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Augmented Sign Language Modeling(ASLM) with interaction design on smartphone - an assistive learning and communication tool for inclusive classroom

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Abstract

Augmented Reality(AR) is growing as an acme of the cutting edge developments in the field of human computer interaction. There is a great potential in AR environments to serve as teaching aids in complementing and improving communication as not everyone is gifted to share their thoughts vocally(deaf-mute) due to physical in capacities.Keeping a pace with advent of technology there is a desperate need of cost-effective devices which could convert Hindi (one of the widely-used languages in India) Varnamala to sign gestures using 3D animated hand movements, to establish an independent learning as well communication facility for deaf/mute. The objective of this study was to create an AR application which could present 3D animated sign gesture on mobile system. When the camera is focused on a media-card, the letter marked on card will be spotted by the application and an animated 3D hand movement for the respective letter will be displayed in real-time.A quasi experimental design was used to assess the efficacy of the system and its resultant learning outcome. Evocative statistics were amended to investigate the data from the deployment of prototype. Experimental outcomes demonstrated a substantial improvement in sign language learning of the deaf-mute students. The initial hypothesis of augmented sign learning is effectually attained in this work and it can be further prolonged to cater to a wider assortment of teaching-learning scenarios.

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Keywords: Augmented Reality, Sign Language, 3D sign gesture, animated sign, Blender sign modeling, Inclusive interaction, Hearing impaired training(HIT).

1. Introduction

Since the dawn of the human civilization communication has existed in many forms. Humans started communicating through cave paintings that slowly emerged to be in the form of words, then drama which was further followed by the expressions. Coming to the present scenario several conflicting situations are stumbled upon, when people make

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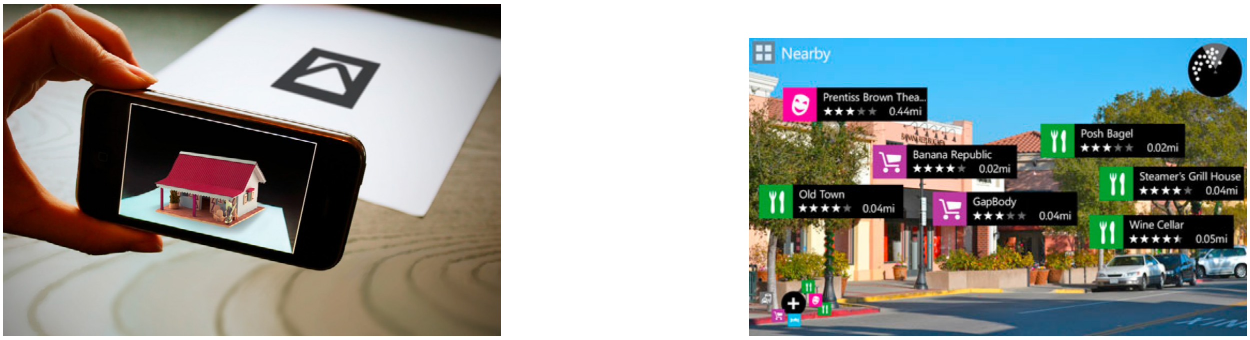


(a) Marker Based Technique.

(b) Marker Less Technique.

Figure 1: Augmented Reality multi layered information representation.

complex expressions or are not able to clearly express there vocals in the exact way their mind wanted to represent. Apart from this there are the people who are devoid of the capability to speak or listen, for whom communication functions are not met by vocals. Therefore, non-verbal means of communication are required, which would act as an ancillary for the speech. The central concern of this work is how to associate and use these technologies all together so that they could turn out to be more pertinent. Several recent studies have shown that both augmented and virtual reality can be used to help people with special needs [1]. Augmented reality gives an opportunity for the physically challenged to regulate and manage the information and acclimatize it easily to expand their interactions with the people around them, by bridging real and virtual objects in an environment, that runs interactively in real-time. Innovative ways for teaching the specially abled provided by augmented reality have been predicted by the educational academics that would empower the visualization of multifaceted spatial affairs and intellectual concepts which is quite difficult in the real world [2] and further advance the significant practices for learning that cannot be endorsed by using some other technology based learning environments [2]. AR follows two different methods for tracking the marker which is recognized to generate a 3D animated object. The first one being the Marker-based tracking technique that elucidates the computer to track the markers created and place the object 3D picture at the position it should be. This technique analyzes the connected components of the matrix code contained in the barcode-shaped markers and then the information obtained from the matrix codes is used to estimate the position of the camera, so that the marker position could be tracked [3]. The second method is the Marker-less techniques which uses the real-world pictures which serve as a marker. This image is then tracked by the camera, containing an array of points, lines, angles, and textures. This technique is generally considered as a problematic technique, because the detection marker is usually affected by the lighting, the characteristics of the object, and the disturbance which tend to affect the performance of the camera to a great extent at the time of detection [4]. Figure 1a and 7a shows an example of marker and the marker-less techniques. The system proposed in our experiment is based on marker-based technology. As found in our study, eighty-one percent of students had their own smartphones. So, it was decided to practice (Bring Your Own Device) BYOD tactic for the mobile smartphones to be used. The experimentation was carried out over ten students and two teachers to quantify the effects of using a AR system in contrast to outmoded systems to teach sign language. The affordance and acceptability of AR system was taken into deliberation. The response of the students and teachers involved in the experiment were evaluated. The results found presented that the students were extremely involved in using AR during the learning process. It was noticed that children were initially confused seeing the 3D hand in the AR view. They could only relate it after the teachers moved their own hands similarly to make them understand that it was similar thing showing on AR view. We have taken note of this usability hindrance. We have agreed to incorporate these changes into the next version of our application software We plan to use a full body human avatar in future and zoom in slowly on the hand to give the children a better perspective of the hand gestures. This should help them relate AR model with their own hands more easily.

2. Augmented Reality

The Researchers in the field of computer sciences and technology have defined[5]augmented reality in a diverse manner. Azuma in 1997 [6] demarcated augmented reality as a technology that accounts the real and virtual objects together in a real environment in 3D. It was in 1994 that Milgram and Kishino [7] delineated the concept of reality-virtuality where the augmented reality[8, 5] is considered just a slice of the mixed reality. Further in a broader sense he termed AR as, augmenting natural response to the operator with the simulated cues. Looking onto the restrictions implemented on AR Klopfer in 2008 [9] signposted that augmented reality should not be specified in a restricted manner rather it could be enforced to any such technology that brings together the real and virtual information in an evocative way[10, 11]. Klopfer stated augmented reality as the circumstance in which the real-world framework is dynamically overlapped with the virtual information[12]. The augmented reality in such situations has the capacity to provide technology-mediated experience which puts up the real and the virtual worlds in one-fold [13], thereby augmenting the intuition and interaction of the users [14]. For the researchers, defining AR in a broad sense would enable the augmented reality to be shaped and executed by various technologies[15, 5, 16], such as computers, mobile devices, head-mounted displays and many more [17]. AR has the ability to achieve the affordances of the real-world by providing added and relative data which enhances the students experience of the realism [2]. Augmented reality tends to simplify the life of the users by providing virtual information to the real environment which could be represented as a live-video stream. The virtual reality environment as termed by Milgram [7] engrosses an individual into an artificial world without having a look into the original one. The augmented reality on other side brings up the sense of reality by bringing together the virtual objects with the real world in the real time. AR represents meaningful digital information in the real environment apart from adding up the objects in the real world [15, 5] .

2.1. Augmented Reality on Mobile

Mobile Augmented Reality is one of the wildest budding research areas in Augmented Reality, somewhat due to the development of smart phones that provide influential and pervasive platforms for auxiliary mobile Augmented Reality. The mobile Augmented reality brings up a powerful user interface (UI) to augment the computing environments. Virtual data is assimilated by the mobile AR systems into physical environment so that the information could be alleged as prevailing in the surroundings systems without obliging the persons locations to a specifically fortified area. Preferably, it could work at anyplace, adding a tangible layer of information to the environment when looked-for. Mobile AR has the potential to transfigure the technique in which information is offered to the people. The mobile AR enables the objects on the computer systems to have direct interaction with the surrounding. The people around can interrelate with it to present the associated information, to position and resolve queries, and even for collaborating with others. The world in the recent centuries has become a user interface. Therefore, mobile augmented reality is implemented on the AR principles in mobile settings; which is away from the research laboratories environments. Some technologies like global tracking technologies, wireless communication etc. are used to bring them into practice.

2.2. Mobile Augmented Reality in Education

Augmented reality can assist a diversity of tenacities into a classroom. It sheets virtual content on the top of real-world, making the students to intermingle with the content in an entirely novel way. It's imperative to ponder augmented reality as more than just a ploy. Unquestionable, it clutches the students' attention, but meaningful learning must be sustained. Below are examples of few recently developed educational augmented reality applications [18]: -

- *Quiver:* Quiver[19] is a fanciful augmented reality app which lets the students go beyond the textbooks to interact with the 3D environments. The app contains coloring pages which enable the cells pop out and the children can then spin a ball in-flight.
- *Elements 4D:* This educational app[20] makes the students to bring together various elements to study chemistry in real-action. One can print and assemble the blocks which could become prompt images for an augmented reality experience.
- *Blippar:* Blippar [21] has been unified with diverse educational experiences. One of them being its implementation with Brainspace magazine. Its cover can be scanned and inside pages could be then linked with interactive

content that transmits life to the two-dimensional demonstration. It can completely transform a child's reading experience by pushing them to think deeply and explore the topic in a different way.
- *Arloon Plants:* This app helps the students to learn about the structure and parts of the plants and the students can even watch the growth and movements of a plant in an AR experience.
- *Math alive:* Designed for Pre K-3 students, this particular application uses augmented reality software which is installed on a computer, a camera, and some specific cards. The prompt cards are placed under a camera to exercise counting and rudimentary proficiency skills.

Bringing augmented reality into the classroom must ensure learning first and that the events attach to the learning objective and the technology has been tried before introducing it to the class. Augmented reality could not only hoist the learning but also invigorate everyday schoolings.

3. Analysis of proposal

Communication and educational growth depends on a language-rich environment. However too often, the hearing impaired children are deprived of such facility restricting them to communicate effectively with their peers and teachers. Because of their unique communication needs, its quite difficult for them to mingle in the inclusive environment.The teacher being the first communicator with the normal children, the special abled children sometimes lack the essence of education. On a contrary the slow phase deliberation of teaching-learning with the special abled makes it unmanageable for the teacher. In this work categorically it has been focused to equip the teacher and the students to interact in a regular temporal scale so that the interest in both the directions and actual need for teaching-learning process is imparted in the inclusive education system. Beside the inclusive education system an independent living is also challenged due to the physical limitation for the large sector of people in our society. One of the most common physical limitation is the hearing impaired which causes auditory impairment also. As these limitations leads to other physical confinement also therefore though the person is physically complete, still he is incapable of independently accomplishing a task. Even requiring requisite knowledge and acquiring professional degrees becomes a hurdle for such person . To compensate this gap initially the traditional learning system for hearing impaired people were studied which gave the opportunity to think of an automated system based on mobile and computer. The primary searching has revealed that internationally several countries have there standard teaching-learning systems including sign language and different applications available. The countries like India lack behind due to linguistic variation and geographical differences in communication for example a large variety of languages and posture and gesture support different activities for a single term. Henceforth, a system has been framed which will look into the generic description of a learning system for the hearing impaired and communication rather than making a specific application covering all the verbal languages. The main focus of this work was an interaction design for better teaching learning as well as communication with machine assistance. Hindi being one of the most spoken languages of India was used as the communication medium along with the assistive technology in order to depreciate the communication gap between the special-abled and the common people.

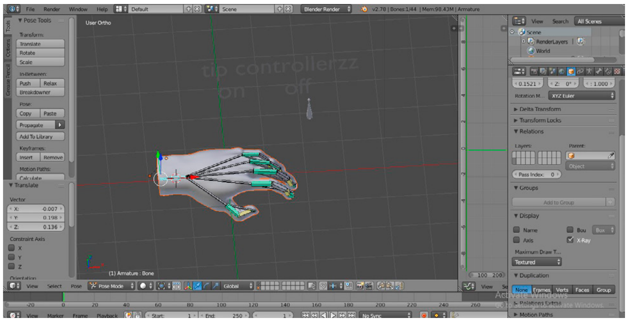
4. Proposed modeling

4.1. Design and modeling

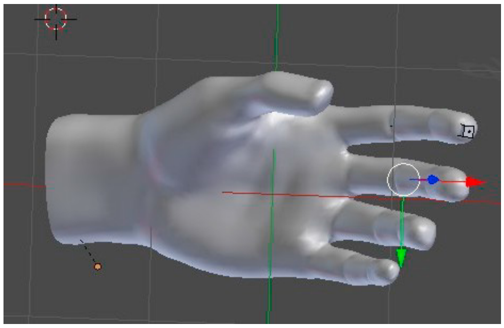
The initial design phase of the proposed system comprises of modeling and rigging the hand model. For designing and modeling hand model blender 2.78 was used. Further moving on to the second phase of designing which involved transferring the hand modelled in blender to the unity platform.

4.2. System Architecture Development phase

The system architecture development phase is categorized into the following six steps:- 1. Camera 2. Image capturing module 3. Image Processing module 4. Marker tracking module 5. Rendering module 6. Augmented display



(a) Mesh modeling



(b) Hand model after rendering

Figure 2: 3D hand modelled and rigged in Blender for Mobile devices

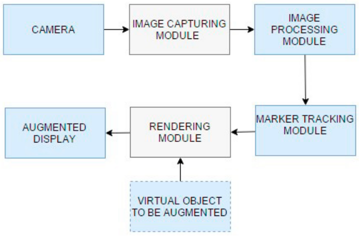


Figure 3: System architecture for the proposed augmented reality mobile application

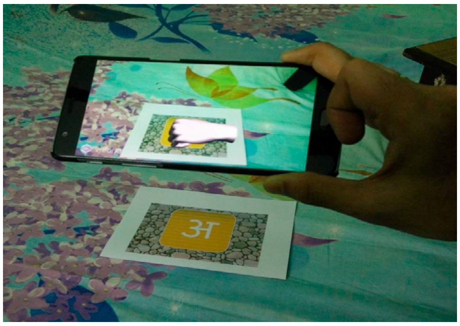


Figure 4: 3D Hand model triggered from 2D image marker

The camera is pointed over the marker and captures the image of the marker. The image capturing module analyses the camera feed and then generates the binary images which are provided as an input to the Image Processing Module. These binary images are managed and processed by the image processing technique to detect the AR Marker. Then comes the marker tracking modules which is responsible for tracking the location of the marker so that the corresponding animated 3D hand model for the respective marker could be displaced over the marker itself. The Rendering Module has two inputs, first one involves the calculation of the pose from the Tracking Module and other one the Virtual Object which has to be augmented. The Rendering Module combines these inputs and renders the augmented image on the mobile device screen.

4.3. Application Development

The application development phase of the proposed model comprises of the development of an Augmented Reality marker-based Letter Recognition Application in which a media-card containing a specific Hindi letter is used as the marker displaying information in the form of 3D animation of the hands motions of each letter. It allows users to learn the details of the motions of the letter cues. By studying the letters, the words can be interpreted by the user. The first stage of the application development involved uploading pictures of every marker in the JPG file format to the Vuforia Library. Then all the markers were downloaded and brought up together into a single database, which was in unity package file format. Unity Package which was downloaded from Vuforia was imported along with Vuforia-android and vuforiaimage targets-android to generate Augmented Reality application. The 3D hand models designed and animated were placed into Image Target Hierarchy and were accordingly arranged to match the marker. The media-cards once placed and matched to the 3Danimated hand models positions would display the 3D hand models in augmented reality interface. The application included the Varnamala menu containing all the letters of the Hindi Varnamala which could be scanned to display the corresponding 3D animated hand model. The menu has several other features including zoom out, zoom in and rotate that allows the motion of 3D objects to be studied with better precision and detail. The markers scanned can be amassed into a word afterwards.

5. Experimental Setup

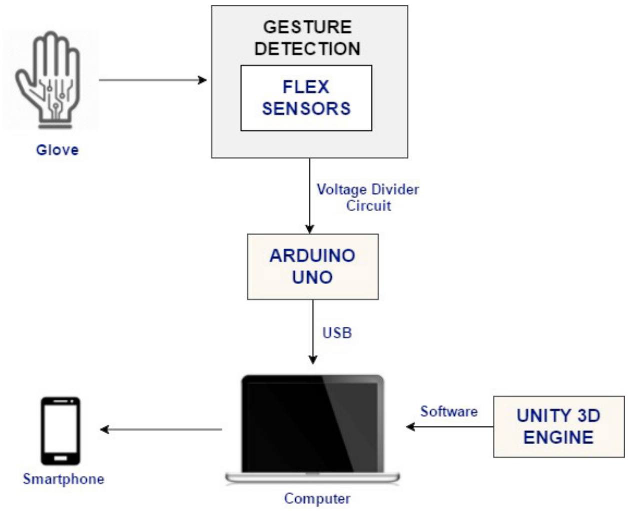
We have put our system through a preliminary field test to locate potential problems and issues. This also allowed us to document initial reactions from students and teachers when exposed to this new technology. The testing was done with a group of 10 children and 2 teachers from a local rehabilitation center in our state. The user profile for the disabilities were: 8 out of 10 children had speech and hearing problems. Of them, 4 required mobility assistance (wheelchair usage). 2 children had only speech problem. 6 children were in the age group 9-10yrs, and 4 in age group 11-12yrs. The two female teachers who participated in our test, both had over 10 years of working experience of teaching and assisting specially-abled children. None of the participants had any kind of prior experience with AR or VR based systems. The students were compensated for their efforts by providing a box of chocolates for each. The teachers declined to receive any gifts, citing that it was just a part of their daily work.

5.1. Procedure

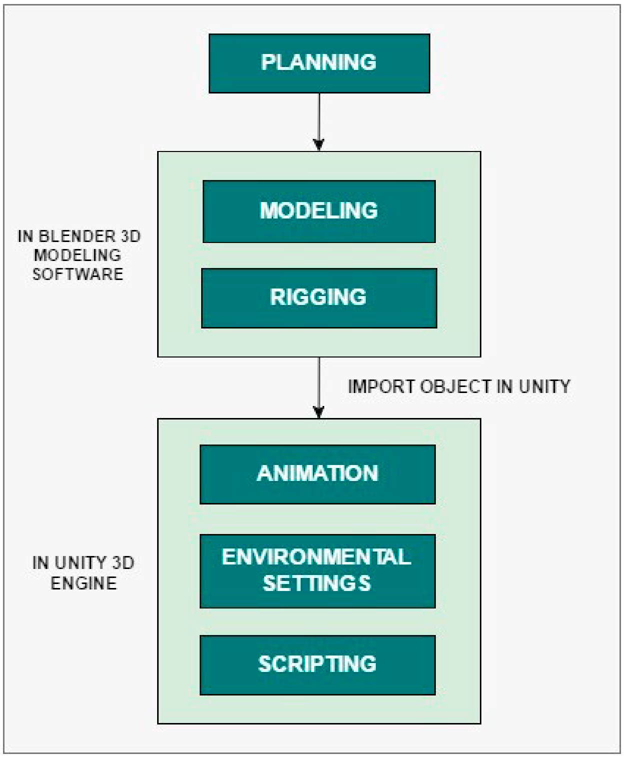
After taking demographic information regarding age, user profile, experience, the teachers were asked to conduct a short class of 10-15 mins using our AR system to teach the children and let them interact with it. The children were divided into groups of 5 chosen at random. Each teacher took one group of 5 for her class. The primary goal was to make the children associate the hand sign with the given Hindi alphabet. Because we dont have an existing system for Hindi sign language, it was their firsttime experience with Hindi. The mobile phone was first handled by the teachers and shown around the children. After a while, the children were allowed to take the mobile in their own hands and look the 3D model from their own perspective. After the class was over, they were shown the same alphabet printed on paper and asked to give the corresponding sign language.

5.2. Results

We noted down some interesting points from our small experiment. First of all, the children were extremely excited and enthusiastic about the whole experiment. This could be attributed to initial wow factor of AR/VR systems. How long this effect lasts has to be tested through extended experiments with much larger audience. However, this is a positive effect and helps teachers to easily direct the children into required tasks. As one teacher said, Today I didnt have to tell anyone to go into classroom, they were waiting when I went. Rarely seen them so much excited to start the class. After the short class, 4 out of 10 children were able to correctly reproduce the sign language with their hand gesture. 3 children gave slightly wrong gestures and 3 others didnt give a specific response. This was an impressive figure given that it was their first encounter with AR system, even for the teachers. Both the teachers complained that using a smartphone was too small for comfortable display among 5 children. We have noted it down to use large screen tablets in our future work. They also suggested that Hindi being a new language for the children, it was best if Hindi alphabets are shown in application UI with a relation to previously taught language like Bengali or English. We have agreed to incorporate these changes into the next version of our application software. It was noticed that children were initially confused seeing the 3D hand in the AR view. They could only relate it after the teachers moved their

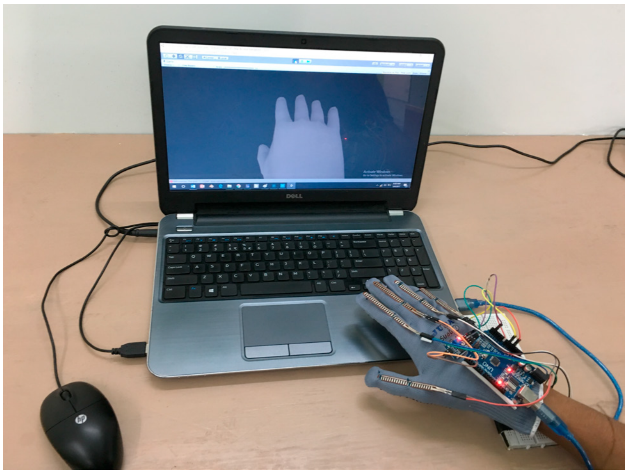


(a) Hardware module interconnection.

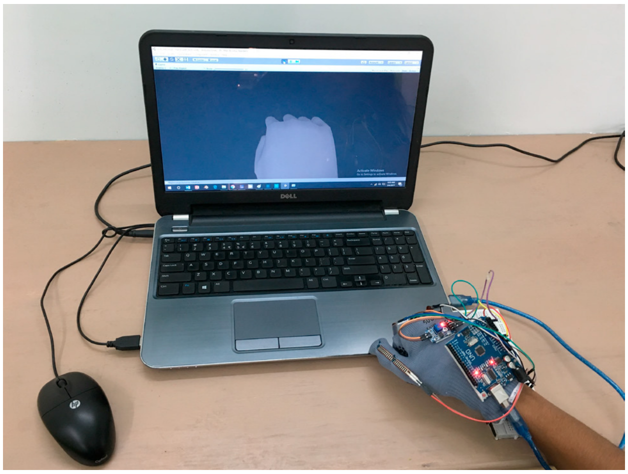


(b) Software module interconnection.

Figure 5: Application module interconnection and layers



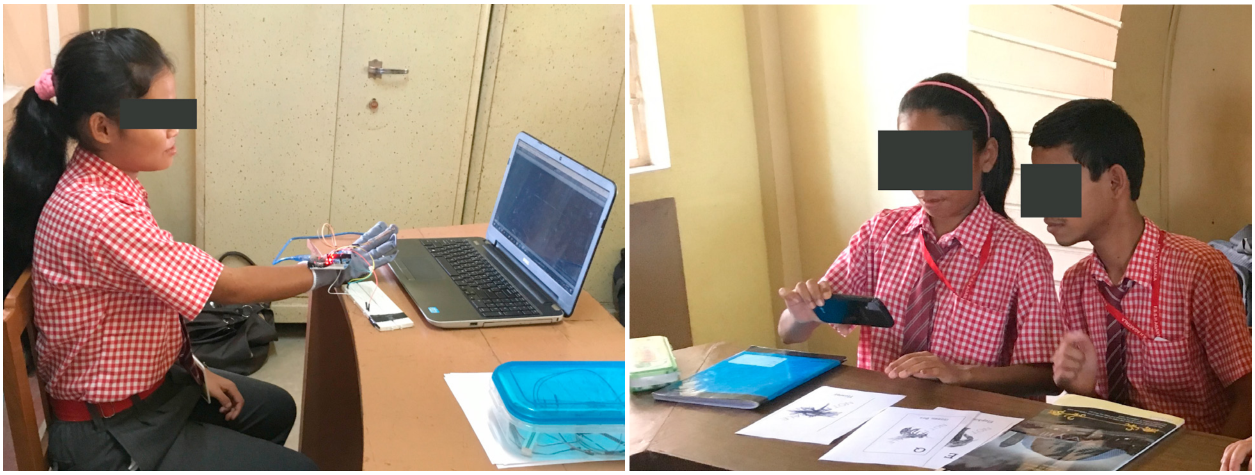
(a) Interaction Prototype stage 1.



(b) Interaction Prototype stage 2.

Figure 6: 3D hand modelled and connected to computer system using custom design glove.

own hands similarly to make them understand that it was similar thing showing on AR view. We have taken note of this usability hindrance. We plan to use a full body human avatar in future and zoom in slowly on the hand to give the children a better perspective of the hand gestures. This should help them relate AR model with their own hands more easily.



(a) Reverse movement of AR model on computer using glove. (b) Marker based 3D gesture understanding on mobile phone

Figure 7: Hearing impaired students are using the prototype.

6. Conclusion

The application proposed here is a marker-based technology that involves the recognition of the letter and displaying the respective 3D hand model on the Android smartphone. The objective of the proposed work is to facilitate learning of the letters of Hindi Varnamala and its corresponding hand gesture movements for sign language. Disparate to the other applications which usually display 2D images and are available for English letters only, this application is likely to assist users intended to learn Hindi letters in a playful animated augmented environment. This system can also be extended to practically implement the AR in real time classrooms interaction for the special abled students. However, it was observed that the children were primarily muddled seeing the 3D hand in the AR view. They could only relate it after the teachers moved their own hands similarly to make them understand that it was similar thing showing on AR view. We would try to overcome this usability hindrance. We also plan to use a full body human avatar in future and zoom in slowly on the hand to give the children a better perspective of the hand gestures. This should help them relate AR model with their own hands more easily. For future work, learning sign language with the marker-tracking techniques could be taken into consideration allowing the users to learn the hand gesture movements of the Hindi sign language.

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