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Arabic Sign Language Recognition System: Using an Image-Based hand Gesture Detection Method to help Deaf and Dump Children to Engage in Education

Dr. Amr Mohmed Soliman

Special Education Dept, College of Education, King Khalid University, Abha, Saudi Arabia

Dr. Mahmoud M. Khattab

Dr. Abdelmoty M.Ahmed

College of Computer Science, King Khalid University, Abha, Saudi Arabia

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Abstract:

Hand gestures help individuals communicate in daily life. Sign languages, however, employ hand motions extensively. People with hearing impairments use sign language. Pattern recognition in computer vision may be used to interpret and translate Arabic Sign Language (ArSL) for deaf and dumb persons using image processing-based software systems. Arab hearing-impaired and deaf persons communicate with Arabic Sign Language Recognition (ArSLR).We propose an image-based ArSLR system employing gesture recognition to enable people with disabilities to engage with the outside world. This work proposes the design and development of an automated Arabic sign language-to-Arabic text translation system. This study extracts stem Arabic words and differentiates related terms. Hand motions capture alphabet letters in the proposed approach. Image isolation occurs after acquisition. Extraction, conclusion, and hand sign pattern characteristics comprise the third step. The fourth phase classifies hand gestures using a powerful classification algorithm. Finally, the sign language letter is interpreted and translated to the Arabic character.

Keywords: ArSL, ArSLR, Features Extraction; Pattern recognition; sign language; Hand Gestures; Hand Detection; Classification.

1. INTRODUCTION

Deaf people use sign language. Vision-based and sensor-based techniques dominate sign language. Vision-based systems do not need complicated equipment, but preprocessing requires adequate calculations. Sensor-based systems employ sensor-enabled instrumented gloves instead of cameras. This study describes a computer vision-based gesture interface and a sign language recognition system for deaf and dump people who use sign language to communicate.

Image-based ArSLR has three levels: continuous, alphabet, and isolated-word. Vision-based approaches use sign graphics or videos as input. Signers must stop between signs to manually segregate them. This paper will report on hand detection research for gesture recognition.

Section 1 describes the image and pattern recognition translation of ArSL to Arabic text language system. Section 2 discusses previous works and literature surveys, Section 3 discusses sign language to deaf and dump using Pattern Recognition, and Section 4 discusses the proposed system. Section 5 presents first-stage computer simulation findings, Section 6 presents second-stage results, and Section 7 summarizes future directions and conclusions.

2. LITERATURE REVIEW

Glove-based recognition systems by Sidney and Geoffrey [1] identify sign language hand shapes and motions under varying lighting. However, a glove-based input device or motion capture system is required, limiting user and system mobility. Kim et al. [2] presented a Korean sign language gesture detection system employing fuzzy-min-max neural network and data-glove. Lee et al. [3] created a novel glove sensor and used K-mean approach to teach Korean finger spelling. Tabata et al. presented hand shape-based finger spelling recognition [4]. Halawani introduced mobile Arabic sign language translation [5]. Tsukada et al. presented a glove-based wearable computer input device [6]. Using data collected by Khalid Alvi et al., statistical template matching recognized Pakistan sign language [7]. AI-Buraiky et al. created a glove-based Arabic sign language recognition system [8]. x. Zabulisy et al. [9] suggested a vision-based HCI hand gesture recognition system.

Vision-based methods overcome sensor-based system constraints. Hamada et al. [10] use two-camera multi-ocular pictures to overcome occlusion in hand form estimation. Rogerio Feris et al. [11] used multi flash camera to leverage depth discontinuities for finger spelling recognition to distinguish between similar signs. HMM [12] and Dynamic Programming [13] recognized American sign words. Salleh et al. [14] suggested using feature extraction and HMM from greyscale photos to transform sign language to speech recognition. Tanibata et al. [15] developed a feature extraction-based prototype for Chinese sign language identification hand occlusion. Mohandes [16], [17] developed an SVM-based prototype system to detect Arabic sign language and an automated translation system to convert Arabic text to Arabic sign language. A Neural Network-based Sign to Sound system prototype by Foong et al. [18] can recognize hand movements by converting digitized hand sign language pictures to voice.

3. SIGN LANGUAGE AND PATTERN RECOGNITION FOR DEAF AND DUMP

Sign language is the term given to a means of communication is the voice used by people with special needs acoustically (deaf) or audio (dump), despite the fact that there are other practices that could be classified as conversational indicative levels such as divers signals and some special signs I have some police forces or military or even between gangsters and other [19]

Sign language has become recognized as the language of global communication between people with special needs. However, it has also become the creators of the Deaf ability to creativity poems and pieces of literature, and the translation of the oral poetry to the language-dependent locomotors rhythm of the body, particularly the hands movement. This is because the hands movement is considered to hand a great way to express your fingers and formations, can laugh and cry, rejoice and become angry, and express the desire to communicate.

3.1.Communication systems for deaf people

There are several communication medias now exist between people with speech and hearing inabilities [20]

1. **Hand Gestures help to teach speech:** It represents putting your hands on the mouth, nose, throat, or chest as a technique to communicate a specific kind of verbal machine outlet and also attempts to assist in the teaching of spoken language to deaf individuals.
2. **Hint language:** These tips provide the reader with the language of the lips and the information that describes what confused them while reading this and make the hidden voices visible. It is a handy way to support spoken language, in which the speaker uses a set of hand

movements carried out near the mouth with all the voices of speech.

3. **Read the lips:** paying attention to and understanding what a person is saying requires monitoring the movement of the lips, as well as the motions of the letters of the mouth, tongue, and throat, as they are pronouncing words. This is known as lip reading
4. **Oral method:** a deaf education and training that does not involve sign language, spelling, or fingers; instead, only reading and writing are used as forms of communication.
5. **Alphabetic fingers spelling:** a strategy to convey reliance upon alphabet and are typically employed in names. Or flags words that have no agreed-upon symbol.
6. **. Method pronunciation tuned:** based on a set of ideas that the most essential speech is not confined to out vote abstract way but that speech complete expression which interfere with body movements such as hand gestures, facial characteristics, rhythm, tone, and signs
7. **Destruction Contact:** This implies that the use of effectively all conceivable methods available to communicate and the integration of all auditory, manual, oral, gestures, signs, motions of hands, fingers, and lips, as well as reading and writing systems to assist communication and facilitation.

3.2.Pattern and hand gestures recognition

Pattern Recognition is described as a categorization of input data by the extraction of essential characteristics from a large amount of noisy data. Pattern Recognition is also known as statistical learning (PR). The purpose of this is to extract information about the picture so that its contents may be categorized. Inputs are provided in the form of digitized binary valued 2D pictures or textures that include the pattern that is to be identified [21], and the science of Pattern Recognition is intimately related with all of the decision-making that is based on intelligent systems.

The fields of computer vision, image processing, and pattern recognition all have a large degree of overlap. The majority of computer vision algorithms operate under the assumption that a significant amount of image processing has already been performed in order to increase picture quality.

Human-computer interaction researchers are developing gesture-interfaces. In virtual environments, video conferencing, and simulation of virtual objects represented by a computer and felt by the user, gestures are an easy and closer alternative to cumbersome communication devices between humans and computers, such as a computer mouse, joystick, keyboard, and machine control buttons. using it in the real world (moving or turning two-dimensional and three-dimensional objects, creating computer images or remote control operations) and in computer-driven abstract physical things (moving a robot arm or arming mechanisms), and its important role in human communication and speech automation applications, as gestures are a support element for speech (gestures accompanying speech that confirm or deny meaning, express feelings, or issue commands, etc.)[28,29].

Pattern recognition, which is also known as machine learning, is the study of a variety of mathematical approaches (including statistical techniques, neural networks, and support vector machines) to identify distinct patterns. Any data may be used as the pattern recognition algorithm's input data. The field of computer vision makes extensive use of pattern recognition algorithms. There are several visual issues that may be recast as categorization issues.

The majority of Pattern Recognition Systems begin by collecting the data that needs to be classified, followed by the analysis of these data, and then describing the important features that are extracted as information numerical symbolism (Analysis/Description), followed by the classification of data entered by features derived from this data, in accordance with one of the Classification methods (Classification/Recognition).

Figure 1 describes an overview of a method for identifying hand gestures, which consists of three primary steps as the primary components. The first step is to gather pictures of people making hand gestures, the second is to process and prepare the gesture by selecting characteristics and deriving them from the form of the hand, and the third is to classify and recognize the gesture in order to understand what it means.

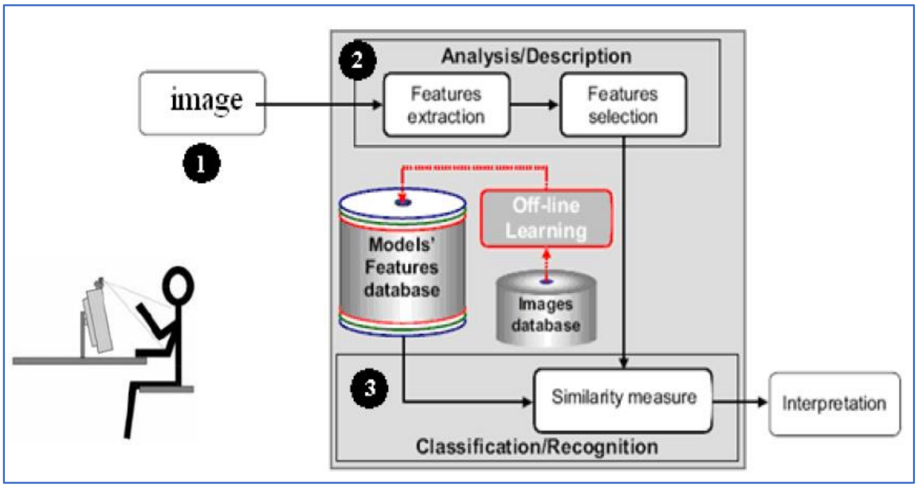


Figure 1 A generic pattern Recognition System (PRS) scheme.

It is clear from the foregoing that it is possible to consider the gesture recognition system as a system for recognizing shapes in which the image of the hand gesture represents the figure studied in it, and computer vision techniques can be used to obtain images of gestures, to be processed and analyzed using digital image processing processes, then the gestures are classified using algorithms Statistical classification or any other classifiers.

There are many classification methods, including statistical method, which relies on statistical features of the pattern of the entrance, structural pattern recognition method (Syntactic method), which relies on relations between features to be recognized on the corresponding pattern of pattern entrance, Image processing uses template matching to find shapes in images. The self-adaptive trainable artificial neural network (ANN) technique may handle complicated problems using existing information. The system receives data to determine the best function in an authorized class that fits the input.

Pattern recognition Technique	Recognition function	Representation	Typical Criterion
Statistical	Discriminate function	Features	Classification error
Syntactic or Structural	Rules, grammar	Primitives	Acceptance error
Template matching	Correlation, distance measures	Sample, pixel, curves	Classification error
Artificial neural network	Network function	Samples, pixels, features	Mean square error

Table 1: Techniques of Pattern Recognition.

Pattern recognition has been the subject of a great deal of study, and a great deal of different algorithms have been developed for it. The varieties of pattern recognition are determined by the design cycle of the pattern recognition system. We are aware that it is comprised of fundamental components such as visual perception, feature extraction, and classification. In order to put these fundamental components into practice, a wide variety of methods and algorithms are available.

Figure 2 is a schematic sketch of the system that can recognize the picture of a character that is indicative of the Arabic language and how to differentiate between them using the sign language Recognition algorithm. [24]

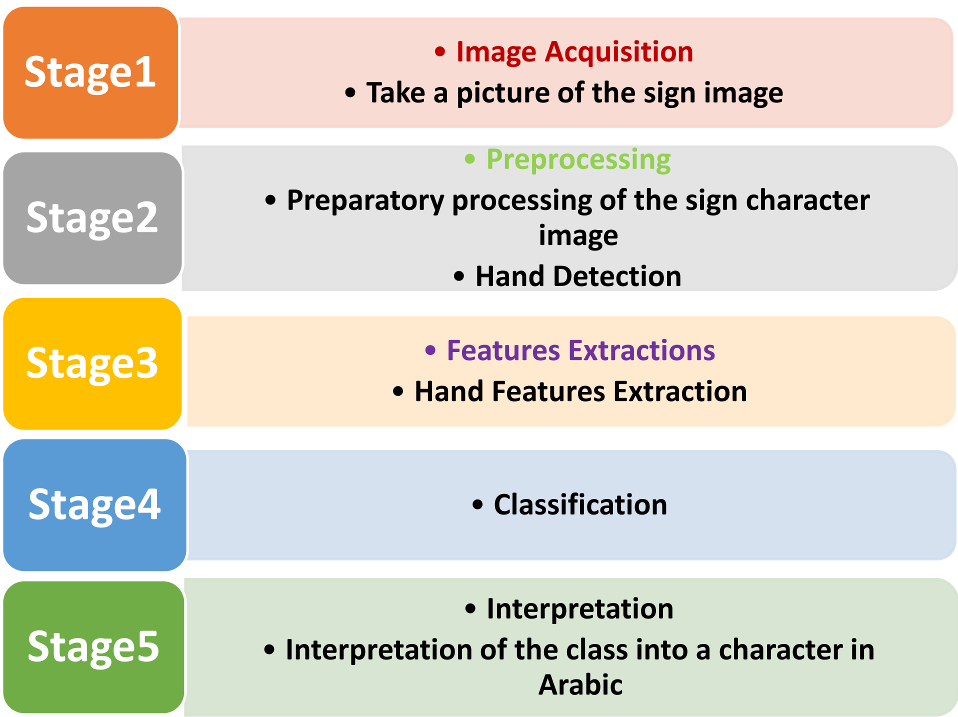


Figure 2: Hand Gesture Recognition scheme outlines

4. THE PROPOSED SYSTEM

In this section an overview of the proposed system is described for the automatic conversion of sign language to Arabic language text. The proposed system for recognizing the alphabet of signifying fingers starts by taking a picture of a sign performer's gesture in front of a camera connected to the computer. The computer then detects the hand, isolates it from the background, and extracts the hand's shape that distinguishes the gesture. This is the use of the numerical attributes to train a statistical classifier to recognize new data for the gesture of a certain indicative character and give the name of the class corresponding to this letter, which is then translated and interpreted into the Arabic letter name. Deaf-hearing communication system work cycle is given in Figure 3.

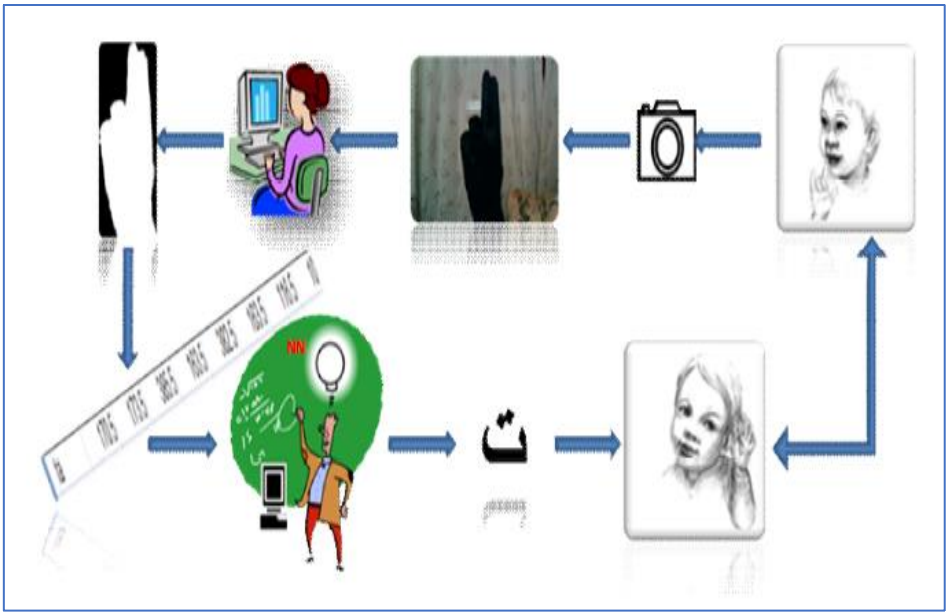


Figure 3: Deaf-hearing communication system work cycle.

Figure 2 shows the five stages of the proposed sign language-to-Arabic translation system. This article will explore the first and second stages: the first stage captures photographs to acquire input data, while the second stage processes images, detects hands, and isolates them from the backdrop.

4.1.Image Acquisition

Pattern recognition systems initially acquire visual data from the surroundings using input devices like cameras. Data submitted for this stage give birth to gestures carried out by a variety of indications by wearing the glove dark color in varied lighting situations with a light backdrop, or without a glove (natural color of the skin) with a dark background or wear a glove. This step outputs a series of RGB images of hand movements for each Arabic sign language letter [25]

(Alif) - أ	**-ب (Baa)**	**-ت (Taa)**	 **(saa) - ث**	**- ج (Geem)**	**(Haa) -ح**	**- خ (Khaa)**
-د (Daal)	**– ذ (Zaal)**	**– ر (Raa)**	 **– ز (Zay)**	**– س (Seen)**	**– ش (Sheen)**	**– ص (Saad)**
– ض (Daad)	**– ط (Tah)**	**– ظ (Zah)**	 **– ع (Ain)**	**– غ (Ghin)**	**– ف (Faa)**	**(Kaf) – ق**
– ك (Kaaf)	**– ل (Laam)**	**– م (Meem)**	 **– ن (Noon)**	**- هـ (Heh)**	 **(Waw) – و**	**– ي (Yaa)**

Table 2: Arabic Sign language (ArSL) alphabets letters

4.2.preprocessing

The act of preparing data for use in a subsequent step is referred to as pre-processing. the preprocessing steps are built on the basis of several combinations from the following image processing operations: transfer the RGB image to Gray, Sobel [26,27] to edge detection, median filtering, histogram equalization, binary image processing (i.e. thresholding) in HSI color space, and de-saturation. The goal of this preprocessing step is to convert the data into a format that can be processed more easily and effectively. These image-processing tasks are broken out in further depth in section 6, which may be found here.

This stage depends on the hand detection of the image; we have concentrated on this step and that by designing an algorithm for image processing and hand detection from it. This algorithm is then applied to the image in several different ways in order to obtain the best sample possible, which can then be used in a later stage of classification.

At this stage, the image is colored of the type RGB, and it contains hand gestures and the back of the hand; as a result, image processing procedures must be used for the hand to be isolated from the image or discovered from it.

4.3.Features Extractions

At this stage, the behaviour was Hand is described in the image caused by the hand detection step in accordance with one of the ways described based on the outer frame and the interior forms. After that, select the best features in the description gesture and differentiate them from other gestures. Finally, feature extraction, which uses the selected features for the processing of income data, which is then used in the training process or test.

4.4.Classification

In the stage of classification, select one of the statistical classification algorithms, neural networks, or any other pattern recognition methods, to design classified and was educated under the supervision of the training data (database formed in the stage prior to this one in the system), in order to classify a new gesture (hand shape) that is not represented in the training set to one of the existing varieties. The features of the hand those are stored in the database serve as the stage's inputs, and the names of new types of thoughtful gestures are expected to emerge as the stage's output.

4.5.Interpretation

In the stage of classification with a letter corresponding to the Arabic language class, the translated product's name is expected to be matched to the predicted product that was a kind gesture. This takes place after the translation stage.

4.6.Experimental RESULTS OF IMAGE ACQUISITION

This section goes into depth on the first stage that was completed. In the first stage, we worked on a system for capturing images through the integrated webcam of the laptop. This allowed us to capture several images in a row and store them. We prepared three sets of these images to use as sets in the training and testing of the system after it was processed. The table 3 below shows the models for these sets of images captured from the proposed system that was programmed using the programming language Python.

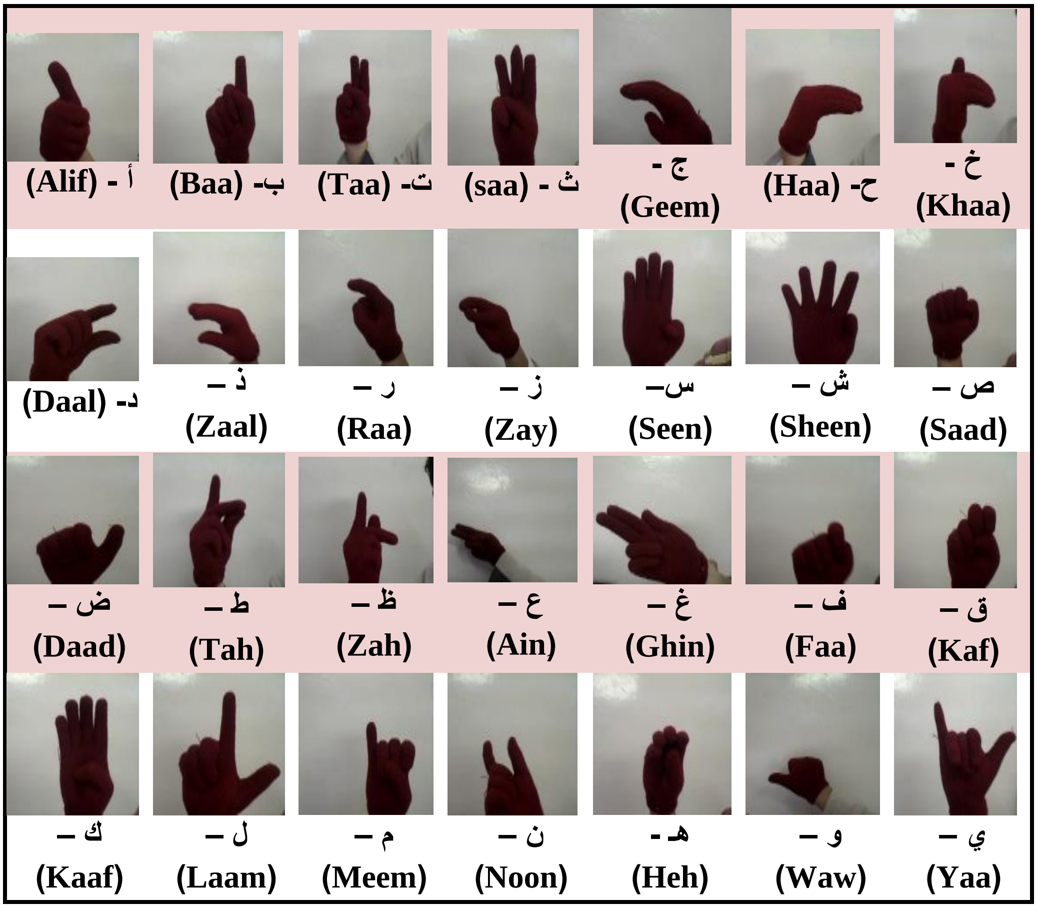


Table3: The. proposed system dataset of alphabets letters befor prprocessing

In this stage, we employ 700 captured images, 25 for each letter of the Arabic alphabet 28. The images are RGB. before isolation, detection, and the aforementioned table, each picture is a gesture hand.

The figure 4 shows the part of the user code in the work of the proposed system for capturing images

```
import numpy as np
import cv2

camera = cv2.VideoCapture(0)
i = 0
while True:
    f,img = camera.read()
    cv2.imshow("webcam",img)
    if (cv2.waitKey(5) != -1):
        break
    cv2.imwrite('{0:05d}.jpg'.format(i),img)
    i += 1
```

Figure 4: Python's image-capture code

5. EXPERIMENTAL RESULTS OF PREPROCESSING AND HAND DETECTION

This section goes into depth on the second stage that was completed. This stage involves the processing of the images that were produced in the previous stage of the characters' indicative gestures and the images that were captured by various methods, as was explained in the table that came before this one, where this stage involves the implementation of a number of different steps.

5.1.Converting color images to grayscale

During this step, the image matrix with the original colors is being converted into a data grayscale image. This is done while preserving the gloss color (luminance) and ignoring the color gamut (Hue) and saturation to components of color in the original image. This is done in accordance with the formula used in the color scheme of change from RGB to gray scale.

$$\boldsymbol{I} = \mathbf{0.2989} * \boldsymbol{R} + \mathbf{0.5870} * \boldsymbol{G} + \mathbf{0.1140} * \boldsymbol{B} \qquad Eq1$$

Figure 5 depicts a section of the user code that was used in the development of the system that was suggested for the conversion of images from their original colors to grayscale.

```python
filename = 'C:\mywork\ALIF.jpg'
image = cv2.imread(filename)
cv2.imshow('color_image',image)
def rgb2gray(rgb):
    return np.dot(rgb[...,:3], [0.299, 0.587, 0.144])

gray = rgb2gray(image)
plt.imshow(gray, cmap = plt.get_cmap('gray'))
plt.show()
```

Figure 5: Python's RGB-to-grayscale code

5.2.Adjust image contrast.

In the second step, noise reduction, edge detection, and image processing fundamentally adjusted picture contrast to recognize hand in grayscale image. The Sobel technique was used to recognize the hand's edges in the image using linear filters to alter the image's contrast.

Sobel detection computes image gradient magnitude using 3x3 filters [26]. The Laplacian approach loses hand shape information, whereas the canny method detects strong hand edges and ignores weak edges. Edge detection methods are compared in table 4.

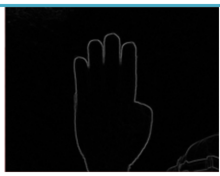
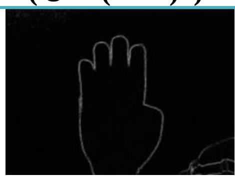
Color Image (ي – (Yaa))	**Sobel Method (ي – (Yaa))**	**Laplacian Method (ي – (Yaa))**	**Canny Method (ي – (Yaa))**
			
Color Image (س – (Seen))	**Sobel Method (س – (Seen))**	**Laplacian Method (س – (Seen))**	**Canny Method (س – (Seen))**
			

Table 4: Edge detection method comparison

The second method uses experimental threshold to adjust the contrast of the image so that the color scheme pixel that is equal to or less than this threshold equal to the black color values be otherwise be white color while maintaining a grayscale image after that this image (Grayscale) convert to Black and white image type and become all matrix values in either black = 0 or White = 1, after that threshold is used to open a structural binary image. , table 5 shows the output of this method.

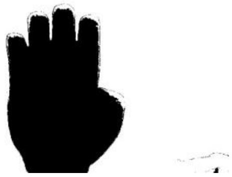
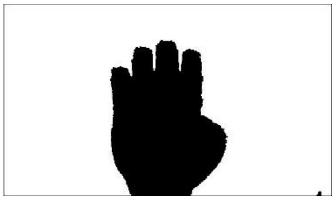
Original Image (Letter Seen - س)	**The Image after cutting by using the threshold = (40) (Letter Seen - س)**	**Morphology Method to close holes (10 times) (Letter Seen - س)**
		

Table 5: The results adjust the contrast of the image according to the second method

The threshold (40) is select on the grounds that the signal performer wearing a dark-colored glove, because the effect of lighting on dark color is less, we can also make the system more flexible programming element visible on the control interface system to control the value of the threshold increase or decrease depending on the color of the glove user, to get a more accurate results,

The levels of gray, ranging from (0) completely black and (255) completely white, And by showing the density of images captured scheme and note the appropriate value that can then separate the image into two different regions, it found that the value of (40) are suitable value experimentally for all the photos.

The third method adjust image contrast density distribution of input image within a new field in the output image values, where the work area with a matching value (0, 0.19) in the income image with the value (0, 1), thus all Pixel in the input image, which is approximately equal intensity (0.19*255≈48.5) will be equal to a white color density 255. It produces a gray image with pixels according to the following figure then converts the resulting gray image to a binary image.

The table 6 illustrates, the stages of implementation of the algorithm detect the edges of the hand, depending on this method.

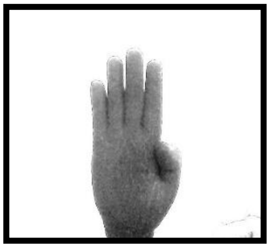
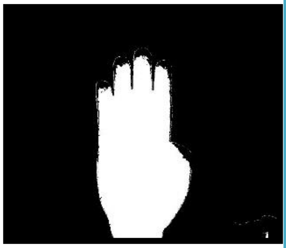
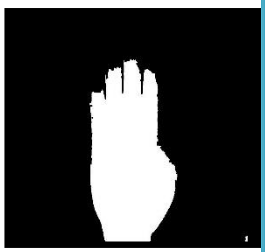
Original Image (Letter Seen - س)	**After adjusting the image Contrast (Letter Seen - س)**	**Binary image (Letter Seen - س)**	**Morphology Method to close holes (5 times) (Letter Seen - س)**
			

Table ٦: The results adjust the contrast of the image according to the third method

5.3.Hand extraction element of the image

In this section hand element is extracted from the captured image in the first stage after preprocessing in second stage by using this proposed algorithm that proves effective in the first and second phase in the construction of the proposed system, the figure 6 illustrates the basic steps of the proposed algorithm.

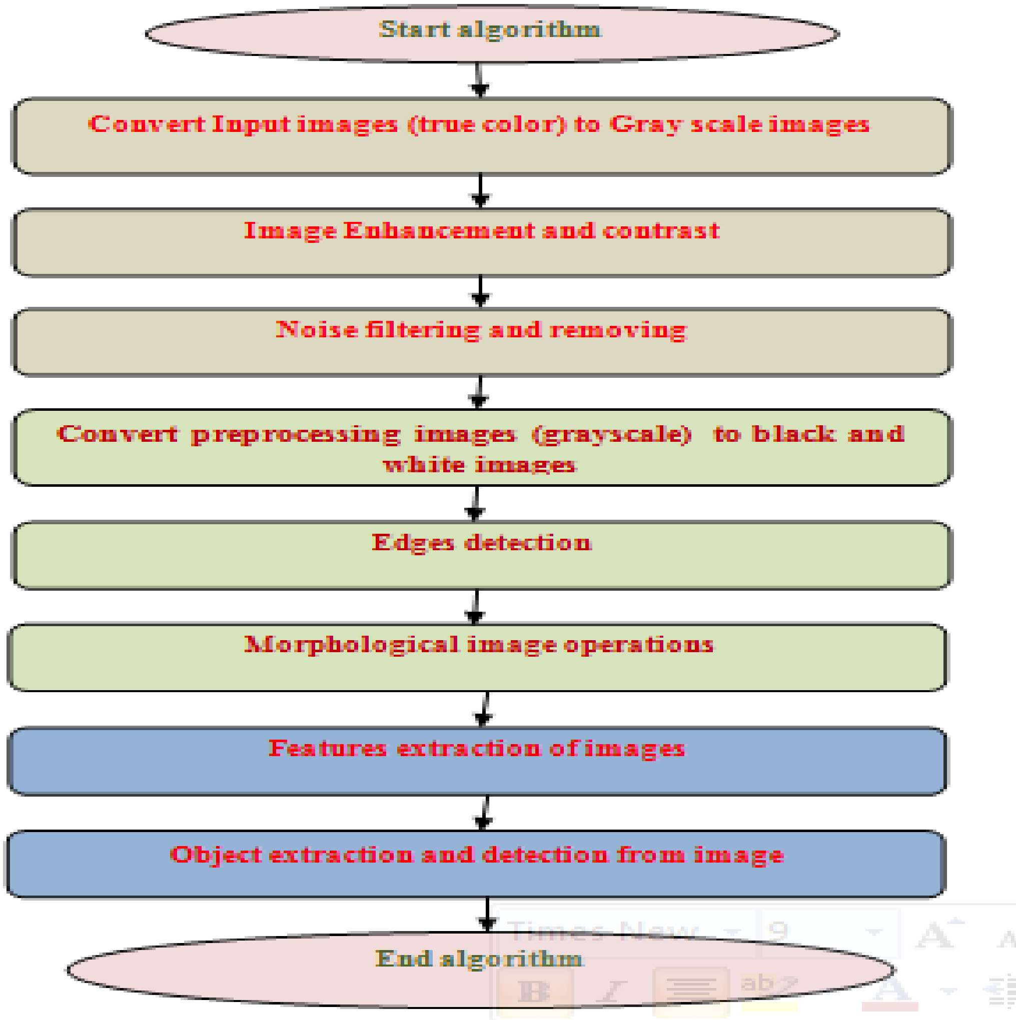


Figure 6: The main stages of the proposed algorithm to hand extraction in ArSLR system

The researcher tries to explain the results of the first six steps in this algorithm, and the results of the last two steps, describe about the extraction of the hand. From the image, hand area is detected and extracted entitles the detected items in the image, the table 7 shows the resulting image from the process of extraction of the hand element of the original image by the three methods used to detect hand gestures.

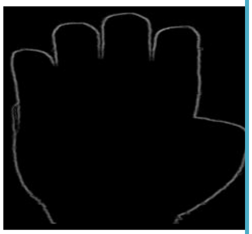
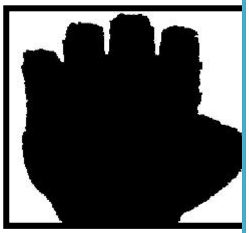
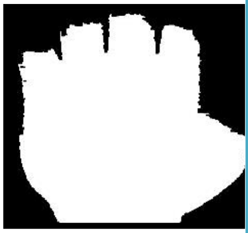
Original Image (Letter Seen - س)	Extraction and exploration of hand shape by the first method(Letter Seen - س)	Extraction and exploration of hand shape by the second method(Letter Seen - س)	Extraction and exploration of hand shape by the third method(Letter Seen - س)
			

Table 7: Hand extract from the background after the detection in the ArSLR system

6. CONCLUSIONS

Simulations capture gesture images that match sign characters and analyse and extract hand images. A basic statistical metric allowed a dynamic system determine hand gesture transitions and recognize Arabic Sign Language sentences (ArSL). Cutting the image with a black glove solves the hand illumination detection issue. Gesture detection improved significantly for static images under varied settings. The image's hand orientation and location were extracted. The author wants to finish a full research of several phases of dynamic ArSL system, which may be utilized in deaf bilingual/bicultural language instruction or as a vivid model in deaf educational programs using sophisticated computer vision methods. This region has considerable potential for a gesture word-based continuous sentence recognition system. This method will assist deaf people communicate.

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نظام التعرف على لغة الإشارة العربية " استخدام طريقة للكشف عن إيماءات اليد لمساعدة الأطفال الصم والبكم للاندماج في التعليم"

د. عمرو محمد سليمان عبدالرحمن

أستاذ مشارك الصحة النفسية جامعة الملك خالد

د. محمود مصطفي خطاب

أستاذ مساعد علوم الحاسب جامعة الملك خالد

د. عبد المعطي محمود محمد أحمد

أستاذ مساعد علوم الحاسب جامعة الملك خالد

الملخص:

تهدف الدراسة إلى أعداد برنامج على الحاسب الآلي يمكن من خلاله التعرف على الأنماط المختلفة للغة الإشارة العربية (ArSL)، وبشكل خاص (أبجدية الأصابع) للصم والبكم باستخدام أنظمة برمجية قائمة على معالجة الصور؛ كما تهدف من خلال أعداد هذا البرنامج إلى مساعدة الأطفال الصم والبكم على التواصل في الحياة اليومية بشكل أفضل، حيث أن العديد من الأطفال الصم والبكم يستخدمون لغة الإشارة سواء كانت (أبجدية الأصابع) أو (الوصفية) على نطاق واسع في الحياة اليومية أو في التعليم داخل المدارس، كما أن تواصل الأطفال الصم والبكم مع الأطفال العاديين أو مع المجتمع بشكل عام يكون فيه صعوبات عدة، تصل إلى أعاقة التوصل بينهم؛ لذلك تقترح هذه الدراسة تصميم وتطوير نظام آلي لترجمة لغة الإشارة إلى نصوص باللغة العربية (مكتوبة على شاشة الحاسب الآلي)؛ ويتم ذلك من خلال تصميم برمجي يستطيع ترجمة حركات (أبجدية الأصابع) وتحويلها إلى نصوص مكتوبة يستطيع من

خلالها المعاق سمعيًا(الصم والبكم) التعبير عن ما يريد إلى الآخرين (العاديين)؛ وبهذا تكون عملية التواصل ايسر على كلا الطرفين (المعاق سمعيا – العاديين)؛ وبذلك يتحقق هدف هذه الدراسة في تمكين الأشخاص المعاقين سمعيًا(الصم والبكم) من التفاعل مع العالم الخارجي، والاندماج بالتعليم.

الكلمات المفتاحية: المعاقين سمعيًا، أبجدية الأصابع، حاسب آلي؛ معالجة الصور.