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Research Article

Gesture Recognition through Android Interface for the Blinds

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Abstract: Blind people cannot actively participate in the society; due to lacking of using capability of latest technology. There is a need of an interface that may help the blind people in communicating with normal people by using latest technology. Human Computer Interaction (HCI) is a hot topic in research areas. This research provided such an interface which is helpful for blind people. A few devices have been designed for the blinds but their accessibility is limited due to specific design of the device. Therefore a standard interface is required that may be acceptable/ adjustable on any device. Mostly Braille language is used for the blinds for alphanumeric text input. There is a standard pattern used for each alphabet or digit. Android is most widely used platform for smart phones in these days. Research's focus is on the usage of Android for blind people by using braille language. Therefore, after researching about the blinds; braille and android suggested an interface based on gesture recognition. It will be operated by fingers movements like drawing the digit pattern on the screen and voice source's involvement is not there.

Keywords: Blind people, android, braille language, touch mobiles, gestures

1. INTRODUCTION

The Blind people are part of this world and due to their limited capacity of using latest technology just like normal humans; they cannot actively participate in the society. There is a need of an interface that may help the blind people in communicating with normal people by using latest technology. Several blinds have shown their endowment in many fields. Just because of communication gap, blind people are unable to become the active members of our society and a lot of talent is being lost. The treatment of completely blinds is impossible and we are inspired to develop an android based interface for blinds and its use will make their lives easy like normal human beings. A few devices have been designed for blinds but their accessibility is limited due to their specific designs. So a standard interface is required that may be acceptable/adjustable on any device. Few years back, Google introduced its mobile operating system (OS) namely 'Android' which has become number one choice for smart phones around the world. Android has overtaken windows and Symbian mobiles in terms of number of users and research agencies have confirmed this report [1, 3]. It's a Linux based Operating System and it is Open source. Reason of this popularity is that it is free of cost and its help is easily available. There are many applications in android available to disabled people. In these days 'Human Computer Interaction' (HCI) is a hot topic in research areas and it motivates me to research about the blind people's needs. Mostly Braille language is used for the blinds for alphanumeric text input. There is a standard pattern used for each alphabet or digit. In this research focus is on the usage of Android for blinds. The voice source is used for all applications used for call making and message creating for blind people. Still there is need of such an application that can be used without voice or some other resource. After conducting research on blinds, Braille and Android suggested an interface that will be operated physically by finger movement like drawing the

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digit's pattern on the screen. In it, there is no voice source involvement. Our proposed interface is proficient in taking information from screen. It will detect the image from screen and will extract the associated digit or alphabet with that image. It will extract information by using predefined patterns of comparing the image made by blind person by touching the screen and listening the voice generated by mobile that what digits or character he has entered in the mobile. After correctly entering the input, blind person will be able to make a call or sending a SMS on any number. This system will pass through different experiments and it will help to reduce the communication gap between blind people and society.

2. MATERIALS AND METHODS

The eye movement of a person can be used for communication. It can be very helpful for people who can't speak due to some hard stuff or deafness. By technical perspective, the phenomenon is that the cameras of our mobiles will detect the movements of eyes and a corresponding algorithm will take the eyes movement as an input and will match it with the action performed against it. Suppose if the eye moves up, it maximizes the screen and minimizes it as the eye moves down [1]. The more related application regarding this eye movement could be something like a message typed by eyes.

Facial expressions play an important role in expressing one's intentions and thinking. At the same time theyare an authentic and useful source to understand the feelings and intentions of a person who cannot express oneself verbally. The above mentioned application will be implemented in a way that only once we will record the expressions of a xyz person and will label these expressions as sad, smile, angry or what so ever [2, 4]. Blind people can be assisted in shopping. This is not a standalone/one-way system; the contribution of shopping malls is required in such a way that they should record the information against every product by tagging a barcode number [4, 9]. The blind user can retrieve the information by scanning the barcode through mobile camera and the application will voice that scanned information. GPS (Global Positioning System) is a worldwide service used to find location on earth [8, 11]. It has many applications like finding location of a specific place, nearest shopping center, bus stop, the shortest path, or to find the location of specific person having the GPS in his mobile by just sending a SMS (Short Message Service) or making a call. The human tongue is not only used for taste and talk but also for some other purposes. As our tongue freely moves in our mouth, it is useful for performing specific tasks [5]. Suppose a person can't move any part of body, a wireless sensor operating by tongue can perform this task. The sensor having buttons on it will be operating by tongue for moving the wheel chair. [11, 10]. The wireless sensor and its button's interaction with tongue are shown in Fig. 1.

Fig. 2 shows how different components of the smart home system are interconnected. User interacts with the system through user interface which communicates with a central control panel, there should be a component with functional Bluetooth and a transceiver for receiving and transmitting data from the user interface. For the sake of ease and accessibility; a system is designed that controls the wheelchair by using touch screen and voice functionality [9]. To implement/install this system, supporting components are installed on the wheel chair. User will simply touch the screen of mobile and it will perform different tasks like controlling the wheel chair. Disable people suffering from tetraplegia needs an efficient human machine interface centered on a camera for controlling an exoskeleton orthosis for upward limb movements [6]. It is optimized that how far an intelligent camera interface can be used for monitoring and controlling the interface for exoskeletonorthosis. A system is proposed that controls the association of mouse by capturing imagery of head movement by using a marker that is placed on the user's head.

Moreover, a special interface can be used for disabled people for interaction with a personal computer or a gaming interface etc. [3]. People

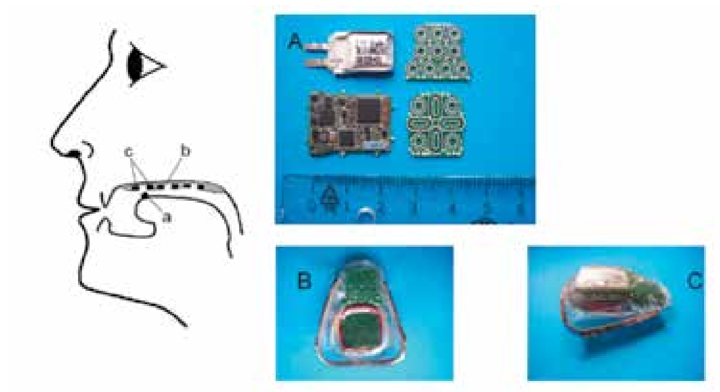

Fig. 1. Wireless sensor and its buttons interaction with tongue [5].

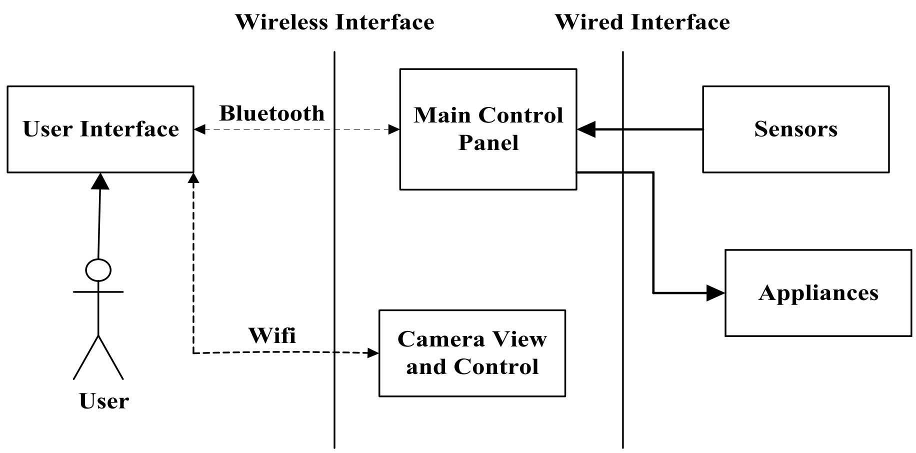

Fig. 2. Android based smart home system for disabled people [7].

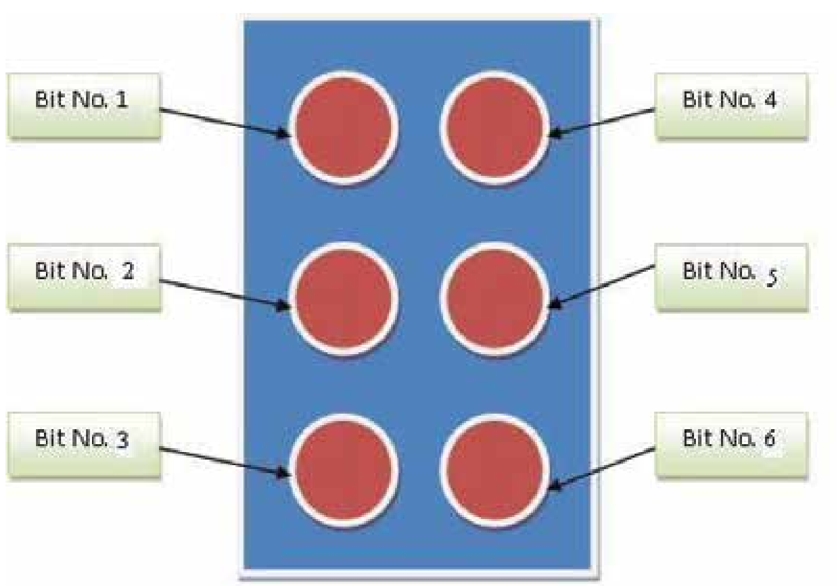

Fig. 3. Representation of braille cell [19].

having the disability of fingers are also assisted in android in such a way that they can use the system by just moving a small move of a single finger. Finger movements are monitored and perform actions accordingly, so that the disable user can use the computer normally [12].In the field of pain research, android provides a tool by the name of Pain Droid [13]. This is used to assist in pain assessment especially for the doctors and also for a lay man. A smart home system supports disabled persons in their domestic activities. A smart home system is developed such that it is wirelessly controlled by Bluetooth and Wi-Fi technology [7]. This application is adaptable to mobile phones and PDAs by using the Android OS. Basic purpose of this application is to control the switches of electrical devices through Bluetooth from a maximum distance of 25 meter from the main controller. Complete pictorial description of the system is presented in Fig. 2.

The blinds are considered sacred with supernatural powers in some nations, whereas in others blindness is considered as penalty for discourteous decent or public behavior. Negative perception about blindness results in the social barring and refusal of blinds. They have limited occasions for learning and service. This decreases self-confidence and creates a sense of insignificance in them. Estimated number of blind people in different provinces of Pakistan is given in the Table 1.

As a kind of disability; blindness results in joblessness, loss of revenue, large scale paucity, and low standard of life and non-affordance of health cautious facilities [18]. A lot of disable persons due to blindness are deprived of their financial efficiency and eminence of life. Visually impaired jobless persons are facing larger complexity of recognition in limited group of people. Moreover, carelessness from Govt. and community delays in delivering a healthy atmosphere for persons affected by blindness and prevents them to become the creative members of society. Both in rural and urban areas the no of males with disability is larger than females. This happens due to the more occurrence of child death among female children caused by social bias, deep rooted gender selfishness and liking for the male child within the households.

Table 1. Blind People distribution in different provinces of Pakistan [18].

Province	Estimated Number of Blind People
Punjab	769000
Baluchistan	52000
KPK	114000
Sindh	200000
Total	1140000

2.1 Braille Transcription

Braille is a tangible scripting system that is utilized by the blind and the visually impaired and it is utilized for signs, books, silo buttons and currency. Operators of Braille are able to read the screen of computers and other electronic provisions by refreshing Braille spectacles. Blinds are able to write down the braille with innovative stylus and slate or write it on a braille writer just like the movable braille note-taker. Blinds can also do it on a PC. Braille is a structure of encoding of printing in stamped dot shapes utilized for writing and reading by blinds. Every character of Braille has a cell of fixed size. It contains 2 columns of dots that are marked from top to the bottom 1, 2, 3 and 4, 5, 6. Representation of braille cell is shown in Fig. 3.

Spot images are used to represent the Braille characters; as an example we are listing the representations of the first ten Braille characters (a-j) of the alphabet. When they are headed through the marks for numeric entry then they also represent the ten numeric digits (1-9, 0). Representation of alphabets (a-j) and numeric digits (1-9, 0) shown in braille cell is given in Fig. 4. Overall there are 64 Braille characters with usage of space character. According to Library of Congress standard size of Braille cell is given. The reality that only sixty four Braille typescripts are accessible, it is obvious that

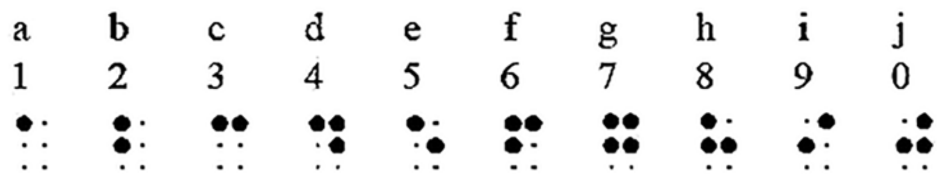

Fig. 4. How Numeric digit represented in braille [19].

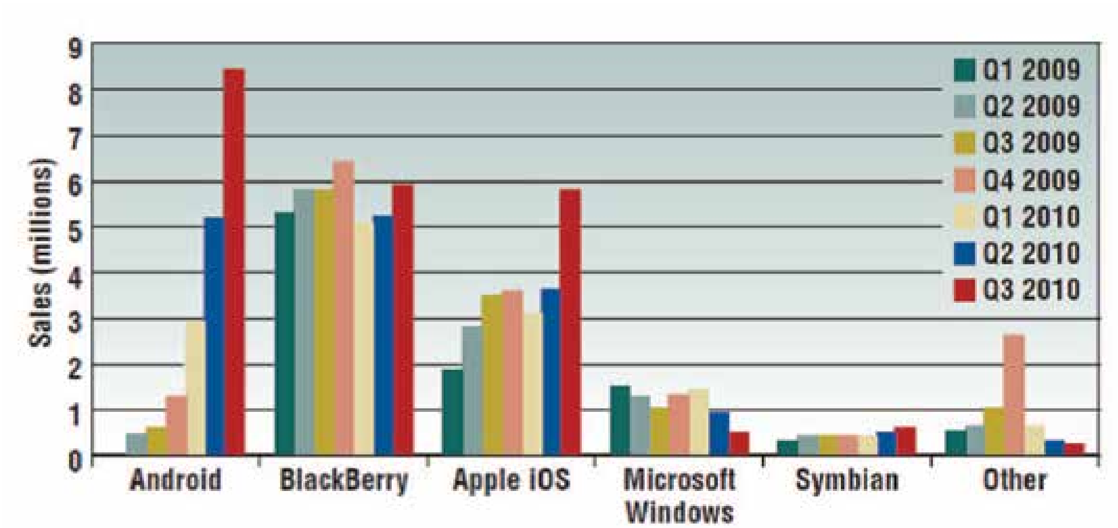

Fig. 5. Android mobiles sale in different time quarter [17].

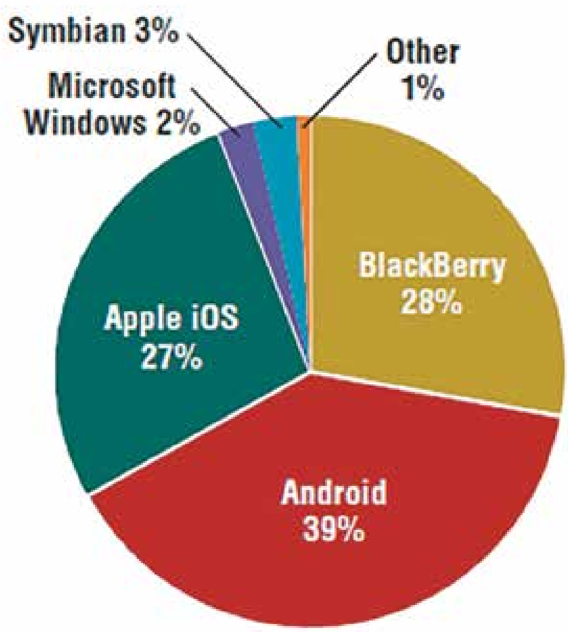

Fig. 6. Android market share in 2010 [17].

particular encoding guidelines have to be settled for diverse apps.

2.2 Android Platform Support

In March 2013, Android's share in the worldwide smart phone market, led by Samsung products, was sixty four percent. At the end of May 2013, forty eight billion applications were downloaded and installed from Play store of Google [14]. In July 2013, there were 11,868 models of Android devices, and 8 operating system types were at the same time employed. On September 3, 2013, total no of active android devices were 1 billion. As a result, instead of usage in tablets and mobile phones, android has further application for digital cameras, television games, consoles and other types of electronic devices. Android's Open nature has ensured huge society of enthusiasts and developers to utilize open source code as a base for public focused developments that affix latest capabilities for complicated consumers. Android mobile's sale is shown in Fig. 5 that is rising day by day as compared to other Mobiles.

So we choose Android platform for our application for Blind's Aid. Features like lenient licensing and open-source code let the software to be revised free of cost and spread by wireless carriers, manufacturer and support developers. Approximately there were 700,000 applications offered by Android in October 2012. Twenty five billion applications were downloaded from the Google Play and Android key Application Store. According to Developer's Analysis in May 2013, it came to know that Android is used by seventy one percent of the mobile developer population as the most admired platform. Linux kernel of Android's has an additional change in architecture by Google exterior to normal Linux kernel improvement series [15]. In 2010, Android turned into market head by 39 percent market shares as given in Fig. 6.

By using Android Software Development Kit (SDK), applications are developed in Java language. SDK comprises of a set of development tools, including software libraries, a debugger, example code, certification and tutorials. Although Linux-based development phase sparked the people attention, but there were further hesitations about Android in front of strong opposition from familiar companies in the smart phone marketplace; for example Microsoft and Nokia and opponent Linux mobiles OS[16].

3. RESULTS AND DISCUSSION

People with special needs are the part of our society. They cannot participate efficiently in our community due to lacking of communication abilities. The Blind people, due to lacking of using latest technology like normal people cannot actively participate in the society. Particularly when talked about blind people, their needs are different from deaf and dumb people. They need a standard interface according to braille language that is mostly used for blinds. Android based Smart phones and touch screen devices are mostly used in these days. A few devices have been designed for blinds but they limit their accessibility to specific designs of such devices. To achieve accessibility to all android based phones, a standard interface is required that may be acceptable/adjustable on any device. Mostly Braille language is used for blinds for alphanumeric text input. There is a standard pattern used for each alphabet or digit in braille. There are bundles of applications available on android regarding disabled people. The voice source is used for input in all applications related to call making and messaging for blind people. There are some drawbacks of such applications such as:

What will be if you are on such a place where noise is disturbing your voice?

What will be if you are going to write a message through voice and voice conversion to words is not accurate due to language problem?

The second thing which we are going to address in this research is the gesture recognition for blinds. After studying different gesture recognition algorithms and techniques, we come to know that they did not fulfill the needs of blinds as they need quick response for their input; so we propose a new technique for the recognition of gestures for blind people. Due to problems relevant to voice input as described above; a single-touch entry system is presented for touch screen devices. By studying different aspects of blind people's needs, Braille language and Android platform we designed an interface based on a specific gesture recognition technique that will help the blind persons to utilize latest technology with ease. With the application named "Application for Blinds Aid (ABA)", blind people will be able to enter input just like they were writing Braille by using the conventional Six-dot code in a matrix form. Braille System is very easy yet influential, in this system any character, can be developed by grouping of 6 or less than 6 dots. This system takes benefit of the information to permit user to enter transcript ordering into a solo display made up of six marks representing the Braille matrix.

An interface is designed for blind people in Android. A blind person can simply make calls and send messages using this system without voice input. User can move mobile in predefined direction and the application get started and enter into the call or message mode accordingly. The application will use the earth gravity to detect the user movement. User dial phone number by drawing digits on the screen. User can draw the digit in braille language on screen by moving his finger accordingly. Our application would be well-organized and efficient to take the information from screen. System will detect the image from screen and then extract the associated digit or alphabet with that image. Finally it will extract info from input by utilizing well defined pattern comparisons with the image drawn by blind person on the touch screen. The application process that drawn image and analyze the digits. After dialing the phone number or typing the message the user will make a call or send message. In addition, the voice output and mobile vibrations can also be implemented in such a way that voice output can be used to hear dialed number and vibration can be used to sense the drawn digit. Mechanism of image extraction from the screen is shown in the Fig. 7.

There are various techniques used to categorize and distinguish gestures as discussed earlier; however, all these techniques are not completely compatible with our problem associated with gesture recognition for blind people. A few researches have also provided the methods to achieve this goal. Although researchers have a number of constraints and limitations yet major difficulty of the real time or immediate gesture recognition process is their trust on a few suppositions to do work appropriately and these suppositions limit user's freedom of utilization. For example, providing few proficient consequences in the laboratory's atmosphere may not give the suitable consequences exterior to the laboratory. Therefore, an innovative technique for gesture recognition is developed called as *Gesture Recognition Technique for Blinds (GRTB).* The steps followed in this technique are given below:

1. User inputs the braille combination for digit; the entered pattern is then matched with sample space's quintile values and then concentrate on standard deviation of the entered pattern with quintile value of the sample space.
2. Next step is to setup a threshold value (that is the greatest deviation value a gesture is able to contain) and based upon threshold value we locate the lowest variation of the sign with the sample space.
3. If lowest or smallest deviation is lesser than the threshold value then the sign is classified for that digit and take into account as that gesture has least standard deviation from the threshold value.
4. When a latest gesture arrives which is not registered and it does not match with the sample space then an audible error message will be generated.

Our recently developed system appears as the adaptation of above procedure, this system is nowadays broadly accepted in touch mobile devices. In this system, the screen of a touch mobile serves as the depiction of Braille cell that contains 6 big dot targets which represents all the dot positions.

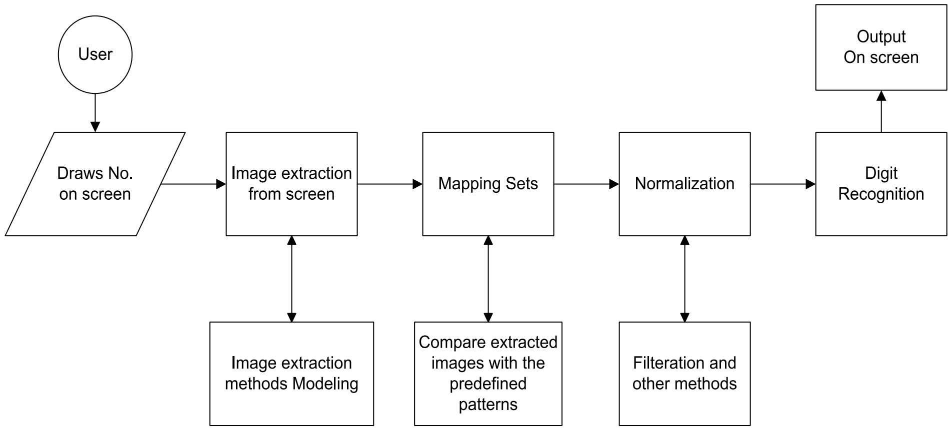

Fig. 7. Extraction of digits from screen.

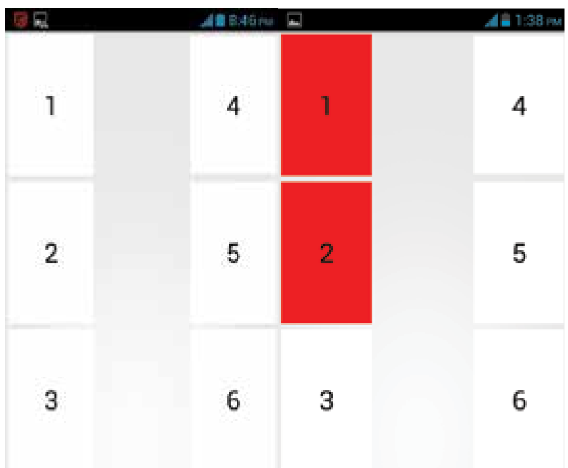

Fig. 8. Representation of the six target zones and how user makes entry.

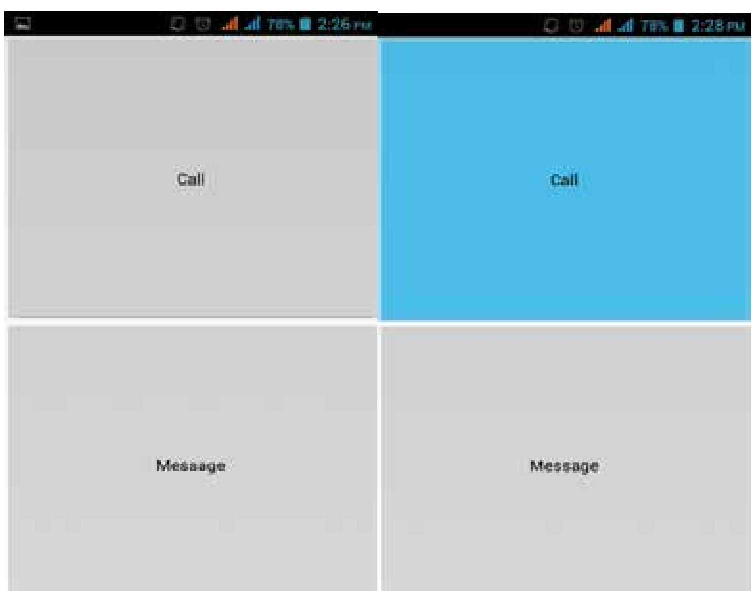

Fig. 9. Interface for selecting call or message mode.

To permit a simple and easy search, these dot targets are set large and are mapped to corner and borders of mobile screen. As these targets are also represented according to the well-recognized and predictable Braille cell, therefore targets becomes easy to locate. Six target zones visual depiction and how user makes entry in show in the Fig. 8.

To maintain the system straightforward and simple, multi touch practices are ignored. Every communication by this system is prepared through solo touch input. Every time a user press or drag his/her finger to the new target then the succeeding dot number will vibrate on selection, but the target will not instantly elected. A little clock is incorporated to avoid unconscious selections from the user and a double tap in center will ensure that user has completed the selection of braille pattern. In the Braille cell, to spot a dot the user simply hasto touch a target and there will be a vibration prompt for confirmation. If he repeats this process on a dot which was previously selected then it would eradicate its selection. Once the essential spots for Braille character will be marked in either category that user wishes then it will be accepted by a double tap in the center of screen. In the developed application "Space" key is obtained by empty Braille cell entry. When user attempt to allow a wrong arrangement of buttons then Braille matrix will be clean and a fault sound like "No Such combination exists" will be announced.

Swipe on left side will clear the entered Braille cell if partially dots are marked in the past or it will delete previously entered character if there is no selection made for any cell. This technique seeks to present a fewer tense initial approach by means of the touch mobiles by dipping amount on the screen target. Through minimizing amount of faults and enable the users to be successful, we would coagulate their assurance and will let them go beyond. Moreover, we can plan to gain the advantages of capabilities of those people, who use Braille on the usual base, however it also permit those persons who did not learn or conserve Braille practice throughout simple everyday connections.

Extracted features are utilized to categorize gestures and to make conclusion on the basis of data group, after applying the feature extraction and segmentation techniques. Gesture recognition is a stage where data investigated from the pictorial figure of sign is documented or categorized in a specific gesture. This stage includes pattern recognition techniques and methods [20]. Classification technique can be divided in two portions, Machine learning methods and Rule based methods. First method is aptitude based or machine learning present disciplined and vigorous mapping among the feature set of highest dimension and gestures. Because of this reason the machine find out the gesture's model from the provided training set rather than by means of brain just like human being. Second method is the rule based approach that follows a few rules that are fixed or determined by particular researchers manually [21]. Gestures extracted from pictorial images are acceptable if the extracted features fulfill these statutes and if the statutes are fulfilled then gesture is documented as predefined.

Cutler et al. suggests a system that utilizes object identification approach based on rules and also suggests 6 rules to differentiate 6 gestures only. Still, dissimilar boundaries are there and it's too hard to utilize. It's not capable for real time apps. It's extremely hard to retain in mind rules and then follow them and describing the rules on runtime, it will increase the calculation expenses and performance problem. We use our newly developed gesture recognition technique for the extraction of features and recognition for specific pattern drawn by blind people on the mobile screen. We have compared the principles of gestural interface for different application for blinds with our newly developed Gesture Recognition Technique for Blinds (GRTB) and different parameters have been considered in context of this comparison, by considering their shortfalls, we can improve them in our new Gesture Recognition Technique. In Table 2, a detailed comparison against different features is given.

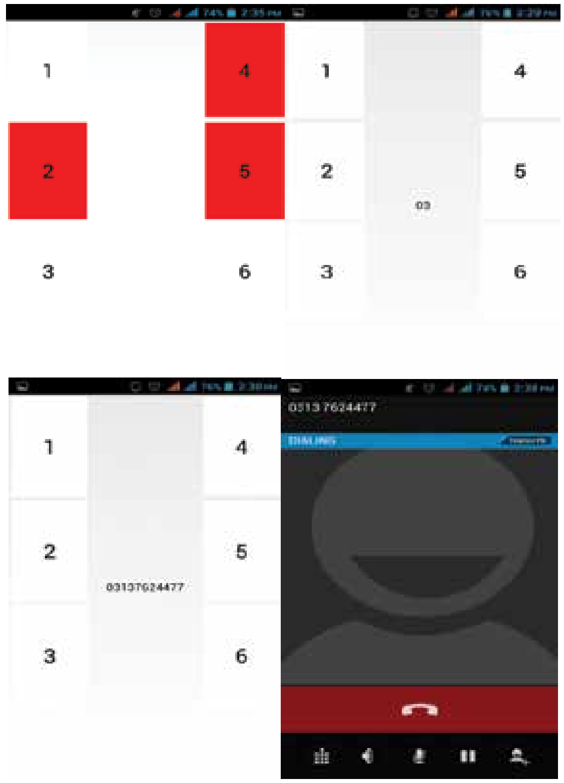

Fig. 10. Making a call on a mobile number.

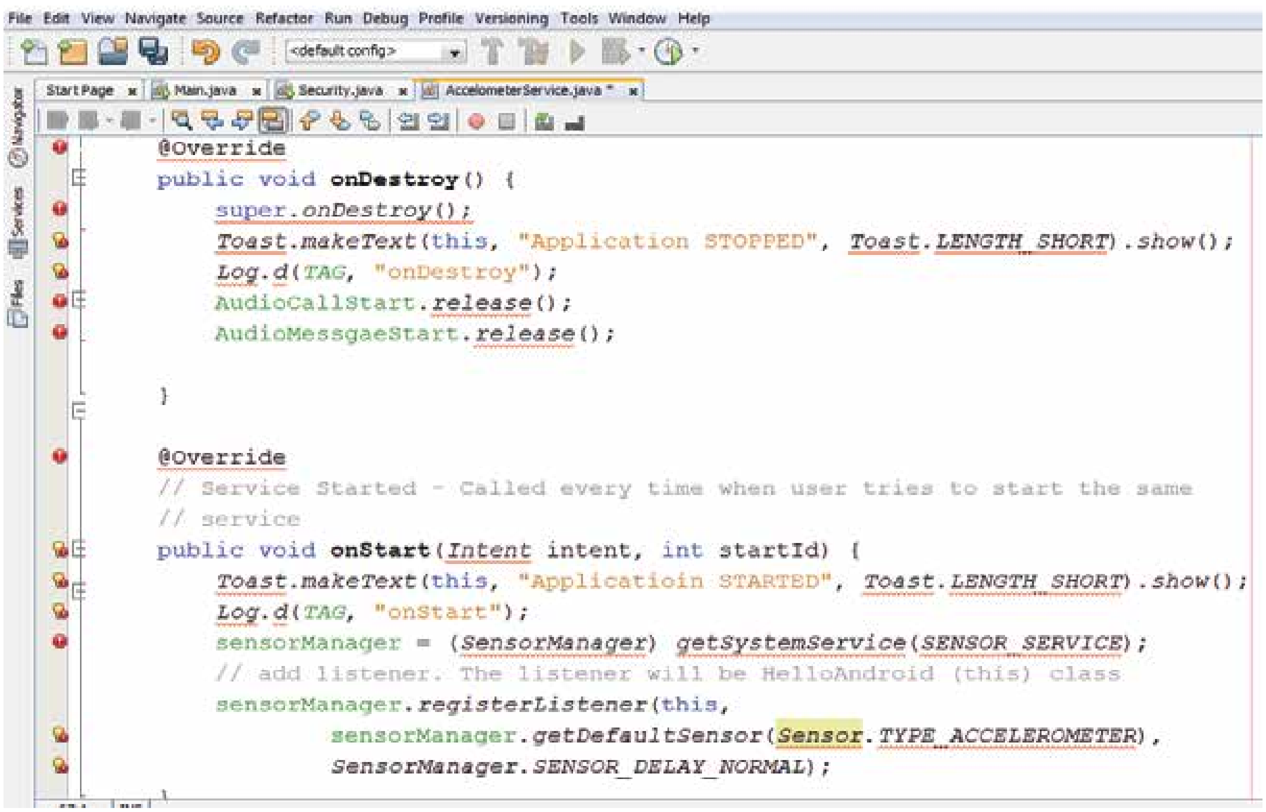

Fig. 11. Accelometer service.

Table 2. Comparison of gestural interface principles for different applications.

Applications/ Features	**VoiceOver**	**No-Look Notes**	**NavTouch**	**BrialleTap**	**ABA**
Learnable	Difficult	Not easy to learn	Easy to learn	Highly learnable	Easy to learn
Memorable	Difficult	Difficult	Hard to memorize	Highly memorable	Highly memorable
Responsive	Highly responsive	Highly responsive	Highly responsive	Highly responsive	Highly responsive
Meaningful	Gestures are meaningful	Highly meaningful	Not very meaningful	Highly meaningful	Gestures are meaningful
Clever	Not so clever	Not so clever	Not clever	Not clever	Not so clever
Playful	Highly playful	Error prone	Hard to make an error	Errors may occur	Highly playful

We have implemented the call and SMS mechanism for the proposed interface, detailed design and implementation for both of them is given in section 7.1 and section 7.2.

3.1 Design and Implementation of Call Mechanism

when we start the application from icon and handover the mobile device to the blind person to make a call or send message then he will shake the mobile with a reasonable velocity and application will be turned into call or message mode upon blind person's selection for call or message. There will be a voice generated for the blind person to tap on the upper half for call and lower half of the screen for messaging. It's shown in the Fig. 9.

Upon selection of call mode, an interface for entering mobile number will be appeared and a voice will be generated for blind person to enter the number for making a call. Blind person will enter the braille pattern for the corresponding digit by selecting the holes and then double tap in the center of the screen to make an entry. Upon selecting hole, its space will be vibrated and blind person will be ensured that he has selected a hole. When he has selected a hole then on double tapping, sound for the corresponding digit will be played and blind people will be ensured that he has entered the correct digit. If a wrong digit is entered then blind user will perform left swiping on the bottom of the screen, the entered number will be removed and a voice will be generated that number is removed. In this way blind user will enter the complete mobile number and then perform right swiping at the bottom to make a call. Call process is shown in the Fig. 10.

We have used Eclipse as an Integrated Development Environment (IDE) for the development of this application. Eclipse is most suitable IDE and it consists of extensible plug-in system for customizing an environment according to your own needs. There is a base work space that is mostly written in Java language. So, we also used Java and Eclipse Software Development Kit (SDK) that consists of Java development tools. Instead of copy pasting complete source code here, we have taken the snapshot for major modules of the application. In the Fig. 11 the code for Accelometer service is shown, that enables the mobile device to detect motion of the device for starting the application. As there are two major parts of this application named "Call" and "Message" therefore, code for the call activity is maintained in a separate ".java" file and it is given in the Fig. 12. Selection for braille pattern is also given in the Fig. 12.

3.2 Design and Implementation of SMS Mechanism

On selecting Message button form the lower corner of the screen, application will be turned into the SMS mode. Like call mechanism, an interface for entering mobile number to send sms will be appeared in front of the blind person. There will be a voice for blind user to enter number for sending text message. Interface is shown in the Fig. 13.

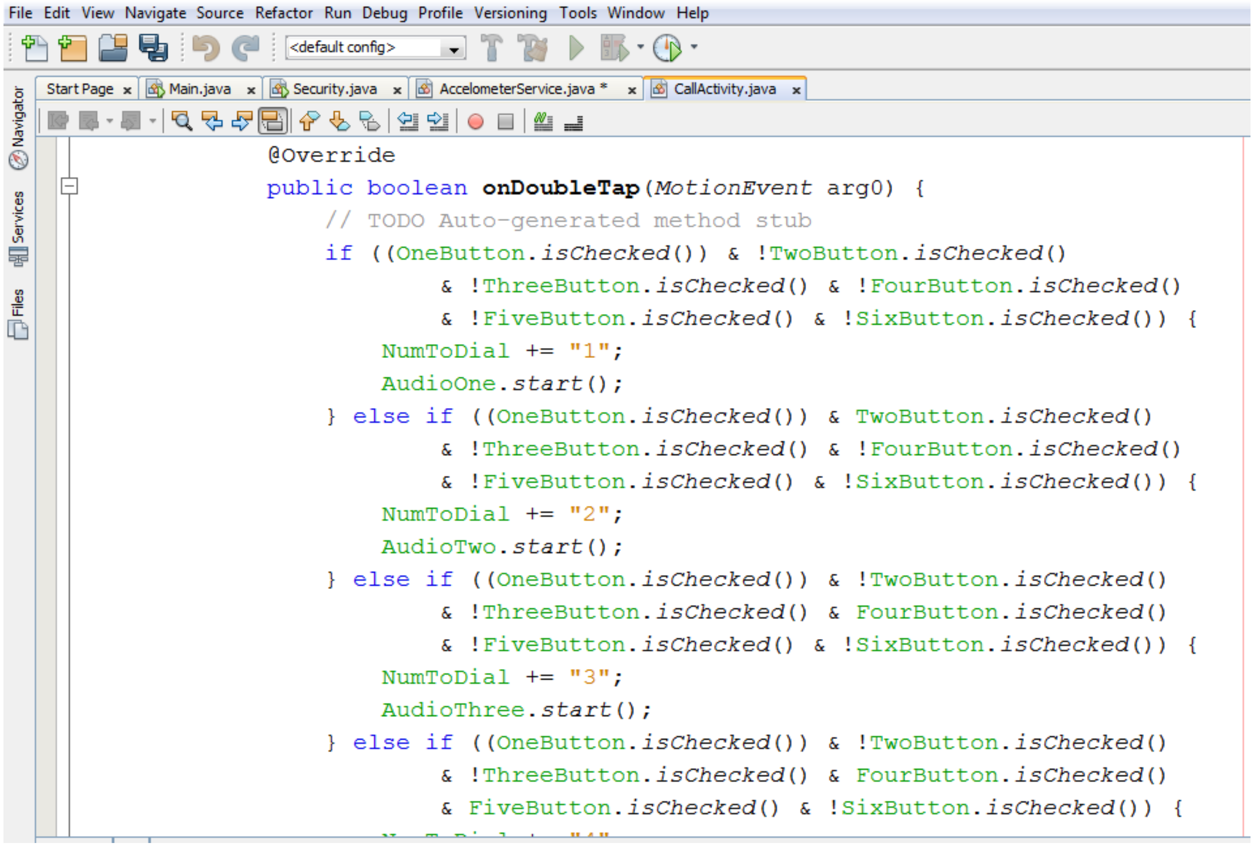

Fig. 12. Call activity.

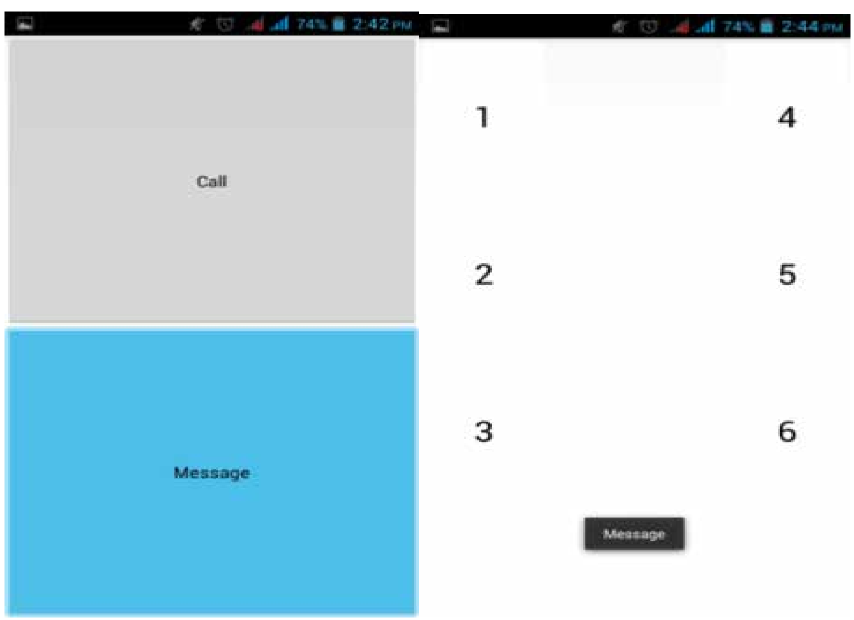

Fig. 13. Selecting message mode.

Fig. 14. Message sending in braille.

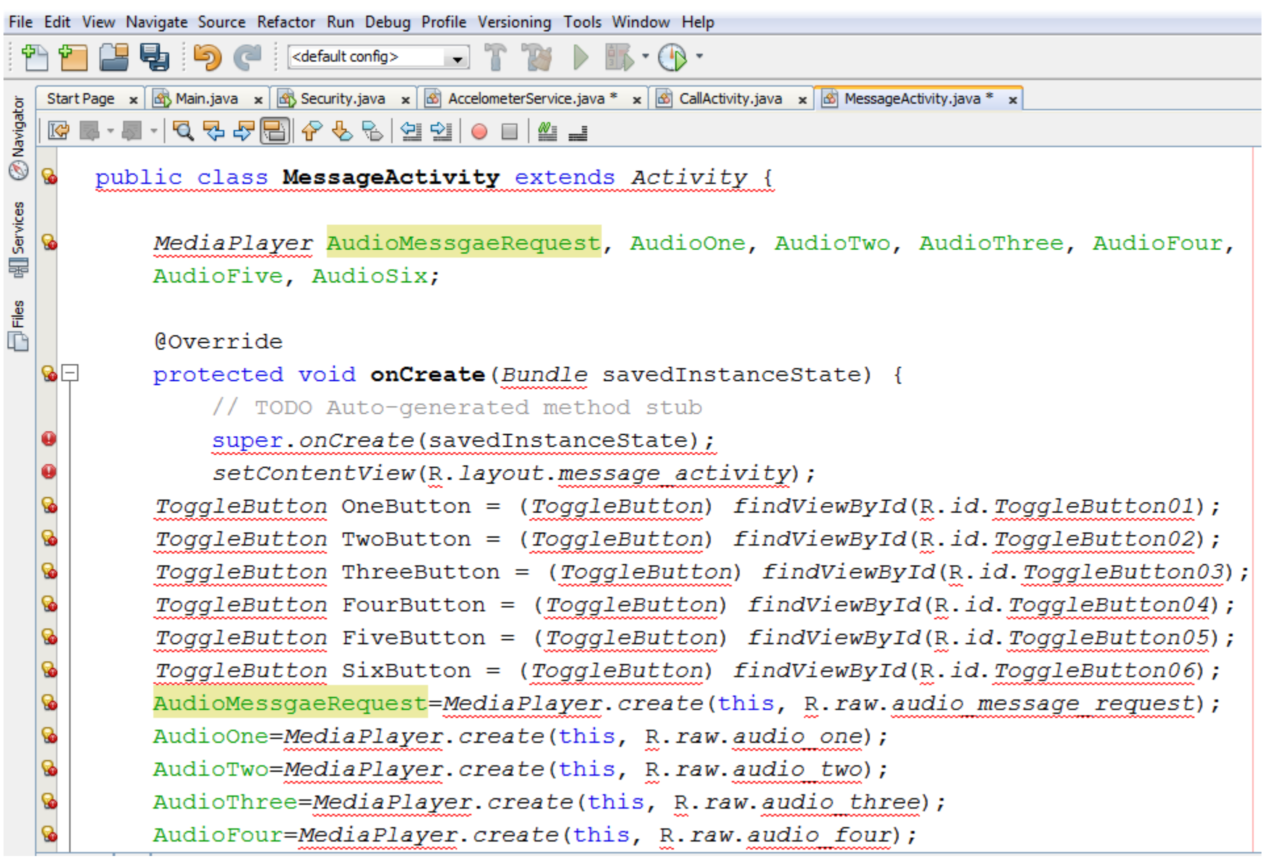

Fig. 15. Message activity.

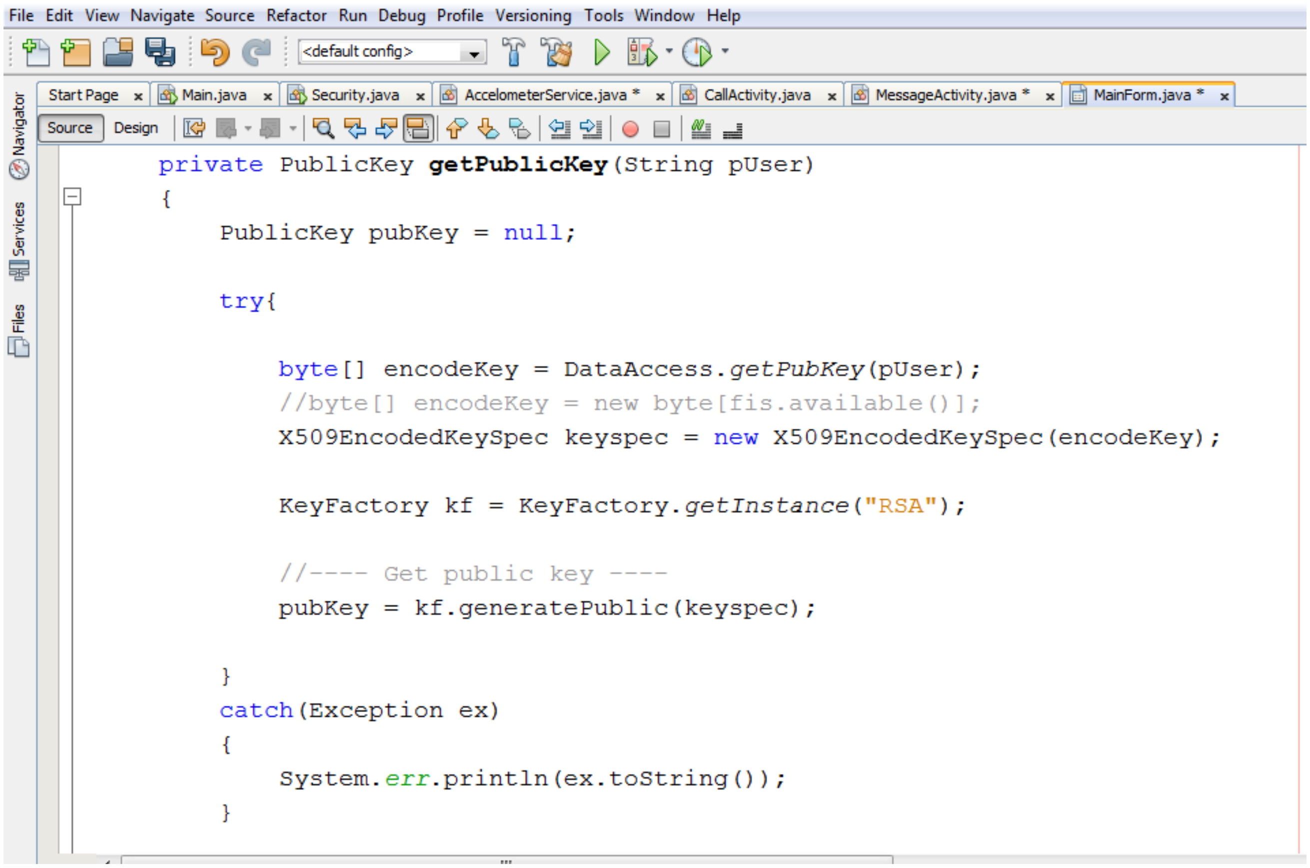

Fig. 16. Main menu.

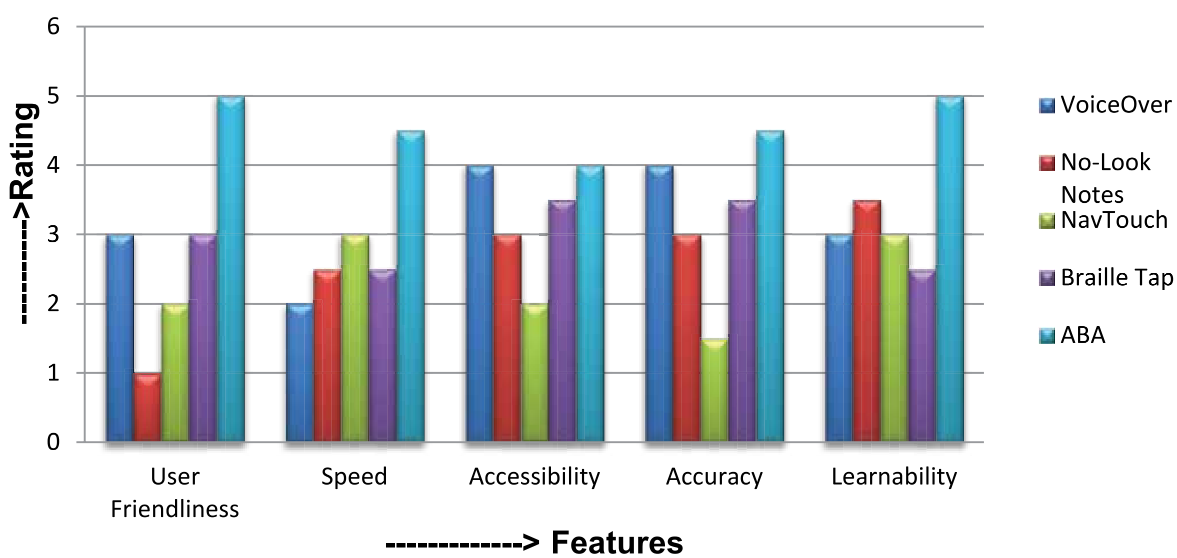

Fig. 17. Comparison of ABA with other applications.

Table 3. Comparison of ABA design with other applications.

Application Design	Easy to use	Speed	Accessibility	Accuracy	Learnability
VoiceOver	3	2	4	4	1
No-Look Notes	1	3	3	2	4
NavTouch	2	4	2	1	3
Braille Tap	4	2	3	1	2
ABA	5	4	4	5	3

After selecting the message mode, user will enter the mobile number where he/she wants to send the text message. This process is similar to entering the number for making call but here after entering the mobile number, user will perform right swiping and application will ask the user to type text message by using the same pattern as used before. Voice will be generated at each step for the guidance of blind user. When user will completely enter the text message then he/she will perform right swiping again to send the message. A sound will be generated for the confirmation of the sent message. Message sending is show in the Fig. 14. Similar to call activity, code for Message activity is given in the Fig. 15.

Code for main menu is given in the Fig. 16, in the "Main Menu.java" all the events are handled regarding this application. We have compared the ABA design with other relevant applications for blinds and noted down the user's view in a tabular form for different parameters. Blind users who have already used other blind specific apps were asked to use ABA application and to give their ratings to this application out of 5 (5 is the highest rating). Average of ratings by different users is given in the Table 3 and Fig. 17. Table 3 shows that our developed application is up to blind user's satisfaction and he/she rates this application in a better way than others. We analyzed shortcoming of other related applications for blinds and developed ABA to overcome these shortcomings, as a result we got better response from the blind users.

4. CONCLUSION AND FUTURE WORK

Gesture recognition based on patterns has been explored since last decade, but it is not qualified up till now. Therefore it requires many researches for strength and competence. After improvement of such kind of method, human being will experience relaxation by utilizing HCI softwares and associated hardware for the valuable purpose. In this research work a new technique for gesture recognition is developed which is discussed earlier. The developed Gesture Recognition Technique for Blinds (GRTB) is efficiently working for the recognition of the braille patterns and it helps to fill the gap between blind people and latest technology. It is better and easy as compare to Voice over and other braille apps. With this application blind user can easily use the latest smart phones for their use like here we implemented the functionality of Call and SMS. Scope of this research work is limited due to shortage of time and resources. Same interface can be used in other touch screen devices like tablets and PCs for text documents writing. Based upon this idea, a blind user can do typing on a computer for writing an email or composing a text document by using the same patterns mapping which is developed for typing sms. Also in mobiles, besides call &sms functionality, other features can be added. For instance, to start a specific application we associate a number with that application and upon selecting this number corresponding application will start running. This research area can be further explored and implemented in other ways mentioned above, to make the interaction of blinds people with the real world more convenient.

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