Enabling Blind and Visually Impaired through Users-Developed Dactylology

Gourav Modanwal and Kishor Sarawadekar
Department of Electronics Engineering
Indian Institute of Technology (BHU), Varanasi,
{gmodanwal.rs.ece, skishor.ece}@iitbhu.ac.in

1 Introduction

With the massive use of computers in every dimension of society human-computer interaction (HCI) has become an essential part of human life. Their widespread use suggests that the ability to handle computers is perhaps equally essential for visually impaired as well as sighted persons. The National Policy on Electronic Accessibility also suggests that differently abled persons should be facilitated with equal and unhindered access to Electronics and ICTs products and services. Over 285 million people in the world are visually impaired, of whom 39 million are blind, and 246 million have moderate to severe visual impairment (WHO, 2011). These facts are shown in Fig. 1. According to Blind Foundation for India, nearly 30 % of the global blind population belongs to India. It is predicted that without extra interventions, these numbers are expected to double by the year 2020.

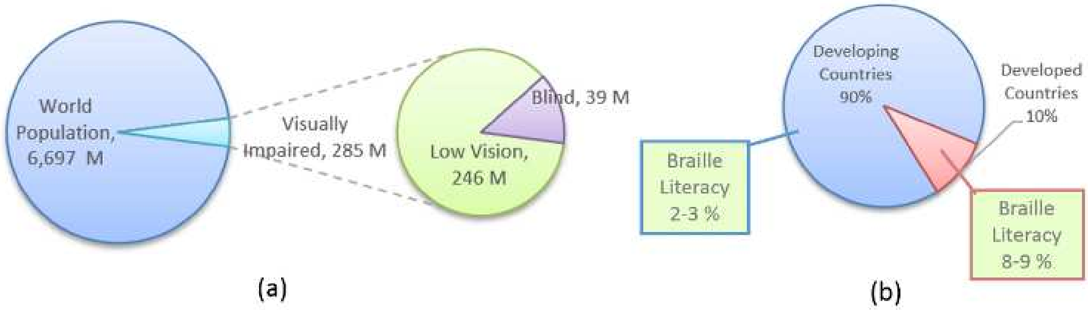

Fig. 1 Some interesting facts (a) Blind population (b) Braille literacy rate.

Mouse and keyboard are the basic input devices to interact with a computer. However, most of the blinds use screen reader software along with the keyboard. This software reads aloud the contents displayed on the screen. After listening to it carefully, blinds provide appropriate input to the system through the keyboard. This action requires hand-eye coordination which makes it difficult for them to use the computer fluently.

Braille-based devices are also available for such users. However, according to the annual report by American Printing House for the Blind [1] only 8.64% blind students in the United States use Braille and merely 10% of the blind children are learning it. This situation is the worst in the developing countries wherein 90% of the global blind population reside, and their literacy rate is almost 3%. A six-dot Braille supports only 63 unique symbols, whereas a keyboard has 104 keys. Due to these reasons, Braille-based devices are not popular for interacting with computers. Another option to interact with computer is speech processing. However, it is ineffective in the crowded environment. Further, it depends on accents, dialects and mannerisms. Its recognition accuracy is also low [2]. Hence, speech processing is unsuitable for this application. This entails, there is a need to develop an assistive technology based on non-verbal communication viz. hand gesture, electroencephalogram (EEG). Building robust and practical system using EEG is a challenging problem because the recorded signals are feeble and noisy [3]. The gesture is considered to have a great potential to create more intuitive, creative and productive experience [4]. Research has already confirmed that vision is not responsible for the production of gesture [5]. Every human being |even those blind from birth produces hand gesture during the interaction [6]. They produce gestures almost similar to the gesture produced by sighted users. However, their gestures are limited, and their emotions and facial expression are less detailed.

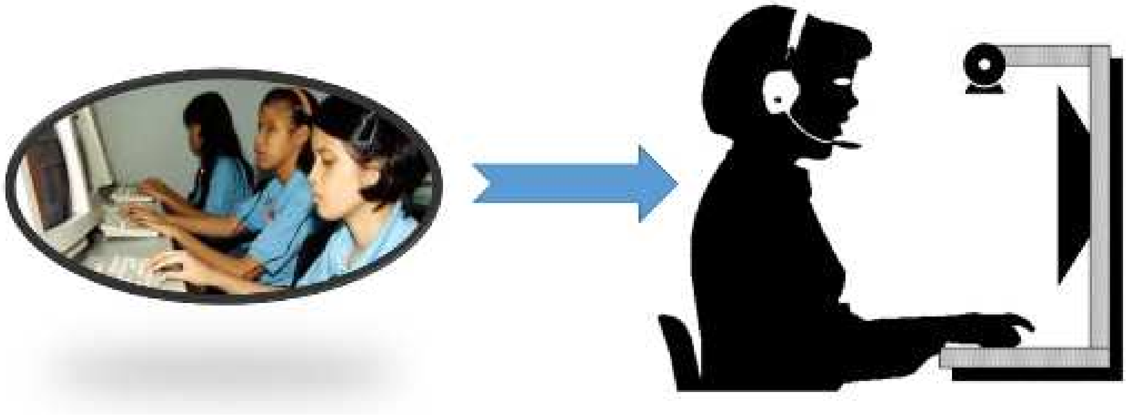

Fig. 2 Illustration of interactive system

Looking specifically towards the use of hand gesture for human-computer interaction. We found that majority of work [7] have used fingerspelling in American Sign Language (ASL) or its subset. Blind and visually impaired people feel difficulty with fingerspelling. Previous studies have suggested to perform user evaluation with target users instead of just using gestures devised for others. Since no study has included blinds in their study. Hence there is a requirement of a user evaluation study with blind and visually impaired which should investigate whether a gesture-based interaction is possible with them. Can it be used to interact with computers? If yes what type of gestures are suitable for them? How should these gestures be matched to the keys of the keyboard? What algorithm should be used to recognise these gesture?

2 Research Approach

The primary objective of the presented research work is to enable blind and visually impaired users through a gestural-based interaction. To address aforementioned questions, further research work is required. The proposal of the interactive system involves following three inter-connected research: design of interaction space, development of dactylology and recognition unit.

2.1 Design of Interaction Space

The proposed system uses hand gestures to interact with the computer. In a conventional gesture-based interaction, blinds feel two significant issues. They find it difficult to precisely locate/hold their pose in space due to no support. Additionally, they find difficulty in maintaining pose perpendicular to camera axis causing perspective errors which result in projective distortion. Brain plasticity theory states that sensitivity relevant to touch is very prominent in blind people [8]. They perceive touch faster than those with normal vision [9]. To take advantage of this, we have changed the conventional gesture-based interaction by providing a table top arrangement as shown in Fig. 2.

This set-up facilitates haptic feedback and support to the arms. The setup consists of the camera to capture the gestures posed in its field of view. To enable feedback to the user, audio output is produced. Through this audio, the user ensures whether the provided input is correct or not. If it is wrong, the user can re-enter by deleting the previously submitted command. Different ergonomic aspects like the form factor, the height of the table, bending of the wrist, etc. are also considered while designing this interactive interface.

2.2 Proposal of Dactylology

In [10], we proposed a novel dactylology based on a concept similar to Brailler. The 6-dot Braille codes consist of two columns, and each column has three dots. A maximum of 63 Braille codes is formed by combining these dot. There are six mechanical keys corresponding to each dot, and one column of dots is controlled by one hand. A desired combination of dots is formed by pressing these keys simultaneously which require the involvement of both hands. The proposed dactylology also uses both hands, but the user only needs to pose finger/s instead of pressing the keys. Further, compared to Braille more numbers of symbols can be produced. Using 31 gestures of each hand almost 1023 symbols can be produced. However, due to physiological constraints, all these gestures may not be comfortable to the user. Hence, a set of optimal gestures are needed to be devised through a user evaluation study.

More than 12,000 questions were asked in the user evaluation study. All possible gestures were evaluated using performance and preference measure metrics. Performance measure includes rating of gestures on the basis of easiness (C1), naturalness (C2), ease of learning (C3), and reproducibility (C4). A Likert scale (1 = strongly disagree to 5 = strongly agree) is used to rate gestures on questions related to four criteria. In preference measure, a preference index is calculated to consider the popularity and preference of a gesture among blind users. Based on the two metrics, optimal gesture set is devised. Finally, a dactylology is proposed using the optimal gesture set obtained through the proposed study. For further details about dactylology, readers are referred to [10].

2.3 Recognition Module

The proposed dactylology is paired with a gesture recognition module [11] to allow writing support system for blinds. Gesture recognition module has three major steps namely image acquisition, processing unit, and gesture interpretation. Image acquisition is the first stage where the optical flow method is used to obtain displacement vector between two consecutive frames. Based on this, frames which seem to be static are captured and processed further. The processing unit extracts distinctive features and performs classification using a rule-based classifier. Finally, the gesture interpretation step recognises the symbol. The processing unit is comprised of three stages (1) Pre-processing, (2) Feature extraction, and (3) Classification. In this work, a new feature extraction technique Reduced Shape Signature (RSS) is proposed which is rotation, translation and scale invariant. Unlike other shape signatures, RSS is compact as on an average 35% reduction in feature sets is achieved. Upon classifying and recognising a symbol, the system sends a command to the computer to perform a specific task as per the dactylology. The symbol recognition rate of the proposed algorithm is 97.53 %. Another work [12] showed an improvement in recognition accuracy to 98.57 %.

3 Discussion & Conclusion

In this research work, we discussed the problem of computer interaction faced by blind and visually impaired users. Braille and other conventional technology are unable to help them. The gesture is considered to be found even in individual who is blind from birth. Despite this none of the work have considered blind and visually impaired users to understand their performance and preference. To bridge this gap, we performed a user evaluation study which is discussed in [10]. In this study, optimal gestures were devised using performance and preference measure. Further, a novel dactylology was proposed. In [11], we have presented a recognition module to recognise the dactylology symbols.

The proposed system will enable the blind community to interact with the computer. This will help them to connect with the cyber world. Blinds can use the proposed system to edit text in e-document, listen to music, play games etc. More than 15 million blinds reside in India, among which less than 5 % receive any education. This innovation will help them to improve their expertise in handling computers or computerised systems which are the most common today and they will become a part of this digital age. This will improve their living standard too. Efforts are going on to increase support for the number of symbols, add dynamic gestures, and provide support for several other applications, etc.

References

1. American Printing House for the Blind. Annual Report 2015: Distribution of Eligible Students Based on the Federal Quota Census of January 6, 2014 (Fiscal Year 2015). http://www.aph.org/federal-quota/distribution-2015/.

2. Moataz El Ayadi, Mohamed S. Kamel, and Fakhri Karray. Survey on speech emotion recognition: Features, classification schemes, and databases. *Pattern Recognition*, 44(3):572-587, March 2011.

3. Shangkai Gao, Yijun Wang, Xiaorong Gao, and Bo Hong. Visual and auditory brain-computer interfaces. *IEEE Transactions on Biomedical Engineering*, 61(5):1436-1447, May 2014.

4. Anna Pereira, Juan P Wachs, Kunwoo Park, and David Rempel. A user-developed 3-D hand gesture set for human-computer interaction. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 57(4):607-621, 2015.

5. Seyda Ozcal skan, Che Lucero, and Susan Goldin-Meadow. Is seeing gesture necessary to gesture like a native speaker? *Psychological science*, 27(5):737-747, 2016.

6. Susan Goldin-Meadow. The role of gesture in communication and thinking. *Trends in cognitive sciences*, 3(11):419-429, 1999.

7. Eleni Efthimiou, Georgios Kouroupetroglou, A Fotini, A St Avroul, et al. Gesture and sign language in human-computer interaction and embodied communication, 2012.

8. Katarzyna Jednorog and Anna Grabowska. Behavioural manifestations of brain plasticity in blind and low-vision individuals. *Acta Neurobiologiae Experimentalis*, 68(1):83, 2008.

9. Arindam Bhattacharjee, J Ye Amanda, Joy A Lisak, Maria G Vargas, and Daniel Goldreich. Vibrotactile masking experiments reveal accelerated somatosensory processing in congenitally blind braille readers. *The Journal of Neuroscience*, 30(43):14288-14298, 2010.
10. Gourav Modanwal and Kishor Sarawadekar. A new dactylology and interactive system development for blind-computer interaction. *IEEE Transactions on Human-Machine Systems*, 2017.
11. Gourav Modanwal and Kishor Sarawadekar. Towards hand gesture based writing support system for blinds. *Pattern Recognition*, 57:50-60, 2016.
12. G. Modanwal and K. Sarawadekar. Development of a new dactylology and writing support system especially for blinds. In *13th Conference on Computer and Robot Vision (CRV)*, pages 362-369, 2016.

Seven Leadership Principles To Learn From An Eagle

1. Eagles fly Alone and at High Altitudes. They don't fly with sparrows, ravens and other small birds.

Meaning: Stay away from narrow-minded people, those that bring you down. Eagle flies with Eagles. Keep good company.

2. Eagles have an Accurate Vision. They have the ability to focus on something as far as 5 km away. No matter the obstacles, the eagle will not move his focus from the prey until he grabs it.

Meaning: Have a vision and remain focused no matter what the obstacles and you will succeed.

3. Eagles do not Eat Dead things. They Feed only on Fresh Prey.

Meaning: Do not rely on your past success, keep looking for new frontiers to conquer.

4. Eagles Love the Storm. When clouds gather, the eagle gets excited; the eagle uses the storms wind to lift itself higher. Once it finds the wind of the storm, the eagle uses the raging storm to lift itself above the clouds. This gives the eagle an opportunity to glide and rest its wings. In the meantime, all the other birds hide in the branches and leaves of the tree.

Meaning: Face your challenges head on knowing that these will make you emerge stronger and better than you were. We can use the storms of life to rise to greater heights. Achievers are not afraid of challenges, rather they relish them and use them profitably.

5. When a female eagle meets male eagle, she tests him for commitments. When a Female Eagle Meets a Male Eagle and they want to mate, she flies down to earth, picks a twig and flies back into the air with the male eagle in hot pursuit. Once she has reached a height high enough for her, she drops the twig, and let it fall to the ground while she watches. The male eagle chases after the twig and catches it before it reached the ground, then bring it back to the female eagle. The female eagle grabs the twig and flies to a much higher altitude and drops the twig again for the male eagle to chase. This goes on for hours with the height increasing each time until the female eagle is assured that the male eagle has mastered the art of picking the twig which shows commitment. Then and only then will she allow him to mate with her.

Meaning: Whether in private life or business, one should test the commitment of the people intended for partnership.

6. Eagles Prepare for Training. They remove the feathers and soft grass in the nest so that the young ones get uncomfortable in preparation for flying and eventually flies when it becomes unbearable to stay in the nest.

Meaning: Leave your Comfort Zone, there is No Growth there.

7. When the eagle grows old, they hurt themselves for new feathers. When the Eagle Grows old, his feathers becomes weak and cannot take him as fast and as high as it should. This makes him weak and could make him die. So he goes to a place far away in the mountains. While there, he plucks out the weak feathers on his body and breaks its beaks and claws against the rocks until he is completely bare, a very bloody and painful process. Then he stays in this hiding place until he has grown new feathers, new beaks and claws and then he comes out flying higher than before.

Meaning: We occasionally need to shed off old habit no matter how difficult; things that burden us or add no value to our lives should be let go of.

Yes, Never Give up, Be an Eagle, Never Ever Give up.