higher priority motif types such as 55, 52, 53, 51, 31, and 32 in comparison with other existing methods [11,12].

Table 6. Motif type comparison by different methods

METHODS	HELIX NAME	MOTIF TYPE (FORWARD/ BACKWARD)
FCM [11]	h2,h5,h7	11,12,21,54,34
FCM with Spectral [12]	h6,h3,,h7,h5	44,42,32,22.21
Rough Set with Mean Shift (Proposed)	h3,h5, h6,h2,h7	55, 52,53,51, 31,22

4- Conclusion and Future Scope

G-Protein-Coupled-Receptor is one of the compelling fields which is mostly involved for cell signaling and more frequently targeted by the entire pharmaceutical domain. In cell membrane, among all integral membrane protein, GPCR is treated as an important super family. Each time, membrane cholesterol targets with this GPCR family to find out the best motif sequences which has biological relevance. Our aim is to investigate the signature motif of cholesterol using above dataset. Due to high dimensionality of the data, this paper projected a hybrid model Rough Set and Mean-Shift based method for cholesterol prediction from human GPCR. Our proposed Rough Set with Mean-Shift based model yielded satisfactory result as discussed in experimental section. The best motifs we found can have reliable clinical treatment and can also be used in drug discovery for diseases. Based on the weight value for each motif type we calculated sub-motifs from huge amount of protein which gave better results. In our analysis we conclude that most of the target sites are included in helix 2 and 7 in addition of motif types 55, 53, 52, 31, 32 etc. which have greater biological relevance. Further study can be extended considering other disease databases which can be used for membrane cholesterol prediction with higher biological relevance and could be helpful for drug designers.

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A Corpus for Evaluation of Cross Language Text Re-use Detection Systems

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Abstract
In recent years, the availability of documents through the Internet along with automatic translation systems have increased plagiarism, especially across languages. Cross-lingual plagiarism occurs when the source or original text is in one language and the plagiarized or re-used text is in another language. Various methods for automatic text re-use detection across languages have been developed whose objective is to assist human experts in analyzing documents for plagiarism cases. For evaluating the performance of these systems and algorithms, standard evaluation resources are needed. To construct cross lingual plagiarism detection corpora, the majority of earlier studies have paid attention to English and other European language pairs, and have less focused on low resource languages. In this paper, we investigate a method for constructing an English-Persian cross-language plagiarism detection corpus based on parallel bilingual sentences that artificially generate passages with various degrees of paraphrasing. The plagiarized passages are inserted into topically related English and Persian Wikipedia articles in order to have more realistic text documents. The proposed approach can be applied to other less-resourced languages. In order to evaluate the compiled corpus, both intrinsic and extrinsic evaluation methods were employed. So, the compiled corpus can be suitably included into an evaluation framework for assessing cross-language plagiarism detection systems. Our proposed corpus is free and publicly available for research purposes.

Keywords: Cross Language Plagiarism Detection; Corpus; Text Re-Use Detection; Obfuscation.

1- Introduction

Plagiarism is the unacknowledged reuse of others' ideas or text without giving a proper credit [1]. Nowadays, due to the high availability of digital content on the web, the malpractice use of others text has been widely spread. Plagiarism detection (PD) is the act of finding patterns of text re-use between a suspicious document and source documents. With the rapid growth of documents in different languages, the increased accessibility of electronic documents, and the availability of translation tools, cross-language plagiarism has become a serious problem, and its detection requires more attention [2]. Nowadays, a vast amount of knowledge is created in rich resource languages like English, and students in low resource languages have a motivation to bring the knowledge to their language through translation. Moreover, detection of plagiarism between two pairs of languages is a more complicated task with respect to monolingual plagiarism detection (MLPD). Cross-language Plagiarism Detection (CLPD) systems try to find plagiarism cases across language pairs.

Paraphrasing and translation can be considered as connected natural language tasks. "Translation represents the preservation of meaning when an idea is rendered in words in a different language, while paraphrasing represents the preservation of meaning when an idea is expressed using different words in the same language" [3]. There are different typologies of transformation from source to the target language through translation. In other words, plagiarism between languages can occur in different types: a simple translation, translation plus paraphrasing, merging of sentences, splitting a sentence into two or more sentences in the target language, and summarization after translation.

In order to investigate various PD algorithms and evaluate their accuracy, the algorithms should be run on a plagiarism detection corpus. A PD corpus is comprised of two sets of text files named a source and suspicious documents. In order to construct a PD corpus, we should select some passages from source documents. In the next step, in order to simulate the action of plagiarism, some

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modifications should be done on the selected passages. In the final step, the paraphrased passages (henceforth called obfuscated passages) are inserted into suspicious documents. The offset and length of each passage in source and suspicious document are written into XML meta-data files.

There are some reasons that the construction of a plagiarism corpus that contains real cases of plagiarism is not a point of interest. First, because of concealed behavior of plagiarism, collecting real plagiarism cases is an expensive and time consuming task. The second reason is that using real plagiarism cases in a public domain needs consent from the original author. Third, a corpus with real plagiarism cases cannot be published due to ethical and legal issues; because of the high availability of search engines, it is difficult to anonymize the real plagiarism cases [4]. Because of the above-mentioned reasons, the researchers usually pay attention to create simulated and artificial plagiarism cases. The synthetically made plagiarized passages should be inserted into a vast amount of text data to build suspicious documents. On the other hand, the plagiarism detection algorithms should then correctly find these passages among suspicious documents and also identify their pairs in source documents. Moreover, the current researches mostly focus on creating cases of cross-language plagiarism based on sentences of parallel corpora and don't pay attention to different typologies of transformation between languages as mentioned above.

In this study, we have investigated a cross-language plagiarism detection corpus with a new approach to obfuscate the plagiarized passages. The plagiarized passages are inserted into topically related English and Persian Wikipedia articles in order to have a more realistic situation. Although we have focused our experiments on English and Persian as the source and suspicious languages, the proposed approach is not dependent on the mentioned languages.

There are some studies to construct bilingual plagiarism detection corpora from English to Hindi, Basque, Portuguese, Spanish, Hungarian, and Italian [5], [6], [7]. But they have simply used the sentences of a parallel corpus to create plagiarism fragments, and so they did not incorporate levels of obfuscation into their corpus. In other research, Asghari et al, in [15] have incorporated types of obfuscation into their corpus to build an evaluation framework. Instead, in this study, we have used a technique in selecting the plagiarism fragments from a bilingual corpus in such a way that different levels of obfuscation can be created, and so we can measure to what extent a translated plagiarized passage is hard to find. For this purpose, various factors (e.g., features based on sentence length, dictionary-based features, alignment-based features, and miscellaneous features) were used to measure the similarity of plagiarized passages.

The paper is organized as follows: In the next section, an overview of previous works in cross-language corpus construction will be presented. Our approach is described in Section 3, in which we will explain the proposed model and also the features that are used to be incorporated into the obfuscation stage. Section 4 comes with experiments and results for evaluation of the constructed corpus, including experimental setup and applying two cross-language plagiarism detection algorithms to evaluate the constructed corpus. Conclusion and recommendations for future works will be discussed in the final section.

2- Related Work

In this section, a survey on the previous research concerning the creation of cross-language plagiarism detection corpora is presented.

Using human and machine translation to translate documents from source languages to target ones can be considered as initial efforts to compile cross-language plagiarism corpora. Barrón-Cedeño et al. [1] and Pinto, Civera, Barrón-Cedeño, Juan, & Rosso [8] have used this approach to create English-Spanish and English-Italian corpora of plagiarism, respectively. In [1] five English original text fragments have been translated to Spanish by nine humans and also five automatic machine translation systems. Moreover, to evaluate plagiarism detection systems in the case of false positive detections, 46 cases of un-plagiarized fragments have been added into the corpus. The proposed corpus by Pinto et al. has been compiled by translating source English documents to 14 different plagiarized fragments using both human and machine translations [8]. Like the proposed corpus by Barrón-Cedeño et al. [1], 46 un-plagiarized fragments have been added into the corpus to simulate more realistic situations of plagiarism.

The PAN plagiarism detection corpus PAN-PC-09 is the first large-scale plagiarism detection corpus which includes a set of cross-language plagiarism cases across different language pairs [5]. The cross-language section of PAN corpus covers 10% of the corpus and includes automatically translated plagiarized fragments from German and Spanish to English. Although the monolingual part of PAN-PC-09 contains some automatic obfuscation methods to paraphrase source fragments (i.e. random text operations and semantic word variation), no obfuscation method has been used to create cross-language cases of plagiarism. Subsequent PAN-PC-10 [4] and PAN-PC-11 [9] corpora contains 14% and 11% cross-language cases of plagiarism, respectively. Moreover, to improve the quality of the cross-language corpus, 1% of automatically translated fragments of PAN-PC-11 had been corrected manually.

To create cases of plagiarism across languages, in recent research, parallel corpora have been widely used instead of incorporating human and machine translation. Parallel corpora contain several sentence pairs in two (source and target) languages, which are translations of each other [10]. ECLaPA cross-language plagiarism detection corpus has been compiled by Pereira, Moreira, and Galante [11] using the proposed methods of PAN-PC-09. This corpus is based on the Europarl Parallel Corpus and contains 300 English documents as the source and 174 Portuguese and French documents as the suspicious ones.

Potthast, Barrón-Cedeño, et al. compiled a cross-language PD corpus using JRC-Acquis parallel corpus and Wikipedia to compare the performance of different CLPD approaches across languages [12]. A total number of 23,000 parallel sentences of JRC-Acquis and 45,000 Wikipedia documents have been used to create the corpus, in which 10,000 aligned documents have been used to test the algorithms and the remaining documents have been used to train the methods.

Ceska, Toman, and Jezek created a multi-lingual plagiarism detection corpus for evaluating their proposed method for plagiarism detection based on Euro Wordnet [13]. The JRC-EU and Fairy-tale multi-lingual corpora are used for this purpose. The proposed corpus consists of 200 English reports from JRC-EU and 27 English documents of Fairy-tale as source documents and a same number of documents in Czech as the suspicious ones. Arefin et al. proposed a new approach for creating a multi-lingual plagiarism detection corpus to evaluate PD systems between Bangla and English documents [7]. They used 110 collected documents from a public university, where two groups of students have been asked to submit their reports in two different languages, namely English and Bangla. In another research, Barrón-Cedeño, Rosso, Devi, Clough, and Stevenson proposed a CL!TR task on cross-language text re-use detection across two languages: Hindi and English [6]. The participants in the competition should find potential English source documents for a Hindi suspicious one. The corpus consists of 5032 English Wikipedia documents as the source documents and 388 Hindi documents as the suspicious ones. To generate cases of plagiarism, the participants are asked to write short answers to a set of questions either by re-using the source documents or by using provided learning materials. To simulate real cases of plagiarism, they asked participants to answer questions with 4 different levels of obfuscation, including: near copy, light revision, heavy revision and no plagiarism. The last method is designed to generate answers which are not plagiarized to be used for comparison.

Although the above mentioned corpora can evaluate cross-language PD systems, they suffer from two main drawbacks:

- Lack of obfuscation degree in plagiarized fragments.
- Lack of topic similarity between plagiarized fragments and documents.

In the case of the first challenge, the reviewed corpora cannot measure the performance of plagiarism detection systems according to different levels of paraphrasing. In spite of cross-language PD corpora, the definition of obfuscation degrees has been widely used in monolingual PD corpora. In the case of second drawback, the topic similarity between plagiarized fragments and source and suspicious documents play an important role for reaching more realistic PD corpora. Ignoring topic similarity between fragments and documents can lead to detection of cases of plagiarism simply by analyzing topic drift in documents [14].

Asghari et.al., presented an approach to cross-language plagiarism detection using word embedding methods [15]. For investigating the performance of the algorithm, a corpus comprised of seven different types of obfuscation was constructed. The simulated cases of plagiarism were compiled by expert crowd workers, and the artificial ones were compiled automatically. For validation of the corpus, it was automatically checked considering the ratio of the length of plagiarized passages to the length of the documents and the distribution of plagiarized passages across the documents as well. Moreover, for evaluation of the corpus, a manual checking was done for investigating the quality of plagiarized fragments [15]. In another research from the same group, Asghari et.al., proposed a bilingual PD corpus from a sentence aligned parallel corpus. To cover different ranges of plagiarism, the degree of obfuscation has been simulated by generating plagiarized fragments by a combination of sentences with different similarity score. The corpus contains 19973 English and 7142 Persian documents [32].

In addition to the highlighted cross-lingual PD corpora, a number of monolingual corpora have been introduced in recent year, too. Al-Thwaib et.al., generated JUPlag, an Arabic PD reference corpus that is dedicated to academic language [16]. They mentioned that the corpus could be for corpus-based linguistic analyses, and also for language learning and teaching. In another research, Khoshnavataher et.al., compiled a monolingual Persian corpus from Wikipedia articles [17]. The articles have been obfuscated automatically to simulate real cases of plagiarism. We followed a similar approach to generate cross-lingual plagiarism cases in this paper. However, unlike the mentioned works, we considered the degree of obfuscation into account in a cross-lingual setting to cover a wider range of plagiarism. Briefly, our contributions in this paper are as follow:

- Construction of a large English-Persian bilingual plagiarism detection corpus, so the results of running PD algorithms on this corpus are considerably reliable.

- Incorporating paraphrasing degree into plagiarized passages. So, the similarity score of paired sentences in the corpus can be used for establishing the degree of obfuscation for plagiarism cases.
- The use of topic similarity to match between plagiarized fragments and related texts to construct suspicious documents of similar topics based on a graph clustering approach.

3- Our Approach

Our proposed approach differs from the widely used framework of previous researches for creating monolingual PD corpora. In order to construct a monolingual plagiarism detection corpus, there are three methods for creating plagiarism fragment cases, namely artificial, simulated and real approaches. As mentioned before, real cases of plagiarism are not used in PD corpora. So, the proposed methodology by Potthast et.al, [18] is a popular approach. They have used simulated and artificial methods for creating their plagiarism detection corpus. In the case of artificial plagiarism fragments, different degrees of obfuscation can be obtained by adjusting the number of operations like addition, deletion, and semantic word variation on fragments of text from a source document to be inserted as plagiarized fragments into suspicious documents. Given that the artificial method of obfuscation would generate fragments that are not understandable for humans, in this study, we proposed a new method to generate fragments with different levels of paraphrasing that are human understandable. To this end, we have used a similarity score between sentence pairs of a parallel corpus for obtaining degrees of obfuscation.

In constructing a monolingual plagiarism detection corpus, the following main steps should be accomplished:

1. Dividing documents into two distinct categories, namely source and suspicious
2. Extracting plagiarism candidate fragments from source documents
3. Applying paraphrasing methods on these fragments (contains exact copy without obfuscation, paraphrasing fragments, random shuffling, and so on)
4. Inserting obfuscated fragments into suspicious documents

Our approach to create a bilingual corpus follows the mentioned steps, except that the plagiarized fragments are extracted from a sentence aligned parallel corpus. Moreover, unlike existing bilingual PD corpora, we have investigated a degree-based paraphrasing method to better simulate real cases of plagiarism and to determine the capability of PD algorithms encountering various types of obfuscations.

For automatically constructing a cross-language corpus, in the first step, we need a parallel bilingual sentence-aligned corpus. In the next step, we should find a way to put together the paired sentences from the parallel corpus in such a way that they are topically related with each other and moreover, topically related to the surrounding text in suspicious document they are inserted. Moreover, in order to obtain some levels of obfuscation, we should apply a method of measuring the similarity between plagiarized passages.

In our bilingual PD corpus, the English and Persian Wikipedia articles have been used for the source and suspicious documents, respectively. Wikipedia is one of the largest multi-lingual corpora, which is highly popular and contains documents in different languages [19], [20]. Wikipedia is a rich vocabulary corpus that contains documents in different domains and contain a wide range of topics [21]. As a pre-processing step, the small size articles were removed from the corpus. Moreover, all the selected documents were normalized. In order to avoid instances of pseudo plagiarism passages, the near duplicate documents were removed from the data. The statistics of the documents in the corpus are presented in Table 1. In the next sub-sections we will deal with constructing the parallel corpus and also compiling the cross-language PD corpus.

Table 1: Corpus Statistics

Document Purpose	Number of Documents	27115
	% of Source Documents (English)	73%
	% of Suspicious Documents (Persian)	27%
Document Length	Short (1-500 words)	16%
	Medium (500-2500 words)	53%
	Long (2500-33000 words)	31%
	Average number of words per document	2353
	Average number of sentences per document	115
	Smallest document (by words)	300
	Largest document (by words)	32620

3-1- Construction of Plagiarism Cases

The main steps being used to construct the English-Persian cross-language plagiarism detection corpus are depicted in Figure 1. The mentioned stages in the figure to construct the plagiarism cases will be described in detail in the following sub-sections.

3-1-1- Extracting Parallel Sentences

In this step we need a parallel bilingual corpus with similarity scores for each sentence pair. Some efforts have been made in other researches that could be useful for developing a bilingual corpus. For example a method has been developed for automatic acquisition of translated web pages based on searching the hyper-links containing strings of the kind “Persian version” in order to download the versions of a given page in other languages [22].

The parallel corpus which we have presented in this paper is created by an approach that automatically extracts

parallel sentences from the web applied to English and Persian Wikipedia articles. To produce the parallel corpus, a Maximum Entropy binary classifier is trained to compute local similarities between sentence pairs of two aligned documents [19].

For building aligned paired sentences, first of all, the aligned English-Persian documents were extracted from Wikipedia. In the second step, in order to extract aligned sentences, a Maximum Entropy binary classifier has been trained in order to evaluate the local similarity between sentence pairs in Persian and English aligned documents [23]. MaxEnt classifiers are log-linear models that try to capture contextual information. They use a conditional probability of a model y given the history x and a parameter vector as follows:

$$P(y|x,\lambda) = \frac{\exp \sum_i \lambda_i f_i(x,y)}{\sum_{y' \epsilon Y} exp \sum_i \lambda_i f_i(x,y')} \quad (1)$$

Where x is the input domain which represents the history, y is a finite label set that represents the model, and $f(x,y)$ is the feature vector representation. In this equation, each feature comes with a corresponding parameter vector weight λ_i. It should be noted that MaxEnt classifiers do not depend on the correlation between features. Barrón-Cedeño, Paramita, Clough, and Rosso have investigated cross-language similarities by incorporating various features such as character n-grams, cognateness, word count ratio, and an approach based on out-links in Wikipedia pages [24]. In this research, a collection of 12 features in four categories were exploited to train the maximum entropy classifier [23]. The four categories are as follows:

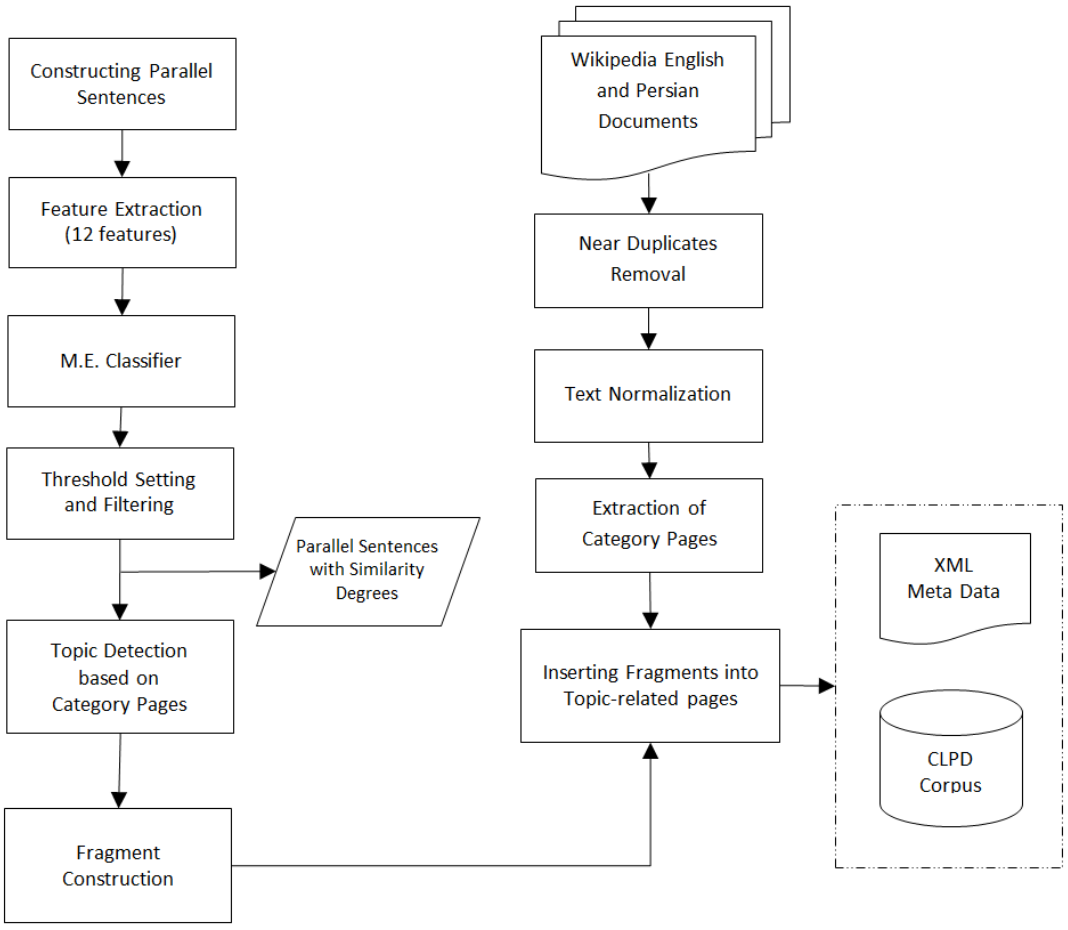

Fig. 1 Flow Diagram of Bilingual PD corpus construction

1. Features based on sentence length
2. Dictionary based features
3. Alignment-based features
4. Miscellaneous features

The features for the construction of a parallel corpus have been thoroughly described in [23]. In order to train the MaxEnt classifier, a non-parallel corpus was also constructed to compensate the bias toward the parallel sentence. As a result, by incorporating these features into the log-linear model, an alignment score is derived from the MaxEnt classifier. This score is used as a measure of similarity between paired sentences and is incorporated in the obfuscation stage of the corpus compiler.

3-1-2- Topic Extraction

In this step, the proposed approach for clustering the sentences of the parallel corpus is presented. The sentences of the parallel corpus are put together in order to construct plagiarism fragments based on their topic similarity. In addition, the plagiarism cases should be inserted into documents with similar topics. This could result in more realistic cases of plagiarism and could make the plagiarism detection process more difficult. Since the parallel aligned sentences are extracted from Wikipedia, so we used the Wikipedia rich structural properties of relevant pages to properly extract the topics and to cluster them for finding similar sentences. Among different structural features, we used the ”Categories pages” bipartite graph extracted from Wikipedia pages to separate distinct pages and extract similar ones.

For searching sentences in the Wikipedia repository, at the first stage, we extracted the relevant Wikipedia page for each sentence in the parallel corpus. Using Apache Lucene, we indexed the Wikipedia pages for finding relevant pages. In the next stage, the extracted pages are clustered based on their connectivity. The pages' connectivity was obtained from the categories- pages bipartite graph. The Infomap community detection algorithm was used to extract the clusters of pages from pages' graph [25]. Fortunato and Lancichinetti tested several community detection methods against a recently introduced class of benchmark graphs, with heterogeneous distributions of degree and community size [26]. They concluded that the Infomap method by Rosvall and Bergstrom has the best performance on the set of benchmarks they examined [26]. So, due to good performance of the Infomap community detection method, and its reliability in applications to real graphs, we used this method to extract clusters from pages' graph. In the last stage, the sentences were clustered based on the clusters of their related pages.

3-1-3- Building Plagiarism Passages

Plagiarism cases in the bilingual corpus are constructed from parallel sentences. Plagiarized fragments have been constructed from Persian sentences, and corresponding source fragments have been constructed from English sentences aligned with the source sentences.

As a result, by defining a similarity score between sentence pairs in English-Persian parallel corpus, we can make various patterns of obfuscation in plagiarized passages by putting together sentences with the same similarity scores into one plagiarized passage. Sentences with low similarity scores create high obfuscated passages, while highly similar sentences will result in low obfuscated passages. Based on this method, a combination of different plagiarism cases was built and added into the source and suspicious documents. Some examples of created fragments by sentences with different similarity scores are shown in Tables 2 and 3.

Table. 2 Example of paired sentences with similarity scores

English Sentence	Persian Sentence	Similarity Score
Willie Nelson at the Teatro	ویلی نلسون در تیترو	0.44
I hate heaven – 1998	من از آن متنفرم بهشت - ۱۹۹۸	0.51
A concise course in physics,	دوره مختصر از علم فیزیک	0.57
Economic history of ancient Greece	کتاب تاریخ کهن یونان	0.41
Sarah Bernhards – French stage and film actress	سارا برنار، هنرپیشه فرانسوی	0.53
Allen Garfield – Leo Kubelsky	الن گارفیلد – لیو کبلاسکی	0.48
President of the American oriental society	رییس جامعه شرق شناسان امریکا	0.62

Table. 3 Example of plagiarized fragments

Passage	Persian Passage	Degree of Obfuscation
President of America oriental society Sarah Bernhards – French stage and film actress	رییس جامعه شرق شناسان آمریکا، سارا برنارد، هنرپیشه فرانسوی	Low
Allen Garfield – Leo Kubelsky, I hate heaven – 1998	آلن گارفیلد – لیو کبلاسکی، من از آن متنفرم بهشت - ۱۹۹۸	Medium
Economic history of ancient Greece, A concise course in physics, Willie Nelson at the Teatro	کتاب تاریخ کهن یونان، دوره مختصر از علم فیزیک، ویلی نلسون در تیترو	High

To consider the degree of obfuscation in plagiarized fragments, we exploited a combination of sentences with different similarity scores. The similarity score of sentences in a fragment specifies the degree of

obfuscation. As shown in Table 2, for constructing “Low” obfuscated passages, we used sentences with scores between 0.5-1.0, for constructing ”Medium” obfuscated passages, we used a combination of sentences with scores between 0.5-1.0 and sentences having the scores in the range of 0.45-0.5, and for constructing ”High” obfuscated passages, a combination of sentences with scores between 0.5-1.0 and sentences having the scores of 0.4-0.45 have been used. As a result, three different degrees of obfuscation have been inserted into the bilingual corpus named as ”Low”, ”Medium”, and ”High” obfuscation which is shown in Table 4. Also, the ratio of different degrees of paraphrasing in the proposed corpus is represented in Table 5.

In this paper, the scores derived from features of the parallel sentences in parallel corpus were considered as the bases criterion for producing plagiarism cases with different level of obfuscation.

Table 4 Degree of obfuscation in plagiarism cases

Degree	Similarity scores of sentences in fragment		
	0.40 - 0.45	0.45 - 0.50	0.50 - 1
Low	-	-	100%
Medium	-	25% - 45%	55% - 75%
High	45% - 65%	-	35% - 55%

Table 5 Statistics of different degrees of paraphrasing

Plagiarism Case Statistics		
	Number of Fragments	11210
Obfuscation	Low Obfuscation	49%
	Medium Obfuscation	50%
	High Obfuscation	1%

3-2- Construction of Source and Suspicious Documents

The Persian and English articles from Wikipedia repository have been used for creating suspicious and corresponding source documents. We considered two restrictions for choosing documents. First, a length restriction was applied for choosing the documents, so that the pages with less than 300 words were not considered. Second, the chosen documents should have similar topics with parallel corpus sentences. Therefore at this point, we used the extracted clusters mentioned in the previous section for choosing proportionate pages. For this purpose, we considered the Wikipedia pages categories as the cluster label. For each cluster, the Wikipedia pages with similar categories are considered as the cluster’s pages.
After clustering pages based on their categories, they are divided into two distinct sets, namely suspicious and source ones. We considered English pages as the source and Persian pages as the suspicious ones. This is because most plagiarism cases occur from English resources translated into Persian text.

Persian belongs to Arabic script-based languages which cover Kurdish, Urdu, Arabic, Pashtu, and Persian [27]. These languages have common features such as common scripting, absence of capitalization, right to left direction, lack of clear word boundaries, and complex word structure. So, there are also some challenging issues dealing with basic NLP operations on Persian text processing, such as tokenization and stemming. We used Parsivar pre-processing toolkit for these operations [28].

3-3- Compiling the PD Corpus

In order to insert the plagiarism fragments into source and suspicious documents, the same parameters as PAN-PC-12 corpus [29] have been considered in this paper. In other words, we used the same distributions for corpus main parameters such as fragment lengths, and the number of plagiarism fragments per documents. In addition, the similarity scores derived from parallel sentences in parallel corpus were considered as the bases criterion for producing plagiarism cases with different level of obfuscation. Table 6 shows the length of plagiarism fragments in terms of the number of sentences.

The percentage of plagiarism in each suspicious document is distributed between 5% and 60% of its length. The ratio of plagiarism per suspicious documents is shown in Table 7. We have used XML tags to specify the meta-data characteristics of the plagiarized segments in suspicious documents and corresponding source documents. The corpus is tagged by specifying the offset of plagiarism cases and its equivalent fragment in both source and suspicious documents. Moreover, the length of plagiarism cases and also the degree of obfuscation (low, medium and high) have also been inserted into XML meta-data files.

Table 6 Plagiarism case statistics

Case Length	Short (20-50 words)	35%
	Medium (50-100 words)	50%
	Long (100-300 words)	15%

Table 7. Ratio of plagiarism fragments in documents

Plagiarism per Document	**Ratio**
Hardly (5% - 10%)	78%
Medium (11% - 25%)	19%
Much (26% - 60%)	3%

4- Corpus Evaluation

There are some methods for evaluation of text reuse detection corpora as follows:

- Evaluation with one or more downstream tasks to inspect the behavior of the corpus with different degrees of paraphrasing (Extrinsic evaluation).
- Evaluation with Pearson correlation coefficient to investigate how the human judgment complies with different degrees of paraphrasing in the corpus (Intrinsic evaluation)
- Evaluation of the size of the corpus; the size of the corpus is increased step by step and in each step, the corpus is evaluated with various evaluation methods. The process is stopped when the evaluation criteria doesn't change and remains fixed.
- Comparing the corpus with a standard corpus to investigate the various parameters of the corpus w.r.t. standard one.

There are also some validation experiments to validate text re-use corpora:

- A manual checking should be done for evaluating the quality of plagiarized fragments.
- The corpus can be automatically validated considering the ratio of the length of plagiarized passages to the length of the documents.
- The corpus can also be validated by inspecting the distribution of plagiarized passages across the documents.

In this section, two approaches for the evaluation of the constructed corpus have been exploited. For the first evaluation approach, the extrinsic method proposed by Clough & Stevenson has been used [30]. In this approach, we use the constructed corpus as input to a downstream task (plagiarism detection) and measure the impact of degrees of paraphrasing on the algorithm's performance. On the other hand, intrinsic evaluations directly evaluate a corpus from different point of views. In the intrinsic approach of evaluation, we have calculated Pearson correlation coefficient to investigate how the human judgment complies with different degrees of paraphrasing in the corpus.

4-1- Extrinsic Evaluation

In the case of the first approach, the main idea is that the degree of paraphrasing should affect the performance of plagiarism detection algorithms. More precisely, the algorithms' performance on finding plagiarized fragments would be decreased by increasing the degree of paraphrasing. Clough and Stevenson have used a simple n-gram based method as a baseline for measuring the influence of the obfuscation degree in the performance of a plagiarism detection method [30]. In this research, we have applied machine translation plus monolingual analysis (T+MA) and Latent Semantic Analysis (LSA) methods along with the Vector Space Model (VSM) to determine whether they can distinguish between the various levels of paraphrasing. In order to test the validity of our approach and compare the results, we evaluated the performance of the methods on the total corpus and also various parts of the corpus with different degrees of paraphrasing as follow:

- Total corpus
- Low degree of paraphrasing part of the corpus
- Medium degree of paraphrasing part of the corpus
- High degree of paraphrasing part of the corpus

For T+MA method, the Targoman [1] machine translation API was used for translating documents in Persian into English. Targoman is the state-of-the-art English-Persian machine translation system that is freely available to be used. After translating Persian documents to English, the source and suspicious documents have been compared to detect cases of plagiarism. To this end, the cosine similarity between vectors (VSM model based on tf-idf weighting) of both source and suspicious sentences have been computed using the following equation:

$$Cos\theta = \frac{S_{src}.S_{susp}}{\|S_{src}\|.\|S_{susp}\|} \quad (2)$$

Where $S_{src}.S_{susp}$ is the dot product of the source and suspicious sentences' vectors, and $\|S_{src}\|.\|S_{susp}\|$ are norms of the source and suspicious sentences, respectively. The Plagdet measure was introduced by Potthast et.al, for evaluation of the algorithm's performance against different levels of paraphrasing in the corpus [18]. Plagdet is a common metric for evaluating PD systems which is a weighted F-measure as depicted in the following Equations:

$$Plagdet\ (S,R\ ) = \frac{F_1}{1 + gran(S,R)} \quad (3)$$

$$Prec\ (S,R\ ) = \frac{1}{|R|}.\sum_{r\in R}\frac{U_{s\in S}\ (s \cap r)}{|r|} \quad (4)$$

$$Recall\ (S,R\ ) = \frac{1}{|S|}.\sum_{s\in S}\frac{U_{r\in R}(s \cap r)}{|s|} \quad (5)$$

$$F_1 = 2.\frac{Precision.Recall}{Precision + Recall} \quad (6)$$

Where S denote the set of plagiarism cases in the suspicious documents of the corpus, and R denote the set of plagiarism that are detected by the detector for these documents, and F_1 denotes the $F-Measure$. Moreover, the parameter $gran$(S,R) indicates the one-to-one correspondence between detected and desired source fragments.

[1] www.targoman.com

The performance of detection in diff erent parts of the corpus is depicted in Figures 4 and 5. The obtained results of applying T+MA and LSA methods on the proposed corpus show the influence of levels of obfuscation on algorithms' performance in detecting cases of plagiarism in the corpus regardless of chosen parameters.

4-2- Intrinsic Evaluation

In addition to the extrinsic evaluation of the proposed corpus, we have used an intrinsic approach in which the human judgment has been used as an assessment criterion to investigate how human degrees comply with fragments' degrees of paraphrasing, using the *Pearson correlation coefficient*. For this purpose, the approach by Paramita, Clough, Aker, & Gaizauskas has been used [31]. A collection of eight Persian speaking persons fluent in reading English texts were asked to assess the similarity of English and Persian fragments based on a 9-point Likert scale in the range of 1 to 9 (very low similarity to very high similarity). A total number of 150 fragments have been annotated by at least 3 persons in the mentioned range of similarity. The Pearson correlation coefficient has been used to compute the degree of correlation between automatically computed degrees of paraphrasing and human judgments based on the following equation:

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2} \cdot \sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}} \quad (7)$$

Where x_i and y_i are "automatically generated degrees" and "degrees assigned by human judgments", respectively. Moreover, $\bar{x}$ and $\bar{y}$ are the mean of degrees.

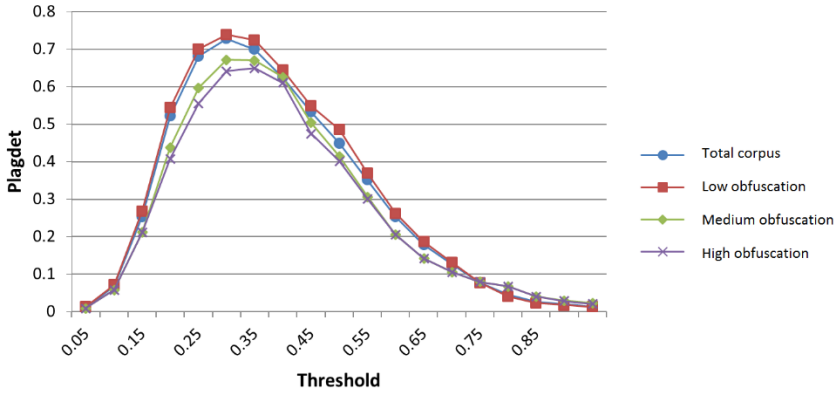

Fig. 4 Changes of Plagdet vs. cosine similarity by applying T+MA on various parts of the corpus

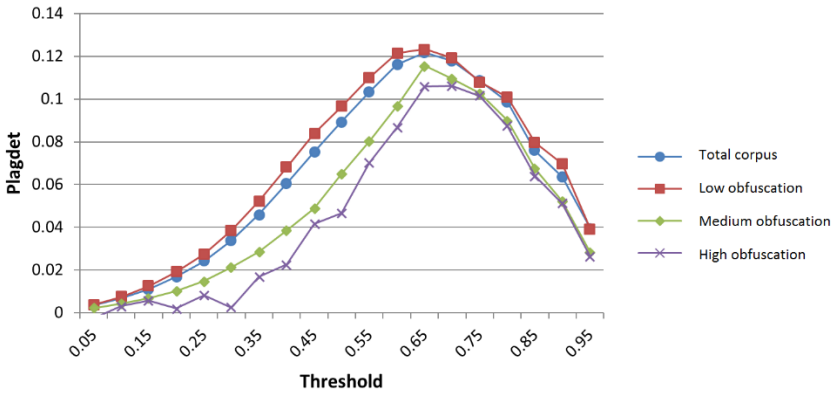

Fig. 5 Variation on Plagdet vs. cosine similarity threshold, by applying LSA on various parts of the corpus

The results show a *Pearson correlation coefficient* of r = 0.665 which shows that; there is a significant correlation between the paraphrasing degrees assigned by the assessors and automatically assigned degrees, that is higher than related studies like what has been done in [31].

To conclude, we applied two different approaches to evaluate the proposed corpus based on level of paraphrasing. Our results show that the proposed corpus and the applied method for ranking the level of

paraphrasing is accurate in both extrinsic and intrinsic evaluations.

5- Conclusions and Future Works

In this study, we have constructed an English-Persian bilingual plagiarism detection corpus by exploiting Wikipedia English and Persian articles as main resource data for source and suspicious text, respectively. We also used a parallel bilingual corpus to construct plagiarized passages. In order to create passages with various degrees of obfuscation, we incorporated some global and local features in order to measure the similarity between plagiarized sentences in the source and target languages. As a result, we can measure the degree of obfuscation in the aforementioned plagiarism detection corpus. So we can adjust the complexity of obfuscation in plagiarized passages in the dataset.

In order to build a more realistic corpus, the plagiarized passages were inserted into the topically related source and suspicious text. We applied two different PD algorithms on the bilingual corpus as extrinsic evaluation and also human judgment evaluation as intrinsic evaluation approach. The results prove the validation of the proposed obfuscation method in our bilingual corpus. The constructed CLPD corpus is freely available on the web for research purposes1.

Further improvements can be conducted by adding compositional text where one sentence in the source document is translated and converted into two or more sentences in the suspicious document or vice versa. Moreover, different types of obfuscation can be applied to the corpus as well. So we can reach a multi-type multi-degree obfuscation CLPD corpus.

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Reducing Energy Consumption in Sensor-Based Internet of Things Networks Based on Multi-Objective Optimization Algorithms

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Abstract

Energy is an important parameter in establishing various communications types in the sensor-based IoT. Sensors usually possess low-energy and non-rechargeable batteries since these sensors are often applied in places and applications that cannot be recharged. The most important objective of the present study is to minimize the energy consumption of sensors and increase the IoT network's lifetime by applying multi-objective optimization algorithms when selecting cluster heads and routing between cluster heads for transferring data to the base station. In the present article, after distributing the sensor nodes in the network, the type-2 fuzzy algorithm has been employed to select the cluster heads and also the genetic algorithm has been used to create a tree between the cluster heads and base station. After selecting the cluster heads, the normal nodes become cluster members and send their data to the cluster head. After collecting and aggregating the data by the cluster heads, the data is transferred to the base station from the path specified by the genetic algorithm. The proposed algorithm was implemented with MATLAB simulator and compared with LEACH, MB-CBCCP, and DCABGA protocols, the simulation results indicate the better performance of the proposed algorithm in different environments compared to the mentioned protocols. Due to the limited energy in the sensor-based IoT and the fact that they cannot be recharged in most applications, the use of multi-objective optimization algorithms in the design and implementation of routing and clustering algorithms has a significant impact on the increase in the lifetime of these networks.

Keywords: Internet of Things (IoT) Based on Wireless Sensor; Clustering; and Routing; Type-2 Fuzzy and Genetic Algorithms; Multi-Objective Optimization Algorithms.

1- Introduction

IoT is one of the new technologies in the present era. The IoT is defined as the communication and integration of intelligent objects. Different objects include cell phones, sensors, radio-frequency identification (RFID) tags are part of the IoT that connect to the Internet through wired and wireless sensor networks. Smart objects can sense, collect, and transfer data to meet users' different needs [1] [2].

The IoT is referred to as the precise connection between the digital and physical worlds [3]. Different IoT researchers have described objects in different ways [4] [5]:

- "A dynamic global network infrastructure with the capability of automatically adjusting based on interactive communication standards and protocols which are physical and virtual "objects" with physical properties, virtual characters, and identities, applies intelligent interfaces and is aggregated with the data network in an integrated manner."
- "A global infrastructure for the data society that provides advanced services by connecting (physical and virtual) objects based on available and evolving data and communication technologies."

In sensor-based IoT networks, the battery is the main power supply for sensor nodes, and in most applications, due to the abundance and unavailability of sensors, replacing their energy resource is impossible or extremely challenging. The energy resource in a sensor is limited, and as a result of energy discharge, the sensor node makes the sensory and covering area smaller. Hence, energy conservation in wireless sensor-based IoT networks is one of the issues that should be considered [6] [7].

There are many approaches to minimize the energy consumption in the sensor-based IoT network, one of the most extensively used and effective of which is the enhancement of clustering and routing algorithms in these

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networks, which has recently been considered by many researchers. Due to the lack of energy resources in sensor-based IoT networks, designing energy- efficient algorithms to reduce sensors' energy consumption is considered significantly important [8].

The network can be divided into small parts where the sensors are partitioned into clusters; a cluster head exists in each of which with the role of collecting data from member nodes and send them to the base station. The advantages of clustering include scalability of the network, localization of route settings, preservation of communication bandwidth through decreasing the relayed packets, minimizing energy consumption rate, and stability of network topology [9].

Clustering supports scalability and is capable of being expanded to any level. There are local communications between the sensor nodes inside the clusters. Moreover, clustering can stabilize the network topology at sensor level and reduce the maintenance overload of the topology. Sensors are not only involved in communication with their cluster heads and are not affected by changes in the surface between the cluster heads [10] [11].

In most of the existing approaches in selecting the cluster heads, two-step processes are applied; in the first stage, the cluster head is randomly selected and then in the second stage, a cluster head that has more energy is selected from among the member nodes to balance energy consumption.

In these approaches, only the nodes' energy is considered, and the location and sensors' density are not taken into account. The network may face the hotspot problem and cause cluster heads in critical paths or near the base station to be discharged and get out of the network [12] [13]. Some solutions to this problem emerged, include unequal clustering, in which clusters of different sizes were formed based on the distance from the cluster head to the base station. In these solutions, the clusters' size closer to the base station is smaller than the farther clusters.

The routing problem is as important as the clustering issue. In general, routing provides a response to the following question: How does an entity get from source to destination? In the IoT network, the entity is a data packet, and a couple of computing devices are the destination and source of the data packet. A computing device can be an internet device (e.g., a personal computer or server) or an IoT device (e.g., sensor node, smartphone, or an RFID tag). The computing device is also called the routing node. Packets must pass through intermediate nodes before entering the destination because there is not always a direct physical path between the destination and source of the data packet. Multi-step routing is another name for this approach. The set of steps, namely the routing of intermediate nodes present in the data packet transfer, is called the routing path [13], [14].

There is a classification in distributed sensor-based IoT network routing compared to the centralized one: This classification has been provided based on the location of the routing decision-making, namely the location that specifies which path the data packets to be transferred. Two options are available: distributed centralized. In a distributed method, a node or set of adjacent nodes makes the routing decision and do not possess the entire network's data but only have information around their local status (and probably, their neighbors' status). Therefore, routing decisions are made only based on this limited knowledge. Flexibility is the advantage of distributed routing because decisions are distributed and can be made by each node. The disadvantages of this method are that the routes may not be optimal, and there is a possibility that the load distribution is not adjusted because only local data is applied. In the centralized method, there is a super-node with resources and complete knowledge of the network's status. This super-node controls all nodes, calculates the optimal path for each data packet, determines unused nodes and bottlenecks, and adapts the paths. Complete control over all network dimensions is the advantage of centralized routing; thus, optimal routes must be calculated. The disadvantage of this method is the high maintenance cost of the super-node [15][16].

In this article, a new reducing energy consumption method is proposed that considers the importance of the parameters of the distance between the cluster heads, the density of the sensors, the residual energy of the nodes, the centrality, and the distance between the cluster head to the base station.

The contributions of the proposed method as follows.

- Applying the parameters of residual energy, density and centrality to select the appropriate cluster heads.
- Applying the shortest route between the cluster heads to the base station.
- Evaluating the effectiveness of the proposed method using a simulation tool in comparison to the counterpart approaches.

The following sections of the present articles are organized as the following. In Section 2, previous works are addressed; the proposed algorithm is discussed in detail in Section 3, in Section 4, the results obtained from the simulations are analyzed by the authors, and a conclusion is presented in the final section.

2- Previous Works

Clustering the network's nodes is a successful topology control and design technique that can be applied to increase network efficiency. Clustering-based routing leads to the enhancement of network conditions. The two main steps in clustering-based routing include selecting cluster heads and routing by cluster heads [16]. Energy conservation is possible by utilizing cluster heads to collect data from other nodes and resend it from cluster heads to central stations [17]. Therefore, selecting the appropriate cluster head from

the nodes can enhance energy efficiency and increase the sensor network's lifetime.

In this section, the authors will discuss some routing and clustering protocols that have been considered in recent years.

Low-energy adaptive clustering hierarchy (LEACH) is a distributed algorithm in which the selection of the cluster head is performed locally [18] [19]. In this approach, the cluster head are randomly selected in the first step, and all data processing, including data integration and collection, are performed locally inside the cluster. In LEACH, the shape of clusters has been distributed using an algorithm in which the nodes make decisions independently without any centralized control. First, a node randomly decides to become a cluster head with the probability of p and broadcast its decision. Any node but the cluster head can be a desired member of the cluster head according to the minimum energy required to communicate with the cluster head. The cluster head rotates alternately between cluster nodes for maintaining the balance of the rotation load [21]. This rotation is done through taking each node i for selecting a random number T(i) in the interval [0,1]. If the number T(i) is lower than the threshold given in
equation(1), each node i becomes a cluster head for the current rotation:

$$T(i) = \frac{p}{1 - (r.mod\frac{1}{p})}, i \in G \quad (1)$$

Where p denotes the desired percentage of nodes in the sensor population, r implies the number of rounds, and G denotes the set of nodes that did not exist in the previous 1/p round. LEACH leads to the development of the topology of the cluster of a hob in which every single node can be transferred directly to the cluster head and then to the base station.

The limitations of LEACH: in spite of the fact that the LEACH leads to the energy conservation of nodes and increases the network's lifetime, it still includes some limitations [22] [23]:

- LEACH is appropriate only for small size networks.
- At the start point of every single round, the selection of the cluster heads from these nodes is performed randomly and regardless of the remaining energy via LEACH.
- Direct communication of each cluster head with the base station is made using LEACH, regardless of whether the distance is small or not.
- Cluster heads can be centralized in one place; thus, nodes will be separated (without cluster head).
- There is no mechanism in LEACH to ensure that selected cluster heads are uniformly distributed on the network.

The MECBCCP protocol was introduced by Rhoni et al. [1] for the WSN-based IoT network. In this method, the network environment is layered for clustering operations. Afterward, gateway nodes, cluster head, and coordinators are specified respectively, and then the normal nodes become the nearest node to the getaway, and gateway nodes are connected to head clusters. The cluster heads are then connected to the coordinators, and also the coordinator nodes are connected to the nearest coordinator node of the upper cluster. In the next step, the coordinators of the last layer are connected directly to the sink, and finally, the cluster head of the last layer is directly connected to the base station.

In this technique, relay nodes (RNs) are picked randomly, and no distance parameter is taken into account for the next RN selection. Consequently, some RNs may overlap, which leads to additional system costs (due to selecting the node as RN) and the use of inefficient resources. The number of selected RNs can vary from cluster to cluster and depends on the cluster nodes' density.

Dynamic clustering with relay nodes (DCRN): In this article [24], a dynamic clustering algorithm using genetics has been presented. In this algorithm, the nodes are first placed in an environment in a random manner, and the sink is placed in a static state outside the environment. Then, the cluster heads are picked by a genetic algorithm, the fitness function of which includes: 1) set of distances of all head clusters from the base station, 2) cluster distance: set of distances of all nodes from their cluster heads, 3) standard deviation of cluster distance, and 4) Transmitted energy. After the cluster heads are determined, the normal nodes become the member of the nearest cluster head.

After this step, the data is collected by normal nodes and sent to the cluster head, and then the cluster heads send the data to the base station in a single-step manner, which leads to an increase in the energy consumption of the cluster heads farther from the base station.

Multi-objective fuzzy clustering algorithm (MOFCA) [25] [26]. MOFCA algorithm is proposed for solving sudden energy loss in homogeneous wireless sensor networks. In MOFCA, in each round, a number between 0 and 1 is picked by each node; if the chosen number is smaller compared to the threshold (a percentage of the number of cluster heads), one can consider this node as a temporary cluster head. Then, temporary cluster heads can calculate their competitive radius using fuzzy inputs and fuzzy logic, fuzzy inputs include node density, distance to the base station, and remaining energy. Every temporary cluster head sends a message based on its maximum competitive radius and predetermined radius. A temporary cluster head withdraws from the competition if it receives this message from another temporary cluster head with a higher energy level. In the case that the two nodes' energy levels are equal, the density parameter is applied to compare them. Higher-density temporary nodes of cluster head are selected as final nodes of cluster head. The non-cluster head nodes join the nearest cluster head After determining the final nodes of the cluster head.

Energy conserved unequal clustering with fuzzy logic (ECUCF) [27]. In this method, a number between 0 and 1 is picked randomly by each node; in the case that this number is smaller compared to the predetermined threshold, one can

consider it as the initial cluster head. Then, on the basis of the proximity of the node, the remaining energy, and the distance to the base station, using fuzzy logic, the whole network is divided into three parts. In each section, the comparison of the energy of the node with the energy threshold is performed. In the case that the node's energy is lower than the threshold, the node goes to sleep; otherwise, the node remains active. Each primary node of cluster head calculates its competitive radius with respect to the inputs, including information of node section, distance to the base station, and remaining energy, and then publishes a message within its competitive radius. In the case that the message receiver has lower remaining energy compared to the sender node, it withdraws from the competition for being a cluster head. In the case that a normal node observes this message, selects the cluster head according to the fuzzy inputs (distance, remaining energy, and proximity of the node) and joins the corresponding cluster [26].

3- System Model

Before describing the proposed algorithm, it is noteworthy to discuss the hypotheses taken into account in this method as the following:

- Simulation is performed in several scenarios; depending on the scenario, the sensors' energy is either homogeneous or heterogeneous. In the state of being homogeneous, the energy of all nodes equals 1 J, and when the environment is heterogeneous, the energy of half of the sensors is equal to 2 J.
- Nodes have been randomly and uniformly distributed in the environment.
- The base station (sink) can be anywhere in the network environment; however, it has been considered outside the environment in the present paper.
- It is not essential for all nodes to be fixed after distribution. However, here, mobility does not involve many alterations of initial location through remote control but only involves ground displacements, including displacements or erosion resulting from external objects that cause in place alterations.
- Energy consumption in the nodes is not a result of mobility because it has been assumed to be performed by external resources.

3-1- Energy Consumption Model

The consumption model of energy in sensor networks is directly related to the way of designing of access control sub layer to media in these networks. However if we want to use a common model which is independent of the design parameters defined in the access control sublayer to the media, we use the following relations for modeling the energy consumption amount in the networks. The energy consumption model is considered just the same as the Leach's one, in the proposed algorithm, which both models use the open space channel (energy dissipation d^2) and the multi-path channel (energy dissipation d^4) depending on the distance between transmitter and receiver. Thereupon, the energy used to send a 1-bit packet at the distance of d is obtained using equation (2) [28] [18]:

$$E_{Tx}(l,d) = E_{Tx}-elec(l) + E_{Tx-amp}(l,d) = \begin{cases} lE_{elec} + l_{\varepsilon fs} d^2 & d < d_0 \\ lE_{elec} + l_{\varepsilon fs} d^4 & d \geq d_0 \end{cases} \quad (2)$$

In this Equation, E_{elec} is the energy required to activate the electronic circuits, ε_{fs} and ε_{amp} are the energies required to amplify the signals sent to transmit a bit in the open space model and the multi-path model, respectively. d is the distance among nodes, also d_0 is the threshold value of distance obtained from equation(3) [29] [18]:

$$d_0 = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{amp}}} \quad (3)$$

The energy used to receive a 1-bit packet is obtained from equation (4) too.

$$E_{Rx}(l) = E_{Rx-elec}(l) = lE_{elec} \quad (4)$$

3-2- Proposed Method

The main objective of the present study is the reduction of the energy consumption of IoT-based sensor networks. Thus, an approach based on multi-objective algorithms has been introduced to minimize energy consumption in the network. Multi-objective optimization methods are used to find the best possible answer (near-optimal) in an acceptable time. In this section, the proposed algorithm will be described in detail.

Proposed Algorithm

```
Select nodes in sensing area for clustering
1  For k=1: number of nodes
2        Calculate remain energy, density and centerality of nodes;
3        Calculate fuzzy a mount of nodes with Relay Fuzzy Logic 2 ();
4        Sort nodes according to fuzzy amount;
5        Select 10 percent of node with maximum fuzzy amount
   as cluster heads;
6  End_For
7        For i=1: number of nodes
8           If node_i is normal node
9              Node_i joins to nearest clusterhead_k;
10                End_IF
11 End_For
Routing to send cluster head information
12 Route= Route Genetic Algorithm ();
13 For i= clusterhead
14       Clusterhead _i joins to route;
15 End_For
16 Last node of route, connects to sink;
```

Fuzzy logic can make precise decisions in real-time and is simple in terms of resiliency. Moreover, the type-2 fuzzy logic model can accurately manage the measurement level of uncertainty compared to the type-1 fuzzy logic model

because its membership functions are fuzzy sets. Figure (4) indicates the type-2 fuzzy block diagram [30].

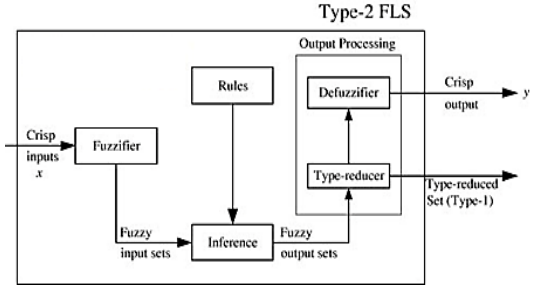

Fig.4. type-2 fuzzy diagram [30]

IT2 FLCs [1] control uncertainties better than IT1 FLCs [2]; therefore, they are used more widely. The two essential differences between IT2 and IT1 FLCs include: 1) Adaptiveness, that is, using embedded T1 fuzzy sets to calculate the type-reduced interval change bounds as input changes, and 2) Novelty, that is using the upper and lower membership functions simultaneously in computing each bound. The T1 FLCs lack the features and cannot implement the complex IT2 FLC control level based on the same rule base [31]. Here are some differences between IT1 and IT2 FLCs:

- IT2 FS[3] membership grade is interval rather than a crisp number in T1 FS, so T2 models intrapersonal and interpersonal uncertainties as an intrinsic feature of natural language better than T1.
- Using IT2 FS to represent FLC inputs and outputs makes rule base reduction better than IT1 FS [32], [33]. FOU[4] ability to express more uncertainties leads to covering input/ output domains with fewer FSs. Thus, the rule base is constructed using expert knowledge and enhanced robustness [34] [35].
- IT2 FLC leads to a smoother control surface than IT1 FLC, especially in the steady state area.
- IT2 FLCs are more adaptive and more capable than IT1 FLCs in realizing the complex input-output relationships. According to Karnik and Mendel [36], the IT2 fuzzy logic system is considered various embedded T1 fuzzy logic system collections.
- According to Wu [37], various membership function degree of IT2 FS is used in the different rule base, while in IT1 FS the same membership function degree is used in the diverse rule base. So IT2 FLC is more complex than IT1 FLC, and T1 FLC cannot implement using the same rule base.

In the proposed method routing and clustering energy aware using multi-objective optimization techniques (RCEMO), the algorithm starts working after the sensors are distributed in the environment. In the proposed method, the cluster heads are specified by the type-2 fuzzy algorithm in the base station, and also, the path between the base station and cluster heads is specified by the genetic algorithm. The proposed algorithm works based on the round, and every single round includes two phases: 1) setup, 2) steady state.

In every round, the cluster heads are specified by the type-2 fuzzy algorithm, and the path between the base station and cluster heads is specified by the genetic algorithm. Then, the base station sends a message to the cluster heads so that the cluster heads to be aware of their role and the specified tree (path) from the cluster heads to the base station. After this step, the sensors that received the message of "becoming cluster heads" inform the other network sensors of their role by sending an broadcast message within the network. Afterward, the normal nodes receive the cluster heads' messages and try to join them and become members of cluster heads so that to use less energy for communicating with them and also their distance to the cluster heads to be short. Then, after the final decision of each normal node to join the selected cluster head, it notifies the desired cluster head of its decision by sending a Join-REQ message.

After all the sensors are joint to the cluster heads, the time-division multiple access (TDMA), scheduling operation is carried out by the cluster head to prevent the data collision during the transfer. Moreover, with the identification of the cluster heads, the operation of routing from the cluster heads to the base station is performed by the genetic algorithm, and the cluster heads are notified to be aware of the considered route for transferring data to the base station in the same round. Then, the steady state phase begins. At this phase, all sensors transmit their data in specific slots by applying unique distribution code. In the proposed algorithm, all sensors start the setup phase according to the coordination of the base station with each other. Cluster heads also use the same distribution code for sending their data and also listen to the channel before sending the data. If the channel is empty, they send the data; otherwise, they wait for a random period of time.

Cluster heads are specified by the type-2 fuzzy algorithm and according to the parameters of remaining energy: density (the ratio of neighboring nodes to all nodes, the higher it is, the node is more suitable for becoming cluster head) and centrality (meaning that the node is central to its neighboring nodes and is equal to the sum of the total distance between the node and its neighbors). The lower value indicates that the node needs less energy and is suitable for becoming a cluster head. Following the selection of the cluster head, other sensors can be members of one of the clusters through communicating with a cluster head and based on the required distance and energy for communication.

The equation of the remaining energy is as follows:

$$E = E_R \tag{4}$$

Where, E_R is the nodes' remaining energy.

The density of the nodes is equal to:

[1] Interval type-2 fuzzy logic controllers
[2] Interval type-1 fuzzy logic controllers
[3] Fuzzy set
[4] Footprint of uncertainty

$$D = \frac{N_n}{N_T} \quad (5)$$

Where, N_n denote the neighboring nodes, and N_T implies the total nodes.

Centrality is also defined as follows:

$$C = \sum d_i \quad (6)$$

Where, d_i is the distance to the neighboring node.

Due to the different ranges of input variables in each cluster and to make them applicable for any size of the network, we adjust the range of values of the input variables between 0 and 1 using equation (7):

$$N_i(x) = \frac{x_i}{\max(x)} \quad (7)$$

x_i is the crisp value of node i, max(x) is the maximum value of the variable in the corresponding clusters of node i, and N(x) is the normalized value which is a value between 0 and 1.

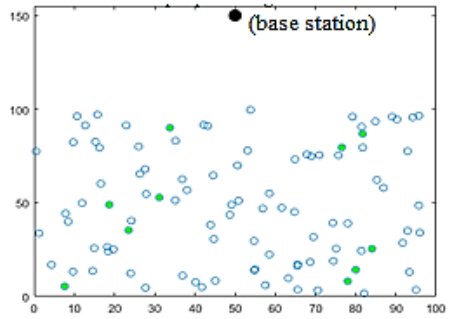

Fig.5. Selection of cluster heads using type-2 fuzzy logic

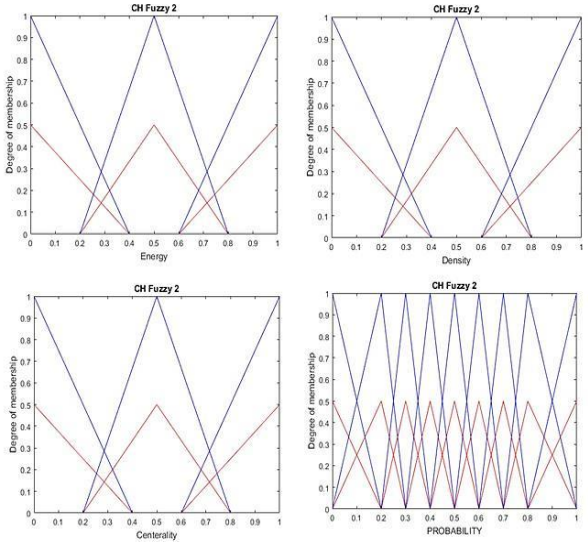

Fig.6. membership function, remaining energy, density, centrality, and output membership function

After the membership functions of all three parameters, as well as the output membership function, are created, the fuzzy rules are formed according to Table (1) and then defined to the fuzzy network.

Table 1. fuzzy rules

Row	Energy	Density	Centerality	Probability
1	Low	Low	Low	3
2	Low	Low	Medium	2
3	Low	Low	High	1
4	Low	Medium	Low	4
5	Low	Medium	Medium	3
6	Low	Medium	High	2
7	Low	High	Low	5
8	Low	High	Medium	4
9	Low	High	High	3
10	Medium	Low	Low	4
11	Medium	Low	Medium	3
12	Medium	Low	High	2
13	Medium	Medium	Low	6
14	Medium	Medium	Medium	5
15	Medium	Medium	High	4
16	Medium	High	Low	7
17	Medium	High	Medium	6
18	Medium	High	High	5
19	High	Low	Low	7
20	High	Low	Medium	6
21	High	Low	High	5
22	High	Medium	Low	9
23	High	Medium	Medium	8
24	High	Medium	High	7
25	High	High	Low	9
26	High	High	Medium	9
27	High	High	High	8

Then the fuzzy value of each node is obtained, and the 10% of the nodes with best values are determined as cluster heads, and the base station informs the cluster heads of their role. Afterward, the cluster heads send a message of "becoming cluster heads" within the network, and each normal node that receives this message becomes the member of the considered cluster head based on its energy and distance to the cluster head node and announces its membership to the cluster head. As mentioned earlier, routing is performed by applying a genetic algorithm, explained in the following. In a population-based genetic algorithm, a population possesses a set of chromosomes, each of which includes a set of genes. In the present article, there is an initial population that includes several chromosomes. The number of chromosomes' genes equals the quantity of cluster heads minus one, the value field of which is initialized with random numbers between 0 and 1. Also, its cost equals the network's energy consumption when creating the path between the base station and cluster heads using the Prüfer algorithm [38] of the desired tree. The cost value is calculated as follows:

$$Cost = \sum_{i=1}^{i=k} E_{Consumed} \quad (8)$$

$E_{Consumed}$ is the energy used by the cluster heads on the path to the base station for sending data to the base station.

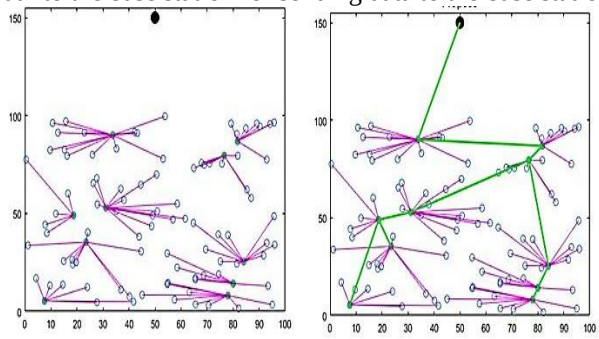

Fig.7. Taking members by cluster heads and identifying the path between cluster heads by the genetic algorithm

In the problem stated in this article, each chromosome can be a solution to the problem. A flow chart of evolutionary algorithms and the structure of the genetic algorithm is presented as the following [39]:

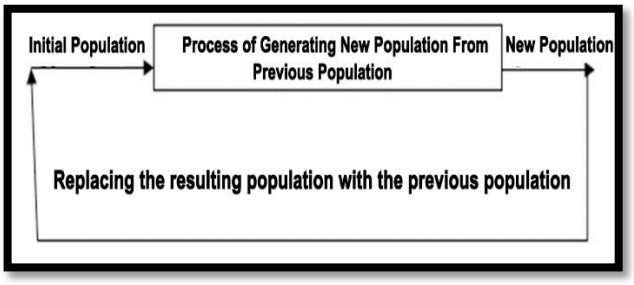

Fig.8. The generation process continues until the desired solution is obtained (normally, the initial population is generated randomly) [23]

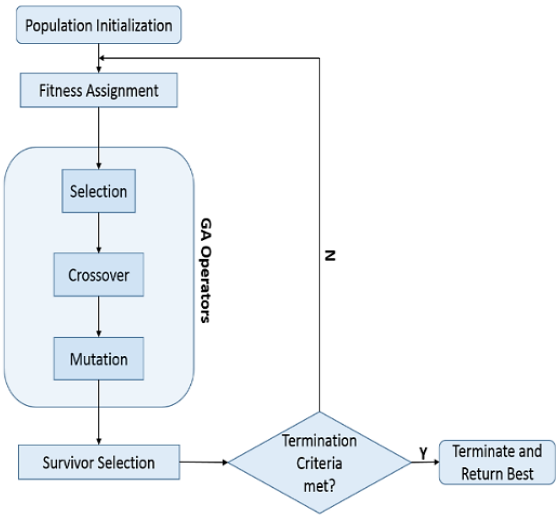

Fig.9. General structure of the genetic algorithm [23]

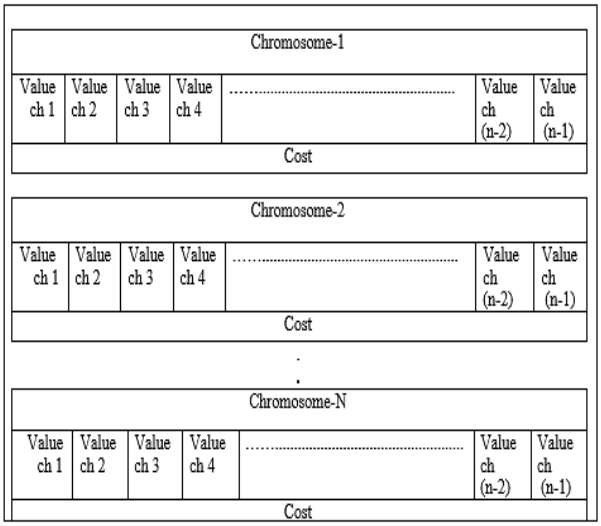

Fig.10. The view of the population in the proposed method

The population is initialized randomly. The number of iterations of the genetic algorithm is set to be 100 for finding the most suitable tree. In the proposed algorithm, 10% and 20% of the population are considered to mutation and selection, respectively.

After random initializing the genes in each chromosome, the paths are determined, and the amount of energy consumed by the network is calculated by the Prüfer algorithm. The next step is selecting parents based on the roulette wheel selection algorithm; 20% of the chromosomes with lower costs (lower network energy consumption) are selected as parents. The single point cross over operation is performed on these parents, and the new chromosomes are known as the children of the next generation. After this operation, a mutation occurs, which is done randomly on the genes of the chromosomes. Then, the new population replaces the previous population, and this operation is performed up to 100 iterations so that the best chromosome to be selected as the path from the clusters to the base station.

Finally, the chromosome with lower cost is picked as the solution to the problem, and a path between the base station and the cluster heads is formed by the Prüfer code, which is announced by the base station to the cluster heads in the setup phase.

The pseudo-code of the proposed method is presented as follows:

Clustering Fuzzy Type2 Algorithm

/ for every round */*
1. Select CH based on *Fuzzy Logic Type-2 if*-then rules from the sensor nodes with Membership Function (Remaining energy, Density and Centrality)
2. In each round, select 10 precent node for CHs

/ for CHs */*
3. All CHs collect and aggregate data

/ end of for */*

/ end of rounds */*

Routing Genetic Algorithm

1. Ititialize random chromosomes;
2. Evaluate chromosomes;
3. While (stopping condition is not met)
4. For i=all chromosomes
5. Select two parents in the population;
6. Generate two offsprings by crossover operation with probability Pc;
7. Add offsprings to population;
8. Mutate some offsprings with probability Pm;
9. End For
10. For i=all chromosomes
11. Fitness(i)=consumed energy for forwarding data according to selected route;
12. End For
13. Sort Population according to fitness;
14. Select best part of population as next population;
15. End While
16. Select best chromosome;

4- Findings

The proposed method has been simulated with MATLAB software in several different scenarios and compared with LEACH, ME-CBCCP, and DCABGA protocols.

Table 2. General parameters for simulations (Transmit Amplifier if destination to BS<=d0 ε_{fs} =10 pJ/bit/m^2 ,Transmit Amplifier if destination to BS >=d0 ε_{amp} = 0.0013 pJ/bit/m^4)

Parameter	Value	Parameter	Value
E_0	1J,2 J	ε_{fs}	10 pJ/bit/m^2
E_{elect}	5 nJ/bit	ε_{amp}	0.0013 pJ/bit/m^4
E_{DA}	5 nJ/bit/message	L_D	4000 bits
d_{break}	87.7 m	L_c	16 bits

In the first test, 200 sensor nodes were randomly distributed in an area of 300*300 square meters, in which the initial energy of all sensors is identical and equal to 1 J (homogeneous environment), and the base station is fixed and in the position 150*400. The sensors are in an environment where the movement of all is through external factors. This movement does not reduce their energy, but their position changes in each round.

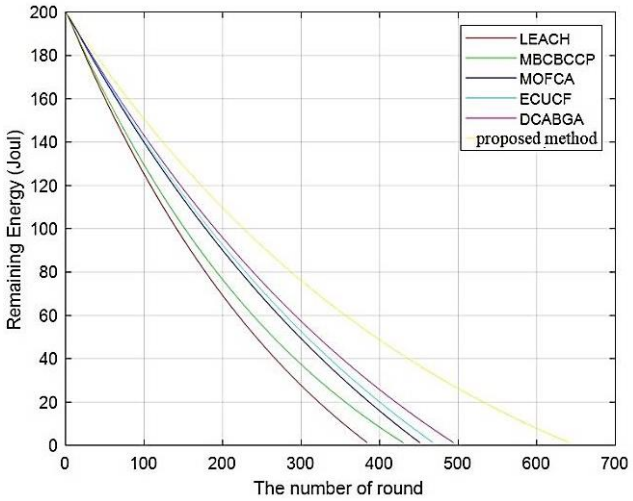

Fig.11. Comparison of remaining energy and energy consumption in the network

It is clear from figure (11) that the proposed method has enhanced the energy consumption of the network compared to previous algorithms. The proposed algorithm has increased the network's lifetime by approximately 30%, 33%,40%, 46%, and 58% compared to the DCABGA, ECUCF, MOFCA, MBCBCCP, and LEACH algorithms, respectively.

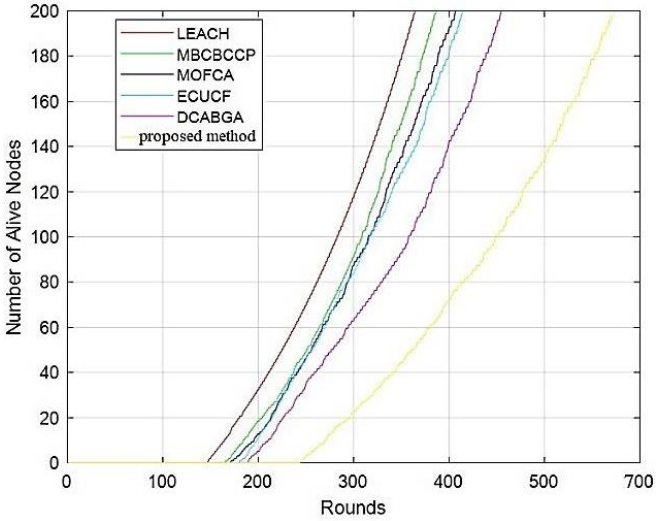

Fig.12. Comparison of the number of dead nodes in the network

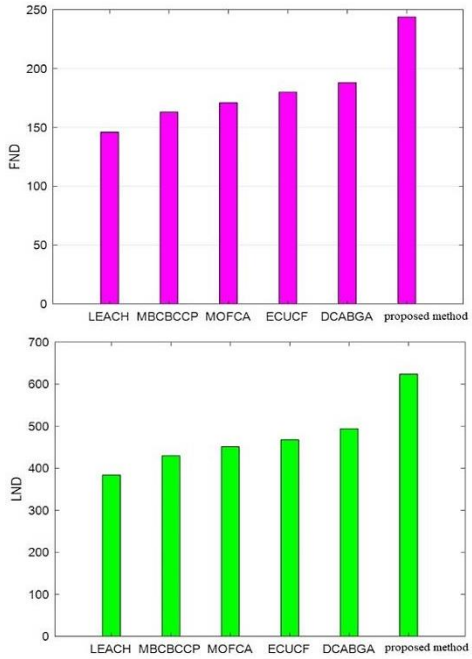

Fig.13. Comparison of the first node dead and last node dead

According to figures (12) and (13), it can be deduced that the proposed algorithm is better compared to other methods in both the first node dead (FND) and the last node dead (LND), and the sensors remain alive for a longer period of time. In the proposed method, FND and LND occur in rounds 244 and 642, respectively. In the DCABGA algorithm, FND and LND occur in rounds 188 and 494, respectively. In the ECUCF algorithm, FND and LND occur in rounds 180 and 488, respectively, In the MOFCA algorithm, FND and LND occur in rounds 171 and 469, respectively, In the MBCBCCP algorithm, FND and LND occur in rounds 163 and 430, respectively. In the LEACH FND algorithm, FND and LND occur in rounds 146 and 384, respectively. These values indicate that the efficiency of the proposed method is more appropriate and acceptable than other algorithms.

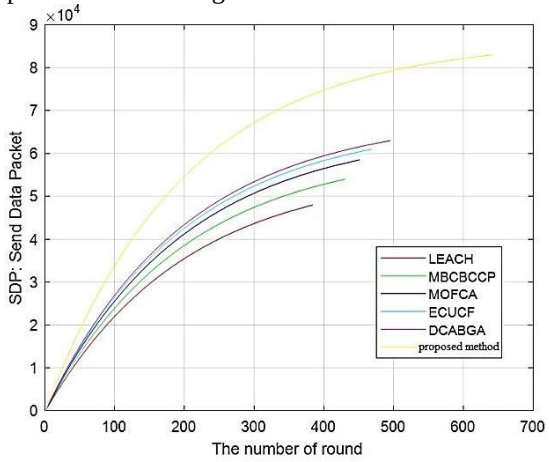

Fig.14. Number of packets sent to the base station

As indicated in figure (14), the number of packets sent to the base station in the proposed method is approximately equal to $8.3*10^4$. While, the numbers of packets sent to the base station in DCABGA, ECUCF, MOFCA, MBCBCCP, and LEACH, are approximately equal to $6.3*10^4$, $6.1*10^4$, $5.8*10^4$, $5.4*10^4$, and $4.8*10^4$, respectively, which indicates that the number of packets sent to the base station in the proposed method is about 33%, 38%, 43%, 48%, and 63% higher than DCABGA, ECUCF, MOFCA, MBCBCCP, and LEACH algorithms, respectively.

Then the mentioned test is performed with the same number of sensors in 400*400 m^2 and base station (200*550) environments as well as 500*500 m^2 and base station (250*750) environments in a state that the environment is heterogeneous (also half of the nodes have the energy twice of other nodes).

Table 3. Comparison of various methods in different environments

Death of the 100% Nodes	Death of the first node	**Lifetime** / **method**	
248	98	LEACH	400*400 m^2
280	110	MBCBCCP	
296	116	MOFCA	
310	121	ECUCF	
325	128	DCABGA	
438	173	RCEMO	
86	46	LEACH	500*500 m^2
103	51	MBCBCCP	
110	54	MOFCA	
115	57	ECUCF	
120	60	DCABGA	
162	81	RCEMO	

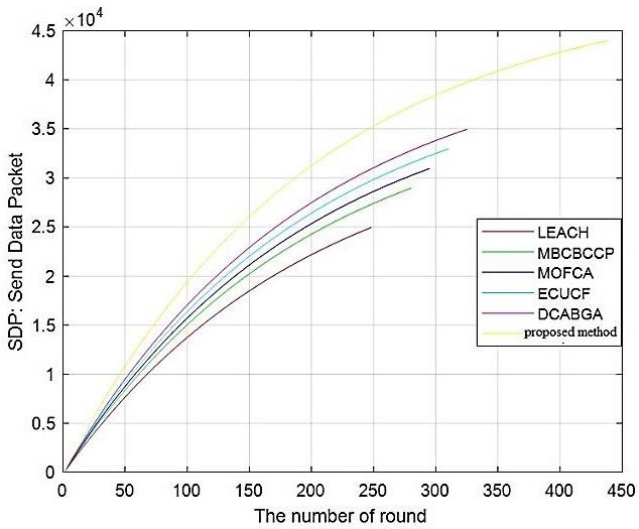

Fig.15. Number of packages sent to the base station in the 400*400 environment

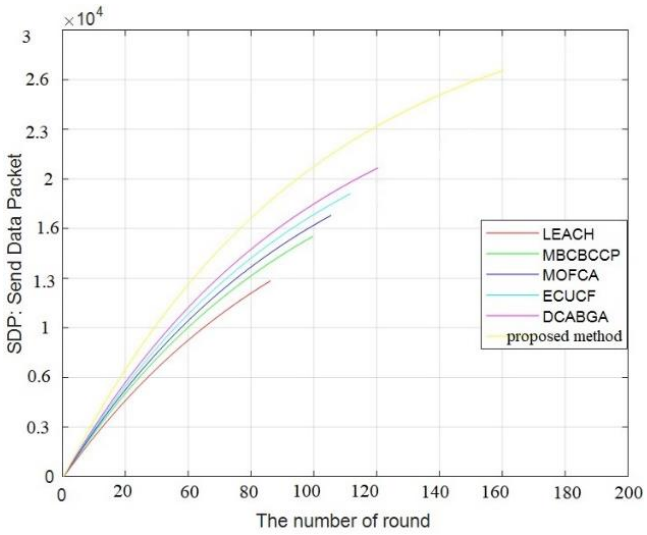

Fig.16. Number of packets sent to the base station in the 500*500 environment

As shown in the above figures, the proposed method improves the network's lifetime by about 35%, 38%, 43%, 47%, and 63% compared to DCABGA, ECUCF, MOFCA, MBCBCCP, and LEACH, respectively. The number of packets sent to the base station is increased by approximately 32%, 37%, 42%, 46%, and 58% compared to DCABGA, ECUCF, MOFCA, MBCBCCP, and LEACH, respectively.

5- Conclusion

In the present article, a clustering-based routing approach based on multi-objective optimization algorithms was proposed for optimizing the lifetime of the sensor-based IoT network and improving energy consumption. The proposed algorithm, called RCEMO, has applied the type-2 fuzzy algorithm for clustering and has used a genetic algorithm for routing from the cluster heat to the base station. According to the conducted tests, it was concluded that the proposed algorithm had improved the energy consumption, and therefore the wireless sensor-based IoT network's lifetime has been increased. Moreover, the number of data sent by the proposed method to the base station has been increased significantly compared to previous methods. In future work, other multi-objective optimization and machine learning algorithms can be applied to develop the proposed protocol. In this way, a model can be created to vote on the selection of the cluster head and routing so that the node for becoming cluster head as well as the path chosen by voting as the cluster head node and the path from the cluster head to the base station to be selected.

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Dynamic Tree- Based Routing: Applied in Wireless Sensor Network and IOT

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Abstract

The Internet of Things (IOT) has advanced in parallel with the wireless sensor network (WSN) and the WSN is an IOT empowerment. The IOT, through the internet provides the connection between the defined objects in apprehending and supervising the environment. In some applications, the IOT is converted into WSN with the same descriptions and limitations. Working with WSN is limited to energy, memory and computational ability of the sensor nodes. This makes the energy consumption to be wise if protection of network reliability is sought. The newly developed and effective hierarchical and clustering techniques are to overcome these limitations. The method proposed in this article, regarding energy consumption reduction is tree-based hierarchical technique, used clustering based on dynamic structure. In this method, the location-based and time-based properties of the sensor nodes are applied leading to provision of a greedy method as to form the subtree leaves. The rest of the tree structure up to the root, would be formed by applying the centrality concept in the network theory by the base station. The simulation reveals that the scalability and fairness parameter in energy consumption compare to the similar method has improved, thus, prolonged network lifetime and reliability.

Keywords: IOT; Wireless Sensor Network; Tree-Based Hierarchy; Clustering; Energy Consumption; Fairness.

1- Introduction

The latest advances made in electronics and wireless telecommunication fields has made the design and construction of multipurpose, small, and low energy consumption sensors at low price. These small sensors are capable of receiving information from the environment, and transmit processed data. This fact has initiated the idea of Wireless Sensor Network (WSN).

The WSN consists of many sensor nodes, scattered vastly in an environment which collect information therefrom. The location of the sensors is not necessarily determined, which allows them to be released in risky or inaccessible conditions. Therefore, the WSN algorithms must be self-organized with the cooperation capability. Each sensor has a processor, to first, run a series of simple and initial processing on the information, and next, transmit them. Each sensor has low capabilities, but a combination of them, introduce powerful possibilities. The strength of WSN is applying the sensors, in supervising the environment conditions, structures and facilities' well performance. WSN is widely used in agriculture, medicine, industry and military [1].

In an environment, the scattered sensors collect information and transmit them to the Base Station (BS), through a multi-hop route, which has no definite infrastructure. WSN designing is subject to many criteria among which fault tolerance, scalability and cost are the essential. Fault tolerance is one of the main challenges in WSN, thus, the researchers investigate to reduce energy consumption in different applications of WSN. Because sensors out of energy directly affect the networks general functionality and fault tolerance, so if the sensors energy are managed well the reliability will be accomplished to a high degree [2].

It is common to apply the hierarchical methods in reducing energy consumption and increasing WSN lifetime. The hierarchical methods are the mechanism to systematize the sensors in a layered structure and assign a specific task to the sensors of each layer before the data is transmitted to the next layer. This structure is a solution for overcoming some of the limitations in WSN.

The tree-based topology is one of the hierarchical structures upon which the method of this article is based on. The advantage of tree-based topology is low energy consumption in data transfer, low complexities and implementation cost.

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The disadvantages consist of: non- scalability, load unbalancing, high probability of error, and unequal delays.
Many researches have been done to tree-based, have tried to solve the disadvantages the method. The most renowned tree-based methods the EADAT, BATR, PEDAP, and ETR would be addressed in brief [3,4].
As to EADAT [5], the BS acts as the root and the algorithm begins to run when the control messages are sent by the root. Every node that receives the control message, adjust a proper timer, inversed with the remaining energy. In this interval, a node selects a parent with more energy and low distance, and propagates the controlling messages before the time ends. The outcome of this method is a multicast tree with a BS root which is updated alternatively. Any node, the residue energy of which is below a threshold, sends a help message and enters the standby until its children join under the new subtree. By receiving the new control message, this node joins the new parent, otherwise it sounds alarm. The main advantage of this method is that the nodes with high energy most probably do not become leaves. Therefore, unsuccessful transfers are reduced and approximately achieved load balancing, while, the formation of longer routes is inevitable. The long unequal routes would increase delay, thus, higher energy consumption.
As to the BATR [6], the BS collects all nodes location and forms the routes. The BS forms a minimum spanning tree concerning the energy consumption as to balance out the children under the subtrees. These features can prolong network lifetime and cause load balancing. Since in tree formation, residue energy is not considering, and it is assumed that the nodes generate uniform data, thus, some nodes die earlier, caused unsuccessful transfer.
As to PEDAP [7], the minimum spanning tree is applied to compute the consumed energy. In PEDAP, the residual energy of the nodes is considered in beside distance and data volume to form tree. The tree based on these features, can balance energy consumption and transfer distance, leading to a reduction in delay. In the large and complex networks, energy computation is hard and constructing a tree would consume more energy, indicating lack of scalability in PEDAP.
As to ETR [8], it is the improved version of TR, applied to be balance both the efficiency and cost. In ETR, each node saves a table with low energy, to determine next node with least hop to the root. The selected route hops are less than that of the actual route. Every node, eventually, selects a route with the least hop count, otherwise, considering their parent as the next node. In ETR, the residue energy of the nodes is not concerned in route selection, thus, paths with less residual energy may be selected, which leads to premature death of nodes and no data transmission.
In mentioned methods, data collection is necessary, while, no Clustering is performed in none of them. The EADAT, PEDAP and ETR are fit for small scale networks and BATR for large scale networks. In the EADAT, BATR and PEDAP, the routs are selected through the BS in a centralized manner, consequently, a high capacity of data should be sent to the BS through the nodes, which is time consuming. In the ETR, the nodes exchange information in forming tables and it is a non-centralized method. The ETR is more flexible, rapid and environment changing adaptable. In the BATR and ETR, the residue energy is not considered in tree formation. Therefore, there exists the possibility of selecting nodes with low energy as the parent, thus, loss of data. In EADAT and PEDAP, the tree is formed by considering the residue energy of nodes, leading to a balance in energy consumption and network lifetime prolongation. In the EADAT, PEDAT and ETR methods, the shortest route is selected for data transfer while in BATR distance is not considered and the tree is balanced based on location and number of nodes. [3,4].
In most studies, the tree-based topologies are independent of clustering, while in this proposed method, to select the parents, the clustering method is applied to balance energy consumption and prevent data loss. To improve scalability of the tree-method, when it is revealed that there is no fairness in energy consumption of sensors, a tree structure will be reformed, to balance the energy consumption of the sensors. With these in mind, the innovation of the proposed method is in overcoming tree-based method disadvantages, specially the lack of scalability and load balancing.
This article is structured as follows: the study design is introduced in Sec. 2; the method is proposed in Sec. 3; the method efficiency is evaluated in Sec. 4 and the conclusion and future works are presented in Sec. 5.

2- The Study Design

A WSN consists of sensors, scattered in an environment, collecting data therein. Each sensor has a sense range, through which it can communicate with the available points, consequently, WSN applies the multi-hop communication protocols in information transmission between sensors and BS. In designing WSN attempt is made to have a complete coverage of the area through the sensors. A sensor consists of sense unit, process unit, send/receive unit and power unit and upon their applications, they can contain GPS, power generator, and motion module. The sensors, according to what they perceive, transmit digital signals to the processing unit. This unit with its small memory manages the sensors' cooperation during the assigned task performance. The power unit is highly essential, which is supported by battery or power collection unit like the solar cells.
Some sensors, for any reason may be out of power or dysfunctional and this should not affect the overall network functionality. Therefore, fault tolerance is defined the WSN operation maintaining, regardless of some

sensors dysfunction. A properly designed WSN, upon some sensor dysfunction would immediately adopt itself to the new conditions and continue its operation.

In WSN, the energy limitation of sensors is the main challenge of fault tolerance. Methods like adapting signal strength to distance, sleep scheduling, number of package sent reduction and hierarchical topologies are applied in reducing energy consumption in WSN [9].

The WSN expansion especially in IOT, has made scalability a challenging issue. The hierarchical structure can be a solution for load balancing, fault tolerance, increasing connections, decreasing delay and WSN lifetime prolongation. In this structure, a specified task is defined for the sensors before they transmit data to higher levels. Clustering is the most popular measure in the hierarchical methods [10-14].

In algorithm of clustering the three main elements consist of the sensor, Cluster Head (CH) and BS. The sensors send the collected data to the CH, and the CH sends the data to the BS, usually, is distanced from the sensors. The CH act as the gate between sensors and BS, that is a CH is considered as a sink for sensors and BS is as a sink for the CHs. There exist the two homogenous/ heterogeneous and static/dynamic mechanisms to classify the clustering methods [15].

In the heterogeneous WSN, there exist two groups of sensors: 1) with high processing power and a complex hardware usually applied as the main backbone of the network, and 2) with proportionally lower processing power, which receive information from the environment. In the homogeneous WSN, all sensors have uniform hardware features and processing power, where they can be CH and this role changes periodically among the sensors. In the homogeneous networks, load balancing takes place and energy consumption would be more uniform. The static clusters are usually formed when the network is being formed by heterogeneous sensors and the network designers seek to form the clusters around strong sensors. The cluster size, CH and the number of involved sensors are all static. Applying this type of clusters is limited to the predefined scenarios. In dynamic structure the sensors do not belong to one cluster and it's possible to form different clusters in due time. Dynamic structure is usually to homogeneous networks, but it's applicable in heterogeneous networks as well. Dynamic cluster structure increases efficiency [16].

In clustering, communication is categorized to the inter-cluster and intra-cluster. The intra-cluster communication exchanged messages delivered between the sensors of cluster and CH. The inter-cluster includes messages exchanged between the CHs and BS. When only the CHs transmit information, the collision between the sensors of a cluster is prevented, thus, a saving in energy. The most famous clustering method is the Leach since introduction, some optimizations have been provided.

The dividing and communication manner of the newly introduced hierarchical routing methods differ from that of the traditional clustering methods. These new topologies are: tree-based, chain-based, grid-based and area-based, Fig. (1) [3,4].

- **Tree-based Topology:** This topology consists of branches, leaves and parents. The data are sent to the parents from the children until the data reach the BS. The accumulation and elimination of the repeated data takes place by passing the data through each sensor. Formation of this tree is simple, no need for clustering. It would suffice that each sensor sent the data to the next higher sensor, which is closer to the root, thus, a reduction in energy consumption. The weak point of tree topology is when a parent sensor stopped, the data sent by the children no guided. In tree-based method, the sensors close to the root consume more energy due to data accumulation and there exist no fairness among the sensors. Also, if number of the sensor is high the delay would be varying to data reaching the BS, lacking of scalability in this topology.
- **Chain-based Topology:** The WSN is formed from one or few chains where for each, one leader is selected. Each sensor sends the data to the nearest sensor in the chain until the data reaches the chain leader. During this data transfer the accumulation is made by each sensor, then, aggregated data is sent to BS by leader. Constructing and maintaining this topology is simple, consequently, a saving in energy consumption. If the sensors stop, all the passing data become lost. Considering the sensors position in relation to leader, data transmission delay and the passed data rate from the sensors would be different, leading to an imbalance in the sensors' energy consumption.
- **Grid-based Topology:** The whole network is divided into grids and for each, a leader will be selected. All grid members send their data to the grid leader which sends them to the next leader, to be reach to BS. Grid formation is simple and is based on the geographic position of the network sensors. In this topology the grid size remains the same and only the leader position is changed, this is why routing in grid is local. If in each grid the number of the sensor is high, and the leaders are not selected properly, their energy consumption would be very high.
- **Area-based Topology:** Here, all WSNs are divided in areas of different size. The BS would send data accumulation request to the closest sensor in each area, in a flooding manner to reach source. Then the data is sent to the BS by source. This topology is appropriate for mobile BS which move in determined geographical area.

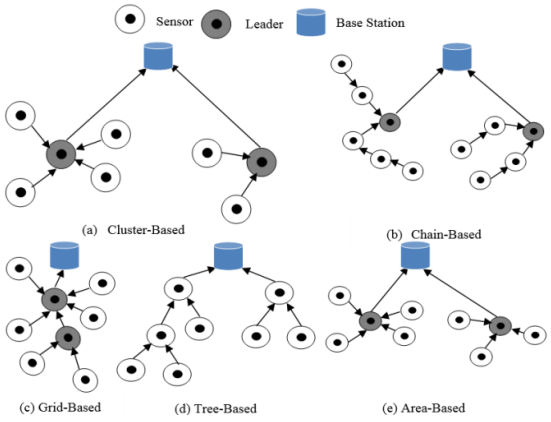

Fig. 1 Hierarchical topologies structure

Because more energy is needed to communicate than to data processing, the objective of hierarchical methods is to reduce sending repeated packets towards BS. (e.g. to send 100-bit at 100 m distance, requires about 10 μJ energy, while to implement a 32-bit instruction in a loop of one-hundred-thousand, the consumed energy would be about 60 pJ). It is obvious that, one of the best means in reducing sensors energy consumption is reducing the data communication. In the hierarchical structures, this issue is performed through the data compression algorithms, repetitive data elimination and applying the location-based and time-based local properties of the data [17].

3- The Proposed Method

The proposed method is hierarchical spanning tree. To construct tree, first, the WSN is modeled through the G=<V, E> graph, Fig. (2), where V is the sensors and E is the total edges of the graph. According to Eq. (1), an edge is defined between two sensors when the distance of both is less than *d*, and the *d* is computed through the free space model [6].

$$\forall x, y \in V, \quad (x, y) \in E \Leftrightarrow dist(x, y) \leq d. \quad (1)$$

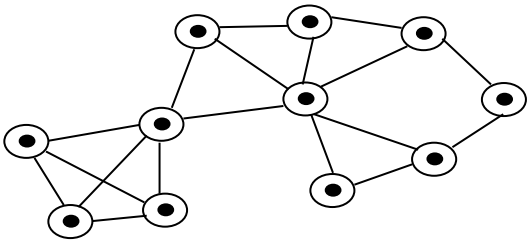

Fig. 2 Modeling WSN through the graph.

The spanning tree construction through the graph consist of two stages: 1) the sensors are clustered through greedy algorithms, and by applying the Leach algorithm a CH is selected for every cluster. These selected CH acts as the sensor (leaves of tree) parents. 2) CHs of stage one are clusters based on network centrality theory, and next renewed CHs are selected trough the Leach algorithm. This process continuous until the tree root, the BS, is achieved. The proposed method is named Dynamic Tree-Based Routing (DTR).

3-1- Constructing Subtree of Leaves

Subtree of leaves is formed based on the communicative properties between the sensors and a greedy algorithm. Because sensors have location-based and time-based properties, attempt is made to allocate the sensors with high dependency under a subtree with one parent. Therefore, for every edge in G, the edge weight is calculated as Eq. (2), to indicate the sensor dependency.

$$D(A_i, A_j) = \left[\frac{\sum D_s}{\sum D_t} * 100\right]. \quad (2)$$

In Eq. (2), if Ai and Aj are the ith and jth sensors, the dependency between them is defined: the sum of similar collected data divided in to the sum of all collected data through them in a specific time. The more similar data is collected, the D (A_i, A_j) is increased, and vice-versa. If the weight between the two sensors is zero, there exists no dependency. The dependency between the sensors is a symmetric function, therefore, the graph is undirected. In order to allocate sensors with high dependency in a subtree, the quality function is defined through Eq. (3).

$$Q(C) = \frac{1}{|A|} \sum_{c_i \in C} \sum_{e_{xy} \in E^i} Dep(a_x^i, a_y^i). \quad (3)$$

During running the Algorithm 1, the subtree of the leaves is formed in a manner to maximize the quality function at each stage. The obtained values by running the algorithm, would be the guide in forming the subtrees of leaves [18]. After running the algorithm, clusters are formed out of the sensors. Then the Leach algorithm is run for each cluster, and the selected CH acts as the sensors' parent in the cluster. The rest of the stages of connecting parent with the leaves, would be in accordance with the Leach algorithm. The clusters formed at this stage are subtrees that the leaves of the tree (sensor nodes) are members, Fig. (3).

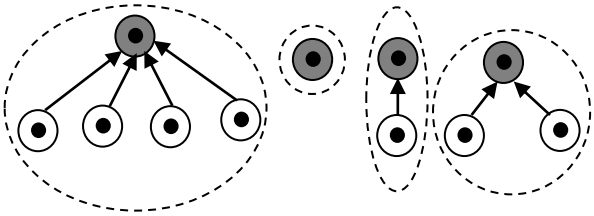

Fig. 3 Formation of clusters each being a subtree of the leaves.

In algorithm 1, the input of the function is the network graph model. The names of the functions are chosen so that they clearly represent their function. In general, functionality of the algorithm is briefed as: the edge with the highest weight is selected so that it is not a member of any cluster; if one of the vertices of this edge has been a cluster member, the

other vertex could join the cluster, in case the quality function is improved. If both the edge vertices are each a member of two different clusters, the two clusters would be merged if the quality function increase. At the end, if any non-cluster member vertex is left, a new cluster is formed for it. After the clustering process, the Leach_Algorithm () is called to determine the CH of each cluster; following this, the model graph is updated and returned [19].

Algorithm. 1 The subtrees formation algorithm of leaves

```
Subtree Leaves_Clustering(WSN  S)

  G(A, E)=Model_WSN_to_Graph(S);
  C=ϕ;

  while(∃ e ∈ E: Unprocessed_Edge(e))

    e_xy=Find_Edge_with_Max_Weight();
    a_x, a_y=Return_Head_of_Edge(e_xy);

        if (∀ c ∈ C: a_x∉ c ∧ a_y∉ c )
            c_new=Create_Cluster (a_x, a_y, e_xy);
            C=C+c_new;
            Update_Graph();

        else if (∀ c ∈ C: (a_x∈ c ∧ a_y∉ c) ∨ ( a_x∉ c ∧ a_y∈ c))
                  Q_new=Q(C);
                   if (Q_new > Q_old)
              c=c+Add_Head_not_Belongs_Cluster(a_x,a_y,e_xy);
               Updating_Graph();

             else
                    Do_nothing();

          else if (∃ c, c'∈ C: (a_x∈ c ∧ a_y∈ c'))
                Q_new=Q(C);
                    if (Q_new > Q_old)
                    c_new=c∪c';
                    C=C-(c∧c');
                    C=C+c_new;
                   Updating_Graph();

                  else
                   Do_nothing();

                     END If

END While

for( ∀a_i∈ A , ∄ c ∈ C : a_i∈ c)
        c_new=Create_Cluster(a_i);
        C=C+c_new;
    END For

     H=Leach_Algorithm(C);
     Updating_Graph();
     return G;

    END Function
```

3-2- Constructing the Rest of the Tree up to the Root

To construct the rest of the tree up to the root, the sensors selected as parent in the previews stage are considered, and clustering is repeated. Since at higher levels, there is not dependency between the sensors according to Eq. (2), the algorithm 1 does not work correctly. Hence, the rest of the tree up to the root is formed through the concept of sensor centrality in network theory. The importance of a sensor in a network depends on its neighbor importance, Eq. (4). Where, X_i indicates the ith sensor importance and A_{ij} is the array of the ith row and jth column of the adjacency matrix of the graph.

$$X_i = C \sum_{j=1}^{n} A_{ij} X_j. \tag{4}$$

Equation 4 can be written in it matrix form, Eq. (5) [20].

$$X = CAX \qquad or \qquad X(I - CA) = 0. \tag{5}$$

X is the eigenvector of the adjacency matrix A. Matrix A determines the relation between the sensors and is defined for the weightless graphs, while as to Eq. (2), for the graph model edges, weight is defined. For this purpose, matrix A is replaced with matrix M, and its arrays are obtained through Eq. (6) [21].

$$\forall i, j: \quad m_{ij} = D(A_i, A_j). \tag{6}$$

Because the eigenvector computation of the matrix M through Eq. (5) is time consuming with the probability of obtaining some negative values, the Perron vector of matrix M is computed. The Perron vector is a type of the matrix eigenvector the values of which are non-negative with a sum of one. Each entity of Perron vector is computed according to Eq. (7) [22].

$$X^k = \frac{\sum_{i=1}^{k} \sum_{j=1}^{n} m_{ij} * X_j^k}{\left\| \sum_{i=1}^{k} \sum_{j=1}^{n} m_{ij} * X_j^k \right\|^1}. \tag{7}$$

After importance values of sensors is obtained, clustering of the next level begins according to the Algorithm 2. The functionality of this algorithm is in a sense that: the sensors with importance above average importance of the sensors, form a cluster. For a non-cluster sensor like P_i, a neighbor with the highest values like h_j is found. If h_j is the cluster member then, P_i join this cluster, otherwise, p_i and h_j form a new cluster. CH of each cluster is selected as parent and the rest children, by the Leach_Algorithm (). Following, the updated graph is returned.

In the first call, the input of algorithm 2 is the returned graph of algorithm 1, while, in the next calls, the returned graph of the previous stage of itself. At each call of Algorithm 2, one tree level is constructed, and this pattern continuous up to the root, BS is reached, Fig. (4) [23].

Algorithm. 2 The algorithm of constructing the rest of the tree

```
Level_of_Tree_Organizing (Modified_Graph  G)

H=Return_Heads_of_Clusters (G);
C= ϕ;

while (∃ h_i∈ H)
    M=M+ Eligibility (h_i);
    Ave = M/|H|;
    END Wile

While (∃ h_i∈ H)

        If (Eligibility (h_i) ≥ Ave)
          c_new=h_i;
          C=C+c_new;
          Update_Graph ();
        else
          Do_nothing ();

      END While

  while (∃ h_i∈ H: h_i∉ c)

        p_i=Find_neighbor_with_Max_Eligibility (h_i);
        if (∃ c ∈ C: p_i∈ c)
          c=c∪p_i;
          Update_Graph();
        else
            c_new=h_i∪p_i;
            C=C+c_new;
            Update_Graph();

      END While

      H=Leach_Algorithm(C);
      Updating_Graph();
      return G;

      END Function
```

3-3- Tree Reformation

If there is no change in the parent nodes close to the root, which consume high energy in sending data of their children, the energy will end rapidly. In a sense, sensors dependency is changed in due time, therefore, reformation of the tree during the network lifetime is inevitable.
In DTR, the sensors next to sending data to their parents, they send the residue energy to let BS become aware of all sensors residue energy. The sending residue energy as piggyback of data, causing energy saving in the sensors. If for a given time no data sent to BS by the sensors, based on the available observation, by applying the Normalized Least Mean Square method (NLMS), the residue energy of these sensors would be predicted through Table 1 [24].

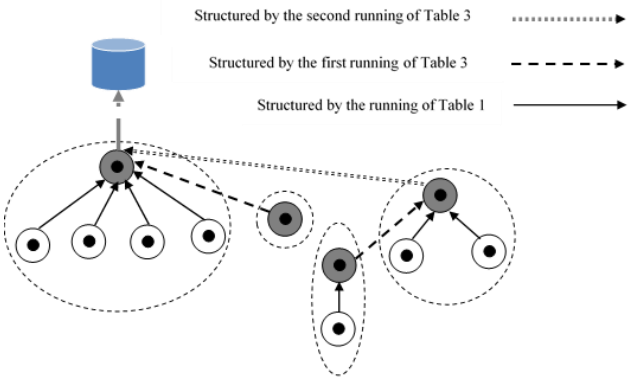

Fig. 4 The tree of network graph model

In Table 1, the underlined variables are vectors and the over-lined ones are to hold the predicted values. The W is the vector of prediction coefficient filter at size q and E is a vector to hold the q value of process residue energy expressed through Eqs. (8 and 9).

Table.1 The sensors' residue energy value prediction by NLMS

Number	Equations
1	$R_{n-2} = E_{n-1} - \bar{E}_{n-1}$
2	$\underline{W_n} = \underline{W_{n-1}} + \omega * \frac{R_{n-2} * \underline{E_{n-2}}}{\|\underline{E_{n-2}}\|2}$
3	$\underline{E_{n-1}} = combine E_{n-1} and \underline{E_{n-2}}$
4	$\overline{E_n} = \underline{W_n^T} * \underline{E_{n-1}}$

$$\underline{W} = [w_1, w_2, \dots, w_{19}]^T. \quad (8)$$

$$\underline{X_n} = [x_n, x_{n-1}, \dots, x_{n-19}]^T. \quad (9)$$

The initial value of W is zero which can be updated per each new data. $\overline{E}_n$ is the predicted residue energy of E_n.
BS accumulates all the residue energy of the sensors that is observing fairness in energy consumption. Therefore, the Jain's index, a statistical scattering measure is applied in measuring the uneven energy consumption level in the sensors. This index with a value within 0-1 is obtained through Eq. (10) [25].

$$J_C = \frac{(\sum_{i=1}^{m} E_i)^2}{k \sum_{i=1}^{m} E_i^2}. \quad (10)$$

E_i is the residue energy of the ith sensor and K is the total number of WSN sensors. The closer the J_c rate to 1, the energy consumption is more balanced and vice-versa. The BS computes the determined J_c rate at different times and if it is below the threshold (T_h), the tree reformation is computed and the order of this formation is send to the sensors in the WSN.

4- Efficiency Evaluation

The MATLAB is applied to analyze and implement the DTR. The DTR is to be compared with BATR. Similar to

most of the available studies the energy model is considered only for communication, the other consumed energy is ignored. In this model, the consumed energy to send and receive L bits of data at a distance of *d* meters, is computed through Eq. (11 and 12), respectively [6].

$$E_{tx}(L,d) = L * E_c + L * e * d^2. \quad (11)$$

$$E_{rx} = L * E_c. \quad (12)$$

E_c is the base energy to turn on the sender and receiver circuit and *d* is the threshold distance defined in Eq. (1). To implement these comparable methods, all homogenous sensors are considered with unequal initial energy, distributed in a 100x100 m^2 environment in a random manner. The BS is situated outside the 50x150 m^2 environment. To determine the accuracy of the obtained data and sensors' independence of spread in the environment, tests are repeated to achieve 95% confidence interval. The values of the DTR parameters and the Leach algorithm are according to Table 2 [26].

Table. 2 The applied parameters' value

Parameters	Value
P_{Leach}	0.05
q	20
E_c	50 nJ/bit
e	10 PJ/bit.m^2
d	86.2 m
L	525 bytes
r	10000 round
T_h	0.9

The First Node Die (FND), the Last Node Dies (LND), the Standard Deviation of Hops Count (SDHC) and the Fairness Parameter (FP) are considered to evaluate the DTR efficiency. The FND is the time duration until the energy of the first sensor is totally consumed. The LND is the time duration until energy of all sensors is totally consumed. This criterion can be defined based on the past rounds. The more distance between the FND and LND indicates an imbalance in sensors' energy consumption and vice-versa. The SDHC determines standard deviation of Leaves' hop count up to the root. The lower the SDHC, the more balanced the tree, with closer leaves' lengths to the root. The FP is computed through Eq. (10), which determines fairness in the energy consumption for all sensors [27].

The DTR requires global information, that is, the residue energy of the sensors, like most hierarchical tree methods. Because the amount of information is low and is carried with data packages or is predicted through BS, the energy consumption for accumulating global information is low. The complexity of the tree formation algorithm run through BS is linear O(n). In algorithm 1, *n* is the number of edge or non-processed vertices. In algorithm 3, *n* is the number of the previous step CHs. Therefore, the complexity of implementing DTR is almost equal to that of Leach algorithm. The complexity of implementing BATR algorithm is O(n2) [6].

4-1- The Results of Evaluation

In the BAR, the purpose is to form a minimum spanning tree with balanced leaves in a specific area, where, the energy consumed for data aggregation by the parents is almost equal. To form BATR, the edges weight is estimating of energy consumption to send data and the residue energy of the sensors are not considered. Therefore, if the energy of the sensors is unequal, the energy of some of them run out faster, shown as to FND and LND in Figs. (5 and 6). In DTR spanning tree structure, in addition to residue energy of the sensors the fairness in energy consumption is considered, and if violation of fairness, the structure would change dynamically. Hence, the DTR provides better FND and LND in Figs. (5 and 6).

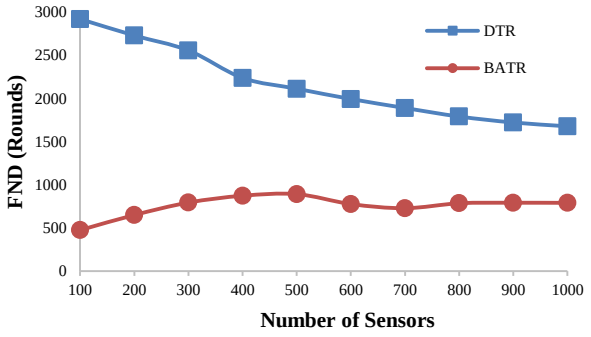

Fig. 5 FND in compared models.

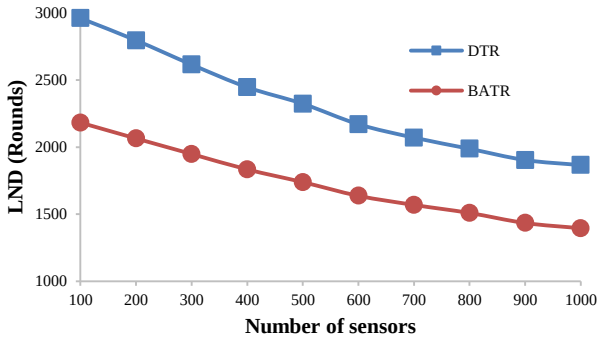

Fig. 6 LND in compared models.

In the DTR, the sensors that accumulate similar data are deployed under the subtree of one parent, thus, the data to be aggregated better by the parents and less energy is consumed to send the data. The less energy consumption between the DTR concerning BATR is shown in Fig. (7).

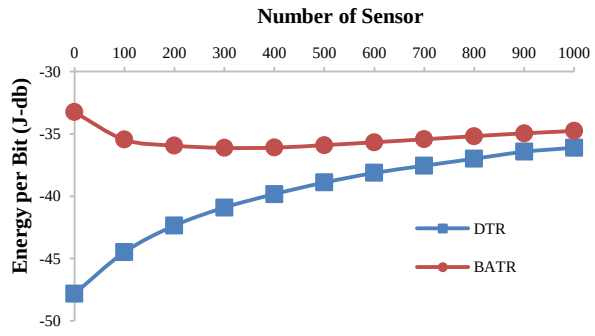

Fig. 7 energy consumed to transfer one bit in the compared methods.

In the DTR, short and long term lifetime of WSN is increased, revealed by the nearness of FND and LND, Fig. (8). Because: 1) less energy consumption to data transmission through clustering with appropriate criterions, and 2) dynamic structure due to justify fairness in energy consuming.

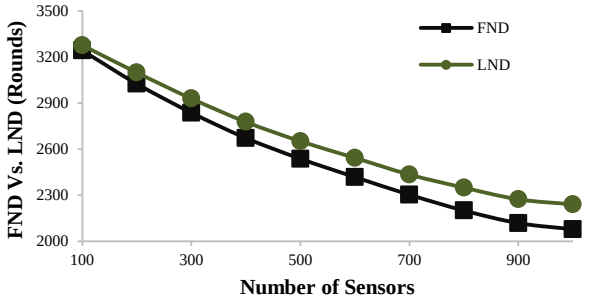

Fig. 8 Comparing FND, LND in DTR.

The comparison of FND and LND in BATR method, reveals that the time difference between the first sensor dysfunction and the whole network dysfunction is high, Fig. (9). This issue leads to premature disconnection of some sensors with the others. Because the residue energy of the sensors is not considered to form minimum spanning tree and energy consummation of the sensors is not fairness, while, in the DTR is contrary.

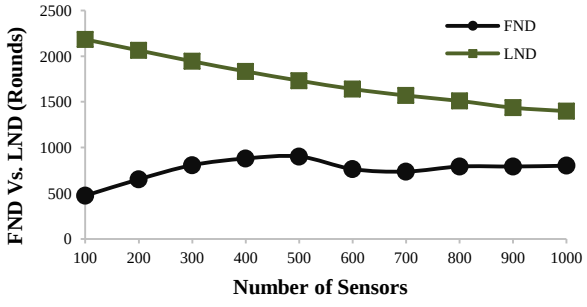

Fig. 9 Comparing FND, LND in BATR.

In BATR and DTR to compare the delay, SDHC is computed at end of each round. As observed in Fig. (10), the BATR standard deviation is lower than that of DTR and this is due to the formation of static balanced-tree. In DTR, the tree is dynamic and changes upon the residue energy, which leads to a change in the leaves' hop count towards the root, thus, more standard deviation into BATR. Because the standard deviation of DTR is close to zero, it can be deduced that delay in DTR is almost moderate and close to the average.

In DTR, the fairness threshold (T_h) is 0.9, Table 2. When the J_c is less than T_h, the BS releases the control messages for structural changes. As observed in Fig. (11), it is evident that J_c for different number of nodes is around the T_h. The slight fluctuation rate around T_h is due to the energy consumed during the above released order for tree reformation.

In BATR, the constant structure, unequal initial energy, and non-uniform energy consumption by the nodes, causing no fairness in energy consumption, which can become worse as the nodes increase.

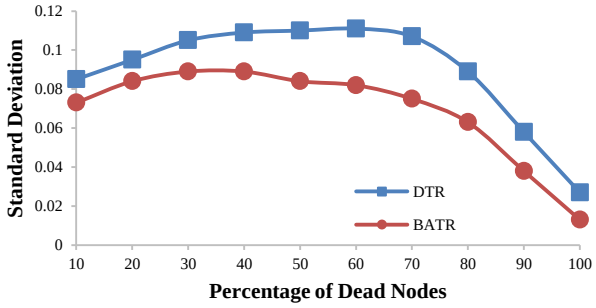

Fig. 10 Comparison of SDHC in the compared models.

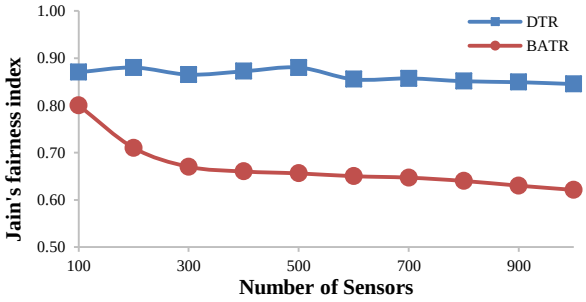

Fig. 11 energy consumption fairness in the compared methods.

5- Conclusion and the Future Works

In this paper, a hierarchical spanning tree method is proposed, the strength of which than the available studies are in having a dynamic structure and considering the sensors' dependency during the tree formation. Applying the sensors with the accumulated similar data under one subtree, leads to a reduction in the main load through the non-leaf sensors. These features, next to low implementation cost have reduced the energy consumption, specifically when the initial

energy of the sensors is unequal. The simulation results indicate the short and long term lifetime of the network is increased. Unlike the available methods, DTR is suitable for networks with numerous nodes and IOT. The features of this method are tabulated in Table 3.

In the WSN, the most of the researches have been done based on simulation therefore, the works similar to proposed method could be analytically presented. Applying the machine learning concepts in determining fairness threshold, proper sensors placement and mobile BS can be considered as the future works. Likewise, in the IOT, if every node be considered as an agent, providing a multi-agent would allow most of the IOT challenging issues to be addressed through the multi-agent systems.

Table. 3 The DTR method features

Control Manner	Mobility	Energy Efficiency	Scalability	Delivery Delay	Load Balancing	Algorithm Complexity	Implementation Cost	Global Knowledge
Centralized	No	Yes	Yes	Moderate	Yes	Low	Low	Yes

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Edge Detection and Identification using Deep Learning to Identify Vehicles

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Abstract

A deep convolution neural network (CNN) is used to detect the edge. First, the initial features are extracted using VGG-16, which consists of 5 convolutions, each step is connected to a pooling layer. For edge detection of the image, it is necessary to extract information of different levels from each layer to the pixel space of the edge, and then re-extract the feature, and perform sampling. The attributes are mapped to the pixel space of the edge and a threshold extractor of the edges. It is then compared with a background model. Using background subtraction, foreground objects are detected. The Gaussian mixture model is used to detect the vehicle. This method is performed on three videos, and compared with other methods; the results show higher accuracy. Therefore, the proposed method is stable against sharpness, light, and traffic. Moreover, to improve the detection accuracy of the vehicle, shadow removal conducted, which uses a combination of color and contour features to identify the shadow. For this purpose, the moving target is extracted, and the connected domain is marked to be compared with the background. The moving target contour is extracted, and the direction of the shadow is checked according to the contour trend to obtain shadow points and remove these points. The results show that the proposed method is very resistant to changes in light, high-traffic environments, and the presence of shadows, and has the best performance compared to the current methods.

Keywords: Deep Convolution Neural Network; Edge Detection; Gaussian Mixing Method; Vehicle Detection.

1- Introduction

Better monitoring of traffic flows is essential to reduce accidents. Therefore, the primary purpose of this article is to provide better traffic monitoring. For the traffic monitoring program, fixed cameras are generally used to the static background (e.g., fixed surveillance cameras) and a common background subtraction approach is employed to obtain an initial estimate of moving objects. The reported solutions for traffic focus on optimization because real-time and convenient data collection methods are essential and promise better traffic monitoring that provides more detail to understand traffic flow patterns. The primary purpose of this article is to create an algorithm that can count vehicles to better monitor traffic. Various tasks such as edge detection, background subtraction, and threshold techniques are performed to provide appropriate video-based surveillance techniques. Edges are one of the simplest and most important parts of image processing. If the edges of an image are correctly specified, the location of all objects in the image is specified, and some of their properties such as surface and environment are specified, and can be easily measured [1, 2]. Therefore, edge detection can be an essential tool in vehicle detection. In an image, edges define the boundary between an object and the background or the boundary between overlapping objects. There are many methods for the edge extraction and detection that differ in finding the right edges [3]. These methods intermittently assess various factors such as light intensity, camera type, lens, motion, temperature, atmospheric effects, and humidity in detecting edges, and then detect vehicles [4,5]. In this paper, the deep learning method is used to distinguish the edges. This algorithm can detect strong and smooth edge information, which increases the accuracy of vehicle detection compared to methods that do not use edge detection. The task of vehicle detection is based on the edge detection theory in image processing, which offers a new algorithm for monitoring traffic using vehicle counting. Vehicle counting is carried out by subtracting the background. Initially, a reference framework is used to extract background information. Hence when a new object

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enters the frame, it is detected by subtracting the background. Background subtraction is performed when the image is part of a video stream and shows the difference in pixel locations that have changed in two frames. Background information is identified using the reference frame as the background model. Video stream are recorded and tested with the proposed algorithm. Some conditions make vehicle detection more difficult. One of these challenges is environmental conditions, such as the presence of clouds of dust. In addition, the presence of shadow, which is part of the vehicle and makes it difficult to detect is another critical problem that reduces the detection accuracy.

The incomplete appearance of a moving vehicle or even a considerable distance between the vehicle cameras, with very low-resolution images, are also among the detection problems. Therefore, to show the stability of the proposed method and its accuracy, various videos that have these conditions have been used for the simulation, and the final results are very satisfactory. Using the deep learning method in edge detection and then using the edges to detect the vehicle increases the accuracy and makes the algorithm resistant to the problems expressed. The proposed algorithm uses several steps to increase accuracy. Thus, the deep CNN is described. In the next part, this network is used to extract the edges, and after that, it is explained how the vehicle is detected and counted. The results are given in the next section, and finally, the conclusion is presented.

2- Related Works

At present, vehicle detection is performed using the traditional machine vision method and the complex deep learning method. Traditional methods of machine vision use the movement of a vehicle to separate it from a still image. Vehicles can be identified using features such as color, pixels, and edges, along with some machine learning algorithms. Some detectors can place and classify objects in video frames using visual features. Among the various methods proposed in this field are the Haar Cascade method [6], the You Only Look Once (YOLO) method [7], the Single Shot MultiBox Detector (SSD) method [8], and the Mask R-CNN [9]. Haar Cascade, initially proposed by Viola and Jones [10], refers to set visual features that can take advantage of rectangular areas in a particular location, pixel intensities and differences between regions. This method is a robust classifier that moves the search window across the image to cover all areas and identify objects of different sizes and has been used to detect vehicle traffic.

The use of deep convolutional networks has led to great success in vehicle detection. These networks have a high ability to learn image features, and perform several related tasks such as classification and finite box regression, as shown in Figure 1.

The YOLO detector consists of a CNN that has 24 layers of convolution for feature extraction and two dense layers for prediction.

In this research, a CNN was proposed based on vehicle detection, and the work is novel in the following three ways, compared to prior studies.

1- This is the first time edge extraction is performed with VGG-16, and used for vehicle detection. One of the features of VGG-16 is that it has a very good architecture for measuring a specific task.

2. Another aspect is the use of edge detection in the algorithm, which leads to increased speed and reduced computations.

3. In addition, removing shadows to increase accuracy can be another aspect of this article's innovation.

Major headings are to be column centered in a bold font without underline. They need be numbered. "2. Headings and Footnotes" at the top of this paragraph is a major heading.

3- CNN

CNN is a particular type of deep learning method. This type of network calculates the output used for subsequent units using the input data. Today, artificial intelligence has grown significantly to increase accuracy and comfort. In this regard, various algorithms and networks have been proposed and utilized. One of the most famous networks developed in the field of deep learning is CNN. The main strength of CNNs is providing an efficient compact network that can predict or identify. A huge data set applied to CNNs, and larger data is thought to require more accuracy.

CNN has the power to detect distinctive features of images alone, without real human intervention. The purpose of using CNNs is to predict and categorize various databases without human intervention. A CNN consists of neural layers with weight and bias, which are capable of learning. Artificial neurons are processing units that can receive inputs, an internal multiplication is done between the neurons' weights and the inputs, and the result is biased. Finally, a nonlinear function (the same as the activation function) is passed [19].

The convolution layer is the core of the CNN in which most calculations are performed. Each convolution layer contains filter sets, each filter has a specific pattern, and the output of the convolution layer is a set of different patterns, so the number of filters indicates the same number of detected features. The output is generated from the convolution of filters and the input layer.

The convolution operator is one of the most essential components that make CNN resistant to spatial variation.

By layering or padding, the input size is increased, and thus, the output matrix is equal to the input matrix in size. A simple, and common way to layer is to add zero rows, and columns symmetrically around the input matrix. In this case, the convolution filter has more space for stepping and scanning, leading to a larger output.

The size of the stride is also defined in the step convolution layer. The meaning of the step is that the filter, after calculation in an input window, has to move a few doors or houses to perform the calculations again. Similar to other neural networks, CNN [20] uses the excitation function after the convolution layer. Using a nonlinear function creates a nonlinear property in the neural network, which is very important. Defining a nonlinear function separately from the canonization layer provides more flexibility. Of all the nonlinear functions, the ReLU function is the most popular. There are other members of the ReLU family, such as PreLU, and Leaky-ReLU, among others. The polishing layer is another important layer in the CNN. The purpose of the polishing layer is to reduce the spatial size of the feature map obtained by using the convolution layer. The polishing layer has no teachable parameter and performs a simple, and effective sampling. Pulling has a convolution-like function, and a window moves on the image. The most common examples of pooling are max pooling and average pooling. Max polishing is usually used in the middle layers, and at the end of the grid, the average polishing layer is typically used. Usually, the last layers of a CNN for classification are the Fully Connect layers. These layers are the same layers that exist in the MLP neural network. One of the main applications of the fully connected layer in the convolutional network is to be used as a classifier. That is, the set of features extracted using convolutional layers are eventually transformed into a vector. Finally, this attribute vector is passed to a fully connected classifier to identify the correct class.

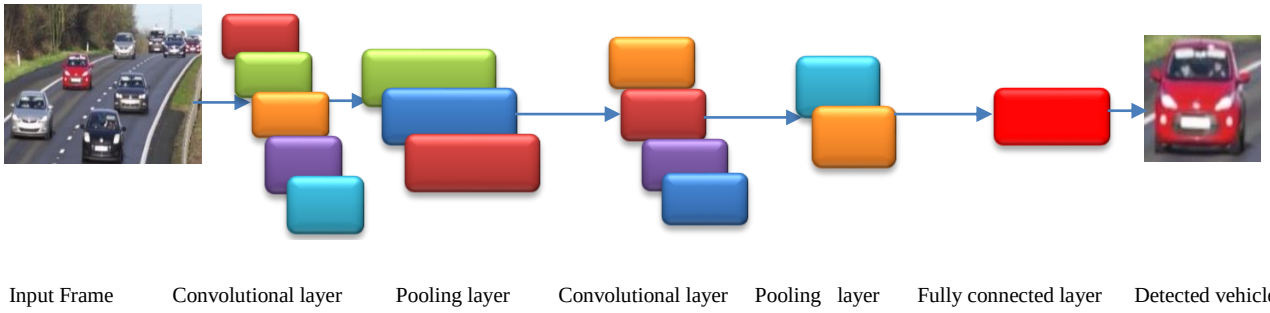

Fig. 1. Demonstration of algorithm and performance of convolution neural network in vehicle detection.

4- The proposed Method

4-1- Edge Detection using a Deep Convolutional Network

Initially, the extraction of basic features is provided, for which VGG-16 [21], VGG-19 [22], ResNet-50 [23], ResNet-101 [24], etc. can be used. Although the accuracy of the VGG-19 and ResNet series is higher, we use VGG-16 due to the need for much more network parameters. The main VGG16 consists of 5 convolutions, each step is connected to a pooling layer with stride = 2, and each step contains a different level of information. To find the edges of the image, it is necessary to extract information of different levels from each step layer to the pixel space of the edge. The next block handles feature retrieval and sampling. Thus, features can be mapped to the edge pixel space. The conv1_2 layer is a 1 × 1 × 1 convolution layer that reduce the size and integration of features. The re-extraction block of the three convolution layers is 1 × 1 × 32, 3 × 3 × 32, 1 × 1 × 28, and so on. At the end of the grid, a 1 × 1 kernel convolution layer is used to generate the final edge recognition image.

In an artificial neural network [25-27], each neuron is connected to all the neurons in the adjacent layer. The output y of each latent neuron is obtained from the sum of each of the weighted inputs w · x plus a bias b from the following equation [25]:

$$y = \mathrm{w} \cdot \mathrm{x} + \mathrm{b} \quad (1)$$

Neural network training is mainly based on the diffusion cost function to set the parameters. The purpose of reducing the cost of the parameters is mainly: the weight of the connection between the nerve cells and the bias of each neuron. Setting is to use the gradient descent algorithm to adjust the size of the parameters along the slope direction. For this purpose, the entropy reduction, and weighting functions are used, which are added according to the following equation [1].

$$C = -[tln(a) + (1-t)\ln(1-a)] \quad (2)$$

$$a = sigmoid(y) = \frac{1}{1 + e^{-y}}$$

C is the reciprocal of the loss of a pixel, and t is the target value; also, a is calculated by the sigmoid equation function. The output y of each latent neuron is calculated from the sum of each of the weighted inputs w · x plus a bias b from Equation 1.

Threshold step: By introducing a threshold and comparing it with matrix pixels, the edge points can be obtained. All pixels are divided into edge and non-edge pixels. The initial matrix T is equal to the mean value of the matrix. The points of the pheromone matrix are then categorized into two groups based on whether their value is less or more than T. The new threshold is obtained by averaging the two mean values of each group. The above steps continue until the threshold value changes too much [2]

$$T = \frac{\sum_{k=1:M_1} p_{k.l}^{(N)} \sum_{l=1:M_2} p_{k,l}^{(N)}}{M_1 M_2} \quad (3)$$

P is the probability. $M_1$and M_2 are the dimensions of the image. The final matrix is divided into two groups; the first group contains all the pixels less than T. The second group contains all the pixels greater than T. A binary decision-maker is then applied to each the pixel to determine ifthe point is on edge ($E_{k,l}$=1) or not ($E_{k,l}$= 0) [2].

$$E_{k.l} = \begin{cases} 1 & p_{k,l}^{(N)} \geq T \\ 0 & \text{otherwise} \end{cases} \quad (4)$$

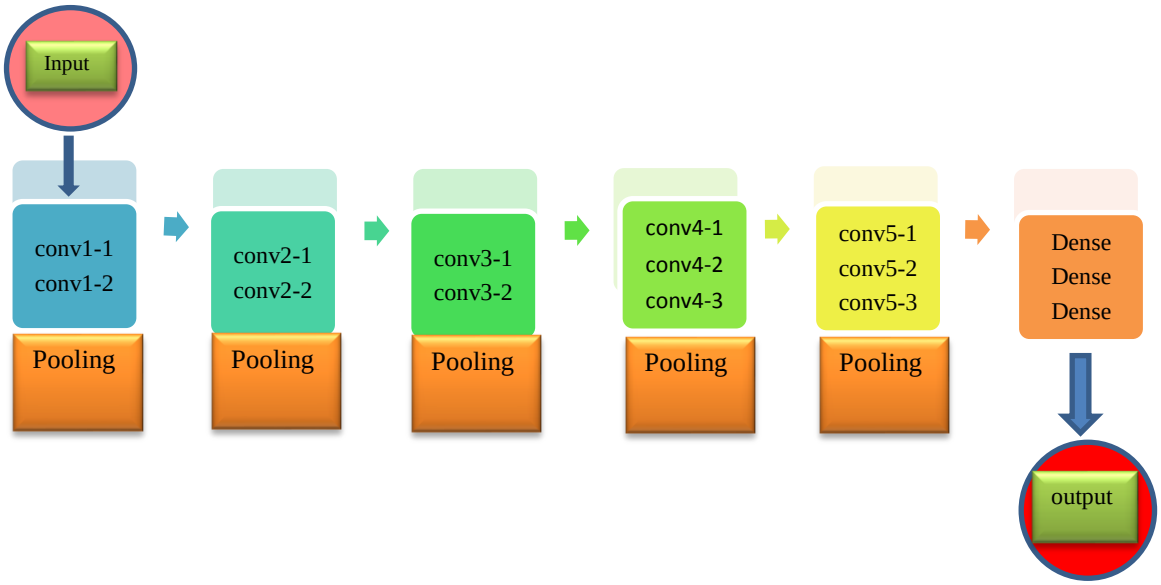

Fig. 2. VGG 16.

4-2- Vehicle Detection and Counting

To provide a monitoring and traffic system with reasonable accuracy and speed after edge detection, the field can be used to extract vehicles, according to Figure 3. In this case, it is compared to a background model to determine if the individual pixels are part of the background or foreground. Then a foreground mask is calculated. Using background subtraction, foreground objects are detected.

Shadow removal is also required to improve vehicle detection accuracy. The method of combining color and contour features is suitable for identifying shadows. For this purpose, a moving target is extracted. The connected domain is marked to be compared with the entire foreground area. The moving target contour is extracted, and the shadow direction is assessed according to the contour trend. Hence, the grain shadow points are obtained

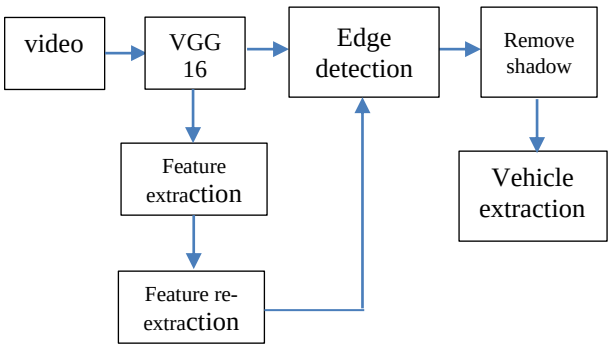

Fig. 3. The overall flow of the method

based on the contour direction, and the found points are removed.

The Gaussian mixture model is used to detect the vehicle. The model needs to be updated for fast and continuous detection. The system is highly resistant to changes in light, high or low speeds, high-traffic environments, and the entry or removal of objects from the scene. In this model, the distribution B is used for the covariance of the function resulting from the density function of the observation probability of the pixel value for the image.

$$B = argmin_b(\sum_{k=1}^{b} W_k > T) \quad (5)$$

T is the threshold value and W is the Gaussian weight. Weight values are updated. Structural features are extracted, and used for identification. The pseudocode of the proposed vehicle detection is presented.

The pseudocode for the vehicle detection:

START
STEP 1: Read Video
STEP 2: Extract a video frame
STEP 3: Convert into gray level image
STEP 4: the extraction of basic features with VGG-16
the input training data set is set to $\mathbf{s} = \{(\mathbf{x_n}.\mathbf{z_n})\}$,

STEP 5: Threshold step:
Old T
calculate threshold $\mathbf{T} = \frac{\sum_{\mathbf{k=1:M_1}} \mathbf{p_{k.l}^{(N)}} \sum_{l=1:M_2} p_{k,l}^{(N)}}{\mathbf{M_1 M_2}}$,
stopping Condition($|\mathbf{T} - \mathbf{oldT} < \boldsymbol{\varepsilon}|$)
All pixels are divided into edge and non-edge pixels with

$$\mathbf{E_{k.l}} = \begin{cases} \mathbf{1} & \mathbf{p}_{k,l}^{(N)} \geq \mathbf{T} \\ \mathbf{0} & \mathbf{otherwise} \end{cases}$$

STEP 6: Shadow removal
STEP 7: detect the vehicle with The Gaussian mixing method
END

5- Results

5-1- Dataset

1) To find the effectiveness of the proposed method, the simulations have been conducted and evaluated on images from Berkeley Segmentation Dataset.

2)The first dataset is Road-Tracing Monitoring [28]. This dataset detects vehicles on a single route and consists of three videos in separate frames. The "M-30" movie, contains 7520 frames recorded on a sunny day with a resolution of 640 × 480 pixels. The second movie "M-30-HD", contains 9390 frames recorded in the same place as the previous movie but on a cloudy day and, with a higher resolution of 1280 × 720. The third set of "Urban1" contains 23,435 frames with a low resolution of 480 × 320. This dataset enables the evaluation of vehicle detectors.

3) To evaluate the vehicle detection performance, the CDnet2014 benchmark dataset proposed in [29] was used. The CDnet2014 dataset includes 11 video categories with 4-6 movie sequences per group. We use the baseline video that shows a highway.

5-2- Evaluation Criteria

1) Entropy: One of the criteria for evaluating the output performance is the Shannon entropy function [30]:

$$H(I) = -\sum_{i=0}^{L} q_i \, log q_i \quad (6)$$

where I and q_i are the desired image and the frequency of the pixel i, respectively.The purpose of this criterion is to measure information. Higher entropy values are due to greater randomness and less information. This criterion can describe the complexity of a part of the image, and the difference between the pixel and the entropy value is positively correlated. The amount of dynamic background entropy or edge of the object is high.

2) The correct metric detections: One of the criteria for evaluating the correct detector is in the extraction of the vehicle; for this purpose, the identified vehicles can be compared with the real vehicle. The result of this evaluation has a significant impact on all the subsequent stages of processing. The criterion for correctly identifying vehicles is calculated for each frame. The evaluator is dependent on the parameters P and G and is expressed by the following relation [31]:

$$J(G.P) = \frac{|G \cap \mathrm{P}|}{|G \cup \mathrm{P}|}. \quad (7)$$

Parameters P and G are vehicle detected, and real, respectively.

3) Calculation time: Another evaluation criterion is the calculation time which is the time required to process one frame per replication, and can be used for evaluation in online applications.

4) Accuracy: The accuracy criterion is obtained by the following equation [31]:

$$accuracy = \frac{(TP + TN)}{(TP + TN + FP + FN)}. \quad (8)$$

P is true positive samples, TN is true negative samples, FP is false-positive samples and FN is false-negative samples.

4) Average precision: Using the formula provided by Equation 6, average precision is calculated:

$$\gamma = \frac{TP}{TP + TN + FP}. \quad (9)$$

5) F-measure: This criterion is a popular metric used to quantify the vehicle detection performance and is determined using the following relation [32]:

$$\eta = \frac{TN}{TN + FP}. \quad (10)$$

$$\phi = \frac{TP}{TP + FP}.$$

$$F\text{-}measure = \frac{2\eta\phi}{\eta + \phi}.$$

5-3- Deep Learning Edge Detection (DLED)

Initialization of the model is performed using a pre-trained VGG-16 model. To run and view the results, the algorithm is first implemented on the Berkley segmentation dataset.

Fig. 4. Results of images edge detection on Berkley segmentation dataset.

The continuous, accurate, and precise edges in the output show the excellent performance of the proposed method.

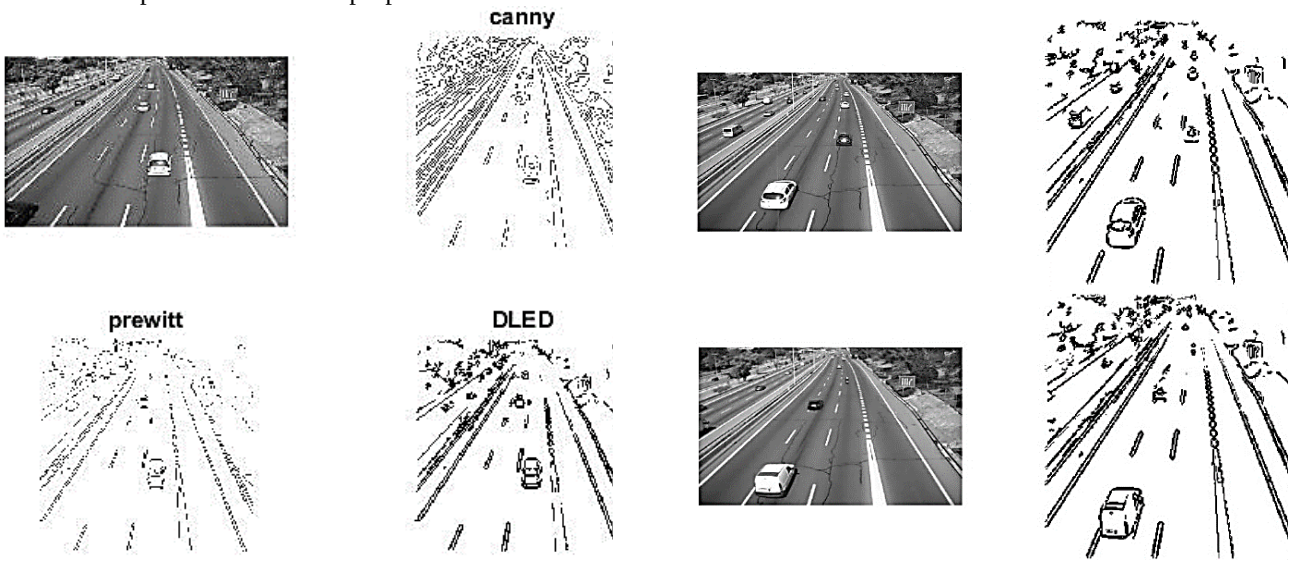

Fig. 5. Edge detection with canny, Prewitt, DLED.

Then, the algorithm is implemented on the Road-Traffic Monitoring dataset [25]. To assess edge detection efficiency, the output of the detected edges is compared with that of robust edge detectors such as CANNY and Prewitt, the results of which are shown in Figure 5.

Table 1: Entropy values for the GRAM images.

Image	Canny	Prewitt	DLED
M-30	0.5385	0.4183	**0.3996**
M-30-HD	0.2815	0.2784	**0.2612**
Urban1	0.4916	0.4625	**0.4501**

Table 1 indicates the entropy values for the images in the dataset studied dataset.

Higher entropy values are due to greater randomness and less information. The proposed method has the lowest value and can detect essential edges.
Table 2 shows the mean values of the edge accuracy on several images in the Berkley segmentation dataset, which are compared with several methods for image edge detection.

Table 2. γ values for the outputs of some of the edge detectors on Berkley segmentation dataset.

Image	GA[11]	PSO[12]	ACO [13]	Deep Learning[14]	BFA[15]	Fuzzy+BFO[16]	Neuro-Fuzzy[17]	PSO for noisy[18]	Proposed method
35010	0.15	0.24	0.07	0.32	0.26	0.30	0.06	0.23	**0.35**
42049	0.11	0.28	0.09	0.31	0.12	0.29	0.08	0.30	**0.33**
118035	0.19	0.14	0.22	0.07	0.25	0.06	0.24	**0.27**	0.12
135069	0.21	0.12	0.21	0.06	0.26	0.07	0.22	**0.33**	0.15
119082	0.22	0.15	0.10	0.27	0.18	0.30	0.09	0.23	**0.31**

For the accuracy to be high, the number of false-positive samples must be reduced, thus decreasing the level of positive sensitivity. High accuracy is required in identifying objects. According to the values in this table, the average accuracy calculated in three images has the highest value. However, in two images, the method mentioned in reference [18] is more accurate.

According to the results in Table 2, the proposed method has achieved the highest value of γ for three images of the Berkley segmentation dataset and more than other methods. Table 3 displays the entropy values for the outputs of some of the edge detectors. The proposed method has the minimum value. A higher value of entropy relates to more uncertainty and less information.

Table 3. The entropy values for the outputs of some of the edge detectors on Berkley segmentation dataset.

Image	GA[11]	PSO[12]	ACO [13]	Deep Learning[14]	BFA[15]	Fuzzy+BFO[16]	Neuro-Fuzzy[17]	PSO for noisy[18]	Proposed method
35010	0.8211	0.7213	0.7715	0.6882	1.6124	0.6331	0.6110	0.6995	**0.5125**
42049	0.8322	0.6811	0.7722	0.6243	1.5216	0.5999	0.6561	0.6778	**0.3798**
118035	0.8836	0.6992	0.7765	0.6836	1.4245	0.5876	0.5788	0.6476	**0.3819**
135069	0.9214	0.8112	0.8833	0.7210	1.2124	0.6675	0.6689	0.7889	**0.4089**
119082	0.9914	0.8365	0.8987	0.7991	1.4642	0.7999	0.7989	0.8999	**0.5592**

Table 3 shows that the lowest entropy value is obtained in the proposed method, which is valid for all the images in this dataset. This method can find meaningful edges.

It is observed that the best score of this value is achieved by the proposed method, followed by the Neuro-Fuzzy method [17] however, the proposed method has a better performance with the lowest entropy.

According to the values given in this table, the highest entropy value is related to the Bacterial Foraging Algorithm (BFA).
Deep learning has significant advantages compared to traditional edge detection algorithms. The proposed method shows higher performance compared to those methods.

M-30 M-30-HD Urban1

Fig. 6. vehicle detection with the proposed method on Road-Traccing Monitoring.

Table 4 reports the vehicle diagnostic results in the Road-Traffic Monitoring GRAM dataset.

Table 4. Comparison of processing time performance and vehicle detection accuracy in object detection in the GRAM dataset.

		M-30	**M-30-HD**	**Urban1**
Haar Cascade[6]	Time [s]	**0.08–0.13**	0.3–0.44	0.02–0.06
	Accuracy	43%	75%	40%
SSD[8]	Time [s]	4–7	11–14	2.6–5.6
	Accuracy	22%	70%	**69%**
YOLO v3[7]	Time [s]	1.0–1.8	1.0–1.8	1.0–1.8
	Accuracy	82%	86%	91%
Mask R-CNN[9]	Time [s]	2.4–3.0	2.4–3.0	2.4–3.0
	Accuracy	89%	91%	46%
Proposed method	Time [s]	2.3-2.8	2.3-2.8	2.3-2.8
	Accuracy	**91%**	**93%**	54%

The results show that the fastest detector is Haar Cascade, but it offers a maximum accuracy of 75%. The proposed method is the best in terms of accuracy.

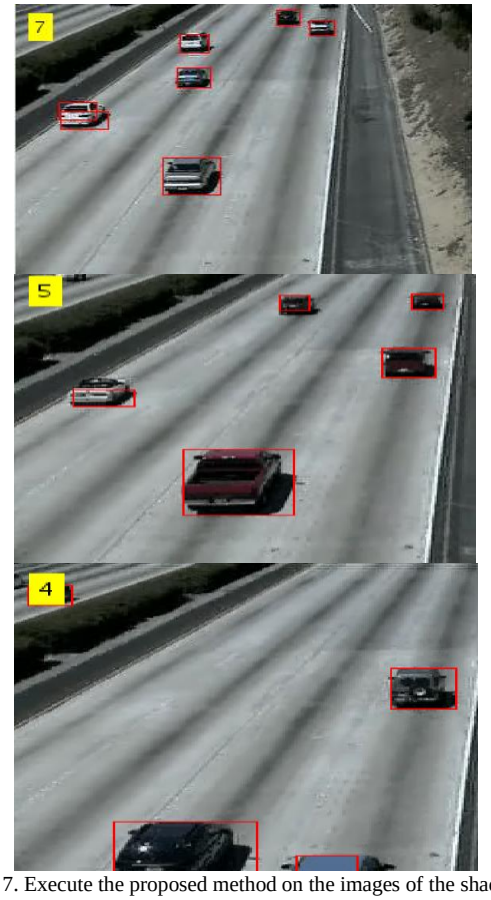

Fig. 7. Execute the proposed method on the images of the shaded vehicle.

In traffic image analysis, shadows are sometimes identified as the background. Therefore, shadows also play a significant role, and during sunny days, it may be difficult to successfully identify the vehicle. To evaluate the success of vehicle identification in this situation, we use the baseline video, which shows the highway and vehicles in this video have shadows. The results of the diagnosis are shown in Figure 7. The findings show that this method is also resistant to shadows and can yield excellent results.

Finally, two criteria on the CDnet 2014 dataset were compared with another method, which is presented in Figure 8.

The results obtained using the proposed method demonstrate that the values of the evaluated criteria have improved compared to the other seven methods, especially in terms of "F-measure". Auspicious results promise higher accuracy and higher performance.

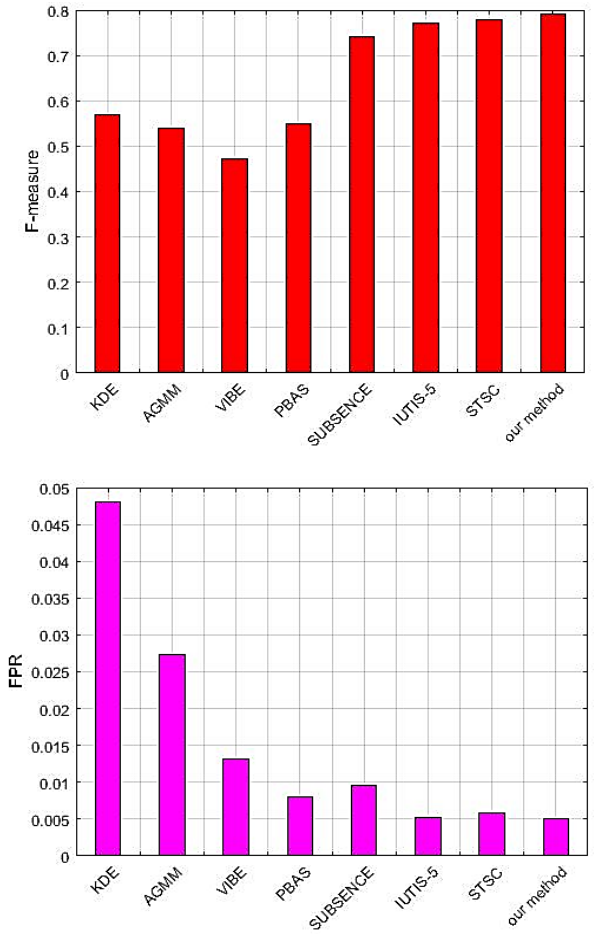

Fig. 8. Evaluation Metrics of Seven Methods on CDnet 2014 Dataset.

6- Conclusions

In this paper, for vehicle detection, first, the deep edge CNN detection is performed and then a comparison with a background model is conducted. Using background subtraction, foreground objects are detected. The Gaussian mixed method is employed to detect the vehicle, which must be updated for rapid and continuous detection. Three different videos are selected in terms, of weather conditions, traffic load, and resolution. The first video is on a sunny day. The second video shows the same place but on a cloudy day and with a higher resolution. The third video is in low resolution and displays the same street. The results are compared with those of several other methods, which shows the higher accuracy of the results of the proposed method. This method is very resistant to entering or removing objects from the scene.

In future research, other neural network architectures can be used to increase accuracy. On the other hand, the proposed method can be utilized to add other purposes such as vehicle classification, traffic classification, and speed detection.

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Rough Sets Theory with Deep Learning for Tracking in Natural Interaction with Deaf

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Abstract
Sign languages commonly serve as an alternative or complementary mode of human communication Tracking is one of the most fundamental problems in computer vision, and use in a long list of applications such as sign languages recognition. Despite great advances in recent years, tracking remains challenging due to many factors including occlusion, scale variation, etc. The mistake detecting of head or left hand instead of right hand in overlapping are, modes like this, and due to the uncertainty of the hand area over the deaf news video frames; we proposed two methods: first, tracking using particle filter and second tracking using the idea of the rough set theory in granular information with deep neural network. We proposed the method for Combination the Rough Set with Deep Neural Network and used for in Hand/Head Tracking in Video Signal DeafNews. We develop a tracking system for Deaf News. We used rough set theory to increase the accuracy of skin segmentation in video signal. Using deep neural network, we extracted inherent relationships available in the frame pixels and generalized the achieved features to tracking. The system proposed is tested on the 33 of Deaf News with 100 different words and 1927 video files for words then recall, MOTA and MOTP values are obtained.

Keywords: Natural Interaction with Deaf; Machine Vision; Persian Deaf News Hand Tracking; Sign Language; Rough Sets Theory; Deep Learning.

1- Introduction

Recognition of states and hand gestures are very important in a natural interaction with a computer. Its importance is due to its widespread applications in virtual reality, sign language recognition and computer games. Fast and robust hand gesture recognition remains an open problem [1].
By tracking the hand in the video, it is simpler to partition it from the image frames. The purpose of tracking methods is to discover and track one or more objects in the sequence of images. Tracking can be thought of as a kind of object discovery in a set of similar images. Many tracking methods are used to discover and track objects in video films, in which a large number of images have to be processed. Various kinds of probabilistic inference models haves been applied to multi-object tracking, such as Kalman filter, Extended Kalman filter and Particle filter. In the case of linear system and Gaussian-distribution object states, Kalman filter is proved to be the optimal estimator. It has been applied. Extended Kalman filter, for the nonlinear case, extended Kalman filter is a solution. It approximates the nonlinear system by Taylor Expansion. Particle filter, Monte Carlo sampling-based models becomes popular in tracking, especially after the introduce of Particle filter Typically, the strategy of Maximum A Posteriori (MAP) is adopted to derive a state with the maximum probability [2,3].
About 466 million deaf people live in the world, this is approximately 5.3% of the world population1, their natural language is the sign language. They are restricted in reading and writing the official language. Education, work, use of computers and the Internet are affected for them. Diagnosing the sign language, if used in interaction with the computer and in the translation of texts to hand gestures, can support them well [2].
Deep learning is a kind of hierarchical learning. In layered hierarchical learning, nonlinear features are extracted, then

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the output layer is usually formulated depending on how many groups that are needed [4]. The output layer is a classifier. It combines all features to make predictions. The layers' hierarchy is deeper, the more nonlinear features are extracted. That is why the number of layers in deep learning is used. Sometimes these complex features cannot be obtained directly from the input image.

A Convolutional neural network, CNN is a popular deep learning architecture that automatically learns useful feature representations directly from image data. CNNs, or ConvNets, are essential tools for deep learning, and are especially useful for image classification, object detection, and recognition tasks. CNNs are implemented as a series of interconnected layers.

A semantic segmentation network classifies every pixel in an image, resulting in an image that is segmented by class. Semantic segmentation networks like DeepLab make extensive use of dilated convolutions, also known as Atreus convolutions, because they can increase the receptive field of the layer without increasing the number of parameters or computations.

Although years have passed since the design of target tracking, this topic is still an active research field with many applications in the world's universities and scientific circles. This issue is of particular importance in tracking the targets that move with quick maneuvers, because the dynamic of target motions is complex and its nature is nonlinear. Given that the targets we are interested in track down have high-level maneuvers, various intelligent methods have all been in line with tracking the best.

The "rough sets" approach to estimate sets has led to beneficial aspects of the grain calculations, and is part of computational intelligence. The basic idea of the rough sets for aggregated information implies that how much the subsets can be used to find the objects of interest for estimating [5]. Also rough sets theory is convenient for picking up irrelevant and redundant features from a dataset [6]. Here the computational intelligence of rough sets is used. The causes of the lack of information in a particular application are identified in order to overcome the problem of the lack of information in a particular application. Then, necessary relationships are used to compensate for the lack of information. In fact, subsets of classes are characterized by rough sets, then the boundary and negative members obtained from the definition of the following sets are guided to their proper position with the definition of functions.

Tracking is very important. Machine learning is used for tracking. Dongxu Li et al. used deep learning for sign language recognition [7]. Literature findings of Wadhawan et al. indicated that the major research on sign language recognition has been performed on static, isolated and single-handed signs using camera [3].

In the case of deaf communication, it is necessary to recognize the signs expressed by the deaf. Facial gesture, trajectory and hand gesture are the three basic features for recognizing the language sign expressed by a deaf person. Hand and head tracking is used to find the trajectory and segment them from the background of the video in the frames. So, the problem is accurately tracking the hands and head in videos of signs expressed by the deaf.

The sign language of countries is different. In this work, a Persian dataset of sign language videos has been collected, which is available at Kashan University. The system proposed are tested on 33 videos of Deaf News with 100 different words and 1927 video files for words, and recall, MOTA and MOTP values are obtained. We used rough set theory with deep Neural network for sign language tracking. The novelty of this paper is the use of rough set theory with deep neural network for tracking. This is the first work on this topic. In this paper, at first, tracking using particle filter is explained. At second, tracking using rough sets and deep learning is explained. In the first proposed method, we used a particle filter, which has high accuracy but is very time consuming. The second proposed method responds much faster but is less accurate. To increase the accuracy of the second proposed method, we used the rough set theory.

2- Proposed Algorithm

Sign language recognition is one of the issues that have been used in many applications. Some of them are the transcription, video rebuilding, and deaf of sign language. In this regard, we have tried to create a system for sign language recognition for Persian, so that ordinary people and the deaf can easily interact with each other. The sign language recognition uses a variety of sub-systems, each of which has its own characteristics and procedures, and the relationship between the various components of the system is an important issue that cannot easily be ignored. The purpose of this research is to design and train the "deep learning network" to sign language recognition for Persian.

The first part that the system focuses on is the multi-tracking. The development of a new multi-tracking method used the theory of rough sets in such a way that it automatically tracks objects in a video signal. The objects in this system are two hands and face. The geometric feature of the object's presence at different times, in other words, the trajectory, can be effective in selecting the area appropriately, improving fragmentation, and identifying the results in this application [1,2,8].

The rough sets approach in estimating collections has led to beneficial benefits from granular calculations and is part of computational intelligence. The basic idea of rough sets for granular information implies that how much of the

subcategories can be used to estimate in the discovery and fragmentation of favorite objects. In this system, the computational intelligence of the rough sets will be used. To overcome the problem of the lack of information in any particular application, it explains the causes of the lack of information. Then, relationships are used to compensate for the lack of information. In fact, with rough sets, the subsets of the categories are determined, and then the boundary and negative members obtained from the definition of rough sets, with the definition of the function, are directed to their proper place [9].

$$g(i,j) = \begin{cases} \frac{I(i,j)}{128} & I(i,j) < 128 \\ \frac{255-I(i,j)}{128} & I(i,j) \geq 128 \end{cases} \quad (1)$$

$$g_p(i,j) = \frac{255}{e^{-1}-1} \times e^{g(i,j)^{0.75}-1}$$

There, the folding function, equation (1) is used. In the equation (1), i and j are location coordinates of pixels in image I. when two hands overlapped or the hands and face overlapped, Weak boundaries are created. At this time the tracker fails, means tracker going from right hand to left hand or to face. The g function shows up a very weak boundary overlapping regions. The g function converts the intermediate values of the gray area of the boundary to completely white values. In this case, the tracker does not cross the boundary and continues to track in its area truly.

2-1- Proposed Method 1: Multi-Tracking using Particle Filter

In simple terms, the filtering method refers to the process of obtaining and accessed targets during the movie screenings. This issue, filter for target, is very important in tracking because the targets move with quick maneuvers by means that dynamic of target motions is complex and its nature is nonlinear. lately, particle filtering has appeared as a tracking approach as compared with meanshif. It is a stochastic approach that models nonlinear motion with non-Gaussian noise.

General approaches in the tracking with filters have two stages: prediction and update. In prediction stage the model must predict the location of the hand in the next frame using motion model, after arriving to next time, the exact location is achieved and update the motion model using observation model. In the particle filter method, this is done pixel-to-pixel, and it raises the computational complexity.

For each position in frame at each time, local score is calculated. The global score is the total score for the best path until now, which ends to each position. For each position in image, the best predecessor is searched for among a set of possible previous scores. This best predecessor is then stored in table of back pointers which is used for the trace back.

Principal Component Analysis (PCA) performed by the Karhunen-Lokve transform produces features that are mutually uncorrelated. The obtained by the KL transform solution is optimal when dimensionality reduction is the goal and one wishes to minimize the approximation mean square error.

Mean face difference images (MFDI) are difference images between the mean face and the tracked face patch computed over a sentence or word segment.

The motion energy feature is used for silence detection in the presented system. Additionally, the use of motion energy as feature for sign language recognition is investigated.

hand position normalized with respect to shoulder and vertical body axis. Gabor wavelet transform is one of the most effective texture feature extraction techniques and has resulted in many successful practical applications.

PCA, MFDI, motion energy, hand position, hand texture speed and RGB to YcBcR and GRAY are features for sign language recognition.

Vision based communicating with compare of speech-based communicating is more complex and meaningful. Direct communication between deaf and other people is very difficult, so there are attempts for making a sign language interpreting system You can see a diagram of it in Fig. 1. In the first proposed method, we used a particle filter, which has high accuracy but is very time consuming. The second proposed method responds much faster but is less accurate. To increase the accuracy of the second method, we used the rough set theory.

2-2- Proposed Method 2: Multi-Tracking using Rough Sets

2-2-1- Rough Set

By using fuzzy and in particular the theory of rough sets with uncertainties in the trace problem, the best trace is attempted. All video frame points are included in the database table as examples in the first column. The properties of each point are stored as a separate column in the table. The value of the attributes for each point is recorded. Due to the fact that a camera mounted in a single place arranges the data, each frame is calculated for each frame as the changes in the positive, negative and boundary sets are added. Each time, the matrix of the hand region in the matrix is multiplied by the general relationship and the matrices of the intermediate and the primary are obtained. By using the definition and use of proper conversion functions, the tracing method improves. If it works online, it is necessary to process the same as the film. This is called active learning [10,11].

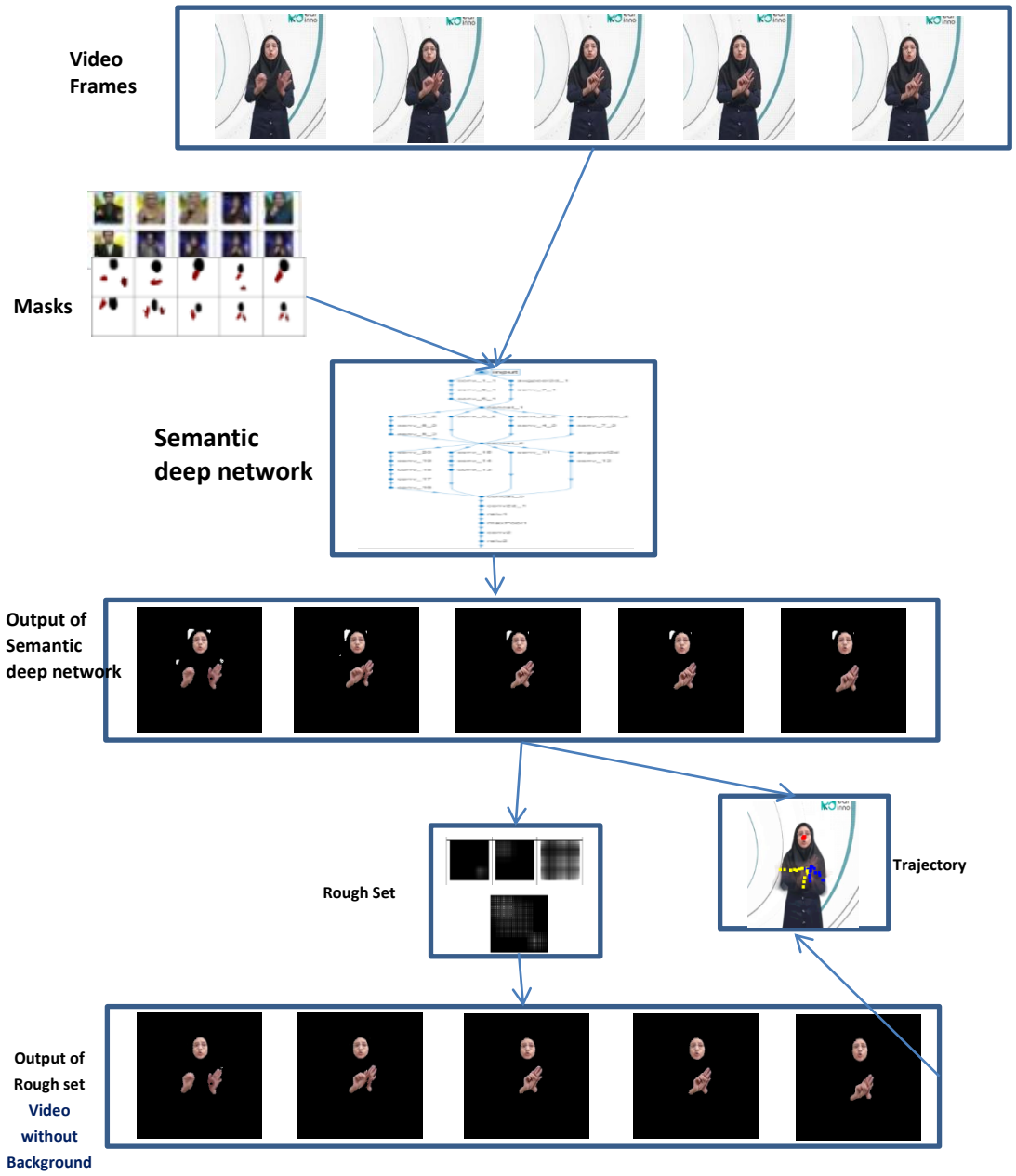

Fig. 1: The outline of Proposed method 2: multi-tracking using Rough sets

Fig. 1 shows the outline of proposed method 2, multi-tracking using Rough sets.

The most important features of rough set theory are:

- Finding relationships that are not discovered by statistical methods.
- Ability to use quantitative and qualitative information.
- Finding a minimum set of data that is useful for categorization (such as minimizing dimensions and number of data).
- Assessing the importance of data.
- Generate decision rules on data [3].

Using the definition and use of convenient conversion functions, the method of tracking is improved. The composite decision is listed in table 1.

Table 1: The composite decision table

U	a1	a2	a3	a4	a5	a6	a7	D
x_1	0	0	0	1	{0,1,..,255}	{0,1,..,255}	{0,1,..,255}	No
x_2	0	0	0	1	{0,1,..,255}	{0,1,..,255}	{0,1,..,255}	No
...	...	...	...	...	...	...	...	...
x_k	0	0	0	1	{0,1,..,255}	{0,1,..,255}	{0,1,..,255}	No

The k is all pixel of every frame of video. The size of frame is 208×186 and k=208×186 = 38688, a_i is 0 or 1, if $x_j \in B_i$ then a_i is 1, otherwise ai is 0. $0 < j \leq 38688$ and $i = 1..4$.

$B_1 = \{a_1, a_5, a_6, a_7\}$, $B_2 = \{a_2, a_5, a_6, a_7\}$, $B_3 = \{a_3, a_5, a_6, a_7\}$, $B_4 = \{a_4, a_5, a_6, a_7\}$ and $B = \cup_{k=1,2,3} B_k$.
If $a_1 = 1$ *or* $a_2 = 1$ *or* $a_3 = 1$, D is *Yes* and othewise No.
R_B is an equivalence relation:

- $R_{B_1}(x_i) =$ *set of pixels* x_i *region of right hand*
- $R_{B_2}(x_i) =$ *set of pixels* x_i *region of left hand*
- $R_{B_3}(x_i) =$ *set of pixels* x_i *region of face hand*
- $R_{B_4}(x_i) =$ *set of pixels* x_i *region of background*
- $CR_B(x_i) = set\ of\ pixels\ x_i\ region\ of\ B_1 \cup B_2 \cup B_3$

The size of matrixes M_* are $k \times k$ and k=38688. For relations RB define M_*.

$$M_{k\times k}^{R_{B_i}}(i,j) = M_{k\times k}^{R_{B_i}}(j,i) = a_i(x_j) \qquad (2)$$

$M_{k\times k}^{R_{B_1}}$, $M_{k\times k}^{R_{B_2}}$, $M_{k\times k}^{R_{B_3}}$, $M_{k\times k}^{R_{B_4}}$ and $M_{k\times k}^{CR_B}$ obtain equation (2). Fig. 2 and Fig. 3 show matrixes $M_{k\times k}^{R_{B_1}}$, $M_{k\times k}^{R_{B_2}}$, $M_{k\times k}^{R_{B_3}}$, $M_{k\times k}^{R_{B_4}}$ and $M_{k\times k}^{CR_B}$.

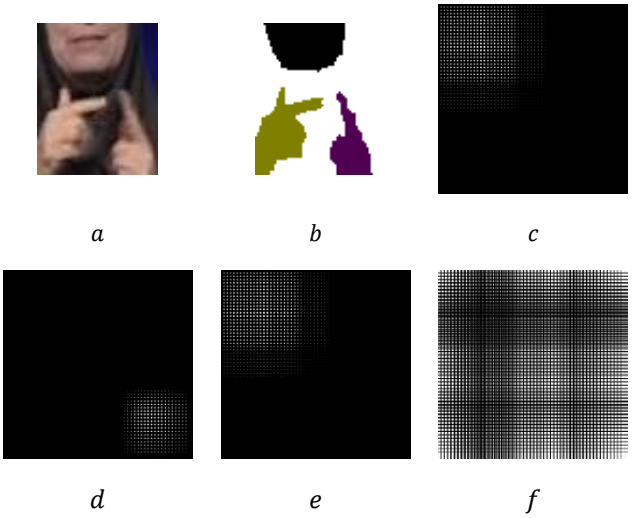

Fig. 2: a. image, b. label of image (a), c. $M_{k\times k}^{R_{B_3}}$, d. $M_{k\times k}^{R_{B_2}}$, e. $M_{k\times k}^{R_{B_1}}$ and f. $M_{k\times k}^{R_{B_4}}$

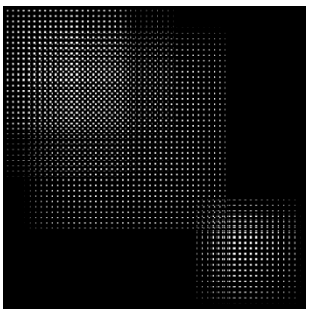

Fig. 3: $M_{k\times k}^{CR_B}$ for Fig. (2. b)

$\Lambda_{k\times k}^{CR_B}$ be an induced diagonal matrix of $M_{k\times k}^{CR_B}$, then:

$$\Lambda_{k\times k}^{CR_B} = diag\left(\frac{1}{\lambda_1}, \frac{1}{\lambda_2}, \frac{1}{\lambda_3}, \ldots \frac{1}{\lambda_k}\right) \qquad (3)$$

That $\lambda_i = \sum_{j=1}^{k} m_{ij}$, $1 \leq i \leq k$.

The calculation of the intermediate matrix:

$$\Omega_{k\times 2}^{CR_B} = M_{k\times k}^{CR_B} \bullet [(D_{1\times k})^T \quad (\overline{D_{1\times k}})^T] \tag{4}$$

The calculation of the basic matrix:

$$HD_{k\times 2} = \Lambda_{k\times k}^{CR_B} \bullet \Omega_{k\times 2}^{CR_B} \tag{5}$$

The n-column Boolean vector $G\left(\underline{CR_B}(D_j)\right)$ of the lower approximation $\underline{CR_B}(D_j)$:

$$G\left(\underline{CR_B}(D_j)\right) = H^{[1,1]}(D_j) \tag{6}$$

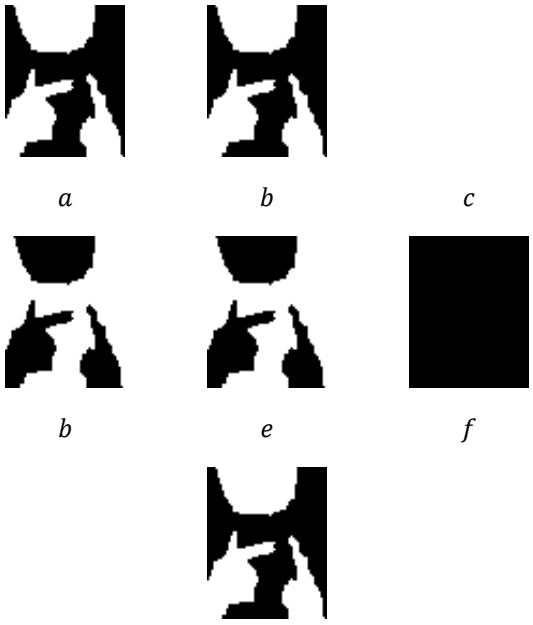

Fig. 4: a. $G\left(\underline{CR_B}(D_{skin})\right)$, b. $G\left(\overline{CR_B}(D_{skin})\right)$, c. $G\left(POS_{CR_B}(D)\right)$, d. $G\left(\underline{CR_B}(D_{background})\right)$,e. $G\left(\overline{CR_B}(D_{background})\right)$,f. $G\left(BND_{CR_B}(D)\right)$ and h. $G\left(NEG_{CR_B}(D)\right)$

The n-column Boolean vector $G\left(\overline{CR_B}(D_j)\right)$ of the upper approximation $\overline{CR_B}(D_j)$:

$$G\left(\overline{CR_B}(D_j)\right) = H^{(0,1]}(D_j) \tag{7}$$

The n-column Boolean vector $G\left(POS_{CR_B}(D)\right)$ of the positive region:

$$G\left(POS_{CR_B}(D)\right) = \sum_{j=1}^{r} H^{[1,1]}(D_j) \tag{8}$$

The n-column Boolean vector $G\left(NEG_{CR_B}(D)\right)$ of the negative region:

$J = (1,1,\dots,1)^T$,

$$G\left(NEG_{CR_B}(D)\right) = J - \sum_{j=1}^{k} H^{(0,1]}(D_j) = \left(\sum_{j=1}^{r} H^{(0,1]}(D_j)\right)^{[0,0]} \tag{9}$$

The n-column Boolean vector $G\left(BND_{CR_B}(D)\right)$ of the boundary region:

$$G\left(BND_{CR_B}(D)\right) = \sum_{j=1}^{r} H^{(0,1]}(D_j) - \sum_{j=1}^{k} H^{[1,1]}(D_j) = \sum_{j=1}^{k} H^{(0,1]}(D_j) \tag{10}$$

The r is number of x_j in the set of D that is Yes for D_1, or No for D_2 . Fig. 4 show matrixes $G\left(\underline{CR_B}(D_{skin})\right)$, $G\left(\overline{CR_B}(D_{skin})\right)$, $G\left(POS_{CR_B}(D)\right)$, $G\left(\underline{CR_B}(D_{background})\right)$, $G\left(\overline{CR_B}(D_{background})\right)$, $G\left(BND_{CR_B}(D)\right)$ and $G\left(NEG_{CR_B}(D)\right)$.

2-2-2- Semantic Segmentation Network using Deep Learning

A semantic segmentation network classifies every pixel in an image, resulting in an image that is segmented by class. To illustrate the training procedure, in this paper we train deep learning net, one type of convolutional neural network (CNN) designed for semantic image segmentation. Other types of networks for semantic segmentation include fully convolutional networks (FCN), SegNet, and U-Net.

We used a semantic segmentation network with 56 layers (Fig.5). We use the dataset [2] training. This dataset is a collection of images containing Right and left Hand Face. But this approach, used with dynamic programming, is very time-consuming.

A 2-D convolutional layer applies sliding convolutional filters to the input. The layer convolves the input by moving the filters along the input vertically and horizontally and computing the dot product of the weights and the input, and then adding a bias term. An average pooling layer performs down-sampling by dividing the input into rectangular pooling regions and computing the average values of each region. A concatenation layer takes

inputs and concatenates them along a specified dimension. The inputs must have the same size in all dimensions except the concatenation dimension. An image input layer inputs 2-D images to a network and applies data normalization. An average pooling layer performs down-sampling by dividing the input into rectangular pooling regions and computing the average values of each region. A relu layer performs a threshold operation to each element of the input, where any value less than zero is set to zero.

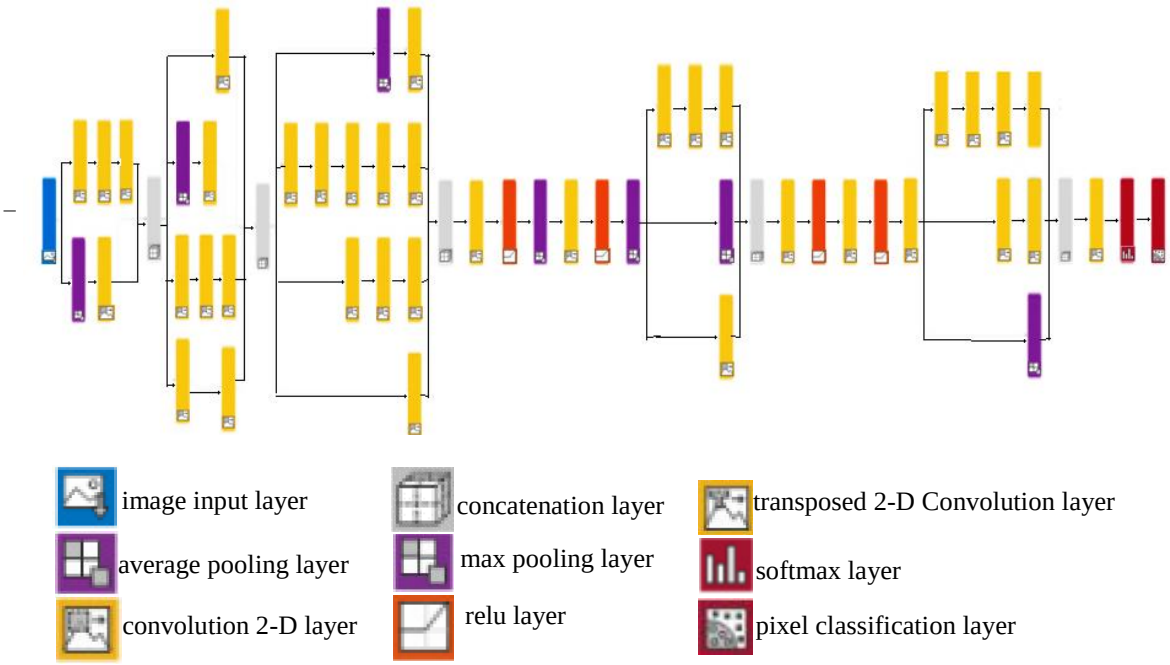

Fig 5. The 56-layer semantic segmentation network.

A max pooling layer performs down-sampling by dividing the input into rectangular pooling regions, and computing the maximum of each region. A transposed 2-D convolution layer upsamples feature maps.This layer is sometimes incorrectly known as a "deconvolution" or "deconv" layer. This layer is the transpose of convolution and does not perform deconvolution. A softmax layer applies a softmax function to the input.

A pixel classification layer provides a categorical label for each image pixel or voxel. The pixel classification layer creates a pixel classification output layer for semantic image segmentation networks. The layer outputs the categorical label for each image pixel or voxel processed by a CNN. The layer automatically ignores undefined pixel labels during training.

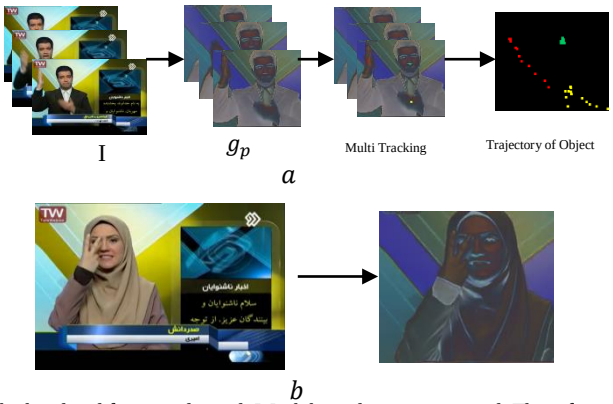

Fig. 6: a. tracking system. b. the hand and face overlapped; Weak boundaries are created. The g function converts the intermediate values of the gray area of the boundary to completely white values

3- Result

The system is tested on the deaf news. The data that will work on the system will be related to the deaf news. 33 different video files, with five different News presenters: three women and two men News presenters. At first, parts of the video associated with each word are separated from the video files

As you can see in the Fig. 10 experiments are performed on the Persian Sign Language Video Dataset. Then it will be tagged for each. Using a series of tracks and rough sets, the two-handed and headed areas will be detected and deployed to the grid. The seven general methods are based on the components and methods used for multi-tasking. In fact, each multi-tasking system consists of two main components of the observational model and the dynamic model. Dynamic model refers to the motion in sequential frames, and the observed model refers to the detection of an object in each frame of the video. Some results of deep learning with rough are shown in Fig. 6.

Recall is ratio of correctly matched detections to ground-truth detections. Multiple objects tracking accuracy (MOTA), Accuracy means the closeness of measurement values to each other, whether these values of reality are no. MOTA is obtained (TP+TN)/(P+N). MOTA combines false negative, false positives and mismatch rate. TP is True Position rate that means the right hand is there and is tracked right. TN is True Negative rate that means the right hand does not exist and has not been tracked. P is Positive that means there is a right hand. N is Negative that means there is no right hand.

Multiple Object Tracking Precision (MOTP), Precision means that in measured amounts of the same value, how close are the measured values. MOTP is obtained TP/(TP+FP). MOTP overlap between the estimated positions and the ground truth averaged over the matched. FP is False Positive, means that the right hand is there but it's not traced. FN, False Negative, means that there is no right hand in the image but it's tracked.

The system is tested on the Deaf News, with 100 different words, with approximately 10 to 20 samples for each word, each word is between 7 to 30 frames. For example, there are 20 samples for the "Deaf" sign, with a minimum number of frames for this word of 9 frames and a maximum number of frames of 30 frames. In total for 100 words, there are 1927 video files. And 23124 is the number of available frames.

Recall, Accuracy and Precision values are obtained in tables 2 to 3.

Table 2: right hand: Rough and Net1: Recall=0.968, Accuracy=0.979, Precision=0.977

Net1 and Rough	TP:18823	FP: 447
	FN:35	TN: 3819

In both methods "Particle Filter" and "Net1 and Rough" for 'Face' region: Recall=1, Accuracy=1 and Precision=1. The both methods obtain good results but the method "Net1 and Rough" answer is in a shorter time.

Table 3: left hand: Rough and Net1: Recall=0.952, Accuracy=0.977, Precision=0.938

Net1 and Rough	TP:946	FP: 62
	FN:473	TN: 21653

In Table 4 Deep learning with rough sets tracking system is compared with other methods.

3-1- Result of Proposed Method 1: Multi-Tracking using Particle Filter

The results of the particle filter show in the Fig. 7.

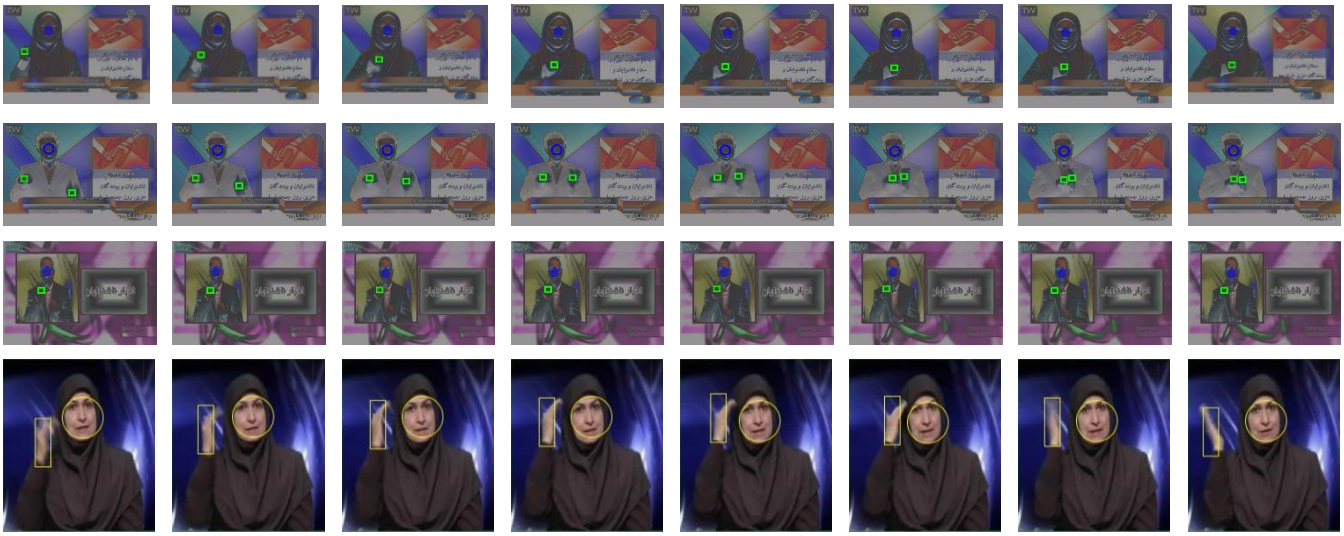

Fig. 7: Some results of Multi-tracking using particle filter on video signal DeafNews dataset

3-2- Result of Proposed Method 2: Semantic Segmentation Network using Deep Learning

Number of layers is 56, number of connections is 66, input is image and output are semantic segmentation. This 56-layer deep learning network, segment the Hands and Face areas from the background. The second-deep learning network is for tracking the right hand, face, and left hand, which in the preceding stage have their areas. Percent accuracy 97.35 on dataset. The dataset that works on the system will be related to the deaf news. The results of deep-learning tracking show in Fig. 9 and Fig. 10. and table 4. In this paper used two separate deep learning for tracking.

a *b* *c*

Fig. 8: result of semantic segmentation network using deep learning, a. one frame of video, b. result of semantic segmentation network using deep learning, c. black is true, green is skin false and pink is background false

In Fig. 8. shows result of semantic segmentation network using deep learning. Fig. 8.a. is one frame of video, Fig. 8.b. result of semantic segmentation network using deep learning, in Fig. 8.c. black is true, green is skin false and pink is background false.

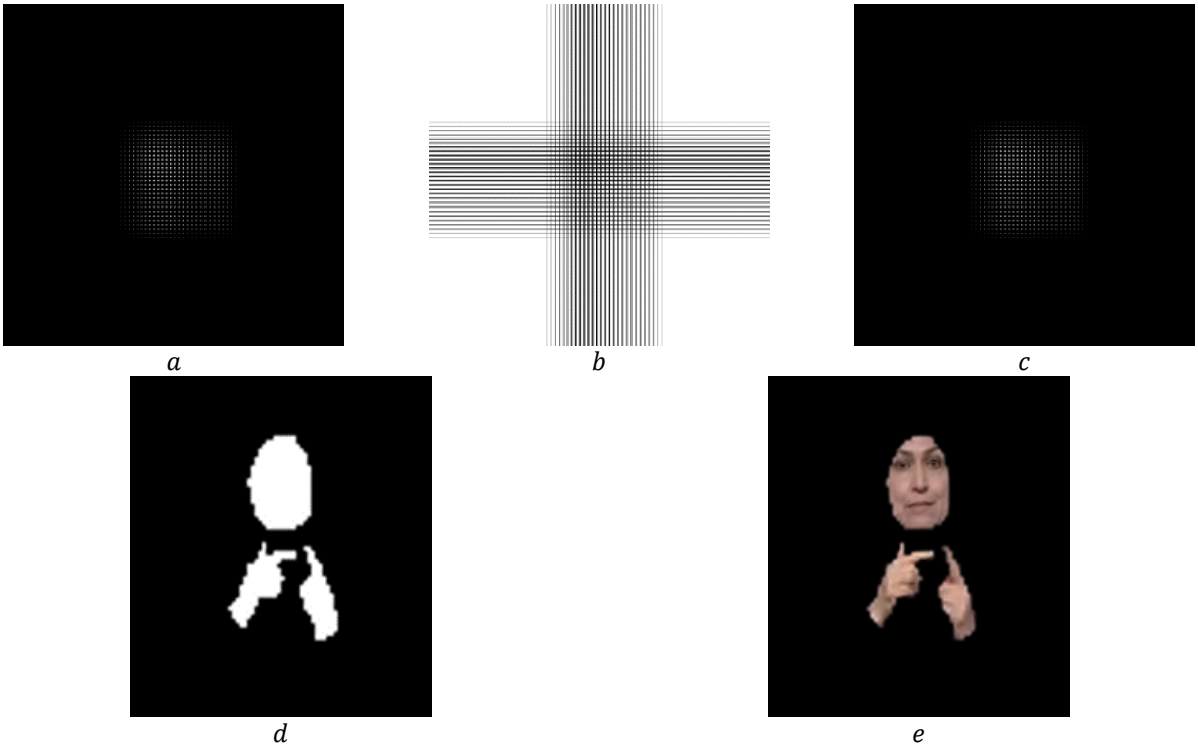

Fig. 9: a. $\boldsymbol{M}_{k\times k}^{R_{B_3}}$,b. $\boldsymbol{M}_{k\times k}^{R_{B_2}}$,c. $\boldsymbol{M}_{k\times k}^{CR_B}$,d and e. result method rough on Fig. 6.b.

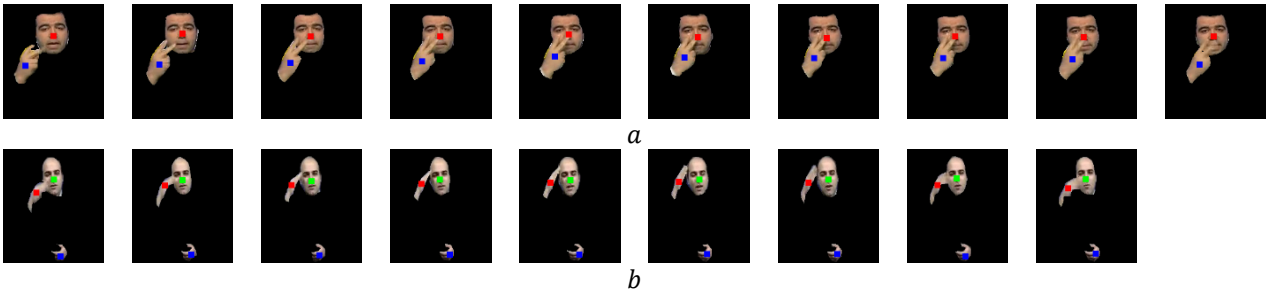

Fig. 10: Tracking with use semantic segmentation network using deep learning, then rough. a. “viewers” sign, b. “hello” sign.

Table 4: Method, MOTA, MOTP and Recall for Dataset

	Method	**MOTA**	**MOTP**	**Recall**	**Dataset**
proposed method1	Particle filter	0.971	0.935	0.948	Persian Deaf News
proposed method2	deep learning with rough	0.980	0.971	0.974	Persian Deaf News

Table 5: Method, MOTA, MOTP MOT16 Dataset

	Method	**MOTA**	**MOTP**
DeepMOT-Tracker [12]	DeepMOT-Tracker	0.548	0.772
Proposed method	Deep learning with rough	0.476	0.765

To test the proposed algorithm, another network is trained using MOT16 dataset. The results are shown in Table 5. It is compared with best result of [12].

3- Conclusion

Tracking is one of the most fundamental problems in computer vision, and use in a long list of applications such as sign languages recognition. We used rough set theory with deep Neural network for sign language tracking. The novelty of this paper is the use of rough set theory with deep neural network for tracking. This is the first work on this topic. This is the first on this topic. In this paper, at first, tracking using particle filter is explained. At second, tracking using rough sets and deep learning is explained. In the first proposed method, we used a particle filter, which has high accuracy but is very time consuming. The second proposed method responds much faster but is less accurate. To increase the accuracy of the second proposed method, we used the rough set theory. The system proposed are tested on 33 of Deaf News with 100 different words and 1927 video files for words, and recall, MOTA and MOTP values are obtained. Also, it with new mask is used for MOT16 dataset for comparing.

We focused our efforts on optimizing tracking with semantic deep network and rough set theory, but we want to use our proposed methods for sign language recognition.

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Recognition of Attention Deficit/Hyperactivity Disorder (ADHD) Based on Electroencephalographic Signals Using Convolutional Neural Networks (CNNs)

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Abstract

Impulsive / hyperactive disorder is a neuro-developmental disorder that usually occurs in childhood, and in most cases parents find that the child is more active than usual and have problems such as lack of attention and concentration control. Because this problem might interfere with your own learning, work, and communication with others, it could be controlled by early diagnosis and treatment. Because the automatic recognition and classification of electroencephalography (EEG) signals is challenging due to the large variation in time features and signal frequency, the present study attempts to provide an efficient method for diagnosing hyperactive patients. The proposed method is that first, the recorded brain signals of hyperactive subjects are read from the input and in order to the signals to be converted from time range to frequency range, Fast Fourier Transform (FFT) is used. Also, to select an effective feature to check hyperactive subjects from healthy ones, the peak frequency (PF) is applied. Then, to select the features, principal component analysis and without principal component analysis will be used. In the final step, convolutional neural networks (CNNs) will be utilized to calculate the recognition rate of individuals with hyperactivity. For model efficiency, this model is compared to the models of K- nearest neighbors (KNN), and multilayer perceptron (MLP). The results show that the best method is to use feature selection by principal component analysis and classification of CNNs and the recognition rate of individuals with ADHD from healthy ones is equal to 91%.

Keywords: Hyperactivity; Electroencephalographic Signals; Convolutional Neural Networks (CNN); Principal Component Analysis (PCA).

1- Introduction

Diagnosis of hyperactivity based on history and experiment remains essentially clinical and can be supported by neuropsychological assessments. But due to heterogeneous cognitive profiles in patients with hyperactivity, it is not clearly diagnosed. In general, there are various conditions that often complicate the diagnosis due to the irregularity, impulsivity, and range of natural cognitive profiles with variable strengths and weaknesses that are widespread in these areas. Hence, a biomarker will be of great value in reducing the intrinsic uncertainty of clinical diagnosis. Electroencephalography (EEG) signals contain rich information related to functional dynamics in the brain. The use of EEG in hyperactive subjects was begun more than 75 years ago with Jasper et al. (1938), that reported the increasing of the power of EEG with low-frequencies in Front-central regions [1]. Studies on EEG abnormalities in hyperactive patients were first performed by Lubber in 1973. He concluded that theta activity increased in the brains of hyperactive individuals, and beta power is significantly reduced in these patients [2]. In other studies, some factors for hyperactivity diagnosis through electroencephalography signals were introduced to learn abnormalities [3]. Since then, human electrophysiological studies have been presented using EEG spectral analysis and Event-Related Potentials (ERPs) of functional performance in the hyperactive patients [4]. In contrast to EEG signals, ERPs reflect changes in the electrical activity of the brain that are blocked by the occurrence of a particular event, i.e., a response to a discrete external stimulus or an internal mental process [5]. ERPs also provide high-resolution

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non-invasive neurophysiological measurements. This allows the inefficient dynamics of the brain to be assessed and cognitive processes that may not be apparent at the behavioral level to be identified [6].

Artificial neural networks have recently been introduced as an encouraging application of artificial intelligence that is very effective in recognizing brain models. Machine learning, a subset of artificial intelligence and deep learning, a specialized sub-discipline of machine learning, have been increasingly used in clinical research with promising results. Machine learning can be described as the practice of using algorithms to train a system using a large amounts of data, with the goal of giving it the ability to learn how to do a particular task and then classify or accurately predict. Deep learning is a subset of machine learning algorithms that introduce tasks in smaller units that often provide higher levels of accuracy [7]. Neural networks are characterized by their network architecture which is defined by the anatomical arrangement of its connected processing units, i.e., artificial neurons with a loss or optimization function that determines the overall purpose of the learning process. Connections are trained or teach how to perform the desired task and by using of a training algorithm, change the parameters of the neural network experimentally. This is done in such a way the target function is eventually optimized based on the inputs received by the neural network. There are different types of neural networks with different designs and architectures from different principles and for various purposes [8, 9].

In this paper, convolutional neural network (CNN) method has been used to find the most efficient electrode to diagnose patients. The hierarchy of our proposed model is such that after reading the signals from the input, they are pre-processed by the filtering method and then a FFT and PF are applied to all normalized signals. The output of this step enters the next step, i.e., feature selection. In this step, Principal Component Analysis (PCA) is used. Finally, the CNN classification method with 8 convolutional layers and 2 fully connected layers will be applied to learn the obtained features and the results will be discussed. The structure of the current study is as follows: In section 2, the database used, is introduced. In Section 3, the methods used in this study are briefly described. In section 4, the main structure of the proposed model is introduced and sections 5 and 6, respectively, introduce the experiments are done and express the results. The conclusion of the present study is presented in Section 7.

2- Database

The present study uses the standard database introduced in [10], which includes 57 females and 39 males. The data used for this study has been processed by Alpha-Neuro Center that is a neuropsychology research laboratory. Sampling rate is 2000 Hz / filter channel is below than 250 Hz. The received signals from 19 channels were recorded at rest for 5 minutes and subjects were instructed to look at a certain point on the wall and move as little as possible and also to prevent movement and or blinking. NeuroGuide / WinEEG software has also been used to remove artifacts [10].

In the section on the separation of effective electrodes in this dataset, five groups of electrodes named Frontal, Central, Temporal, Parietal, Occipital are introduced, and the spectrum of brain waves in this dataset named delta (4-0), theta (4-8), alpha (8-13) and beta (13-32) Hz (11) are divided into Hz(11).

3- Method

The dataset used in the current study includes pre-processed EEG signals on which filtering operations have been performed. On all signals the gap filter of 55-65 Hz, the low cut filter of 0.3 Hz, and the high cut filter of 30 Hz have been applied (the reason for such a low filter is that this data is used to create the neuro feedback protocol and does not use gamma wave bands for neuro feedback). Therefore, after reading the recorded brain signals of hyperactive individuals and in order to convert the signals from time range to frequency range, FFT is used and to select the effective feature for examining hyperactive subjects from those of healthy, PF are utilized. Important features of EEG signals are then extracted and PCA is applied to all features. Finally, the outputs obtained from the previous stage are sent to the classification to first determine the most effective electrode and second to determine the recognition rate of hyperactive subjects from those are healthy (Fig. 1).

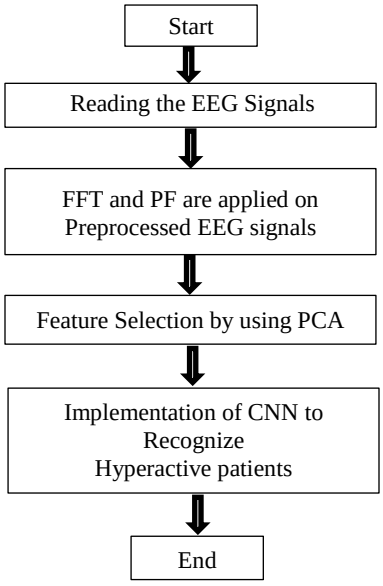

Fig. 1 General overview of the proposed method

3-1- Fast Fourier Transform (FFT)

FFT is one of the most important algorithms used in signal processing and data analysis. Fourier analysis can transform a signal from the main domain, which is usually time or space, into a frequency domain display and vice versa.
It is assumed that the discrete version is represented at the time of the audio signal by length N and the sampling rate f_s with x [j]. The frequency content of the x [j] signal over a given period of time can be expressed using discrete Fourier transforms (FT) over time as a function of frequency and by using of the FT coefficients x [k]. The parameters transform between the time domain and the frequency begins using the Perceval's theorem; Perceval's theorem states that the sum of the squares of a function with the sum of its transformed squared is equal to the Eq. (1):

$$\sum_{j=1}^{N-1} |x[j]|^2 = \frac{1}{N}\sum_{k=0}^{N-1}|X[k]X^*[k]| = \sum_{k=0}^{N-1} p[k] \qquad (1)$$

Where P [k] is the power spectrum without phase and k is the frequency index. Usually the content of the frequency resulting from the FT is symmetric with respect to the zero frequency, so when using the power spectrum, the whole or only a part of it can be considered [12].
Since FFT converts a signal from a time or space range to a frequency range, it facilitates the analysis of a given signal, which is why this method is used in the present study.

3-2- Peak Frequency (PF)

The PF is defined as the maximum amount of power in the EEG frequency spectrum between the range of 7.5 and 12.5 Hz. According to researches accomplished on PF, several important interpersonal and intrapersonal differences have been identified. Interpersonal differences are attributed to genetic factors. Low values of this feature indicate brain damage such as chronic fatigue syndrome (CFS), Alzheimer's disease, hyperactivity, etc. [10]. Based on the researches, it can be noted that the amount of PF is different in subjects with ADHD and healthy subjects [17]. The PF also varies with age and gender. In healthy adults, for example, the PF is hidden between 9.5 to 11.5 Hz. At PF, the PF location within the alpha band increases with age in childhood, culminates in early adulthood, and then decreases in older adulthood [17].

3-3- Feature Selection

The performance of a classifier depends on the relationship between the number of samples, the number of attributes, and the complexity of the classifier. Therefore, by having appropriate features, classifier performance and recognition rate could be increased. On the other hand, it is observed practically that if the number of training samples compared to the number of features is relatively small, additional features could reduce the classifier performance. Therefore, in the present study, principal component analysis is used.

3-3-1- Principal Component Analysis (PCA)

In PCA, the principal data space is described based on the special vectors of the covariance matrix, and the specific values corresponding to the special vectors express the attributes' energy in line with these vectors. When the correlation between the variables of the problem is linear, linear PCA will be the first choice. However, in situations where the problem has a nonlinear correlation, taking benefit of nonlinear versions could improve the function [13].
Technically, PCA removes the least important variables, while the most valuable parts of all variables are remained. That is why, this method is used in the present study to reduce the complexity of the calculations and keep the best features.

3-4- Convolutional Neural Networks (CNN)

The CNN is a kind of artificial neural network that is inspired by the function of the human and animals' visual cortex of the brain and is applied for functions such as image and video recognition, speech recognition, recommendation systems, natural language processing and other cases. The basic assumption of CNN's architecture is that operations are performed on input data to preserve spatial and neighborhood information in the data, and ultimately a vector of encoded attributes is obtained. In general, a CNN network consists of three main layers: the convolutional layer, the pooling layer, and the fully connected layer. Different layers perform different tasks. There are two phases of training in each CNN. Progressive phase and Back propagation phase [7]. During the training process, the common weights in the convolutional layers as well as the weights among the fully connected convolutional layers significantly reduce the number of free trainable network parameters and thus increase generalizability. The CNN used in this study is generally consists of the following layers:
Convolutional layer: This layer is the main core of the CNN. The convolutional layer parameters include a set of learnable filters. In these layers, the CNN uses various filters to convolute the input data as well as the mapping of intermediate features, and such mapping of different features has several main advantages. First, the weight-shared mechanism in each feature mapping drastically reduces the number of parameters, and the local connection learns the relationship among neighboring pixels. It also causes the invariability and stability of the object's displacement, and the ratio of the freedom degree of the system and the number of samples required for learning is remarkably increased, which makes the generalizability of the system stronger. As mentioned

above, this layer performs convolution on the input EEG signal using the kernel.

ReLU layer: This layer introduces a nonlinear method to the network, which is the most common activator function (Fig. 2):

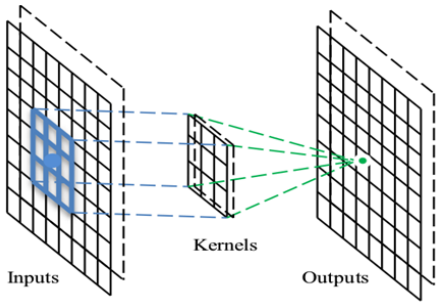

Fig. 2. Convolutional operation

Fig. 2 shows the ReLU layer, in which it introduces a nonlinear method to the network that is the most common activator function.

Pooling Layers: A pooling layer is usually placed after a convolutional layer and can be used to reduce the mapping size of network attributes and parameters. Like convolutional layers, pooling layers are remained unchanged toward displacement considering of the neighboring pixels in their own calculations. Pooling layer implementation using the maximum and average functions are the most common implementations (Fig. 3).

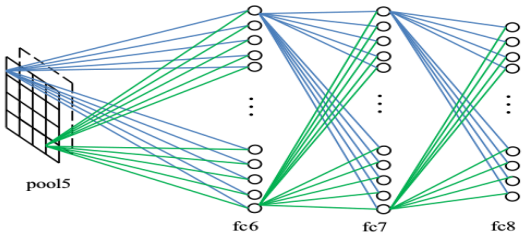

Fig. 3. Pooling operation on feature mapping,

Fully connected layer: After the last pooling layer, as shown in Fig. 4, there are fully connected layers. Fully connected layers perform like their counterparts in traditional artificial neural networks. The fully connected layer allows the network result to be displayed in the form of a specific size vector. This vector can be used for following further processing.

4- The Proposed Method

The purpose of the current study is to provide an efficient method based on reducing the dimensions of selected features and appropriate classification in order to achieve the best recognition rate for diagnosing subjects with ADHD at the right time. The proposed method operates in such a way that first the recorded brain signals of hyperactive individuals are read from the input, then, FFT is applied for the signals to be transformed from time range to frequency range. Also, to select an effective feature to check hyperactive individuals from those of healthy, PF is used. Therefore, the reason for selecting FFT is the easier analysis of pre-processed signals, and the reason for choosing the PF is that the amount of this feature varies in individuals with ADHD and healthy subjects, and depends on gender and age factors. So, it can be claimed that these two features could help increase the diagnosis rate of ADHD patients. PCA and No-PCA will then be applied to all features in the feature selection section. The reason for giving importance to this section is that the feature selection and extraction stage are very important. Because the more correctly the features are selected, the better the results will be in the classification stage. Finally, CNN classification is applied to diagnose and evaluate subjects with ADHD from healthy ones [16].

The reason for selecting CNN classification is that this classification is able to store data throughout the network and the ability to work with incomplete knowledge, as well as the ability of high error tolerance. Therefore, the classification is expected to show desirable results. The architecture of the deep neural network is that first a convolutional layer with a nonlinear ReLU function along with Dropout and BN, and then a Max-pooling layer is added. Over several times of repeating, a two-dimensional matrix will be obtained and will produce a total of 78,432 parameters. In the architecture, the first layer of large size filter (128 × 1) and in the next layers, smaller size filters (16 ×1) are used, and finally, the feature vectors selected with two fully connected layers with nonlinear function ReLU and Softmax are used to automatically recognition of different stages of ADHD. Also, in the network training section, and to determine the network meta-parameters, the Trial-error method and the Cross-entropy function and the Adam optimizer with a learning rate of 0.002 have been used. The total number of epochs applied in the proposed model is 150 and the 10 Fold method is used for Cross Validation of data.

5- Performance Analysis

This section presents an efficient method based on PCA, No-PCA and CNN to optimally identify hyperactive subjects using electroencephalography signals and also to determine the best and most effective electrode for better diagnosis of the disorder. Also, to display the performance of the proposed model, it will be compared with Multi-Layer Perceptron (MLP) and K-Nearest Neighbors (KNN). MLP classification with back-propagation learning

algorithm consists of three layers: input, hidden and output. In input layers, the number of neurons is equal to the length of the input vector or the number of features. The most important parameters are the number of hidden layers, the number of neurons in each layer, the amount of learning and the learning time in data training and testing. Here, for data classification, a hidden layer with five neurons is considered [18].
In KNN classification, the number of neighborhood is considered 2, and Euclidean distance is used to calculate the distance between neighbors [10]. The findings in the following section are resulted from the features obtained from PCA and No-PCA and CNN, MLP and KNN classifications on central, temporal, occipital, frontal and parietal electrodes and include Accuracy, Recall, and F1-score of the classification [14, 15].

6- Discussion of the Results

The experiments performed in this study are divided into several sections. The first section is related to the investigation of the most functional and effective electrode in the diagnosis of hyperactive subjects, which will be calculated using PCA and NO-PCA feature selection. The second section deals with the recognition rate obtained of the most efficient electrode introduced by CNN classification. The third section of the tests is allocated to diagnosing the total rate of hyperactive patients who have been normalized in the pre-processing stage, and the extent of their disorder by applying the standard deviation threshold obtained from the clinic that the amount of which is presented in the dataset. Then, the patients are divided into three groups including those with low hyperactivity, moderate hyperactivity and hyperactivity. In the last part, the experiments are allocated to comparing the proposed model with the competing models of KNN and MLP in the current study.

6-1- Results Obtained from PCA and No-PCA Features and CNN Classification

In the proposed model, first all normalized signals are read from the input and will be divided into three groups of patients with low hyperactivity, moderate hyperactivity and hyperactivity, and FFT and PF are applied on all read signals. In the feature selection stage, on all the selected signals, once PCA and once No-PCA are applied, and at the end, the output of the feature selection stage enters the CNN classification. The results of the experiments performed based on the 10-fold evaluation criterion are reported in Tables (1) and (2), respectively.

Table 1: Results of PCA and CNN classification on different electrodes

Electrode's name	***Accuracy***	***Recall***	***F1 score***
Central	54%	0.08	0.66
Temporal	43%	0.07	0.66
Occipital	33%	0.05	0.45
Frontal	45%	0.08	0.61
Parietal	66%	0.04	0.73

Table 2: Results of No-PCA and CNN classification on different electrodes

Electrode's name	***Accuracy***	***Recall***	***F1 score***
Central	60%	0.08	0.69
Temporal	54%	0.09	0.66
Occipital	60%	0.08	0.69
Frontal	44%	0.10	0.56
Parietal	63%	0.07	0.54

Tables (1) and (2) shows that the most effective electrode is related to the parietal which has a recognition accuracy of PCA and CNN classification of 66% and a recognition accuracy by No-PCA and CNN classification of 63%. This means that the use of PCA is effective in increasing the accuracy of the disorder diagnosis.

6-2- Experiment Results on the Proposed Model and Competing Models of KNN and MLP

In this part of the experiments, the purpose is to evaluate the performance of the proposed model. That is why, the introduced method will be compared with competing models of KNN and MLP. The results based on the 10-fold evaluation criterion are shown in Table (3).

Table 3: Review of the three classifiers of CNN, KNN, and MLP

Classifier	***FFT +PCA***	***FFT +No-PCA***
CNN applied on the whole subjects in the dataset	accuracy: 90%	accuracy: 85%
KNN applied on the whole subjects in the dataset	accuracy: 84%	accuracy: 83%
MLP applied on the whole subjects in the dataset	accuracy: 61%	accuracy: 71%
CNN applied On parietal electrode	accuracy: 55%	accuracy: 51%
KNN applied On parietal electrode	accuracy: 61.5%	accuracy: 44%
MLP applied On parietal electrode	accuracy: 42%	accuracy: 35.5%

Table (3) shows the results of the three classifiers of CNN, KNN and MLP on all electrodes as well as the most effective electrode (parietal electrode). As it was explained, the input of the proposed model is the signals of healthy and unhealthy subjects that first the pre-processed

data is read and then the FFT and PF will be applied to the signals. Next, the PCA feature selection is applied to the extracted features and the best features will be selected. Eventually, all features will enter the classification stage. Also to ensure the correct operation of the proposed model, the experiments with No-PCA are performed once again. The results reveal that the best method is to use PCA and CNN classification on the subjects in the database with a recognition rate of 91%. While the competing models, KNN, and MLP show recognition rate of 88% and 66%, respectively.

As shown in Fig. 5, for the accuracy of the PF performance in the feature extraction section, all of these experiments have been performed once by eliminating this feature. Investigating the results obtained from Fig. 5, it is observed that the use of FFT methods and PF facilitates the analysis of the results, and PCA causes raising the classification rate presented in this study by selecting the appropriate features.

7- Conclusion

The present study investigated the recognition of brain signals in hyperactive patients and the goal was to find the most effective model with the highest recognition rate to diagnose hyperactive subjects. Also, during the experiments, the most effective electrode with a high recognition rate in diagnosing hyperactive subjects has been identified. The proposed model hierarchy works in such a way that after reading the pre-processed signals from the data set introduced in the text, the FFT and PF are applied. In order to select the appropriate features, once PCA (to reduce the complexity of the calculations and select the best features), and once again No-PCA (to check the performance of PCA) are performed.

The output of this section entered the three classifiers of CNN, KNN and MLP and the recognition rates in all three categories were examined. The results revealed that the most effective parietal electrode with a recognition rate of 66%. Therefore, it could be proven that parietal lobe neurons play an important role in the etiology of this disorder. Also, the best method was to use the PCA feature and CNN classification applied to the subjects in the database and the recognition rate was equal to 91%.

To justify the proposed model and the weakness of the competing models, it could be concluded that in the KNN classification, since the algorithm was very sensitive to the amount of value and was suitable for multivariate environments with small space, in this experiment it did not provide a high rate diagnosis. Also in the MLP network and due to the low rate of this model, we can point to problems such as failure to learn or retain information. This happens when the network parameters do not converge to a certain value after a long time or sometimes reach the state of data retention due to over-training. One of the biggest advantages of CNN and its good performance is that it does not change much against small input errors and applies the weight sharing principles, which drastically reduce the number of free parameters. Therefore, they increase generalizability.

In the conclusion part and according to the obtained results, it could be proved that CNN is suitable for implementing large and complicated issues, and the structure presented in the proposed model reduces training time, the number of trainable parameters, and increases the classification accuracy. Also, according to high accuracy of the algorithm, it could be used to automatically diagnosis of ADHD patients on EEG signals.

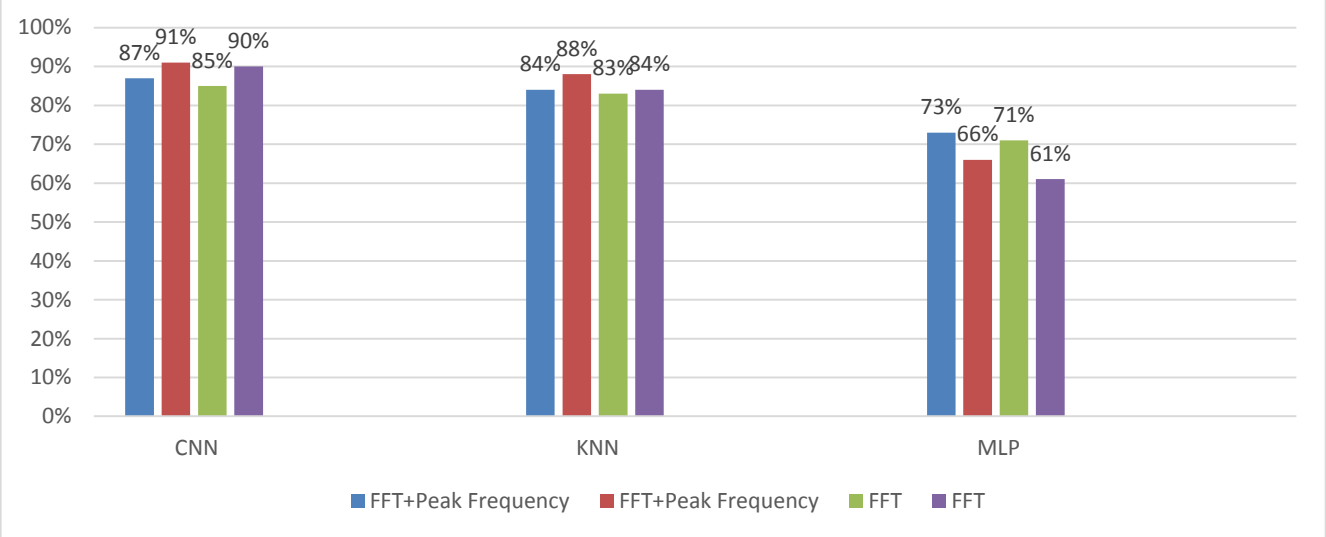

Fig. 5 Review of Fast Fourier Transform and peak frequency performance on the classification rates

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An ICT Performance Evaluation Model based on Meta-Synthesis Approach

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Abstract

Information and Communication Technology (ICT) is one of the key determinants for today's organizational success. Therefore, companies spend a significant amount of money each year on ICT, while not being sure that they will get a good result. The purpose of this study is to identify the dimensions and indicators of ICT performance evaluation and suggesting a model for assessing it in organizations. This research is mainly a qualitative study with a meta-synthesis approach which uses the seven-stage qualitative method of Sandelowski and Barroso to systematically review the literature to find sub-indices (codes), indices (themes) and dimensions (categories) of ICT performance evaluation. The search of scientific databases with appropriate keywords found 516 articles, among them, 89 articles were chosen finally and used for analysis. Moreover, a questionnaire has been designed and answered by ICT experts and managers to determine the importance of each of the indicators of the model. Based on data analysis, the proposed ICT performance evaluation model has three dimensions: strategic, quality, and sustainability. The strategic dimension includes indicators of organization strategy, IT strategy, and alignment. The quality dimension includes maturity, and performance indicators; and finally, the sustainability dimension includes environmental, economic, and social indicators. For each of these indicators detailed list of sub-indices (104), which are substantial for evaluation of ICT performance in organizations, were identified and explained.

Keywords: Information and Communication Technology; Meta-synthesis; ICT Performance Evaluation; Strategic; Quality; Sustainability

1- Introduction

ICT offers a great opportunity to acquire flexibility in globalized markets, ICT helps companies to recover resilience in uncertainty demands because sharing information is associated with a fast-decision-making process [1]. The fact that the developments in the internet and information and communication technologies (ICT) have made a great contribution to the internationalization of enterprises is a generally accepted approach. For instance, in addition to accelerating the internationalization of corporate ICT, it has also created tools for companies with sophisticated operating structures to communicate more effectively with their customers.

Moreover, it provides new ways for enterprises to conduct their business, has an exchange of ideas and information and transfers them [2]. With the increasing need to have immediate information and flexible working practices in a global market, information transfer tends to be electronic [3]. Management Information System in the education system, using, blog surfing and publishing, social media interaction, which are natural record of student and staff ICT activities. With the help of big data (BD) technology and internet of things (IoT) technology, people's daily lives are logged and kept in binary data [4]. Information technology in a way has influenced changes to the method, purpose and perceived ability of education [5]

ICTs are being integrated into structures, procedures, and products throughout companies, governments, and communities. The use of ICT increases the supply of information as ICT plays a key role in information sharing and dissemination [6]. Most organizations endeavor to employ Information Communication Technology as a tool for competitive advantage for the accomplishment of the objective of organization as well as enhance the alignment between Information Communication Technology and management strategy. To achieve the former, ICT has been leveraged to improved service and lower the cost of

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conducting strategic management functions [7]. Generally, technology has made it much easier for people all around the world to gain access to resources, for example, these days technology-assisted learning has been rapidly expanding due to the Coronavirus pandemic [8].

The ICT revolution that has happened over the last several decades has transformed societies across the world. ICT has improved communications, expanded social networking, and has made information more accessible than in any period in history [9]. Information theory and its different applications have profoundly changed our industry, services, and daily life [10]. Indeed, over the past decade, the world has become gradually "hyperconnected." We live in an environment where the Internet and related services are readily available and accessible, where people and businesses can communicate instantly and machines communicate equally. The exponential development and growth of mobile devices, social media, and big data, are all drivers of this process of hyperconnectivity. Consequently, we are beginning to see fundamental transformations in society [11].

There is an increasing requirement for stronger cost control and a demand for higher returns while diminishing risk in investments, in today's increasingly competitive business environment. Recognition of the potential impact of ICT on the strategic power of businesses and increasing levels of ICT-expenditure have made the evaluation, justification and control of ICT investments a critically important issue [12].

IT performance management is defined as the areas of goal setting, accountability and monitoring, analyzing, governing and improving ICT performance. IT performance management to achieve business goals requires effective IT management. So, an IT performance measurement process must be selected. Performance measurement frameworks should be balanced, multidimensional, comprehensive and integrated into the framework of organizational performance measurement [13].

For each aspect of the company's IT under investigation, the questions arise what needs to be measured and how, and what to compare it with, to assess the as-is situation of a company and to assign it a specific quality or degree [14]. Currently, management faces some real dilemmas with respect to IT. Because of competition, organisations invest substantially in IT, even when economically is not justified. Moreover, as IT infrastructure becomes an integral part of an organization's processes and structures, it becomes very difficult to distinguish the impact of IT (positive and negative) from other assets and activities.

Thirdly, it would appear that comparatively few senior executives feel that they understand IT adequately, despite high levels of expenditure [15].

The evaluation of Information Technology (IT) has been seen as a complex task owing both to the difficulty in determining the value of information as well as to the special economic characteristics of the technology which produces it. One proof of this complexity is the dichotomy that exists between the practice and the theory [16]. There have now been many studies on the relevance between the application of information technology (IT) and organizational efficiency or firm performance. It has been shown a significant and positive correlation between IT and firm performance [17.

ICT is the main factor of communication, cooperation, development, knowledge and information management, project management, etc. Therefore, a deep understanding of the impact of ICT on the performance of the organization and its management is very important and very useful for organizations. Large companies need ICT to manage, coordinate, communicate and reduce administrative costs, also they need it to develop skills for social interaction, civic participation, information retrieval and processing, and professional success.

Alignment with the goals of the organization is possible when the application of new technology begins with a study of the needs and strategy of the organization. Therefore, evaluating the performance of organizations in terms of organizational technologies is very important and increases the ability of the organization to progress.

Reviewing the literature regarding the evaluation of ICT performance in organizations indicated there is no consensus on how to evaluate the performance of ICT. Moreover, studies in this respect evaluate ICT performance from different perspectives based on the field of each organization which may confuse organizations to apply them. Therefore, there is a need for a comprehensive model which include all important component and indexes for evaluation of ICT performance in organizations. A model that can play a guiding role for organizations in evaluating their ICT performance and preventing deviation from the right path.

Also, due to the wide range of ICT areas that encompass the areas of strategy, efficiency, maturity, security, and so on, the need for a wide-ranging model that encompasses the key indicators of ICT is necessary. This model can guide an organization to use ICT to achieve organizational goals. This study uses the Meta-synthesis method to provide a model for evaluating ICT performance. Therefore, the purpose of this study is to identify the indicators and dimensions of ICT through the Meta-synthesis method. This research seeks to find answers to these questions:

1. What are the dimensions of evaluating ICT performance in organizations?

2. What are the main and secondary indicators of evaluating the performance of ICT in organizations?

2- Literature Review

Finding a precise definition of what information technology is would probably be a difficult endeavor. If one includes communication technologies then the scope of possible theories and artefacts contained in information technology becomes hard to delimit. One possible definition can be found in Mason et al. stating that IT is "the tangible means by which information is manipulated and carried to its ultimate users". They continue by pointing out some further ingredients modern information systems contain; those are "hardware, software, people, data, and procedures - designed to deliver services intended to improve a social system"[18, p80].

ICT is defined and discussed differently in construction writings but Kraemer and Daniziger, [19, p.593] define the communication element of technology as 'the actual hardware employed to perform a basic information-processing task'. Gorse and Emmitt [20] also take the view that communication within organizations and between them is concerned with the exchange of information and the management of it. There is a need to distinguish between 'information technology' and 'communication technology' since information technology is essential in construction for the storage of information but its use does not necessarily mean communication has to take place [3]. Figure (1) shows the typical flow of information through a medium of communication:

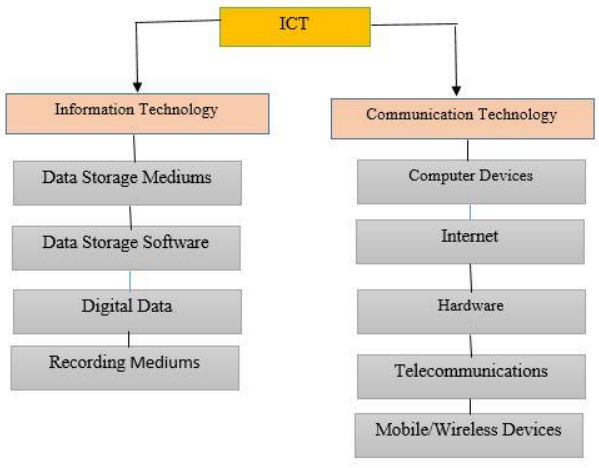


Fig. 1. Typical flow of information through a medium of communication [3]

The old adage says: "You cannot manage what you don't measure." [21]. By the importance of using information technology for almost every scope, measurement is needed to identify how optimal the IT governance is [18]. By knowing the IT's importance, it's necessary to have a measurement or assessment of IT [22].

2-1- Models Presented in the Field of ICT Performance Evaluation

Balanced Scorecard: The balanced scorecard is a method to determine IT performance management that contains both financial and operational measures as solely using financial measures is not enough anymore. The scorecard can be described as an effective tool for performance measurement, organizational assessment and operational alignment. The balanced scorecard can provide organizations with a measurement and management system that supports the IT governance process through a combination of the business balanced scorecard and the IT balanced scorecard. The balanced scorecard contains financial views and is complemented by operational measures of customer satisfaction, internal processes and the organization's innovation. These operational measures are the drivers of future financial performance [13].

IT Governance: During the last decade, IT has been playing a significant role for organizations in achieving their objectives. Recently, IT governance (ITG) has become a critical issue for many organizations in different industries. ITG is a component of the decision-making structure, including processes, as well as relational tools to manage and control [23]. Many organizations suffer from expending too much on IT and other processes due to inefficient alignment between IT and business strategies which leads to the weak performance of the organizations [24].

IT governance is the selection and use of relationships such as strategic alliances or joint ventures to obtain key IT competencies. This is analogous to business governance, which involves make- vs.-buy choices in business strategy. Such choices cover a complex array of interfirm relationships, such as strategic alliances, joint ventures, marketing exchange, and technology licensing [25]. Weill and Ross [26] mentioned that IT governance encompasses five major decisions related to the management and use of IT in a firm:

1. IT principles: high-level decisions about the strategic role of IT in the business.

2. IT architecture: an integrated set of technical choices to guide the organization in satisfying business needs.

3. IT infrastructure: centrally coordinated, shared IT services providing the foundation for the enterprise's IT capability and typically created before precise usage needs are known.

4. Business application needs: business requirements for purchased or internally developed IT applications.

5. Prioritization and investment: decisions about how much and where to invest in IT, including project approval and justification techniques [26].

Control Objectives for Information and Related Technology (CobiT): One commonly used framework for developing and evaluating technology-intensive information systems is CobiT. This framework was originally a benchmark of best control practices developed and maintained by the Information Technology Governance Institute, the umbrella organization to the Information Systems Audit and Control Association [27]. It covers operational, financial, implementation, planning and monitoring issues for each IT process [28]. COBIT is a comprehensive framework with 34 control objectives that has been developed from 41 international sources. IT processes are clustered into four domains: planning and organization, acquisition and implementation, delivery and support and monitoring. As the framework considers all aspects of information and its supporting IT, management can use COBIT to help provide an appropriate control system for IT [29].

VAL IT Framework: This Framework is a comprehensive and pragmatic organizing framework that enables the creation of business value from IT-enabled investments. In optimizing business strategy and Information Technology (IT) to generate value for the company, the implementation of Val IT Framework is required. Val IT framework helps increase the probability of optional investment and create value by the highest potential [30]. There are three domains in VAL IT framework: Value governance, Portfolio Management and Investments Management. Each domain has a specific number of processes, goals, inputs, outputs and process metrics [31].

ITIL (Information Technology Infrastructure Library): ITIL is a de-facto standard which introduced and distributed by the Office of Government Commerce (OGC) in the UK and includes all IT parts of organizations [6]. Presently, ITIL is the most widely accepted approach to IT Service Management in the world. It has an iterative, multidimensional and lifecycle form structure [32]. ITIL enables organizations to deliver appropriate services and continually ensure they are meeting business goals and delivering benefits. The ITIL best practices are currently detailed within five core publications that introduce five Service Lifecycle stages: Service Strategy, Service Design, Service Transition, Service Operation, and Continual Service Improvement [33]. Identified ITIL adoption benefits include: improved focus on ITSM, more rigorous control of testing and system changes, more predictable infrastructure, improved consultation with IT groups within the organization, smoother negotiation of service level agreements, reduced server faults, seamless end-to-end service, documented and consistent IT processes across the organization, an effective change advisory board, and consistent logging of incidents [34].

Models and frameworks like: Committee of Sponsoring Organizations (COSO), Project Management Body of Knowledge (PMBOK), Project Resource Organization Management and Planning Techniques (Prince 2), Capability Maturity Model Integration (CMMI), Technology acceptance model (TMA), The Open Group Architecture Framework (TOGAF), Zachman Framework, Next Generation Operational Support Systems (NGOSS) and ICT standards have also been used in the proposed Meta-synthesis model.

By reviewing and studying articles in the field of ICT, we came to the conclusion that studies and models of evaluating and managing ICT fall into three dimensions: strategic, quality and sustainability. In table (1) each of the models that have been examined in the field of ICT performance evaluation and the degree of emphasis of each model on the dimension is shown.

Table 1: Models relevant to the field of ICT performance evaluation

Reviewed models	strategic	quality	sustainability
Balanced scorecard	✓		
IT Governance	✓		
Control Objectives for Information and Related Technology (CobiT)	✓		
VAL IT framework	✓		
ITIL (Information Technology Infrastructure Library)		✓	
Committee Of Sponsoring Organizations (COSO)	✓		
Project Management Body of Knowledge (PMBOK)		✓	
Project Resource Organization Management and Planning Techniques (Prince 2)		✓	
Capability Maturity Model Integration (CMMI)		✓	
Technology acceptance model (TMA)			✓
The Open Group Architecture Framework (TOGAF)		✓	
Zachman Framework		✓	
Next Generation Operational Support Systems (NGOSS)		✓	
External quality standard of ISO 9126 software (ISO / IEC 9126)		✓	
IT Corporate Governance Standard-2008 ISO / IEC 38500	✓		
Information Technology Software Development Standard ISO / IEC 12207 - 2008		✓	

Information Security Management System Standard (ISO / IEC 27001)		✓	

3- Research Method

This research is fundamental in terms of purpose. It is qualitative in terms of how data is collected. In this research, the meta-synthesis method is used to identify the indicators of ICT performance evaluation. The study of indicators in this study started in April 2019 and lasted until January 2020.

Considering that the meta-synthesis method has been used to identify the indicators for evaluating the performance of ICT, qualitative research method was considered for its implementation.

In order to identify the criteria for evaluating the performance of ICT through the meta-synthesis method, the seven-step method of Sandelowski and Barroso (2007) has been used. In the first step purpose and research question has been set. In the second step, relevant researches were extracted over a specified period of time by systematic searching of the databases. So, the appropriate keywords were used in combination and individually, then the literature was reviewed systematically. In the third step, in searching and selecting appropriate texts, the researchers eliminated a number of articles in each review, based on ten CASP criteria for each of the rated articles, and finally, 89 final papers were selected. In the fourth stage, the extracted codes are presented in a table and submitted to the experts to reach the final conclusion. In the fifth stage, after reviewing the codes and classifying them, 108 codes were selected and categorized into 9 themes and 3 categories; actually, in this stage, the qualitative findings were analyzed and composed. In the sixth stage, quality control, the kappa coefficient of the SPSS software was used to evaluate the reliability of the findings. The kappa coefficient of 0.733 showed the reliability of indexes and dimensions classification. The last stage was the presentation of findings.

In this research, various databases, journals, conferences and search engines have been examined. Table (2) shows the research database

Table 2: Models studied in the field of ICT performance evaluation

Scientific and public resources	Informational Base	Documents and journals reviewed
International scientific databases	www.scholar.google.com	Scientific-research extension and conference articles
	www.sciencedirect.com	
	www.proquest.com	
	www.springer.com	
	www.emeraldinsight.com	
	www.isi.edu	
	www.elsevier.com	
Persian scientific databases	www.sid.ir	Scientific-research, extension and conference articles
	www.noormags.ir	
	www.magiran.com	
	www.civilica.com	
	www.ensani.ir	
	www.elmnet.ir	
	www.ganj.irandoc.ac.ir	
Public Database	www.google.com	Valid scientific-research articles
	www.yahoo.com	

In this research, 32 different keywords related to the evaluation of ICT performance have been used for search. These are preliminary main search terms: Performance Evaluation of Information and Communication Technology, IT Evaluation, IT Governance, ICT ability, IT Information, IT Assessment, Configure ICT systems, IT Change, Electronic government performance, IT Measurement, IT Alignment in organization, Efficiency and effectiveness in IT, Evaluation of Technology, IT Control, IT Strategy, Coordination in IT, Virtual system evaluation, IT Monitoring, IT Management in IT, Reliability, Maturity, IT Risk, IT Engineering, Evaluation of hardware in organization, Evaluation of software in organization IT. Both "information and communication technology" and its abbreviation namely ICT and IT were searched. Table (3) indicates the criteria for accepting articles.

Table 3: Acceptance criteria for articles

Acceptance criteria	This study
Scope of studies	field of IS, ICT & management
Research language	English and Persian
Period of Studies	1997 to 2018
Study method	Qualitative, quantitative, review
Subject of studies	Evaluating ICT performance
Study conditions	Evaluating ICT performance
Type of studies	published in journals & conferences

A search of databases using the keywords mentioned found 516 articles. Among them, 89 articles were used for analysis. 40 articles were related to domestic researches (Persian) and 49 articles were related to international researches. Appendix 1 shows the list of selected articles. Figure (2) shows a summary of the article selection process

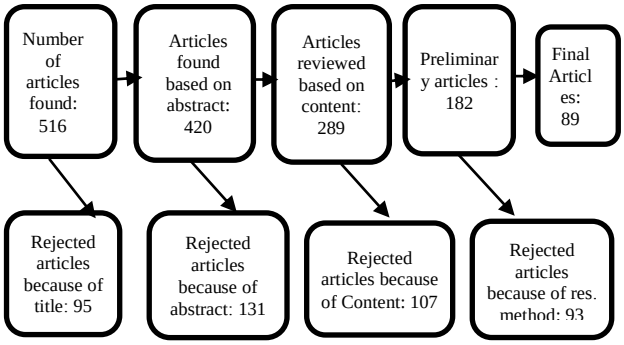


Fig. 2: Article search and selection results

The final articles were evaluated in terms of research objectives, methodology, research design, sampling, data collection, perfection, ethical considerations, the accuracy of analysis, clear expression of findings, research value and categorized from excellent to poor. The chart (1) shows the ranking of articles based on the ten criteria mentioned

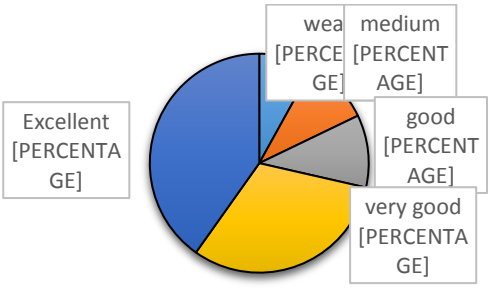


Chart.1 .Ranking of reviewed articles based on the ten criteria

In the analysis process, the researchers identified 920 sub-indices (codes). Based on the frequency of 104 sub-indices (code) in the form of an online questionnaire (based on the Likert scale) which was distributed among 22 ICT experts. The detailed information about these experts who were ICT managers and specialists are presented in Table (4).

Table 4: Detailed information about the research participants

Row	Age	Sex	Experience	Field Of Study	Education	Position
1	31-35	M	6-10	Software Engineering (S.E.)	M.S.	Mid-level Manager
2	25-30	F	1-5	Hardware Engineering (H.E.)	M.S.	Expert
3	36-40	M	6-10	IT Engineering	Ph.D	Mid-level Manager
4	50-60	M	16-20	Math	Ph.D	Top Manager
5	31-35	M	6-10	S.E.	M.S.	Expert
6	36-40	M	16-20	S.E.	M.S.	Operational Manager
7	41-45	F	6-10	Computer Science (C.S.)	M.S.	Top Manager
8	31-35	F	16-20	IT Engineering	M.S.	Mid-level Manager
9	46-50	M	11-15	IT Engineering	M.S.	Mid-level Manager
10	31-35	M	11-15	C.S.	M.S.	Operational Manager
11	31-35	M	11-15	Industrial Engineering	B.S.	Mid-level Manager
12	25-30	M	1-5	C.S.	B.S.	Mid-level Manager
13	25-30	F	11-15	Business Management	Ph.D	Mid-level Manager
14	40-45	M	6-10	S.E.	M.S.	Expert
15	31-35	M	1-5	H.E.	M.S.	Expert
16	31-35	M	11-15	Executive Management	M.S.	Expert
17	31-35	M	6-10	S.E.	M.S.	Mid-level Manager
18	36-40	M	6-10	C.S.	Ph.D	Expert
19	31-35	F	6-10	Business Management	B.S.	Expert
20	41-45	F	11-15	C.S.	B.S.	Expert
21	41-45	F	6-10	H.E.	B.S.	Mid-level Manager
22	31-35	F	11-15	H.E.	B.S.	Expert

Finally, according to experts, 104 sub-indicators (code) were classified into 9 indicators (themes) and 3 dimensions (categories). In this research, the main author used his comparison of opinions with another expert to control the classification of the extracted indicators and for this purpose, It was used the method of agreement between two coders. In this research, in addition to the researcher, another expert of the same text encodes separately without knowing the classification of the researcher codes. In the present study, this evaluation was performed on 116 codes extracted with the help of the expert in which the Kappa index value in SPSS software was equal to 0.733. According to the significance coefficient of 0.000 of this coding and category, classification is accepted. The results of SPSS software calculations are shown in Table (5).

Table 5: Test of agreement between the researcher and one of the experts in coding indicators

	Value	Asymptotic Standard Error[a]	Approximate T[b]	Approximate Significance
Measure of Agreement Kappa	0.733	0.45	19.251	0.000
N of Valid Cases			104	Number of samples acceptable

4- Research Findings

By examining the research background related to ICT performance evaluation and also reviewing the models that have been presented in this field, it is realized that each of the models and researches relatively evaluates ICT in a one-dimensional and somehow different way. For example, models such as Balanced Scorecard, Qubit, Val IT, IT governance, Zakman framework, etc. examine IT from an organizational and strategic perspective. Models and standards related to the system and software such as ITIL, further evaluate the quality or operational dimension of

ICT. However, the issue of sustainability (environmental, economic and social) is unnoticed or a little considered in most ICT evaluation models and studies. In this study, bearing in mind the many advantages of using a hybrid approach to identify the most important indicators of ICT, we provide an evaluation model for organizations to be aware of the state of their ICT and manage it well.

Using the meta-synthesis approach 104 sub-indices (code) were classified into 9 indices (theme) and 3 dimensions (category). Indicators related to ICT performance evaluation are presented in Table (6). Its main dimensions include strategic, quality and sustainability. The strategic dimension is related to long-term goals and proper planning for the implementation and use of technologies and, if necessary, replacement of that technology and considering whether this technology meets long-term and short-term organizational goals, its alignment. It also shows the level of organizational participation in the proper use of technology. The strategic dimension includes the strategy of the organization that shows the general orientation of the organization regarding ICT. And ICT strategy, which is used to synchronize technology with the goals of the organization, and finally, alignment and participation are a subset of the strategic dimension which aligns the correct orientation of the ICT strategy and the organization's strategy against each other and cooperation: It is a two-sided relationship. Participation is the amount of effort of personnel in order to use the right technology and in the direction of the right organizational goals for maximum efficiency.

The quality dimension includes maturity and Performance. Maturity of IT indicates the degree of progress and potential and actual ability of technology in the organization to advance organizational goals. In general, the maturity of ICT means the extent to which it can adapt to change in order to achieve its goals. The "performance" part is related to the quaintly or operational and engineering dimension related to ICT.

Sustainability is one of the new areas in the field of ICT and includes three environmental, social and economic dimensions that go beyond organizational goals and show how much information technology supports the environment and, how much economically and socially contribute to the society .Indicators in this article extracted from 89 studies; The subject of these articles is related to the most repetitive articles in the field of evaluation of ICT performance. Most articles are about the strategic, quality or operational, and sustainability dimensions. By studying articles and extracting direct and indirect indicators (derived from the general concept of articles), the indicators have been extracted; and then reviewed by experts in this field and selected based on the importance of the indicators in Table (6), which is categorized based on strategic, quality or the concept of sustainability.

Table 6: Strategic Dimensions, indicators and sub-indices of ICT performance evaluation

Indices	**Sub-indices**
Organizational strategy	1. The extent of ICT support for the organization's strategy 2. ICT support for organizational structure (business organization) 3. ICT support for the organization (coordination of activities within the organization) 4. Alignment of ICT with the priorities of the organization 5. Clarity of ICT goals and strategies for the organization and vice versa 6. ICT compliance with key policies and regulations of the organization 7. The level of organizational readiness in improving the field of ICT and vice versa 8. The impact of ICT on the strategic development of the organization 9. ICT attention to the long-term and short-term vision of the organization 10. The impact of ICT on the development of organizational relationships (internal and external relations) 11. Identify and meet the needs of stakeholders through ICT 12. ICT attention to organizational values and norms and organizational culture
IT strategy	1. Support IT strategy 2. The extent of ICT governance in the organization 3. Clarity of criteria and standards related to the ICT sector 4. Paying attention to the architecture of ICT-related departments (coordination of ICT activities inside and outside the organization) 5. The degree of attention to ICT goals 6. Compliance with ICT requirements (laws, policies, etc.)
Alignment	1. Coordinate and support ICT of the organization's results and goals 2. Coordinating ICT with the needs of the organization 3. Coordinating ICT activities with the organization's vision
Participation	1. Involvement of senior executives in the field of ICT 2. Participation of all managers in the field of ICT 3. Employee participation in the field of ICT 4. Participation of foreign stakeholders in the field of ICT

Table 6: Quality Dimensions, indicators and sub-indices of ICT performance evaluation

indices	**sub-indices**
	1. Human Resource Management ICT Project (Organizational Planning, Employee Recruitment)

Maturity	2. Time management of ICT projects (definition and estimation, sequencing, creation and development, time control) 3. The impact of ICT on reducing organizational risk 4. Risk level in the field of ICT 5. Scope management of ICT projects (defining the steps from start to finish) 6. Integration management of ICT projects (program creation and integrated change control) 7. Procurement management of ICT projects (selection of supply source and contracts for the project) 8. Communication management (information distribution and reporting) ICT projects 9. ICT project environment (creating a suitable environment for implementation) 10. Prioritization of ICT (implementation of the most important projects as needed). 11. Existence of innovation vision for ICT (considering the technological needs of the organization in the future) 12. Innovation in ICT system (software and hardware) 13. Innovation in organizational processes through ICT 14. Innovation in individual and team ICT performance 15. Data and application architecture (coordination between data and applications) 16. Management of technical and physical infrastructure (hardware) 17. ICT installation management (creating infrastructure and platform for installing alternative technologies) 18. Ability to maintain equipment in the field of ICT 19. Contract management of new technology systems (contracts with individuals, organizations and institutions to implement and create technology) 20. Performance of software computing and software networks 21. Interchangeability (Ability to replace and replace with new technology) 22. Testability (existence of test courses before the implementation of new technology) 23. Improving the software environment 24. Consistency and continuous improvement of ICT processes 25. Process maturity management 26. The degree of intelligence of ICT processes 27. ICT Process Reengineering 28. Technology change management (competitive, cultural and organizational change) 29. Life cycle management of ICT products
Maturity	30. Portability or (Transition scheme: the degree of ability to create a new ICT system) 31. Interoperability of different areas of ICT with each other 32. Ability to analyze information 33. Flexibility in the field of ICT
Performance	1. Ability to understand information and software trends 2. Ease of use of ICT systems 3. Accuracy of information in the field of ICT 4. Management of accidents and problems in the field of ICT 5. Security and use of security equipment in the field of ICT 6. Privacy in the field of ICT 7. The attractiveness of the software environment for users and employees 8. Avoid mistakes and rework 9. Timely information 10. User and staff accessibility 11. Reliability (validity) of the ICT field (fault tolerance and repair) 12. Usefulness (usefulness) for the organization 13. Up-to-date information 14. Satisfaction of users and employees with ICT

Table 6: Sustainability Dimensions, indicators and sub-indices of ICT performance evaluation

indices	**sub-indices**
Environmental	1. Use of technologies in line with reducing environmental pollution 2. Green IT training 3. Green supply chain management in information technology 4. Use technology for energy efficiency 5. Equipment aligned with the green landscape
Economic	1. The amount of investment in the field of ICT 2. The amount of profit through ICT 3. Investment effectiveness in ICT 4. Budgeting according to the cost of ICT 5. Return on investment through ICT 6. Increase the market share of the organization using ICT 7. The amount of budget allocated to ICT 8. Cost reduction in ICT 9. Effectiveness through ICT 10. ICT audit 11. ICT asset management 12. The impact of ICT on creating a competitive advantage

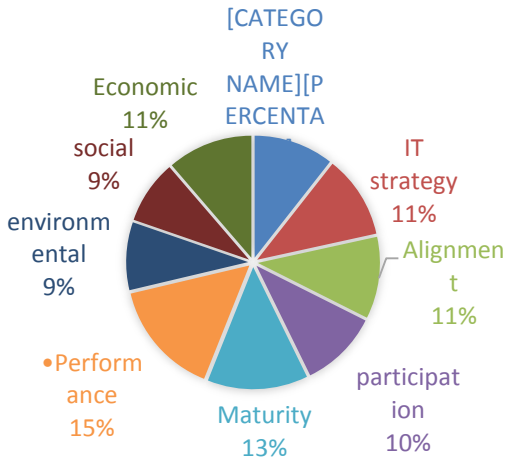
Social	1. Specialized training courses in the field of ICT 2. Creating knowledge through research and development and learning in the field of ICT 3. Motivate the acquisition of knowledge in the field of ICT 4. Attract and retain specialized and capable personnel in the ICT sector 5. Update ICT staff skills 6. Educate users on the use of ICT technologies 7. Staff training in the field of ICT 8. Observance of ethical principles in the field of ICT 9. The impact of ICT on the social environment and vice versa 10. The extent to which ICT is affected by the legal environment and vice versa 11. Social support for ICT 12. The impact of ICT on strengthening social relationships 13. Transparency and accountability in the field of ICT 14. Acceptance of new technologies and technologies used 15. Establishment of reward and incentive system in the field of ICT

The final model for evaluating ICT performance is shown in Figure (3).

Fig. 2: ICT Performance Evaluation Model

At this stage, the selected indicators to evaluate the performance of ICT in the form of a questionnaire were offered to ICT experts and managers in this field. The questionnaire consisted of 113 questions based on the number of indicators extracted from the meta-synthesis stage. In this questionnaire, the importance of indicators was asked in order to be rated from insignificant to very significant. The participants also were asked to mention their suggestions regarding the indicators and the model detentions. Chart (2) shows the importance of each of the ICT performance evaluation indicators based on the opinion of study participants. This data was obtained using SPSS software.

Chart 2: The importance of ICT performance evaluation indicators



5- Conclusion, Discussion, and Suggestions

Today, ICT is one of the main enablers of any organizational success, as well as one of the most important features of an advanced and modern society. Organizations need to have sound performance in the field of ICT. Hence, due to some unfavorable experiences of organizations in the field of ICT, a comprehensive evaluation of ICT performance is an undeniable principle.

With the hybrid approach, which is one of the most widely used methods for reviewing and summarizing the literature, a relatively comprehensive model to evaluate the performance of ICT is presented. This qualitative meta-synthesis research, which is conducted in seven steps, identified the detentions, indicators and sub-indicators for evaluating the performance of ICT in organizations. In the meta-synthesis method, 516 articles were reviewed, of which 85 articles were used for the final analysis. Out of 85 final articles, about 920 sub-indexes (codes) were extracted, then 104 sub-indexes (codes) were selected from them according to the opinions of ICT

experts and managers. These codes were classified into three dimensions namely strategic, quality and sustainability and 9 indicators. The extracted indicators are: organizational strategy, IT strategy, alignment, participation, maturity, performance, environmental, social and economic. Among the extracted indicators, performance and maturity, according to experts in the field of ICT, were more important.

In general, the contribution of this study is offering a model that includes the most important and practical indicators for evaluating the performance of ICT in all organizations. Every organization regardless of the type of operation, whether in the field of manufacturing or service, can evaluate its ICT performance based on the model presented in this study. Paying attention to strategic, quality and sustainability dimensions can help the organization to gain the advantage of ICT and consequently has better performance in all aspects including social responsibility.

To examine the three dimensions of the model in an organization, the most important goal of the strategic dimension of ICT is the strategic alignment of IT and business, which means the development of plans and activities in a way to enable the realization of the goals and business strategies of the organization. The operational dimension of ICT refers to storage, processing speed, IT updates, maintainability, memory and more on the technical and physical aspects of information technology. This dimension is related to ICT infrastructure.

ICT not only forms an industry; rather, it affects all sectors of the economy and works to integrate and activate technologies. ICT has a serious impact on society and uses the important consequences of development in the economic, social and environmental fields. In terms of sustainability, attention to the environment, economy and social aspects are very important. Moreover, ICT effects on almost all aspects of a country, it should be considered at the micro and macro levels of the country. ICT, as an enabler of reforming the public sector, has been implemented to reinvent governments to improve performance and create public value.[35]

In the social and cultural field, technologies including ICT should be evaluated because they have a great impact on the culture of a society. Many technologies, if not used properly, can lead to cultural poverty. The environmental aspect of technology is very important for the new generation and the next generation. Environmentally friendly technologies can save society from destruction. Due to this consideration, the presented model in this study covered this aspect as well.

Organizations should use ICT that align with their strategic goals. The application of ICT tools and technologies must help organizations to achieve better its goals which can be gaining competitive advantages or financial performance or improvement in internal processes which all of these criteria are included in the presented model.

Evaluating the performance of ICT shows how much the technology that is used has taken into account the strategic, quality and sustainability dimensions. The evaluation of the ICT performance can indicate the need for ICT to be changed or stabilized or improved. In all organizations even societies, ICT evaluation and updating play a very important and key role; it can guarantee the success of the organization in today's competitive society.

This research has made every effort to suggest a relatively comprehensive model for evaluating the performance of ICT in organizations; and the indicators provided can, to a large extent, inform the organizations of its situation and progress in using the right ICT services, technologies and tools. As an implication for practice, managers can apply ICT performance evaluation indicators which found in this study in their organizations.

Due to the fact that the performance index of the model has the highest percentage of importance among other indicators, it is necessary for the organization to work on the attractiveness of the software environment for users, up-to-date information and its availability to users. Furthermore, the maturity index of the model found as the second most important index in evaluating ICT, so to improve the maturity index, organizations need to improve the architecture of data and applications, the management of the configuration of ICT components, the interoperability of different areas of ICT in the organization.

The distinguishing feature and contribution of this meta-synthesis research is the presentation of relatively a comprehensive model of ICT evaluation from a managerial and professional point of view. Because the developed model out of the literature review, were evaluated and confirmed by ICT specialists and managers in the field. Although, as a study limitation, it must be mentioned that we did not have access to all of the scientific and specialized resources.

Future researches can examine this model in evaluating some organizations in different fields to further refining the model if necessary. Moreover, this study applied a static approach in evaluating ICT performance, future researches can use a dynamic approach in this respect.

Carrying out more detailed research in the field of ICT maturity can be a useful study.

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