Higher Mathematics Sign Language Interpreter

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Abstract: ***One of the important problems observed in society is that the deaf mutes are finding it hard to cope up with the fast growing technology. The aim of proposed topic is to introduce new sign language gestures for higher mathematics. It also focuses on design of portable interpreting device which convert this math's sign language into corresponding text and voice. The flex sensors are used to identify the gesture. The change in resistance across each flex sensor is recorded as high or low resistance for each finger position. Arm Cortex M3 is used to process this data. Total 13 alphabets, 9 digits, 13 math's notation notations and 17 trigonometry identities are successfully interpreted by the module.***

Keywords: Math sign language, Flex sensor, Arm Cortex M3, portability

1. Introduction

The prevalence of deafness in India is fairly significant. It is the second most common cause of disability.According to an estimate there are 70 males and 50 female deaf-mute people in every 1 lakh population. Approximately 63 million people (6.3%) in India suffer from significant auditory loss[1]. According to 'Person with disability Act, 2011(working draft 9th February 2011 version 3) – all the persons with disability have a right to be provided aid and appliances of recognized quality at an affordable cost along with requisite training to utilize it.

Higher mathematics is different as compare to applied mathematics. The applied mathematics is easy to express in ASL but this is not the case with higher mathematic. This is because higher mathematic is the branch of mathematics which deals with problem arising in science and engineering. The proposed topic is new as no literature exists on the expression of higher mathematics in ASL. ASL mathematical vocabulary is not enough to express concept and techniques of higher mathematics [2]. Few of the dictionaries of math sign language are available but we could not find sign term used in higher mathematic. All though Texas math sign dictionary and ASL-STEM forum (2013) include more than 1000 maths terms, but very few of them are accompanied by sign glosses.

Using finger spelled abbreviation trigonometry function might be expressed in following way:
S-I-N S-Q-U-A-R-E T-H-E-T-A + C-O-S S-Q-U-A-R-E T-H-E-T-A = 1

It shows that finger spelled abbreviation can be as exhausting for the student to read.

In personal discussion with some of the teachers in deaf mute school in Aurangabad (M.S) it is observed that they are finding difficulty in interpreting lectures on mathematic even at high school level. Students are made to focus on practice exercises than on true problem solving situation. Therefore the Maharashtra state board had mild down the syllabus of maths at high school level. The 10th standard student appeared for the 7th standard maths syllabus at S.S.C Board examination. Practically observed scenario motivated us to design and development of proposed topic. The objective of proposed work is to design portable interpreting device which convert higher mathematics sign language into corresponding text and voice. The flex sensors are used to identify the gesture. The change in resistance across each flex sensor is recorded as high or low resistance for each finger position. Arm Cortex M3 process this data.

2. Survey of Literature

The under mentioned research reviews are related to my research topic but my research topic is specifically deferent in view that it works in real time "higher mathematics" sign gesture to speech and text conversion.

Christopher A.N. Kurz in his report[3] discussed on the pedagogical struggle of mathematics education for the deaf during the late nineteen centaury. Later in 2005[4] Joaquin Gimenez and Nuria Rosich presented the paper on improving geometry by using dialogic hypermedia tools.

Elizabeth Ray in her paper [5] reported that in order for deaf/hearing-impaired children to develop cognitively, particularly in a mathematical sense, the learning environment must have a wide range of meaningful mathematical experiences that are visually engaging and hands-on.

Foez M. Rahim, Tamnun E Mursalin, Nasrin Sultana[6] uses image processing system to identify, especially Bengali alphabetic sign language used by the deaf people to communicate. Initially the data is processed from raw images and clustered to accommodate similar pattern images into a clustered database. Later, two type's data were fed into the neural network. The output text files for 24 images with 10 clusters. The system is based on the command prompt interface which would be converted to a graphical user interface.

Another system entitled "Multi-Purpose Embedded Voice Assistance Gadget" was developed by S.Hariharan , S. Sriram Vignesh, Santhosh Shanker & B.Appoon[7] . It include speech recognition unit along with audio pre recorder and embedded controllers which will be helpful for deaf and dumb persons to express their needs to normal person. The frequently spoken words are stored in audio pre recorder which can be easily retrieved and also displayed using liquid crystal display.

An innovative idea was propose by[8] [11]P. Subha Rajama, G. Balakrishnanb by introducing binary sign language. This work proposes a method that provides the conversion of a set of 32 combination of the binary number Which represents the UP and DOWN positions of fiver fingers into decimal numbers and then converted it into corresponding Tamil letters i.e 12 vowels, 18 consonants and 1 Aayutha Ezhuthu.

Later in "A Static Tamil Sign Language Recognition System."[9] An image processing technique has been presented and designed for recognizing the signs of Tamil language for deaf-dumb persons. Instead of taking only static hand gestures additionally hand with facial gestures are taken. The results of the classification technique are evaluated with 91% accuracy. The work presented in this paper recognizes static signs only. The system deals images with uniform background, but it could be made background independent.

The glove based deaf-mute communication interpreter introduced by Anbarasi Rajamohan, Hemavathy R., Dhanalakshmi M[10][12][13]. The glove is internally equipped with five flex sensors, tactile sensors and accelerometer. The evaluation was carried out for ten beginners for letters 'A' 'B' 'C' 'D' 'F' 'I' 'L' O' 'M' 'N' 'T' 'S' 'W'. Word formation from letters is also performed using an end signal. The project can be enhanced to include two or more accelerometer's to capture the orientation of hand movements once the gesture is made. This will expand the capability to translate larger gestures.

3. Research Elaboration

System hardware consist of flex sensor mounted on five fingers of hand gloves. As shown in Table 1 below newly introduced maths sign language uses the combination of up and down position of fingers only, need of accelerometer is eliminated. The flex sensors are resistive carbon element which shows the property of change in resistance from 10Kohms to 30Kohms for normal to full bend condition. Thus for each gesture we get combination of high and low resistance which is converted to equivalent voltage using voltage divider bias circuit. Further voltage signal is provided to inbuilt ADC of the processor. This data can further processed via Arm Cortex M3 to display corresponding maths function. Processor is also interfaced with external memory. Depending upon voltage across each flex, processor checks the lookup table and accordingly fetched pre-recorded file from external memory to give audio output simultaneously. For equation formation processor is trained for mode selection to display trigonometry identity shown in table 3.

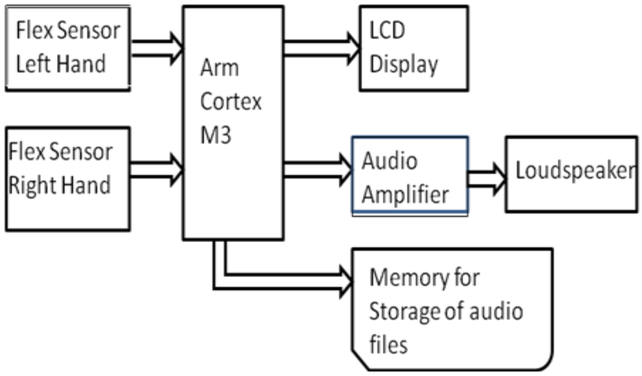

Figure 1: Block Diagram of Proposed System

The system is trained for the proposed signs. As shown in table 1 below the position of finger is either straight or bending. 10 flex sensor of 4 & half inch each is used to record the position of each finger. Though 1024 (2^{10})combination are possible with 10 fingers, at present we have attempted to expressed only 13 maths notation ,13 alphabets, 9 digits which are further used in combination to expressed 17 trigonometry function.

Table1: Proposed sign language for maths notation

Sr.No	Finger position of left hand [L,R,M,I,T]	Finger position of right hand [L,R,M,I,T]	Corresponding maths notation
01	0 0 0 0 0	0 0 1 1 1	Sin
02	0 0 0 0 0	0 0 0 1 1	Cos
03	0 0 0 0 0	0 0 1 0 0	Tan
04	0 0 0 0 0	1 0 0 0 0	(
05	0 0 0 0 0	0 0 0 0 1	)
06	0 0 1 0 0	0 0 1 0 0	^
07	0 0 0 0 0	0 0 0 0 0	ϴ
08	0 0 0 1 0	0 0 0 1 0	+
09	0 0 0 0 0	0 1 0 0 0	-
10	0 0 1 1 0	0 0 0 1 0	÷
11	0 0 1 1 0	0 0 1 1 0	×
12	1 1 1 1 0	1 1 1 1 0	∫
13	1 1 1 1 1	1 1 1 1 1	=

Table 2: Proposed sign language for English alphabet and digits 0 to 9

English Alphabet	Finger position of left hand [L,R,M,I,T]	Digits	Finger position of right hand [L,R,M,I,T]
A	0 0 0 0 0	1	0 0 0 1 0
B	1 1 1 1 0	2	0 0 1 1 0
C	0 0 0 0 1	3	0 1 1 1 0
D	0 0 0 1 0	4	1 1 1 1 0
F	1 1 1 0 0	5	1 1 1 1 1
H	0 1 0 1 0	6	1 0 0 0 0
I	1 0 0 0 0	7	1 1 0 0 0
K	0 0 1 1 1	8	1 1 1 0 0
L	0 0 0 1 1	9	1 1 1 0 1
U	1 0 0 1 0	0	0 0 0 0 0
V	0 0 1 1 0		
W	0 1 1 1 0		
Y	1 0 0 0 1		

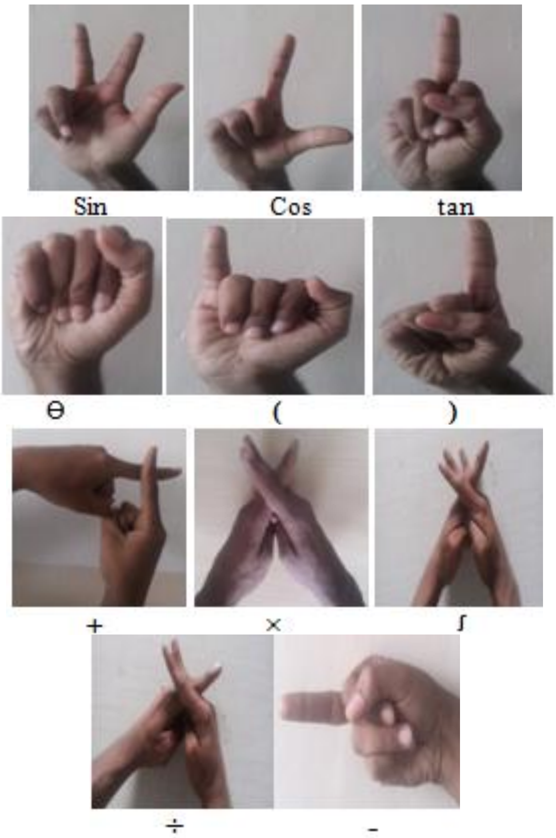

Figure 2: Gesture for sign proposed in Table 1.

Table 3: Trigonometric identities interpreted by the system

Sr.No	Trigonometric Identity
01	Sin ϴ
02	Cos ϴ
03	Tan ϴ
04	Sin^2 ϴ
05	Cos^2 ϴ
06	Tan^2 ϴ
07	Sin^2 ϴ+ Cos^2 ϴ=1
08	$Cos^2 \Theta = \frac{1}{2}(1+ \cos 2\Theta)$
09	$Sin^2 \Theta = \frac{1}{2}(1- \cos 2\Theta)$
10	Sin2ϴ=2sinϴcosϴ
11	Cos2ϴ = Cos^2 ϴ - Sin^2 ϴ
12	Sin(A+B)=SinACosB + CosASinB
13	Sin(A-B)=SinACosB – CosASinB
14	Cos(A+B) = CosACosB – SinASinB
15	Cos(A-B) = CosACosB + SinASinB
16	Cos3ϴ = $4Cos^3$ ϴ - 3Cos ϴ
17	Sin3ϴ = 3Sin ϴ - $4Sin^3$ ϴ

4. Samlpe Results

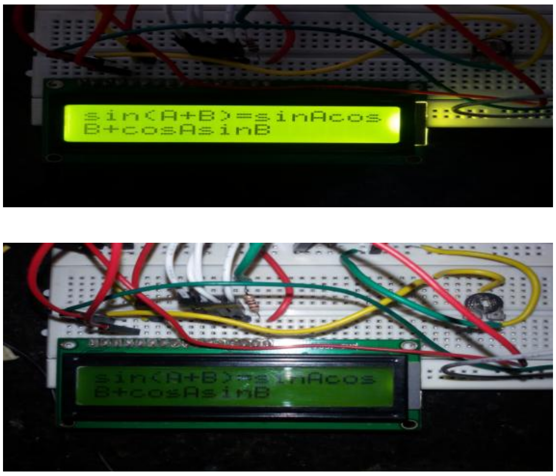

Figure 3: Trignometric identiy interpreted by the system

5. Conclusion

The proposed system has successfully interpreted 13 alphabets, 9 digits, 13 math's notation notations and 17 trigonometry identities It is hoped that the proposed system, which solely concerned with higher mathematics function will be the first one to explore the need and importance of system in deaf community. Learning mathematics will become learning like a language. For deaf/hearing-impaired children proposed language of mathematics features as their third/fourth language, using more than one language to express mathematical ideas is additive in itself. It will give sufficient proficiency in both languages, students are liable to have better understanding because they have two modes in which to think and communicate.

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