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Assistive Computing Technology for Learning to Write Braille
Extended Abstract

If they are to play a meaningful role in modern society, people who are visually impaired need to obtain information in an effective and timely manner. Accessing information requires the ability to read and write fluently. The Braille language provides a mechanism for the visually impaired to be fully literate participants in modern-day society. However, learning to write Braille is a non-trivial process that often takes long hours of tedious work. This research project enhances the Adaptive Braille Writing Tutor system, developed by TechBridgeWorld program [1] at Carnegie Mellon University. Specifically, we enhance the Adaptive Braille Writing Tutor software to write Arabic Braille and re-design the Tutor based on the core methodologies used in Intelligent Tutoring Systems (ITSs) [2]. In addition to that, we are designing and implementing an educational computer game for learning to write Braille that involves the enhanced Adaptive Braille Writing Tutor system and a computer. Both outcomes of this research project are indirect use by children at Al-Noor Institute for the Blind in Qatar as well as for the visually impaired students in developing communities. Thus, this research project combines between the assistive technology, ITSs, and the educational games field.

I organize the remainder of this report as follows. I describe the problem and the motivation of this research project. Then, I give an introduction to the Adaptive Braille Writing Tutor System developed by TechBridegeWorld program [1] at Carnegie Mellon University. I describe the re-designing of the Adaptive Braille Tutor to have the capabilities of both tutoring Arabic Braille alphabets, the five components of the Intelligent Tutoring Systems (ITS) [2], and their mappings to the tutor. Finally, I discuss the design of the computer educational game for teaching blind children to write Braille alphabets in order to increase their enthusiasms for learning to write Braille.

The Braille language has allowed visually impaired people to actively participate in modern-day society. Despite its significance and the accessibility it brings, learning to writing Braille still has a number of barriers. Developing communities have more than 90% of the world's 161 million blind and visually impaired people [3]. The literacy rate of this population is estimated below 3% [4]. Unfortunately, poorer areas tend to have both a disproportionately high number of blind people [3] and fewer resources for educating them [5]. However, the challenges for learning to write Braille are not limited to the poor communities. Al-Noor Institute for the Blind, a school for the visually impaired people in Qatar, offers many programs and facilities that serve the needs of visually impaired children in Qatar. The teaching methodologies used in the school reveal the tremendous role of computing technology in serving the needs of visually impaired children when learning to write Braille for grade seven and higher. Unlike developing communities, the resources for educating blind children are plenty in Qatar. Despite the resources and tools that are available in Qatar, the methods used for learning to write Braille still cause barriers for a number of reasons. First, using a tool like slate and stylus in developing communities or a Perkins Brailler in Qatar has proven to be difficult for children. They must learn mirror images of all letters which doubles the alphabet in both languages English and Arabic [5]. In the case of writing Arabic Braille in Qatar, the children have to write from left to right so that the page can be read from right to left when it is removed from the Perkins Brailler, whereas, in the case of writing English Braille in developing communities, the children have to write from right to left so that the page can be read from

left to right when it is removed from the slate. Second, the act of writing Braille using these tools has no discernible or immediate feedback to the child. This slows the learning process [5] because the feedback is delayed until the paper is removed and then flipped over and read [5]. Moreover, in developing communities, the thick papers are either expensive or out of supply, whereas in Qatar the use of computers is more preferable and spread among the visually impaired students. From several visits to the Al-Noor Institute, the children who are in grade four expressed strong enthusiasm for using a laptop. Our goal is to harness this enthusiasm for computers to increase the children's enthusiasm for learning to write Braille.

The Adaptive Braille Writing Tutor, developed by TechBridgeWorld program [1], is a tool designed to assist blind children to learn the art of writing Braille. It consists of an electronic slate and stylus known as the E-slate which monitors the student's writing and transmits data in real time to the computer. The tutor's software runs on an external PC and translates the data from the E-slate to provide immediate audio feedback to the user [5]. The original version of this tutor was field tested in the Mathru School for blind children in Bangalore, India. Based on feedback from this early field-test, a second version of the tutor was designed and implemented by several Carnegie Mellon University students and faculty. Our work is implemented on this second version of the tutor. The tutor provides guided practice for learning to write Braille using a slate and stylus, or six buttons that represent the six dots of the Braille cell. The E-slate monitors the student's writing and transmits the data in real time to a computer linked via a USB cable. The transmitted data is then interpreted to provide immediate audio feedback to the user via text-to-speech synthesis or the teacher's recorded voice [5]. We also learnt further details of the hardware and software implementations for both versions of the tutor in prior publications by Kalra et al. ([5] and [6]).

Last semester we successfully implemented the Arabic portion of the Adaptive Braille Writing Tutor system. This enhancement required us to learn the Arabic Alphabets and the teaching methodologies of writing Arabic Braille at Al-Noor Institute for the Blind in Qatar. Collaboration with teachers at Al-Noor Institute for the Blind helped us in learning the alphabets of Arabic Braille and testing the enhanced Adaptive Braille Writing Tutor. In addition, we re-design the Adaptive Braille Writing Tutor according to the methodologies of Intelligent Tutoring Systems design (ITS). ITSs offer a great ability in presenting materials and respond incredibly to the student's needs. We learnt in great details about the main components of the ITSs and the interaction between them. Then, we mapped each component to the Adaptive Braille Writing Tutor system.

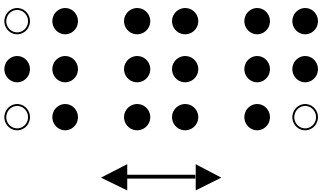
Intelligent Tutoring Systems consists of five main components. Student Model is one component that is responsible for capturing the variety of information levels between individuals. The main goal of our Student Model design is evaluating the student's performance and his problem solving skills. The information learnt from the Student Model gives an initial state of the student's knowledge about writing Arabic or English Braille alphabets. Then, this knowledge is feed to the Pedagogical Module. The Pedagogical Module acts like a teacher who takes two different strategies, meta-strategy and instructional strategy [7]. Meta-strategy consists of decisions about what is the right topic to introduce, what exercises should be provided, and planning. Instructional-strategy handles the process of teaching like how students can be assisted

and guided. These decisions are taken based on the sent information about the student from the Student Model. Once these decisions are taken, the student initial knowledge of learning Arabic or English Braille will be updated then sent to the Student Model. Then we keep going into this loop between the Student Model and the Pedagogical Module until the student shows an indication of learning all the alphabets. We have studied different algorithms like Bayesian Network, Overlay Model, and Decision Trees to design our Student Model.

In addition to the Student Model and the Pedagogical Module, ITSs consist of a Communication component. This component represents the interface between the student and the Tutor. The adaptive Braille Writing Tutor depends on the audio feedback since it's designed to tutor visually impaired students. The Communication component of tutoring the Arabic Braille letters is implemented as audio feedback. A sound file of each letter is played once the student finishes writing an Arabic letter. The Domain Knowledge and the Expert Model are two similar components. The Domain Knowledge consists of all the Arabic and English alphabets. Whereas the Expert Model compares between the learner's solution and the computer's solution then points out the difficulties the learner might have, then sends this data to both the Student Model and the Pedagogical Module.

The second aspect of this research project is designing and implementing an educational computer game for teaching children the art of writing Braille. Our game design in this project is similar to the idea of the Domino game [8]. Braille characters are formed using six dots placed in a cell of two columns and three rows. A subset of these six dots is embossed to represent each character. The positions of the six dots are universally numbered from one to six. Thus, Arabic Braille alphabets consist of 28 patterns; each represents a unique pattern of the six dots.

The idea of our game is dealing with Braille characters as the Domino cards. The 28 Arabic Braille letters will be our deck where each letter represents a card. The computer randomly places a letter and asks the player to match the placed letter from both ends. The following diagram represents how letters can be matched.



The main goal of the game is to encourage students to match letters with the most dots filled. The idea of the game was presented to a blind teacher at Al-Noor Institute for the Blind. The feedback from the teacher was highly encouraging.

Braille literacy is required for blind people to pay a meaningful role in modern society. Our research on the methodologies of teaching Arabic Braille, and our interactions with the Al-Noor Institute for the Blind in Qatar have helped us to identify some of the challenges faced by visually-impaired people during the learning process for writing Braille. These challenges motivated us to improve the Adaptive Braille Writing Tutor according to the Intelligent Tutoring

Systems methodologies in order to provide students with guided practice in writing Braille. In this project, we are re-designing the Adaptive Braille Writing Tutor to have the capabilities of tutoring both English and Arabic Braille. In addition, we are designing and implementing a computer educational game that uses the Adaptive Braille Writing Tutor system and a computer. Thus, the project combines research in Assistive Technology, Automated Tutoring Systems, and Educational Game Design, resulting in the design and implementation of a Braille Writing Tutor that significantly enhances the state of the art in educational technology for the visually impaired.

Citations

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