Fostering Better Deaf/Hearing Communication through a Novel Mobile App for Fingerspelling

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Abstract. Fingerspelling is a critical communication of sign language used not only by deaf children but also by parents, teachers and interpreters who support them. The recognition of fingerspelling is particularly difficult for sign language learners and support software for practice is particularly limited due to the fluid and natural way that signers will spell with their hands. Any software tool that helps people practice reading fingerspelling must be natural enough to represent the fluidity of this motion while at the same time being flexible enough to spell any list of words in the target language in any order.

To address these needs, this paper introduces a novel mobile app called "Fingerspelling Tutor" that produces natural full-motion fingerspelling using a realistic 3D computer animated character. The app can fingerspell any word that the user types in and can provide practice and quizzing opportunities for the user that are not limited to a fixed set of word lists. The software also allows users to post on social media sites to share their progress with fellow students.

1 Application Need

Fingerspelling is a method of signing letters of an alphabet that is used in deaf education and often serves as a bridge between signed and spoken languages. In the United States, fingerspelling is used for proper nouns and for technical terminology for which there is no generally accepted sign. [1]

Fingerspelling recognition is a critical communication skill not just for deaf children, but also for hearing parents, teachers of deaf children and for interpreting students. Deaf children face enormous barriers to education and opportunities, due in large part to difficulties in learning to read. For example, in the United States, deaf students have great difficulty in acquiring English. The average reading skill of deaf high school graduates is at or below the fourth-grade level, which precludes college [2]. To address this problem, many deaf education programs are introducing American Sign Language (ASL) and/or signed communication systems based on English such as Signed English (SE), Signing Exact English (SEE) and Pidgin Signed English (PSE). For all of these, fingerspelling plays an essential role in communication [3]. Studies have shown that increased contact with fingerspelling has a significant positive impact on a deaf child's reading ability [4].

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Regardless of the sign language or communication system used, teachers, interpreters and parents, who foster and serve deaf children need to be fluent in fingerspelling, but fluency in fingerspelling is a rare commodity. Many teachers of deaf children are not skilled in fingerspelling, and have to rely on an interpreter for this critical skill [5]. This is often not possible due to the scarcity of qualified educational interpreters [6]. In addition, over 90% of deaf children have two hearing parents [7]. Hearing parents do not have the same means of communication with their deaf children as they do with their hearing children, and must face the challenges of learning a second language.

Unfortunately, fingerspelling is a difficult skill to acquire. In interpreter training programs, it is the first skill taught, but the last skill mastered [8]. This problem is common to all adult learners. Particularly difficult is fingerspelling *recognition*, which involves viewing a person who is fingerspelling and reading the words being spelled.

There are several barriers to fingerspelling fluency. First, fingerspelling is rarely, if ever, perfectly produced [9]. Handshapes corresponding to the letters are heavily influenced by the letters preceding and succeeding them. Second, finger-spelling is not a series of static forms, but a continuous motion where the fingers move constantly, and do not stop after forming each handshape. During finger-spelling, the hand is rarely in a canonical letter form. As Wilcox [9] observes, "If students are trying to perceive unambiguous handshapes – the forms they were probably taught in class – then there is little wonder why they find fingerspelling so difficult. They are looking for something that isn't there".

Other barriers include limited practice opportunities, and lack of materials for self-study. A common suggestion in ASL classes is to practice with a partner [10]. Due to demanding schedules, this is not always possible. Self-study is also difficult due to the lack of supporting media. For learning spoken languages, there are a vast number of free and commercial interactive programs that are available for laptops and mobile devices. This is not the case for fingerspelling.

2 The State of the Art

There are three main alternative technologies for fingerspelling practice, each with its merits. The earliest electronic resources were video recordings which appeared in the 1980s. The 1990s saw the appearance of CDs and DVDs designed for finger-spelling practice [11]. In all of these media, the fingerspelled words were fixed. It was not possible to create / study new words, as this would require more video recordings at an added cost. Since the videos were recorded at low frame rates, motion blur was also a problem, as was lack of variation in the presentation order. As a student viewed the recording repeatedly, it was not clear if the student was improving their recognition skills or merely memorizing the recording.

The rise of the Internet paved the way for several web sites such as [12] that offer fingerspelling practice. On these sites, students can view a word as a succession of snapshots, each showing a single letter. Once the spelling is complete, students can guess the word and receive feedback. The advantage of these sites is their flexibility. A site can spell any word by simply shuffling the snapshots of the letters and can

produce new words without incurring costs for additional recordings. However, there is a drawback due to the static nature of the snapshots. Per Wilcox, most of fingerspelling is comprised of the motion between the letters, not the letters themselves. There is no connective movement in these practice tools.

3D animation is a promising alternative that has the flexibility to shuffle letters to create new words, as well as having the potential for producing the natural transitions between letters, as Wilcox describes. These are the same transitions that occur when a human fingerspells a word. With 3D animation, it is also easy to display fingerspelling without motion blur.

Despite the enormous potential of 3D animation, there are significant challenges to adapting it for fingerspelling. Similar to the requirements for a 3D character in an animated movie, the 3D hand model for fingerspelling must closely resemble a human hand, including a simulation of the behavior of the hand's soft tissue, especially in the webbing between the thumb and palm. The joints of the 3D hand must mimic the articulation of human joints, of which the base of the thumb is particularly problematic [13].

This is where the similarity between animating movie characters and animating fingerspelling ends. In a movie, the motion of a character is created once and is then frozen for all time. Animation for fingerspelling must be flexible enough to accommodate the spelling of any word while maintaining natural motion. The lack of physicality in 3D animation complicates the situation. Unless prevented, the fingers will pass through each other when transitioning between closed handshapes such as in the letters M, N, T, S and A in ASL. This requires a system to prevent finger collisions.

These complexities entail large computational requirements, and require significant CPU/GPU power to render the animation in real time. For this reason, previous efforts have either sacrificed realism to gain real-time speeds by using a simplified 3D model that did not accurately portray a human hand and/or did not prevent collisions [14], [15]. Other systems sacrificed real-time responsiveness to maintain the realism of the model [16].

3 Methodology Used

Our goal was a real-time display that would not severely impact computing resources but would preserve the realism of 3D animation. We achieved this by *pre-rendering* the animation and carefully organizing the renderings as a series of small video clips that each contained a single letter-to-letter transition. Since each clip had a transition between only two letters, the problem of collisions became more tractable. This technique creates any word by combining clips to display the fingerspelled word in real time. We have used this technology in a fingerspelling recognition drill and practice application called "Fingerspelling Tutor", which provides self-study opportunities for improving fingerspelling recognition skills. Users can type any word and see it fingerspelled, or they can quiz themselves. The software tracks user performance, including average fingerspelling speed (letters per second) and recognition accuracy (number of correct responses).

As a desktop application, this software has been in used in interpreter training programs, deaf education programs and for parent support both locally and nationally

[17]. A previous study [18] revealed that the software is easy to use and the avatar's appearance is appealing. Additional feedback from this study indicated a desire for a mobile version of Fingerspelling Tutor that would run on tablets and smart phones.

4 Results

To address this need we have built a completely new version of the software. Figure 1 shows two screen shots from the mobile app. It has adds enhancements to the original desktop software including improved natural motion and a more lifelike avatar.

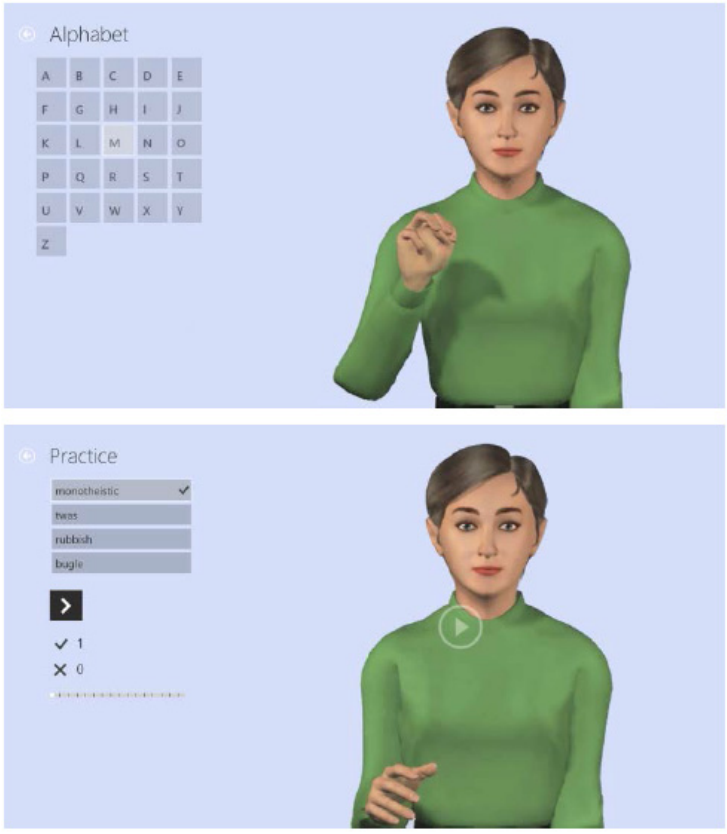

Fig. 1. Screen shots from new mobile Fingerspelling Tutor

Once downloaded, the mobile app can be used without additional Internet resources. However, it will also allow users to share their progress on one of several social media sites, adding a social element to the overall experience and introducing a new layer of engagement with the app.

5 Impact

The introduction of this new mobile app provides practice opportunities to foster a skill that is in great need, where previously no such opportunity existed. Students, teachers and parents are no longer constrained to a desktop for fingerspelling recognition practice. With the mobile app, they can now practice anywhere or at any time.

As more parents and teachers become skilled in fingerspelling, they will be better able to communicate with deaf children. This will in turn give deaf children more language contact which fosters improved literacy skills and better access to higher education, jobs, and social services.

6 Conclusion and Future Work

Our goal is to deploy this app in education programs where the desktop software was used previously and to conduct a study of user preferences and usage. Based on the feedback from this study, we plan to make any necessary changes to the app and freely distribute it to the general public. In addition, we plan to expand the app be-yond ASL. In every country, the national signed language has its own unique fingerspelling system, and people who are learning their country's signed language would benefit from a resource for fingerspelling practice.

References

1. Battison, R.M.: Lexical Borrowing in American Sign Language. Linstok Press, Silver Spring (1978)
2. Gallaudet Research Institute: Stanford Achievement Test, 9th edn., Form S, Norms booklet. Gallaudet University, Washington DC, USA (1996)
3. Strong, M. (ed.): Language Learning and Deafness. Cambridge University Press, Cambridge (1988)
4. Ramsey, C., Padden, C.: Natives and Newcomers: Gaining Access to Literacy in a Classroom for Deaf Children. Anthropology & Education Quarterly 29(1), 5–24 (1998)
5. Jones, T., Ewing, K.: An analysis of teacher preparation in deaf education: Programs approved by the Council on Education of the Deaf. American Annals of the Deaf 147(5), 71–78 (2002)
6. Schick, B., Williams, K., Kupermintz, H.: Look Who's Being Left Behind: Educational Interpreters and Access to Education for Deaf and Hard-of-Hearing Students. Journal of Deaf Studies and Deaf Education 11(1), 3–20 (2006)
7. Meyers, J.E., Bartee, J.W.: Improvements in the Signing Skills of Hearing Parents of Deaf Children. American Annals of the Deaf 137, 257–260 (1992)
8. Grushkin, D.A.: Lexidactylophobia: The irrational fear of fingerspelling. American Annals of the Deaf 143, 404–415 (1998)
9. Wilcox, S.: The Phonetics of Fingerspelling. John Benjamins Publishing, Amsterdam (1992)
10. Smith, C., Lentz, E., Mikos, K.: Signing Naturally - Student Workbook Level 1. Dawn Sign Press, San Diego (1988)

11. Jaklic, A., Vodopivec, D., Komac, V.: Learning sign language through multimedia. In: Proceedings of the International Conference on Multimedia Computing and Systems 1995, pp. 282–285. IEEE, Washington DC (1995)
12. Vicars, B.: Dr. Bill Vicars' American Sign Language (ASL) Fingerspelling Practice Site, http://asl.ms
13. McDonald, J., Alkoby, K., Carter, R., Christopher, J., Davidson, M., Ethridge, D., Wolfe, R.: An improved articulated model of the human hand. The Visual Computer 17(3), 158–166 (2001)
14. Su, A.: VRML-based Representations of ASL fingerspelling on the World-Wide Web. In: Third International ACM SIGCAPH Conference on Assistive Technologies, http://www.csdl.tamu.edu/~su/publications/assets98_.html
15. Dickson, S.: Advanced Animation in Mathematica. The Mathematica Journal 15(2) (2013), doi:dx.doi.org/doi:10.3888/tmj.15-2
16. Adamo-Villani, N., Beni, G.: Automated finger spelling by highly realistic 3D animation. British Journal of Educational Technology 35(3), 345–362 (2004)
17. Jamrozik, D.G., Davidson, M.J., McDonald, J.C., Wolfe, R.: Teaching Students to Decipher Fingerspelling through Context: A New Pedagogical Approach. In: Roberson, L., Shaw, S. (eds.) Putting the Pieces Together: A Collaborative Approach to Educational Excellence - Proceedings of the 17th National Convention of Interpreter Trainers, San Antonio, USA, pp. 35–47 (2010)
18. Jamrozik, D.G., Wolfe, R.: Using Contextual Cues in Deciphering Fingerspelling: New Discoveries and Techniques. Deaf Studies Today! Orem, Utah, USA (2009)