Intelligent Sign Language Recognition Using Image Processing Techniques: A Case of Hausa Sign Language

By

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ABSTRACT
Hausa sign language (HSL) is one of the main sign language in Nigeria. It is a means of communication medium among deaf-mute Hausas in northern Nigeria. HSL includes static and dynamic hand gestures. In this paper we present an intelligent recognition of static, manual and non-manual HSL using a Particle Swarm Optimization (PSO) to enhanced Fourier descriptor. A vision-based approach was used. A Red Green Blue (RGB) digital camera was used for image acquisition and Fourier descriptor was used for features extraction. The features extracted were enhanced by PSO and fed into artificial neural network (ANN) which was used for classification. High average recognition accuracy of 93.9% was achieved; hence, intelligent recognition of HSL was successful.

Key words: Hausa Sign Language; Fourier Descriptor; Particle Swarm Optimization Algorithm; Artificial Neural Network

INTRODUCTION

Sign language is a coordinated gesture that is either manual or non-manual, and it is meaningful; it is a means of communication that is visual. Sign language is a well-coordinated gesture that a hearing impaired or deaf-mute community use to communicate among themselves. Sign language differs from one culture, country to another against the popular knowledge. According to [1], sign language originated from France and many other country's sign languages developed from French sign language. There are different sign languages across the world; in [2] the author introduced American Sign Language, Chinese Sign Language was presented in [3], Arabic Sign Language was introduced in [4], Indian Sign Language was presented in [5], and to mention a few. In Nigeria, Sign language varies across the region, Hausa sign language is the most unique and very difficult for the deaf-mute from other region to comprehend, according to statistics, no fewer than 360 million people across the world are living with hearing impairment [6]. In Nigeria, 8.5 million people are living with hearing impairment and the larger cent percent are Hausas, The use of sign language as a means of communication is mostly limited to the deaf-mute community and the deaf-mute from another region or country often find it difficult to understanding a sign of another dialect, hence there is a need for interpreter or translator which is costly and not timing, although so many researchers have been working on different local dialect, therefore it is imperative to develop an intelligent recognition system for effective communication between the hearing impaired and the society. To the best of my knowledge there is no existing work on recognition or translation of HSL, this paper present intelligent recognition of HSL using PSO to enhanced features from Fourier descriptor using ANN for classification which gives us results of accuracy of recognition.

The rest of the paper is organized as follows; section 2 presents related work on sign languages, section 3 is on methodology, section four presents' experimental results, and finally, section 5 presents conclusion and recommendation.

LITERATURE ON SIGN LANGUAGE RECOGNITION

A lot of research work has been done on sign language recognition and so many methodology and different recognition accuracies have been recorded. An example is the Indian local sign languages [7], owing to the difference in grammatical rule of each language, using the same methodology for different sign language gave different recognition accuracy. Currently, there are several techniques that are applicable for hand gesture recognition with the invention of sensors. In [3], the authors developed an ARM9 sensor data glove [8] that will be connected to computer; it was applied on Chinese sign language recognition. They developed the hardware and the underlying software for data processing and feature extraction for recognition, embedded in the gloves. The approach was able to obtain a good accuracy but it is not natural to user or user's friendly, not cost effective and not error free.

Another recent approach is the Leap motion controller sensor. A small device that is connected to a computer through universal serial bus (USB), It has high accuracy and low cost unlike Microsoft Kinect sensor. Leap motion controller sensor [9] is used to capture data in series of snapshot called frames; each frame contains measured position, velocity and other information from the finger. [4] Worked on Arabic sign language recognition system that translates Arabic sign to test using leap motion controller sensor, the features extracted were fed into classifier for recognition. It was noted that non-manual sign language was not adequately covered; hence, it was recommended that other sensor should be used with leap motion controller so as to obtain higher and better recognition. Microsoft Kinect sensor is a device that is used to capture features from images of signs made by a signer and it is very effective for non-manual signs, [10] used Microsoft Kinect and leap motion controller to capture features from signers, the results gotten from the two features when combined and fed into classifier were better than when the features were used independently. The work was able to complement the limitation of leap motion controller by combining Microsoft Kinect sensor with leap motion controller. Apart from sensor-based recognition system, many works have also been done using vision based approach [11]. [12] Worked on Bengali sign language recognition system based on fingertips finder algorithm, the paper proposed a new algorithm for automatic Bengali sign language recognition system.

Vision based approached was used; images were captured and eleven features were extracted after preprocessing and segmentation [7], and fed into a multilayer feed forward neural network with a back-propagation training algorithm, the finger finder algorithm was able to record 91% accuracy in finger tips recognition.

Another important and fundamental stage in recognition process is feature descriptor. Feature descriptor can be either discontinuity based or similarity based. Discontinuity or edge based is mostly used for shape description since it is a contour based, that is, edge of the shape. Fourier descriptor is a contour-based descriptor; it is invariant to size or scale, translation and rotation which are the primary conditions used to know a good descriptor. There are many works that have used Fourier descriptor to extract features, [13] and [7] used Fourier descriptor and other descriptors to achieve better recognition rate, and [14] also used Fourier descriptor with 7hu moment for features extraction. The next section is on methodology used for intelligent Hausa sign language recognition using enhanced Fourier descriptor.

METHODOLOGY

The flow chart below shows the stages of implementation of the work.

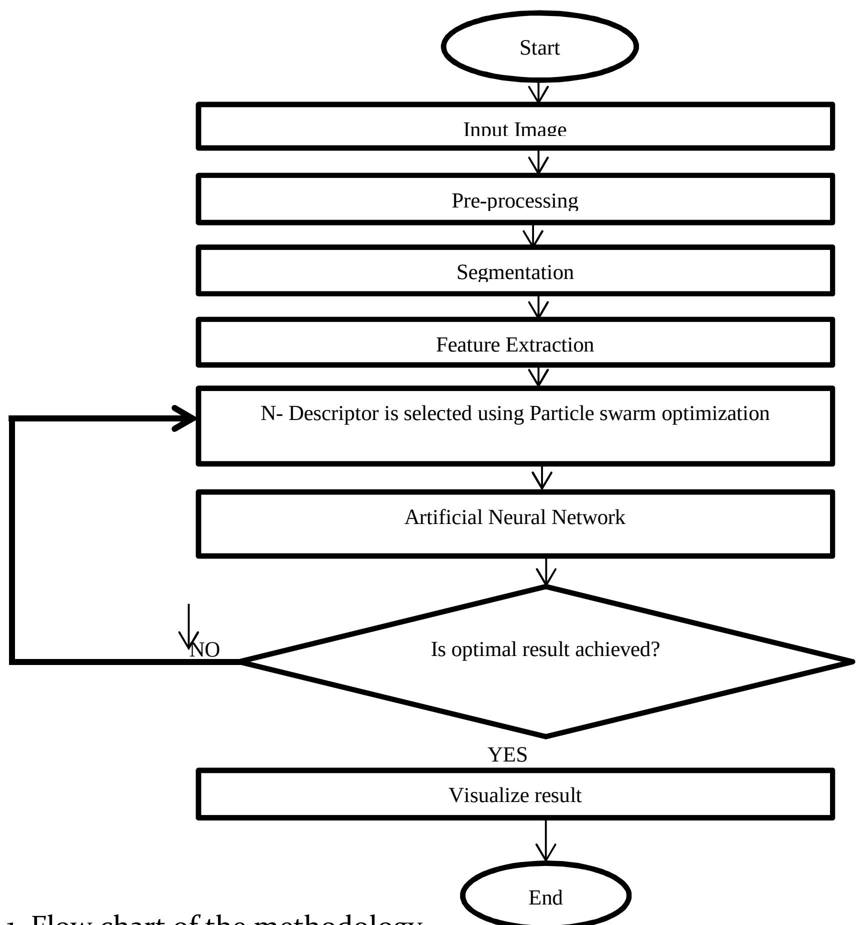

Fig. 1. Flow chart of the methodology

A. Input Images, Preprocessing and Segmentation

There is no source of Images or video standard dataset of HSL. Images were captured using RGB digital camera; the 21 captured images were static, manual and non-manual signs and they were labeled class 1-21 and each of the class has 10 samples. The captured images were resized to a uniform dimension 500X500. The images were converted from RGB images to gray-scale images with varied intensity of 0 to 255, and then, the images were converted to binary images. Thresholding (adaptive) method – the simplest method of segmentation was used in the said conversion and 7X7 median filtering was used to remove unnecessary noise. After these preprocessing and thresholding, we had segmented images. The Prewitt edge detection was used to detect the edges so as to obtain the boundaries coordinates – x and y coordinates.

B. Feature Extraction

For the features extraction, a contour or discontinuity-based shape descriptor is needed, we used Fourier descriptor because of its advantage over other descriptors. The Discrete Fourier Transform of the contour pixels is what made up of the feature vector which was gotten with the mathematical illustration in (1) and (2).

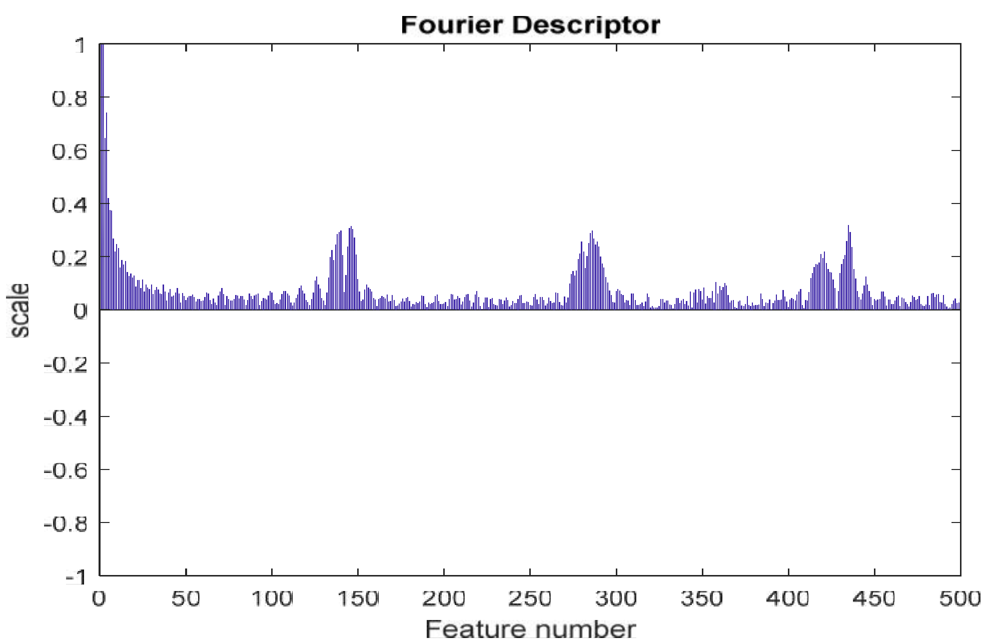

Figure 2: Fourier Descriptor plot

$$I(K) = [x_k + jy_k] \quad (1)$$

$$k = 0,1,2,\dots,k-1$$

$$a(u) = \sum_{k=0}^{k-1} I(k)e^{-j2\pi uk}/_K \quad (2)$$

$u = 0,1,2,\ldots,k-1$.

Where I(K) is the complex coordinate of the boundary pixels, K is the total number of pixels in the image, a(u) complex coefficient of the Fourier descriptor of the boundary coordinates [12], the information compactness of DFT and its rotation, translation and scale invariance properties added to the accuracy rate of the transformation. The Fourier transformation produce a complex output, the magnitude and the phase value, both are needed to preserve the information but most information is available at the magnitude of the spectrum, however, since no need for inverse transformation, only the magnitude value of the data was being considered. The fig.2 below shows the sample of the features extracted using DFT on the coordinates of the processed image.

C. Application of Particle Swarm Optimization

The Particle Swarm Optimization algorithm was used for the selection of the descriptors and it will check for best fitted global descriptors among all the swarm of the candidate solutions, the algorithm will ensure that the positions of the candidate solutions and the search for the best fitness are in order and keep memory of the previous event and that will enable the classifier to have highest and best recognition accuracy. The mathematical equation for the algorithm is as shown below:

$a_i =$ Candidates' solution (the descriptors gotten using Fourier descriptor).

$a_i = \{a_1, a, a_3, a_4, \ldots, a_D\}$

$$a_i(t+1) = a_i(t) + v_i(t+1) \quad (3)$$

$$v_i(t+1) = v_i(t) + c_1(p - a_i(t))r_i + c_2(g - a_i(t))r_2 \quad (6)$$

Where $v_i(t+1)$ is the vector collecting the velocity component of the its particle along the D-dimensions, $v_i(t)$ is the inertial components, $c_2(p - a_i(t))r_i$ is the cognitive component, $c_1(g - a_i(t))r_2$ is the social component, p is the personal best of the descriptor and g is the global or overall best of the descriptor.

D. Artificial Neural Network

Artificial neural network is a computational model inspired by the neural structure of human brain. A feed forward neural network in combination with a supervised learning scenario is used in this work. It is a back-propagation algorithm. The input patterns are given to the network through the neurons in the input layer and the output of the network is obtained through the neurons in the output layer. Training Phase; the neural network is trained to classify 21 static, manual and non- manual HSL. The training dataset contains 70% of the total data set. Testing Phase; in this phase, 15% of the dataset containing all the classes and the samples were used. Lastly, the Validation phase uses the remaining percentage of the dataset. Below are mathematical equations and explanations that illustrate the training and testing processes;

RESULTS AND ANALYSIS

This section presents the implementation results of the intelligent

Hausa Sign Language recognition system. The system was implemented on MATLAB R2015b on a personal computer. Experiments were conducted for 21 classes with 10 samples each for the static, manual and non-manual signs. 70% of the dataset was used for training, 15% for testing and 15% for validation. The results of the simulation are shown in the table 1 below and the corresponding plot in Fig 4 below, an average recognition accuracy rate of 93.9%. Eight, of the signs show 100% accuracy and the lowest percentage accuracy is 81%. Fig. 3 shows the Cross-Entropy plot showing best validation performance at 0.073834 at epoch 28.

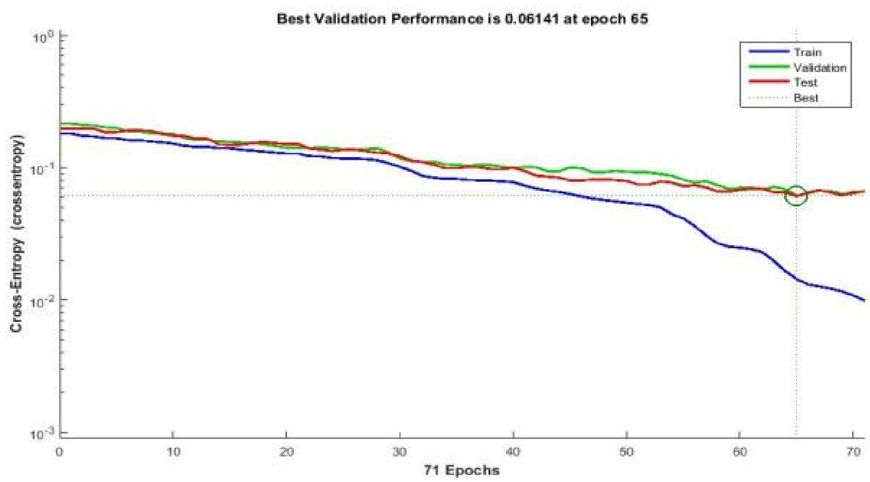

Figure 3: Cross Entropy Plot

CLASS	SIGNS	% ACCURACY
1	ALUBARIKA	100
2	ANABI ISA	90.0
3	BOYE	90
4	BABBAN MANJAMIA	90.9
5	BAKI	100
6	BABA	90
7	DANSANDA	90
8	FARI	90.9
9	GASKIYA	90
10	GWAMNATI	90
11	HUSHI	100
12	JAA	83.3
13	KANI	90.0
14	KOSHI	88.9
15	KUNYA	100
16	MAMA	81.8

17	MATA	100
18	MUGU	90.9
19	MUNAFIKI	100
20	RUWA	100
21	SHUGABA	100
	AVERAGE ACCURACY	93.9

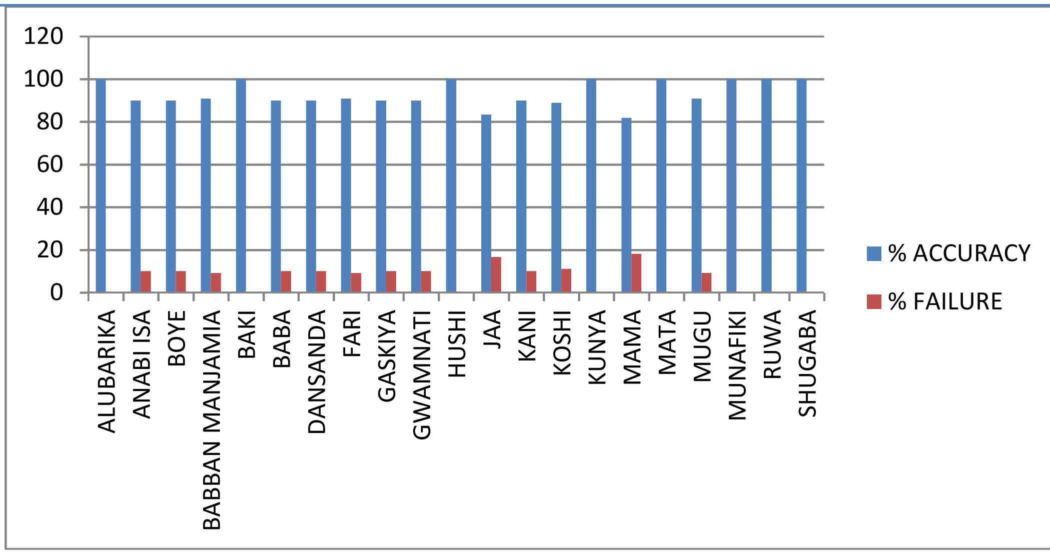

Figure 4: Plots of the Cent Percent Accuracy and Failure

CONCLUSION

Communication between the hearing impaired and the hearings is difficult without translator. We have not seen existing work on HSL recognition system. This work was able to develop intelligent recognition system for HSL using features obtained from Fourier descriptor. The features were optimized using ANN in order to check the fitness of the features. The average recognition accuracy obtained when optimized was impressive, thus, we have succeeded in developing intelligent recognition of HSL which in turn annihilate the barrier of communication between the deaf-mute and the hearings. It is recommended that consideration be given to dynamic signs in future work.

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