Intelligent Arabic Sign Language to Arabic text Translation for Easy Deaf Communication

A. E. E. El Alfi
Dept. of Computer Science
Faculty of Specific Education
Mansoura, Egypt

S. M. EL Atawy
Dept. of Computer Science
Faculty of Specific Education
Damietta University Egypt

ABSTRACT
This paper presents an intelligent translation system for the signs of some words and letters in the Arabic sign language. The proposed translation system does not depend on any visual markings or gloves used to complete the recognition process. The proposed translation system deals with images, which allows the user to interact with the system in a natural way. The proposed translation system consists of four main phases; Preprocessing images phase, feature extraction phase, matching strategy phase, and Display Text Translation phase. The extracted features used are combining intensity histogram features and Gray Level Co-occurrence Matrix (GLCM) features, Experiments revealed that the proposed system was able to recognize the 19 Arabic alphabets and word with an accuracy of 73%.

Keywords
Deaf, Arabic Sign Language, GLCM, feature extraction, intensity histogram, Classification

1. INTRODUCTION
In Egypt, the number of deaf people according to "Central Agency for Public Mobilization and Statistics" last study is around 2 million and increased in 2012 to be close to 4 million (http://www.who.int/mediacentre/factsheets/fs300/en/). So they need an effective and easy communication method between them and normal people. Sign languages such as Arabic Sign Language (ArSL) are natural human languages with linguistic structure. Deaf people were facing many difficulties in education and when communicating with other hearing people [1]. Children who are born to hearing parents and who become deaf after learning language also tend to exhibit better academic and social abilities than children who became deaf prior to learning language. Thus, the important factor is not necessarily the ability to speak. But the ability to communicate through language [2]. Automatic sign language translation systems generally use two different sensor-based approaches, which are data glove and visual-based approaches. In the sensor-based approach the deaf needs to wear Electronic Gloves which contains a number of sensors during the performance of the gestures. In the visual-based approaches Images of the signer are captured by a camera and video processing is done to perform detection of the sign language [3].

Many research focused on translation sign language to spoken language and vice versa, will it is not easy to do by machines since it depends on the natural language processing and image recognition, On the other hand, the traditional way of translation need a translator that specializes in sign language may not be present in all situations, especially when the deaf continues with the person hearer. Translation of Arabic sign language (ArSL) is facing many challenges; the lack of linguistic studies on ArSL, sign language (SL) is assumed to be a universal language,). ArSL is assumed independent on the Arabic language, size of the translation corpus, method of representing output sign sentences and finding a way to evaluate any sign language (SL) translation system [4]. This study presents a proposed system for translating ArSL to Arabic text. It is based on image processing approach the extracted features used are combining intensity histogram features and Gray Level Co-occurrence Matrix (GLCM) features. In general, this system aims to translation from Arabic language to ArSL for improving the communication between deaf and hearing people.

The structure of this study is as follows: section1

Is the introduction, section 2 related work of Arabic sign language recognition, section 3 proposed method, explains the system description section 4 presents the experimental, results, finally section 5 includes conclusion and future work.

2. RELATED WORK
Translation of sign language into text language is an important issue that many researchers have worked on.

Khaled Assaleh and M. Al-Rousan [5] proposed the use of polynomial classifiers as a classification engine for the recognition of Arabic sign language (ArSL) alphabet. Based on polynomial classifiers, an ArSL system has been built and measured its performance using real ArSL data collected from deaf people. The proposed system provides superior recognition results when compared with previously published results using ANFIS (Adaptive-network-based fuzzy inference system) -based classification on the same dataset and feature extraction methodology. The comparison is shown in terms of the number of misclassified test patterns. The reduction in the rate of misclassified patterns was very significant. 36% reduction of misclassifications on the training data and 57% on the test data.

Menna ElBadawy et al [6] developed the system recognition for Arabic sign language. 3D Convolutional Neural Network (CNN) was used to recognize 25 gestures from Arabic sign language dictionary. The recognition system was fed with data from depth maps. The system achieved 98% accuracy for observed data and 85% average accuracy for new data.

M. AL-Rousan et al [7] were presented recognition system for Arabic sign language. This system can detect visual sign language without using gloves or input devices. The operation of this system begins by capturing a video of a person making a sign language word. The next stages include segmentation, background and feature extraction, and end with sign recognition.

Aly, S et al [8], propose a system for alphabetic Arabic sign language recognition using depth and intensity images which acquired from SOFTKINECT™ sensor. The proposed method does not require any extra gloves or any visual marks. Local features are learned using method called PCANet. The extracted features are then recognized using linear support vector machine classifier. The obtained results show that the performance of the proposed system improved by combining both depth and intensity information which give an average accuracy of 99:5%.

E. Hemayed and S. Hassanien [9] introduces a new hand gesture recognition technique to recognize Arabic sign language alphabet and converts it into voice correspondences. The proposed technique captures a color image for the hand gesture and converts it into YCbCr color space.Prewitt edge detector is used to extract the edges of the segmented hand gesture. The Euclidean distance is used to measure the similarity between the signs feature vectors. The nearest sign is selected and the corresponding sound clip is played. Applied the technique to more than 150 signs and gestures with accuracy near to 97% at real time test for three different signers.

B. Hisham and A. Hamouda[10] propose a model to recognize both of static gestures like numbers, letters, and dynamic gestures. Used an affordable and compact device called Leap Motion controller, which detects and tracks the hands' and fingers' motion and position in an accurate manner. The proposed model applies several machine learning algorithms as Support Vector Machine (SVM), K- Nearest Neighbour (KNN), Artificial Neural Network (ANN) and Dynamic Time Wrapping (DTW). Applied on 38 static gestures (28 letters, numbers (1:10) and 16 static words) and 20 dynamic gestures. For static gestures, KNN model dominates other models for both of palm features set and bone features set with accuracy 99 and 98% respectively. For dynamic gestures, DTW model dominates other models for both palm features set and bone features set with accuracy 97.4% and 96.4% respectively.

3. PROPOSED METHOD

The proposed method comprises four stages: preprocessing, feature extractions, matching strategy and display translocation text. Figure (1) shows the block diagram of the proposed system to translate Arabic sing language to Arabic language.

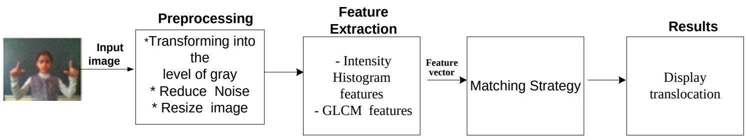

Fig 1 the block diagram of the proposed system to translate ArSL into Arabic language.

The proposed method is detailed in figure. (2).

Input: a set of Arabic singe language images

Output: Text Arabic language which translate from images

Begin

Step1: preprocessing phase (image processing)

- resize the images
- convert images to gray scale
- reducing noise by Using the function (medfilt2)

Step 2: feature extractions Algorism

- Compute the intensity histogram features: Mean, Standard deviation, Skewness, Kurtosi.
- Compute GLCM features: Correlation, Entropy, Contrast, and Homogeneity.

•Save features in data base

Step 3: Matching strategy (training and testing)

- A set of input features of Arabic singe language images to be classified
- Matching with features in data base.
- Compute Euclidean Distance Measure
- Select the maximum similarity ratio
- Indexing the retrieved images
- The final classification output

Step 4: display text Arabic language

End

Fig. (2). the proposed method is detailed.

Figure (3) shows a flow chart of the total stages of proposed system.

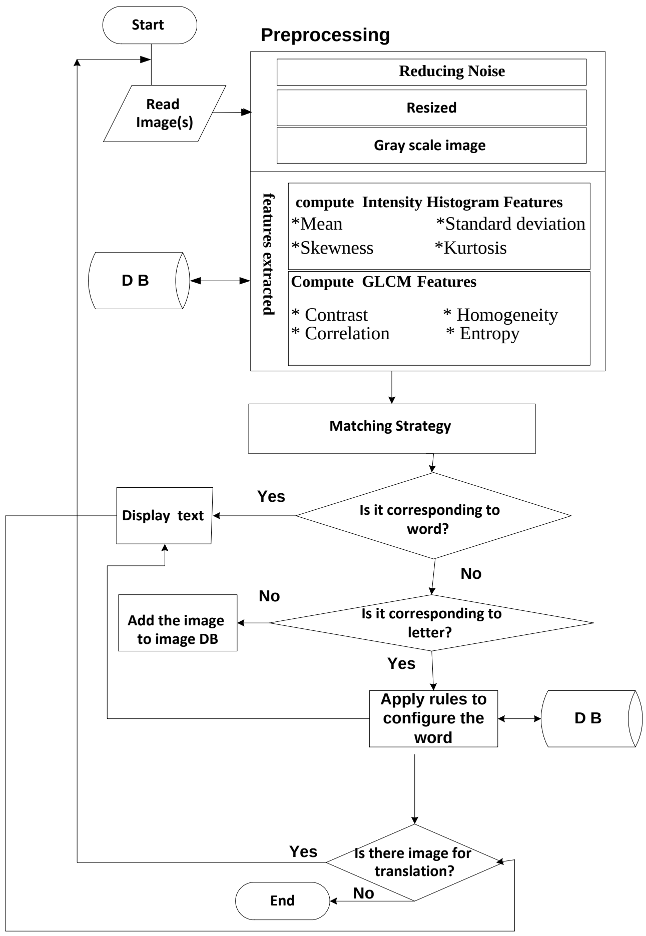

Fig (3) Flow chart of the total stages of proposed system to translate ArSL into Arabic language

3.1 Pre Processing Images

It's referring to the initial processing of raw image to correct geometric distortions, and eliminate the noise and clouds in the data [11]. A preprocessing phase is necessary to improve the quality of the images and to make the later feature extraction phase more reliable. Pre-processing is always a necessity whenever the images to be mined are noisy, inconsistent, or incomplete [12].

The preprocessing consists of many main operations, which applied on the original image (Arabic singe language images), after it is taken from the camera. to make the image better and enhance. The following four operations are used for this purpose: resize the images, convert images to gray scale, and reducing noise by using the function (medfilt2).

3.1.1 Resize the Images

When taking the image from the camera, they are of substantial size, in this step make the constant size of each image (128, 128) pixel. To re-size the image used function:

IM=imresize(im,[x,y])

Where re-sized image on the value of x, y specified. Figure (4) illustrates the original image and the image after re- sized.

Original image **Image re-sized**

Fig (4) the original image and the image after re-sized

3.1.2 Convert Images to Gray Scal

After taking the image from the camera, image is a color, this system was dealing with images that contain grayscale only. So must convert the image to grayscale. In this proposed, using the function's rgb2gray existing in the MATLAB program. Which transformed the image of the primary colors (RGB) to Grayscale.

1M = rgb2gray (image name)

Where image name represent the image in color, and 1M represents the image converted to grayscale. Figure (5) illustrates the original image and the image converted to grayscale.

Original image **Image grayscale**

Fig (5) The Original Image and the Image Converted to Grayscale

3.1.3 Reducing Noise

When taking an image of the camera, the image may accompany some noise as a result of distortions exist in the form of a person, or in the background of these distortions have a negative impact when extracting features from the image. Using the function’s medfilt2 existing in the MATLAB program. Which works to remove noise in the image.

1M = medfilt2 (image name)

Where image name represent the Original image, and 1M represents the image after removing noise. Figure (6) illustrates the original image and the image after removing noise

Fig (6) the image before and after the removal of noise.

3.2 Features Extraction

Feature extraction is defined as the first stage of intelligent image analysis [13]. It is a necessary step for any classification task [14].

Feature extraction play a primary role for most image analysis tasks. But they are critical in pattern recognition. Over the years. Many techniques and algorithms have been proposed for feature extraction [15]. Automated feature extraction from images is the key to real-time map updates. Automated digitization and many other tasks that involve robotic vision [16]. Texture analysis is an important and useful area of study in machine vision [17].

Texture is a key component of human visual perception. Like color, this makes it an essential feature to consider when querying image databases [18].

Texture property of an image has a very important aspect in the human visual system of recognition. Interpretation and perception [19].

The method of texture analysis is principally divided into two approaches: statistical and structural. For biological section images, the statistical approach is appropriate because the image is normally not periodical like a crystal. In the statistical approach, there are various ways to measure the features of the texture. tested the discriminating power of various tools: spatial gray-level dependence method (SGLDM), gray-level difference method (GLDM), gray-level nun length method (GLRLM), power spectrum method (PSM), Gray Level Co-occurrence Matrix (GLCM), Intensity histogram, **t**wo-scan method, a Fourier-transform based method, and a wavelet-transform based method [20-23]. Intensity histogram features and GLCM features are extracted in our proposed method

3.2.1 Intensity Histogram Features

The intensity histogram offers a concise representation of the global intensity characteristics of an image and facilitates the determination of global features. In statistical terms. The histogram is a distribution of sample values for a population of intensities. Just as for any distribution, a statistical analysis may be performed for a histogram to extract what we refer to as global image features. Intensity levels, defined as the difference between maximum and minimum pixel values represented in the histogram [23]

Two main approaches concerning with texture analysis: statistical model-based and spectral measure. Statistical approach is based on statistical properties of the intensity histogram [24]

A useful approach to texture analysis is based on the intensity histogram of all or part of an image**.** Common histogram features include: moments, entropy dispersion, mean (an estimate of the average intensity level), variance (this second moment is a measure of the dispersion of the region intensity), mean square value or average energy, skewness (the third moment which gives an indication of the histograms symmetry) and kurtosis (cluster prominence or "peakness"). For example, a narrow histogram indicates a low contrast region. While two peaks with a well-defined valley between them indicates a region that can be readily separated by simple thresholding [25]. One of the simplest ways to extract statistical features in an image is to use the first-order probability distribution of the amplitude of the quantized image may be defined as

$$P(b) = p_R\{F(j,k) = r_b\} \quad (1)$$

Where r_b denotes the quantized amplitude level for $0 \le b \le L-1$. The first order histogram estimate of P (b) is simply

$$P(b) = \frac{N(b)}{M} \quad (2)$$

Where M represents the total number of pixels in a neighborhood window of specified size centered about (j, k) , b is a gray level in an image, and N(b) is the number of pixels of amplitude r_b in the same window [26].

The following are some statistical measures used in analyzing an image based on the intensity histogram features in table (1) [26].

Table (1) some features extracted based on the intensity histogram features

Features	***Equation***
Mean	$S_M = \bar{b} = \sum_{b=0}^{L-1} bP(b) \quad (3)$
Standard deviation	$S_D = \sigma_b = \left[\sum_{b=0}^{L-1} (b-\bar{b})^2 P(b)\right]^{1/2} \quad (4)$
Skewnes	$S_S = \frac{1}{\sigma_b^3} \sum_{b=0}^{L-1} (b-\bar{b})^3 P(b) \quad (5)$
Kurtosis	$S_K = \frac{1}{\sigma_b^4} \sum_{b=0}^{L-1} (b-\bar{b})^4 P(b) - 3 \quad (6)$

3.2.2 Gray Level Co-Occurrence Matrix (GLCM) Features

In 1973. Haralick et al. proposed the gray level co-occurrence matrix (GLCM). And 14 features based on GLCM [185][25] . In 1992 Ohanian and Duhes compared four types of textural, namely Markov Random Field parameters, multi-channel filtering features, fractal based features, and co-occurrence features. The results show that co-occurrence features perform best followed by the fractal features [26].

The GLCM contains the information about gray levels (intensities) of pixels and their neighbors, at fixed distance and orientation. The idea is to scan the image and keep track or gray levels of each of two pixels separated within a fixed distance d and direction 0[27].

Co-occurrence texture features are extracted from an image in two steps. First. The pair wise spatial co-occurrences of pixels separated by a particular angle and distance are tabulated using a gray level co- occurrence matrix (GLCM). Second. The GLCM is used to compute a set of scalar quantities that characterize different aspects of the underlying texture. The GLCM is a tabulation of how often different combinations of gray levels co-occur in an image. The GLCM is a N x N square matrix, where N is the number of different gray levels in an image. An element, (i, j. d. I)) of a CLCM of an image represents the relative frequency, where i is the gray level of the pixel pat location (x, v). And j is the gray level of a pixel located at a distance d from p in the orientation θ [28]. Figure (7) illustrates different orientation to calculate the GLCM matrices where d=1, and orientation θ = 0º, 45º, 90º and 135º [27].

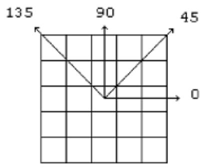

Fig (7) Different orientation to calculate the GLCM matrices

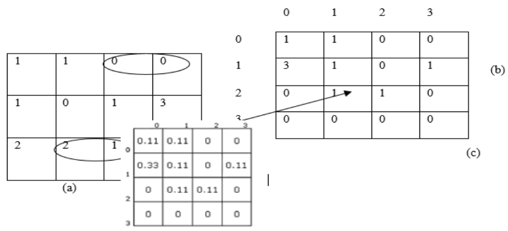

Fig (8). Example of GLCM

a) source image with 4 gray levels: b) illustration of counting co-occurrences for *d* = 1, θ= 0°; c) GLCM, *d= 1*, θ= *0°* (counted co - ocuurrences are divided by number of all considered pairs of points (here 9); in this example the values were rounded to two places after comma [189][29].

Table (2) shows some texture features extracted from GLCM using in this proposed [29].

Table (2) some texture features extracted from GLCM.

Features	***Equation***
Contrast	$C = \sum_{n=0}^{G-1} \left\{ n^2 \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} P(i,j) \right\} \lvert i-j \rvert = n \quad (7)$
Homogeneity	$H = \sum_{i=0}^{G-1} \sum_{i=0}^{G-1} \{P(i,j)\}^2 \quad (8)$
Correlation	$O = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} \frac{ijP(i,j) - (m_i m_j)}{\sigma_i \sigma_j} \quad (9)$
Entropy	$E = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} P(i,j) \log\{P(i,j)\} \quad (10)$

Where i and j: row and column numbers in the GLCM matrix, m_i and σ_i are the mean and standard deviation of P (i,j) rows, and m_j and σ_j the mean and standard deviation of P(i, j) columns, respectively.

3.3 Matching strategy

Pattern recognition is the scientific discipline whose goal is the classification of objects into a number of categories or classes. Depending on the application, these objects can be images or signal waveforms or any type of measurements [30].

At this stage is defined texture classes. For each texture class were selected three samples describe Arabic words to be recognition. Selected those samples based on the knowledge of experts in the field of Arabic sign language translation.

The feature vector computed for an image has to be compared and matched with a class of features' vectors stored a priori (reference). This yields to establish the correspondence between the given images

(Of unknown object or pattern) and a standard image (of known object or pattern) [31].

A feature vector corresponding to an image ***k*** can be denoted by:

$$V^{(k)} = \left\{ V_1^{(k)}, V_2^{(k)}, V_3^{(k)}, ..., V_n^{(k)} \right\} \quad (11)$$

Where, each component $V_i^{(k)}$ is typically an invariant moment function of the image. The set of all $V_i^{(k)}$'s constitute the reference library of the features vectors. The images for which the reference vectors are computed and stored is a set of patterns used for pattern recognition. The problem considered here is to match a features vector V^q :

$$V^q = \left\{ V_1^q, V_2^q, V_3^q, ..., V_n^q \right\} \quad (12)$$

Where V_i^q is typically an invariant moment function of the query image [32].

The retrieval is performed by the similarity measure [33]. Which using to compute distance between stored images classes in the database and the query image. The most common technique for distance measurement used Euclidean distance measure, correlation coefficient, Manhattan distance, and nearest neighbor classifier (KNN) [28]. In this proposed using weighted Euclidean distance measure to compute distance between stored feature vectors in the database and the feature vector of query image. The formula of weighted Euclidean distance measure can be written as follows: [32].

$$d\left(v', v^k\right) = \sqrt{\sum_{i=1}^{n} w_i \left(v_i' - v_i^k\right)^2} \quad (13)$$

Where; W_i denotes the weight added to the component V_i to balance the variations in the dynamic range.

The value of *k* for which the function *d* is minimum, is selected as the matched image index. The value of n denotes the dimension of the features vector and the N value denotes the number of images in database.

The weight is given by;

$$w_i = \frac{N}{\sum_{k=1}^{N} \left(v_i^k - \bar{v}_i\right)^2} \quad (14)$$

Where $\bar{V}_i$ is given by:

$$\bar{v}_i = \frac{\sum_{k=1}^{N} \left(v_i^k\right)}{N} \quad (15)$$

The retrieval image is performed **as** following**:**

Step 1: Measure the distance between the new query image Q and training images in database by weighted Euclidean distance

$$d\left(v', v^k\right) = \sqrt{\sum_{i=1}^{n} w_i \left(v_i' - v_i^k\right)^2} \quad (16)$$

Step 2: Sort the distance values as $d_{i \leq} d_{i+`1}$.

Step 3: Select the sma1lest distance ratio.

Step 4: Select Texture class which will retrieved results on them.

Step 4: App1y displaying translation text.

3.4 Display Text Translation

After selected the texture class which it belongs query image by the discussed earlier, at this stage as display a result of translation the sign language image into Arabic text. At this stage, extracted the knowledge from the knowledge base

3.5 Training Stage

A training stage consists of five major steps:

1. Load images from a database.
2. Pre-process for each images by the discussed earlier.
3. Extract Intensity Histogram Features, which content (Mean, Standard deviation, Skewness, Kurtosis).
4. Gray level co-occurrence matrix (GLCM) Features, which content (Homogeneity, Contrast, Correlation, Entropy.)
5. Save the texture features as .mat file.

3.6 Testing stage.

A Testing stage consists of five major steps:

1. Loading an image to be tested from a database.
2. Pre-process of image by the discussed earlier.
3. Extracting the features of the image by the feature extraction techniques discussed earlier.
4. Apply Euclidean distance measure to test the similarity between the query image and the images stored in database.
5. Decreasing order for the similarity retrieved images with the query image.
6. Select the maximum similarity ratio.
7. Display translation text.

3.7 Knowledge Base (K.B)

In the current research, knowledge was acquired from many sources, such as:

- Human experts: a group of experts in the translation Arabic sign language. In these study, knowledge was acquired through a number of structured interviews.
- unified Arabic sign language dictionary
- Previous studies in the field of translation Arabic sign language. The researcher was got a training course in translation sign language

- **Knowledge Representation**

The representation of the knowledge acquisition through the two sets of rules take format:

IF condition THEN conclusion

The knowledge of the proposed system was encoded usin Matlab.

In this proposed the role of the inference engine was apply a measure of similarity between the query image features and features of the images stored in the database, then applying the process of coding and retrieval, and finally display text translation. Can be represented as follows in table (3)

Table (3) Example for Result of Inference Engine

Fact	**Result of Inference Engine**
*IF the first letter l_1 is "ش" *And the second letter l_2 is "ر" *And the third letter l_3 is "ب"	Display "text is شرب"

3.8 The Graphical User Interface (GUI)

Allows the user to select the number of images to query and display retrieved similar images and displayed text translator as shown in figure (9)

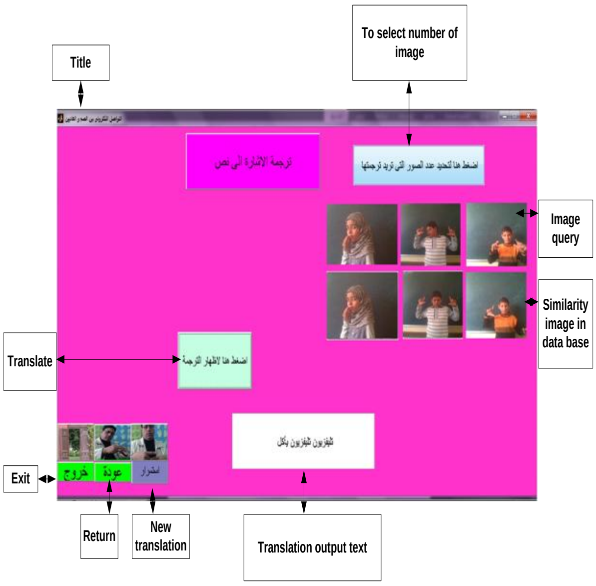

Fig (9) the Graphical user interface of the proposed system

4. EXPERIMENTAL & RESULTS

The proposed method has been implemented using MATLAB. The image database in the experiment is provided by "Al-Amal Institute damitta". Our database contains 180 Arabic sign language images. These images are organized in 19 classes as shown in table (4).

Table (4) classes of images.

w10	w9	w8	w7	w6	w5	w4	w3	w2	w1	No
حرف الباء	أنا	يشاهد	طماطم	أسرة	أب	يأكل	يجلس	كمبيوتر	تليفزيون	Classes
10	7	12	5	16	17	12	5	6	13	Number of images
	w19	w18	w17	w16	w15	w14	w13	w12	w11	No
	الألف	النون	الكاف	الراء	اللام	العين	الشين	السين	الثاء	Classes
	11	8	8	7	11	8	11	8	7	Number of images

The performance evolution of the proposed system was based on (accuracy, precision, and recall)[34,35].

In the experiment, 93 images of Arabic sign language were used as test images. The proposed method was used to distinguish 19 different sign through automatic recognition.

The results were then compared with the results of manual interpretation by experts in domain to determine the accuracy rate of the proposed system Figure (10) shows the accuracy rate of the proposed system.

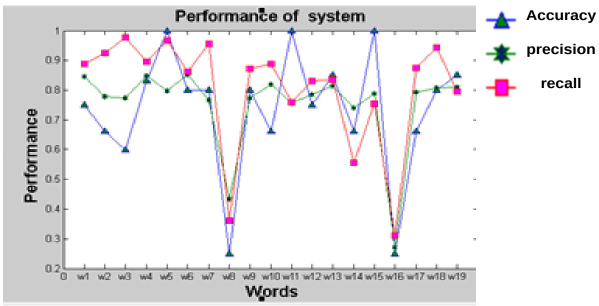

Fig (10) the relation between accuracy, recall and precision

The experimental results shown in figure (10) suggest that the proposed scheme is indeed capable of automatically recognizing different Arabic sign language word. The accuracy rate shown in table (5).

Table (5) the accuracy rate

No	Classes	Number of test images	Accuracy rate
w1	تليفزيون	4	.75
w2	كمبيوتر	3	.66
w3	يجلس	5	.6
w4	يأكل	6	.83
w5	أب	3	1
w6	أسرة	5	.8
w7	طماطم	5	.8
w8	يشاهد	4	.25
w9	أنا	5	.8

w10	حرف الباء	6	.66
w11	حرف التاء	5	1
w12	حرف السين	4	.75
w13	حرف الشين	7	.85
w14	حرف العين	3	.66
w15	حرف اللام	3	1
w16	حرف الراء	4	.25
w17	حرف الكاف	6	.66
w18	حرف النون	5	.8
w19	حرف الالف	7	.85

The total accuracy rate was 73%, the experimental results confirm the efficiency of the proposed method in recognizing of Arabic sign language word.

5. CONCLUSION AND FUTURE WORK

This work aimed to serve Arabic deaf for easy communication. The proposed method of feature extraction is the combination of intensity histogram features and GLCM features. All these features which used to identify the sign language Arabic word. The performances of the classification algorithm are evaluated using precision-recall and accuracy rate. The results demonstrate the effectiveness of the proposed algorithm. The future work aims to integrate video processing and text processing in order to get on line sign language translator system.

6. REFERENCES

[1] Ameera M.Almasoud and Hend S. Al-Khalifa," A Proposed Semantic Machine Translation System for translating Arabic text to Arabic sign language" , Second Kuwait Conf. on E-Services and E-Systems, April 5-7, 2011, pp 79-84.

[2] Aberdeen Marc Marschark, " Raising and Educating a Deaf Child: A Comprehensive Guide to the Choices ", Oxford University Press, 2007.

[3] A.Z Shukor, M.F Miskon, et al. “A New Data Glove Approach for Malaysian Sign Language Detection”. IEEE International Symposium on Robotics and Intelligent Sensors, Volume 76, 2015, p. 60–67.

[4] Abdul aziz Almohimeed et al , " Arabic Text to Arabic Sign Language Translation System for the Deaf and Hearing-Impaired Community", Proceedings of the 2nd Workshop on Speech and Language Processing for Assistive Technologies, Edinburgh, Association for Computational Linguistics, 2011, pp 101–109.

[5] Khaled Assaleh and M. Al-Rousan," Recognition of Arabic Sign Language Alphabet Using Polynomial Classifiers" , EURASIP Journal on Applied Signal Processing, vol (13) , 2005, p.p 2136–2145.

[6] Menna ElBadawy, A. S. Elons, and Howida A. Shedeed, “Arabic sign language recognition with 3D convolutional neural networks”, Proceedings of the International Conference on Intelligent Computing and Information Systems (ICICIS), 5-7 Dec. 2017.

[7] M. AL-Rousan, K. Assaleh, A. Tala'a, “Video-based signer-independent Arabic sign language recognition using hidden Markov models”, Applied Soft

[8] Computing Volume 9, Issue 3 (June) pp. 990-999, 2009.

[9] Aly, S., B. Osman, W. Aly and M. Saber, 2016. Arabic sign language fingerspelling recognition from depth and intensity images. Proceedings of 12th International Computer Engineering Conference, Dec. 28-29, IEEE Xplore Press, Cairo, Egypt, pp: 99-104. DOI: 10.1109/ICENCO.2016.7856452

[10] Elsayed E. Hemayed and Allam S. Hassanien : Edge-based recognizer for Arabic sign language alphabet (ArS2V-Arabic sign to voice), **International** Computer Engineering Conference , 27-28 Dec. 2010 IEEE Xplore Press, Giza, Egypt, **DOI:** 10.1109/ICENCO.2010.5720438

[11] Basma Hisham and Alaa Hamouda, “Arabic Static and Dynamic Gestures Recognition Using Leap Motion”, Journal of Computer Science 2017, 13 (8): 337.354

[12] Youssef Kadri & Jian-Yun Nie, "Effective Stemming for Arabic Information Retrieval”, THE CHALLENGE OF ARABIC FOR NLP/MT, Available: http//atour.iro.umontreal.ca/rali/sites/.../BCS-2006.

[13] Loannis Pitas," Digital Image Processing Algorithms and Applications”, john Wiley & Sons Inc, 2000.

[14] Vinu V. Das, R. Vijaykumar," Information and Communication Technologies: International Conference, ICT 2010", communication in computer and information science 101, Springer village Berlin, 2010.

[15] Mehemmed Emre Celebi, “Development of Algorithms for Dermoscopy Image Analysis", ProQuest, 2006.

[16] Thomas M. Deserno, “Biomedical Image Processing”, Springer village Berlin, 2011.

[17] Muhammad Noorazlan Shah Zainudin and et al, “Feature extraction on medical image using 2D Gabor filter", Applied Mechanics and Materials Vols. 52-54, 2011, p.p 2128-2132.

[18] Evangelos Triantaphyllou, Giovanni Felici, “Data Mining and Knowledge Discovery Approaches Based on Rule Induction Techniques", Springer Science + Business media, LLC, 2006.

[19] Mihran Tuceryan , Anil K. Jain," Texture Analysis" , The Handbook of Pattern Recognition and Computer Vision (2nd Edition), by C. H. Chen, L. F. Pau,P. S. P. Wang (eds.), pp. 207-248, World Scientific Publishing Co., 1998.

[20] Peter Enser, et al," image and video retrieval", third international conference CIVR2004, Springer – verlag Berlin Heidelberg, 2004.

[21] Marina L. Gavrilova," Generalized Voronoi Diagram: A Geometry-Based Approach to Computational intelligence", Springer – verlag Berlin Heidelberg, 2008.

[22] Donat P. Hader," Image Analysis: Methods and Applications, Second Edition", CRC Press ,2001.

[23] Manuel Graña، Carlos Toro،Jorge Posada،Robert J. Howlett, and Lakhmi C. Jain ," Advances in Knowledge-Based and Intelligent Information and Engineering Systems", IOS Press, 2012.

[24] Lawrence O'Gorman, Michael J. Sammon‹Michael Seul,"Practical Algorithms for Image Analysis with CD-ROM", Cambridge University Press , 2008.

[25] Dhinaharan Nagamalai, Eric Renault‹Murugan Dhanuskodi, "Advances in Parallel, Distributed Computing: First International Conference on Parallel, Distributed Computing Technologies and Applications, PDCTA 2011 Tirunelveli, Tamil Nadu, India, September 2011 , Proceedings ", Springer – verlag Berlin Heidelberg, 2011.

[26] Paul F. Whelan‹Derek Molloy," Machine Vision Algorithms in Java: Techniques and Implementation", ", Springer – verlag – Landan limited , 2002.

[27] Madhuri A. Joshi," Digital Image Processing: An Algorithm Approach ", Prentice Hall of India private limited, 2006.

[28] Hanalick. R.M. Shanmugam. K. Dinsiein. I.: Textural Features for Image Classification. IEEE Trans. Systems. Man. and Cybemnetics SMC-3(6). 610-621, 1973.

[29] Ohanian. PP... Dubes, R.C.:" Perfomance Evaluation for Four Classes of Textural Features", Pattern Recognition 25(8), 819—833, 1992.

[30] Tatyana Yakhno," Advances in Information Systems: First International Conference, ADVIS 2000 preceding ", Springer – verlag Berlin Heidelberg, 2000.

[31] Punitha P. Swamy, Devanur S. Guru," Multimedia Processing, Communication and Computing Applications: Proceedings of the First international Conference, ICMCCA, 13—15 December 2012 ", Springer India, 2013.

[32] Ryszard S. Choras," Image Processing & Communications Challenges 2 ", Springer – verlag Berlin Heidelberg, 2010.

[33] Sergios Theodoridis, Konstantinos Koutroumbas, " Pattern Recognition" Elsevier Inc , 2009.

[34] R. Mukundan, K. R. Ramakrishnan" Moment Functions in Image Analysis: Theory and Applications", World Scientific, 1998.

[35] Sri`savakon Dangsaart et al ," Intelligent Thai text – Thai sign translation

[36] For language learning", science direct, Computers & Education 51, 2008, pp 1125–1141.

[37] Dan Melamed et al,"precision and recall of machine translation, Available: nlp.cs.nyu.edu/pubs/papers/hlt03eval.pdf.