



**Department of Computer Science and Engineering**

**Thesis Report**

**On**

**Basic Bangla Sign Language Recognition and  
Sentence Building using Microsoft Kinect**

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## DECLARATION

We hereby declare that this is an original report written by us with our own findings, and has not been published or presented in parts or as a whole for any other previous degree. Resources and materials by other researchers used as guidelines for our research are duly mentioned in reference citations.

Signature of the Authors:

Signature of the Supervisor:

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## **Abstract**

How do a deaf of mute people communicate with each other? Or, even bigger question, how do they make other people understand their messages? The answer is, Sign Language.

It is not that easy, most people do not know sign languages. To improve that situation, there have been many researches going on to translate sign language into spoken language. The main purpose of our thesis was to build a system similar to that in Bangla language.

When one signs a language, he mostly uses his hands and head. The facial impression is also important. In our system, we tracked the skeleton with the help of Kinect. The system performs hand segmentation, finger identification and the number of fingers the signer has used using K-curvature algorithm while making the gesture. To determine the movement, the information about the skeleton joints is checked from the data set for each gesture. Finally the system shows the output for which the conditions are matched. Thus, the system recognizes the sign language gestures.

**Keywords:** Bangla Sign Language, Kinect, Skeleton Tracking, Finger Identification, K-curvature algorithm

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# Chapter 1

## INTRODUCTION

Sign language is a language which needs a simultaneous use of hand gestures, or directions of the hands and body, and facial gestures to deliver the speaker's thoughts. Moreover, sign language is a language that can be communicated manually. [1]

According to linguists, natural language has two forms- Spoken and Signed. Sign language differs from one language to another, though there is a misconception that it is universal. Just like spoken language, sign language has also gone through a wave of period and evolved.

### 1.1: Motivation

Communication with deaf and mute people has always been a challenge. Scientists all around the world had been working to come up with a proper way as a solution for a very long time. Sign language is used as the core of the deaf and dumb people. Children who are deaf by born, learn sign language as their mother tongue. It has come a long way since it started. They have vocabulary and grammar of their own.

Many forms of sign language are used all over the world now, since it is different for every language. But the field is still trying really hard to achieve its way in Bangladesh. Here, the schools for the speech and hearing impaired follow the formal sign language for Bengali deaf and dumb community developed by the Centre for Disability in Development. There has not been many research in this area, and the physically handicapped people are left out. So it was our goal to establish a better way for their communication through our research.

We chose a computer vision based approach. Our own technique , which includes skeleton and finger tracking with the help of Microsoft Kinect Sensor.



## **1.2: Objectives**

We have created a system for translating Bangla Sign Language into written form in our thesis. This system will perform as:

- Removing the barrier of sign language and spoken language.
- There are very few works in the field of Bangla sign language, our system will be of great help in our country.
- Deaf and mute people are neglected in this country. If they can communicate like regular people, the communication gap would be reduced massively.

## **1.3: Report Overview**

Chapter 1 contains the formal instructions for the report. This includes the introduction, motivation and objective of the proposed system. Chapter 2 contains the literature review; definition and history of sign language, Bangla sign language and works related to the field of translating sign language into spoken language. In chapter 3 there is the proposed method and the architecture of the proposed system. Chapter 4 contains details of the experimental setup, brief introduction of the equipment which are used for the proposed system. Chapter 5 contains the result. Chapter 6 contains the conclusion and the future work.

## Chapter 2

### Literature Review

#### 2.1: Sign Language: Origin

No one can answer the question- “Who invented the sign language?”; most likely it was the deaf community themselves. One of the earliest written records of a sign language is from the fifth century BC, in Plato's Cratylus [3], where Socrates says: “If we hadn't a voice or a tongue, and wanted to express things to one another, wouldn't we try to make signs by moving our hands, head, and the rest of our body, just as dumb people do at present?”. We can assume that the history of sign language goes further than this.

Humans have an unavoidable need for communication. Before language came along, people gestured to convey their messages. Even in some communities people use manual form of communication where language still does not exist. Sign language did not always have a smooth path. Up until 1960, it was not considered as real language.

Before 19th century, people only used manual alphabets so sign a language. It was just transformation of words from an oral to a sign language. Native Americans used one or more signed systems to communicate with each other. It was before 1492. These systems were a sort of “Lingua Franca”[3]. In 1500 or 1600, Turkish Ottoman Court were using a form of sign languages. They used to trust the deaf and dumb servants, because they were more trustworthy.

In 1620, Juan Pablo Bonet published ‘Reduction of letters and art for teaching mute people to speak’ in Madrid; which is considered the first modern formally concluded and ratified agreement of speech therapy and phonetics.

A French priest, Charles Michael De L’Epepe, was considered the “Father of Sign Language and Deaf Education”. He established the first school for the deaf in Paris. The school was free and was open for public. [3]

In the 1800’s, American Sign Language became prominent. The accomplishments in France and other European countries found their way to the U.S. through mainly two people, Laurent Clerc

and Thomas Hopkins Gallaudet. It was then developed into a modified form called American Sign Language (ASL).

ASL was not the only developed sign language. England developed BSL, Australia went forward with Auslan. Every form of sign languages has their own vocabulary and grammar. It is almost impossible to understand BSL for ASL using people unless they learn it. The signs are very different.

The origin of sign language has a vivid history. It started the official journey in France and has spread all over the world. We are very happy to inform that Bangladesh is not left behind anymore, we are going forward with our research as well.

## **2.2: Bangla Sign Language:**

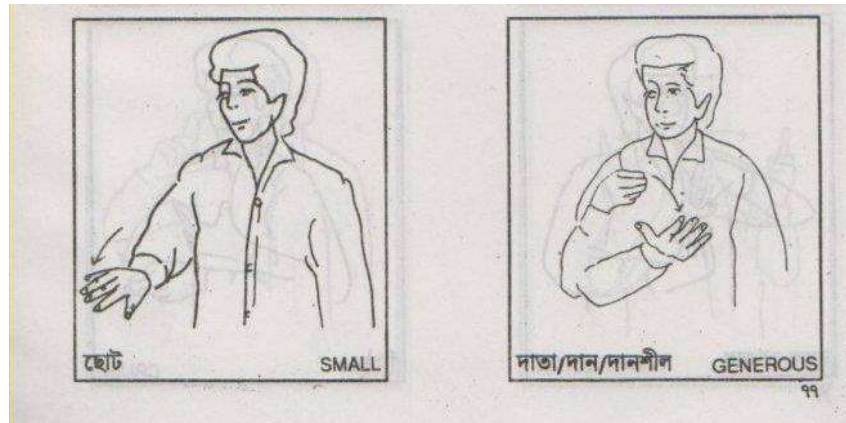
Bangla Sign Language (BSL) has started the official journey not very long ago. Centre of Disability in Development (CDD) has been working on this since the 2000's. CDD believes in working with disable people to improve their communication ability to strengthen their self confidence.

CDD started with spreading awareness and began to understand the disability using different communication methods. To make the people with disability express themselves, they removed the barriers to communication. They have developed Bangla Sign Language. Prior to 2001, there was only a modified form of ASL, BSL and Auslan and some aboriginal sing languages available. CDD now has a full set of sign language. [5]

Sign languages is not just about moving hands. It is nothing like pantomime. Signing a language to express one's feelings require not only the movement of hands, but also gesturing into the space and facial expressions.

We can discuss that over a few examples:

Moving hands in different ways is the basis of sign language. Same gesture, but difference in the movement means two different things.



**Figure 1.1: Hand moving downward to mean “Small” (Left). Hand moving forward to mean “Generous” (Right). Different movement of hands[6]**

Another important feature is signing into the space. It is like drawing a picture to show people what one wants, instead of a canvas, drawing the picture in the space. The signing space requires the area around head, belly and both arms. During a sign, if the person wants to refer to another person or a object, s/he just points at that particular person or object.



**Figure 1.2: Signing into space to mean “Build” [6]**

Sign languages have their own grammar. It takes a long practice to master this language. CDD has published a dictionary for Bangla Sign Language.

There are 51 letters in Bangla alphabet. For BSL, 38 signs are published for the letters. Rules are very specific for sign languages. But just like there are illegal combinations of letters in spoken languages, sign languages have sign outside of the rules as well. To understand what is said by the signer completely, the person has to use all components correctly.

### **2.3: Related Work:**

There are countless apps and devices to convert one language into another, but very limited work is happening in the world of sign languages. Sign language is not understood by most of the people, so there is a major communication gap between the signers and people who speak.. So to turn sign language into spoken language, some steps were necessary to be done. Scientists have been working with this for a long time.

First of all, around 1970's, the idea of a robotic hand occurred that could sign letters using wrist movement, but it failed [7]. In 1977, the robotic hand was finally developed and it could spell actual words using alphabets. In 1994, "Ralph" was built. Ralph- a computer controlled finger spelling hand. It used tactile sensor. It would perform the signs of finger spelling, and a non signer would type input on Ralph's display which is felt by the deaf and blind person [8].

In 1991, Takahashi and Kishino [9] developed a system of wired gloves to convert the movement of hands into messages. This system was only capable of recognizing hand shaped. It could not take the other features into account. This system required all words to be spelt rather than signed [4,9]. Their experiment could show 30 out of 46 pre- defined gestures of the Japanese Kana manual alphabet.

T. Starner, J Weaver and A. Pentland built two systems for recognizing sentence level ASL [10] in 1998. They used Hidden Markov Model for their research. The first of those two systems includes a desk camera. The user needs to face the camera and sign at it. This system achieved 92 percent accuracy. The second system has a camera on a cap worn by the user, which has 96 percent accuracy.

J.L. Hernandez- Rebolgar, N. Kyruakopoulos, R.W. Lindeman developed a system in 2004. They proposed a work based on Hidden Markov Model and Neural Networks [11]. To capture and translate isolated gestures of ASL into spoken and written words. The system was built using an AcceleGolve and a two link arm skeleton. Recognition rate was 100 percent for 42 postures.

A proof of concept ASL translator was designed by four people, Kin Fun Li, Kylee Lothrop, Ethan Gill, Stephen Lau in 2011 [12]. This project was for the empowerment of hearing impaired people and 3D video processing technique was used. It is mandatory for the translator to have a portable input device to capture gestures. Kinect device, used in XBOX, was applicable to this. There was a pre-built library with pre recorded signs. Kinect captured the 3D data of the joints of the user. Then the system would analyze it and match it to the the library. The matched signs would translate the sign to words. This system was very cost friendly and easy to use.

While a lot of progress in going on in the development in this sector, very little work has been done in Bangla. In 2009, 9 people made a software to translate Bangla words into gestures. B. Sarkar, K. Datta, C.D. Datta, D. Sarkar, S. J. Dutta, I. D. Roy, A. Paul, J. U. Molla, A. Paul developed a software to convert texts into gestures that a deaf can understand [13].

Scale-invariant feature transform (SIFT) was used by F. Yasir, P.W.C. Prasad, A. Alsadoon, A. Elchouemi in building a geometrically computational approach to recognize Bangla Sign language. In 2015, they applied Gaussian distribution and grayscale techniques to process the image. Then transform the sign image into spoken language. Then SIFT computes the k-means clustering, Each cluster represents a visual word [14].

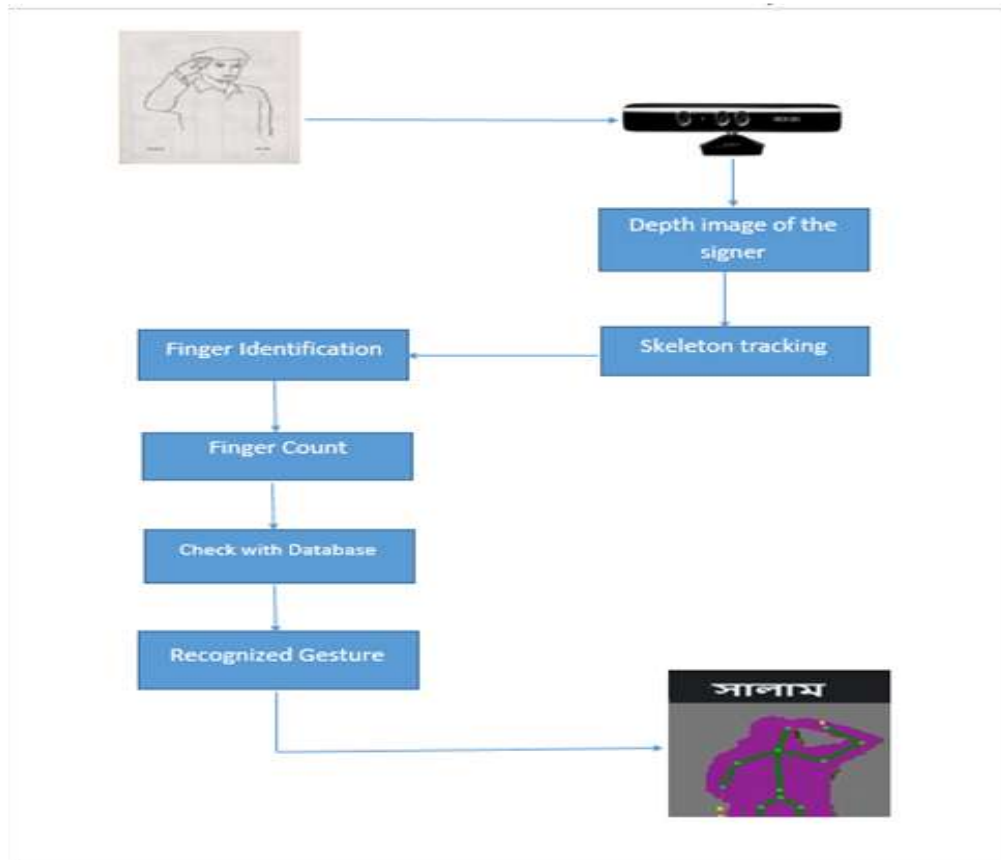
# Chapter 3

## Proposed Model

### 3.1: Architecture:

Figure (3.1) shows the architecture of the proposed system. The process of this system is given below:

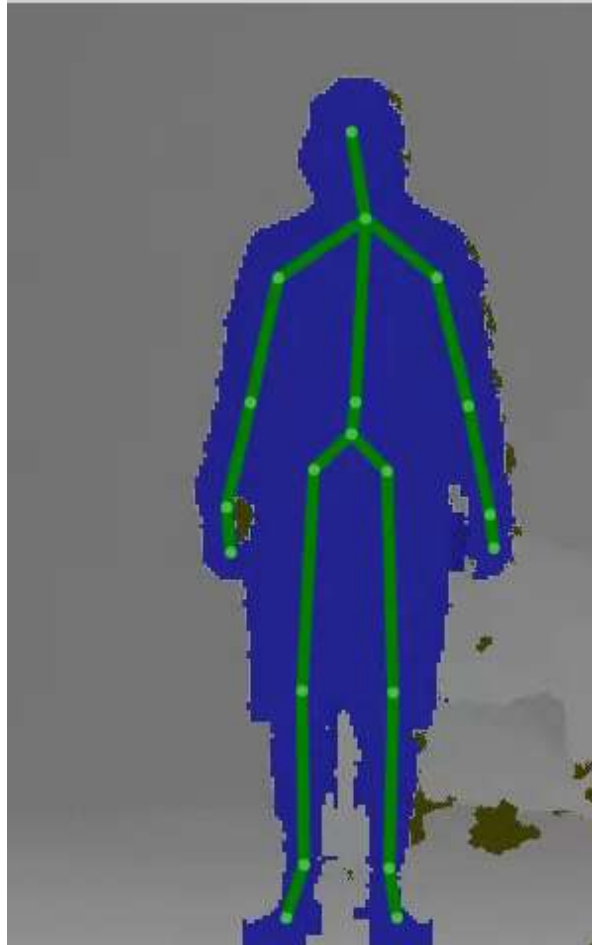
- 1) Signer performs a gesture
- 2) Kinect takes the depth image of the signer
- 3) Skeleton is tracked using the Kinect
- 4) Finger identification and counting is done using the K-curvature algorithm
- 5) Those data information are then checked with the dataset
- 6) If it matches with the dataset, that specific gesture is shown



**Figure 3.1: Architecture of the proposed System**

### 3.2: Skeletal Tracking

First, the depth image of the signer is taken and then Skeletal Tracking was done using Microsoft Kinect. Skeletal joints coordinates (head, shoulder, hand, leg, spine, hip, elbow) were collected from skeletal tracking for the purpose of the system.



**Figure 3.2: Skeletal Tracking using Microsoft Kinect Sensor**

### 3.3: Finger Detection & Counting

To detect finger, first we find the interior and contour (outline of the hand) pixels.

Then we check for palm center & fingertips if there's one or more contour found by using this:

- 1: if (null != contour)
- 2: palm = PalmCenter(interiorPixels, contour);
- 3: fingerTips = FingerTips(contour, palm);



To determine palm center, minimum euclidean distance between two pixels of contourPixels is calculated.

The formula for Euclidean Distance between two points that's used here:

$$\text{Euclidean\_Distance} = \text{Math.Sqrt}((\text{pointA.X} - \text{pointB.X}) * (\text{pointA.X} - \text{pointB.X}) + (\text{pointA.Y} - \text{pointB.Y}) * (\text{pointA.Y} - \text{pointB.Y}))$$

K-curvature algorithm is used to determine the fingertips for the system. First of all, the contour of the hand is executed. For this system, the value of K is determined as 22 and i is the contour point. The algorithm used to detect and count fingertips is given below:

- 1: p1 = [i - k];
- 2: p2 = [i];
- 3: p3 = [i + k];
- 4: A = p1 - p2;
- 5: B = p3 - p2;
- 6: **if** (angle > 0 && angle < 40 \* (π / 180)) //point2D angle of the vector points A & B
- 7: Midpalm = (p1 + p3) \* 1/2;
- 8: **if** (Euclidean\_Distance(Midpalm, palm) < Euclidean\_Distance(contour[i], palm))
9. fingerTips.Add(newPoint2D(contour[i])); //fingertip is added
10. return list.count //this would return the number of fingers



**Figure 3.3: Showing the finger and number of fingers found**

### 3.4: Proposed Method

Salam (সালাম):



For this gesture, the following conditions should be true:

The number of Right hand fingers used by the Signer has to be four for making this gesture. If the Z coordinate of Head is greater than the Z coordinate of Right Hand, if Y coordinate of right hand is greater than Y coordinate of shoulder center, if X coordinate of right hand is lesser than X coordinate of right shoulder, if Y coordinate of hip center is greater than Y coordinate of left hand.

You (তুমি):



For this gesture, the following conditions should be true:

The finger count of the right hand has to be one for this case. If the X coordinate of right hand is greater than the X coordinate of left elbow and the X coordinate of right hand is less than the X coordinate of right elbow. If Y coordinate of shoulder center is greater than Y coordinate of right hand and Y coordinate of right hand is greater than Y coordinate of hip center. If Z coordinate of right hand is less than Z coordinate of right elbow and Y coordinate of hip center is greater than Y coordinate of left hand.

Fever (জ্বর):



For this gesture, the following conditions should be true:

The number of fingers of the Left Hand used by the Signer has to be five for making this gesture. If X coordinate of right shoulder is greater than X coordinate of left hand and X coordinate of left hand is greater than X coordinate of left shoulder. If Y coordinate of left hand is greater than Y coordinate of shoulder center and Y coordinate of left hand is greater than Y coordinate of head. If X coordinate of left elbow is equal to Y coordinate of left hand and X coordinate of right hand is greater than X coordinate of right shoulder and X coordinate of left shoulder is greater than X coordinate of right hand. If Y coordinate of right hand is lesser than Y coordinate of hip center.

Age (বয়স):



For this gesture, the following conditions should be true:

If X coordinate of right hand is greater than X coordinate of left shoulder and X coordinate of right hand is less than X coordinate of right shoulder and Y coordinate of right hand is less than Y coordinate head and Y coordinate of right hand is greater than Y coordinate of shoulder center.

Barber (নাপিত):



For this gesture, the following conditions should be true:

The number of Right hand fingers used by the Signer has to be two for making this gesture.

If Y coordinate of right hand is less than Y coordinate of head and Y coordinate of right hand is greater than Y coordinate of shoulder center and X coordinate of right hand is greater than X coordinate shoulder right and X coordinate of right hand is greater than X coordinate of elbow right. And Y coordinate of left hand is less than Y coordinate of hip center and X coordinate of left hand is less than X coordinate of shoulder left.

What (কি):



For this gesture, the following conditions should be true:

If the X coordinate of left hand is less than the X coordinate of left shoulder and if X coordinate of right hand is greater than the X coordinate of right shoulder. If Y coordinate of hip center is less than Y coordinate of left hand and Y coordinate of shoulder center is greater than Y coordinate of left hand. If Y coordinate of right hand is greater than Y coordinate of hip center and Y coordinate of right hand is lesser than Y coordinate of shoulder center.

Brush (ব্রাশ):



For this gesture, the following conditions should be true:

The number of fingers used by the Signer has to be one for making this gesture.

If X coordinate of right hand is greater than X coordinate of right shoulder and X coordinate of right hand is less than X coordinate of left shoulder. And Y coordinate of right hand is greater than Y coordinate shoulder center and Y coordinate of right hand is less than Y coordinate of head. And Y coordinate of left hand is less than Y coordinate of hip center.

Food (খাবার):



For this gesture, the following conditions should be true:

If X coordinate of left hand is less than X coordinate of right shoulder and X coordinate of left hand is greater than X coordinate of left shoulder. And Y coordinate of left hand is greater than Y coordinate shoulder center and Y coordinate of left hand is less than Y coordinate of head. And Y coordinate of right hand is less than Y coordinate of hip center.

Hand (হাত):



For this gesture, the following conditions should be true:

The number of right hand fingers used by the Signer has to be five for making this gesture.

If Y coordinate of right hand is greater than Y coordinate of head. And Y coordinate of right hand is greater than Y coordinate of shoulder center. And X coordinate of right hand is greater than X coordinate right shoulder and X coordinate of right hand is greater than X coordinate of right elbow. And Y coordinate of left hand is less than Y coordinate of hip center and X coordinate of left hand is less than X coordinate of left shoulder.

Lip (লেপ):



For this gesture, the following conditions should be true:

The number of right fingers used by the Signer has to be two for making this gesture.

If X coordinate of right hand is greater than X coordinate of right shoulder and X coordinate of right hand is less than X coordinate of left shoulder. And Y coordinate of right hand is greater

than Y coordinate shoulder center and Y coordinate of right hand is less than Y coordinate of head. And Y coordinate of left hand is less than Y coordinate of hip center.

Peace (শান্তি):



For this gesture, the following conditions should be true:

The number of fingers used by the Signer has to be five for each hand to make this gesture.

If X coordinate of left hand is greater than X coordinate of left shoulder and X coordinate of right hand is less than X coordinate of right shoulder. And Y coordinate of left hand is less than Y coordinate of head and Y coordinate of left hand is greater than Y coordinate of shoulder center. And Y coordinate of right hand is less than Y coordinate of head and Y coordinate of right hand is greater than Y coordinate of shoulder center.

Punishment (শাস্তি):



For this gesture, the following conditions should be true:

The number of right hand fingers used by the Signer has to be five for making this gesture.

If Y coordinate of right hand is less than Y coordinate of head. And Y coordinate of right hand is greater than Y coordinate of shoulder center. And X coordinate of right hand is greater than X coordinate right shoulder and X coordinate of right hand is greater than X coordinate of right elbow. And Y coordinate of left hand is less than Y coordinate of hip center and X coordinate of left hand is less than X coordinate of left shoulder.

Song (গান):



For this gesture, the following conditions should be true:

The number of right hand fingers used by the Signer has to be two for making this gesture.

If X coordinate of right hand is greater than X coordinate of left elbow and X coordinate of right hand is less than X coordinate of right elbow. And Y coordinate of right hand is less than Y coordinate shoulder center and Y coordinate of right hand is greater than Y coordinate of center



hip. And Z coordinate of right hand is less than Z coordinate of right elbow and Y coordinate of left hand is less than Y coordinate of center hip.

Spectacles (চশমা):



For this gesture, the following conditions should be true:

The number of fingers used by the Signer has to be two for each hands to make this gesture.

If X coordinate of left hand is less than X coordinate of right shoulder and X coordinate of left hand is greater than X coordinate of left shoulder. And X coordinate of right hand is greater than Y coordinate shoulder left and X coordinate of right hand is less than Y coordinate of right shoulder. And Y coordinate of right hand is equal to Y coordinate of head and Y coordinate of left hand is equal to Y coordinate of head.

Surprise (অবাক):



For this gesture, the following conditions should be true:

The number of fingers used by the Signer has to be five for each hands to make this gesture.

If X coordinate of left hand is less than X coordinate of right left and X coordinate of right hand is greater than X coordinate of right shoulder. And Y coordinate of left hand is less than Y coordinate head and Y coordinate of left hand is greater than Y coordinate of shoulder center. And Y coordinate of right hand less than Y coordinate of head and Y coordinate of right hand is greater than Y coordinate of shoulder center.

They (তারা):



For this gesture, the following conditions should be true:

The number of right hand fingers used by the Signer has to be one for making this gesture.

If Y coordinate of right hand is less than Y coordinate of head. And Y coordinate of right hand is greater than Y coordinate of shoulder center. And X coordinate of right hand is greater than X coordinate right shoulder and X coordinate of right hand is greater than X coordinate of right elbow. And Y coordinate of left hand less than Y coordinate of hip center and X coordinate of left hand is greater than X coordinate of left shoulder.

Warn (সতর্ককরা):



For this gesture, the following conditions should be true:

The number of fingers used by the Signer has to be five for each hands to make this gesture.

If X coordinate of left hand is less than X coordinate of center hip and X coordinate of right hand is greater than X coordinate of hip center. And Y coordinate of left hand is less than Y coordinate hip center and Y coordinate of right hand is less than Y coordinate of hip center.

### 3.5: Sentence Builder:

Total number of sentence ID is used for this system is 8.

ID	Sentences	Words
1	তারা গান করে।	তারা + গান
2	তোমার বয়স কত?	তুমি + বয়স + কি
3	তুমি কি ব্রাশ করেছো?	তুমি + কি + ব্রাশ
4	সালাম তোমায়।	সালাম + তুমি
5	তোমার কি স্বর?	তুমি+ কি+ স্বর
6	তুমি কি খাবা?	তুমি + কি + খাবার
7	তোমাকে শাস্তি দিবো।	তুমি + শাস্তি
8	তারা অবাক হয়েছে।	তারা + অবাক

**Table 3.5.1: Sentence Structure**

For the system to recognize any of the 8 sentences that's been mentioned in the table, all those words (Gestures) has to be performed in that specific order. This process is shown below:

Gesture performed= “তুমি”

Sentence:

তুমি							
------	--	--	--	--	--	--	--

Matched ID:

1	2	3	5	6	7	8	
---	---	---	---	---	---	---	--

Gesture performed= “কি”

Sentence:

তুমি	কি						
------	----	--	--	--	--	--	--

Matched ID:

3	5	6					
---	---	---	--	--	--	--	--

Gesture performed= “খাবার”

Sentence:

তুমি	কি	খাবার					
------	----	-------	--	--	--	--	--

Matched ID:

6							
---	--	--	--	--	--	--	--

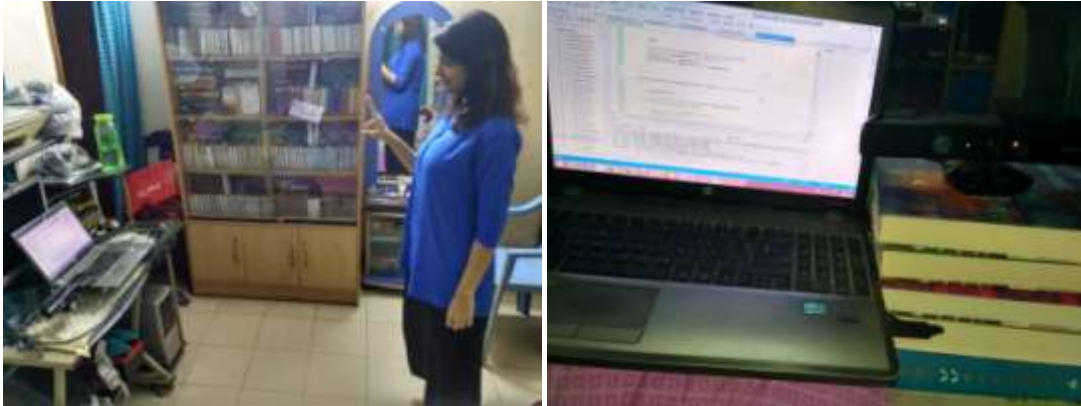
Thus we get the sentence from ID no. 6. This is how the sentence builder of the system works for all the other gestures.

For the purpose of proposed system, তুমি/তোমায়/তোমার, কি/কত, খাবার/খাবা are all the same.

## Chapter 4

### Experimental Setup

#### 4.1: Experimental Setup:

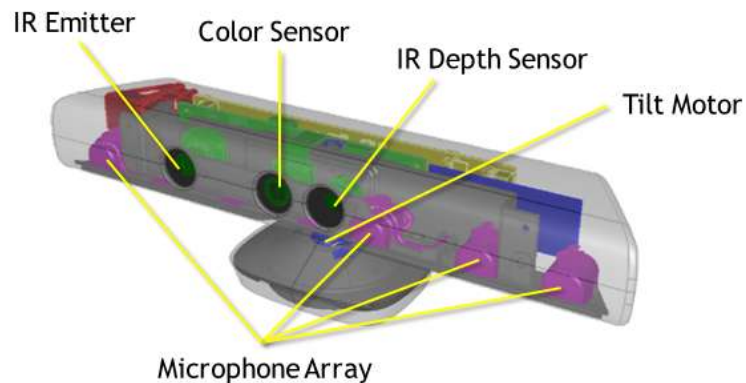


**Figure 4.1: The System Setup with Microsoft Kinect and Microsoft Visual Studio**

#### 4.2: KINECT

Kinect is a motion sensing input device. It was brought to us by Microsoft, in 2010. Inside the sensor case, a Kinect contains the following [16]:

- i. A RGB camera
- ii. An infrared emitter and an infrared depth sensor
- iii. A multi array microphone
- iv. A 3 axis accelerometer



**Figure 4.2: Kinect components [16]**

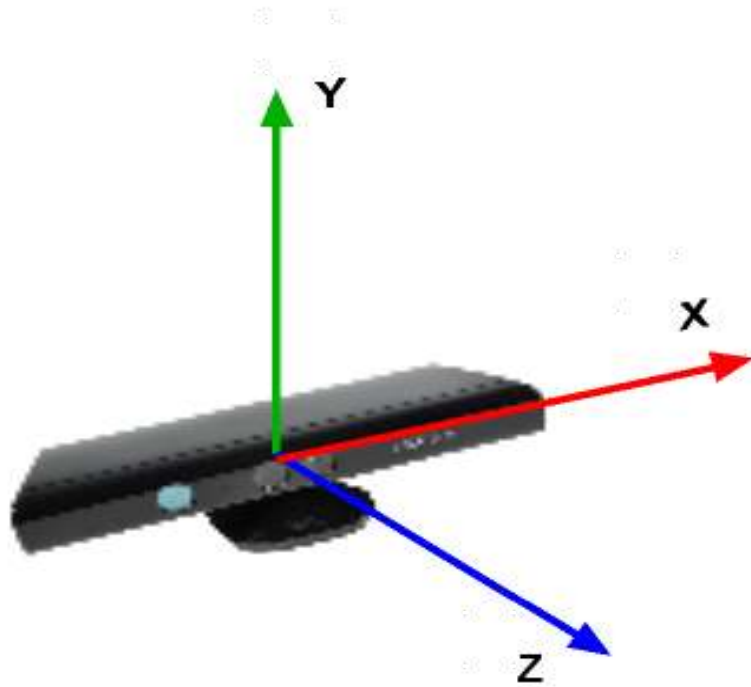
### Kinect Specifications:

Property	Specifications
Viewing angle	57° horizontal, 43° vertical
Vertical tilt range	±27°
Frame rate	30 FPS
Audio format	16-kHz, 24-bit mono PCM
Audio input	Four microphone array with 24-bit ADC
Accelerometer	2G/4G/8G accelerometer configured for the 2G range

**Table 4.2 (a): Kinect Hardware Specifications [16]**

Currently there are three frameworks available for Kinect. SDK and OpenNI by Microsoft, and Open Kinect from Prime sense. The frameworks cannot track one single finger, so it cannot distinguish between hand shapes. A multi touch display manufacturer, Evoluce AG, announced a multi gesture SDK for Kinect to overcome this issue [4].

For the proposed system, we bought the Kinect version 1 which is the 1414 model. Since it's for XBOX360, we had to buy an adapter to run Kinect on the Computer. The Kinect Sensor power supply did the trick for us. The main purpose of using Kinect for this project is to get the depth image as we can't get the depth information from a normal webcam device. So, Kinect was used in this project to get the depth data along with the Skeletal joints coordinates. The Skeletal joints coordinates information played a major role in completing our project successfully.



**Figure 4.3: Microsoft Kinect [17 ]**

We used Kinect to track skeleton. In SDK framework of Kinect, the system of coordination is on the sensor. These three coordinates X, Y, Z represents distance. X represents length, Y represents width, Z represents height.

### **4.3: Microsoft Visual Studio Version 11.0:**

Visual Studio is a software released by Windows which is used to debug, build and run codes in C++ and C# languages among others. This IDE is used to develop APIs, windows applications and web applications. The Code editor panel helps the users to run their code in the panel and then run it. Microsoft Visual Studio has got many built in tools as well which makes things easier for users to get their desired output or GUI. Because of its high flexibility and easier way of using, Microsoft Visual Studio is used by huge number of users for app or web development purposes.

For this system, We used Microsoft Visual Studio version 11.0. We did our coding using C# and to build the GUI We used XML coding. We included Kinect libraries in Reference of our project to build a connection between our project in Visual Studio and the Kinect device we are using. XML coding is done to get our desired GUI. After debugging and building the solution, we were finally be able to achieve our goal.



# Chapter 5

## Results

### 5.1: Results

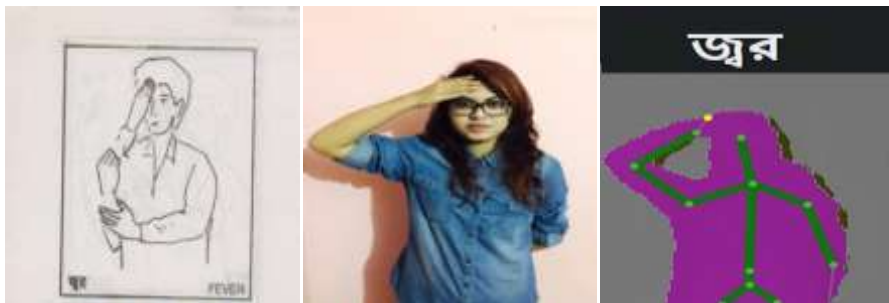
Salam (সালাম):



You (তুমি):



Fever (জ্বর):



Age (বয়স):



Barber (নাপিত):



What (কি):



Brush (ব্রাশ):



Food (খাবার):



Hand (হাত):



Lip (লিপ):



Punishment (শাস্তি):



Song (গান):



Spectacles (চশমা):



Surprise (অবাক):



Peace (শান্তি):



They (তারা):



Warn (সতর্ককরা):

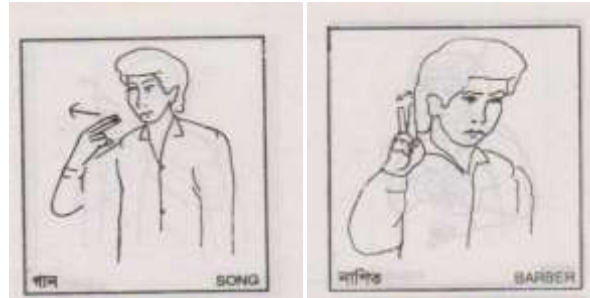


Now, in order to demonstrate the effectiveness of the proposed system using K-curvature Algorithm and skeletal joints coordinates here are few of the sample output given:



Figure 5.1: Sample Bangla Sign Language Recognition of the proposed system

One of the limitations of the proposed system is that, it has difficulties differentiating between similar type of gestures such as “গান” and “নাপিত” as signer has to show two right hand fingers to perform the gesture.



**Figure 5.2: Limitation of the proposed system**

# Chapter 6

## Conclusion

### 6.1: Conclusion and Future Work

The system signifies to interpret the sign language (known as non-verbal communication or non-vocal communication) of the deaf/ mute community and eases the communication process in their daily life. The easy interpretable system may facilitate the communication process to those who are unknown to the formal sign language and can certainly aid them to understand their needs, emotions and views better than the existing techniques. Best features of this system are that:

- 1) It builds sentences after signer performs the gestures
- 2) Gesture is recognized in real time and very fast
- 3) User friendly due to making words in sentence form.

There are practically countless possibilities for the betterment of the project in the future. The project can change the human perception towards the deaf/dumb. So, the concerned authority should provide proper support towards this kind of projects for the human welfare.

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