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Capacitive Touch Sensitive Vibro-Haptic Typing Training System for the Visually Impaired

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ABSTRACT

The proposed system implements a vibro-haptic glove device which works in tandem to a customized computer keyboard with capacitive touch sensitivity, facilitating a fast-paced typing method for the visually impaired. A normal keyboard is retro-fitted with a "capacitive sense" membrane that activates on human touch, along with a pair of fingerless haptic gloves with vibrators on each finger and a pair of Bluetooth earphones. The visually impaired user receives audible and haptic cues facilitating learning to type the correct key using the right finger on the computer keyboard. This utilizes the Passive-Haptic-Learning (PHL) paradigm for fast paced multisensory learning. A group of blind students were chosen and trained on this system for one month. There were pre and post training assessments conducted, and their scores compared. The findings showcased positive results.

KEYWORDS

Passive Haptic Learning, Soft Computing, Tactile, Training, Typing, Vibro-Haptic, Visually Impaired

INTRODUCTION

There are certain mechanical tasks that humans do to on a regular basis. These tasks are generally (but not mandatorily) repetitive in nature, and the more often these tasks are performed, our brain tries to store some of the muscular/mental procedures in a special way (by creating multiple neural connections to the same destination), so that they are accessed faster, and thus requiring lesser and lesser amount of active involvement of the brain, therefore developing the "muscle memory" (Zukin & Snyder, 1984). The concept of Passive Haptic Learning is when an external haptic stimulus is provided to the user in order to accentuate the learning process. These tasks could vary from riding/balancing a bicycle, driving, playing any musical instrument, or as in this case, learning to type on a "qwerty" keyboard, (Coon, 2005) and (Zukin & Snyder, 1984).

The proposed system utilizes the above philosophy and implements a PHL (Passive Haptic Learning) based training system for the visually impaired. This system encourages the user to use natural movements, and learn to type without the need for "seeing" the actual keys, as the visual inputs are substituted and routed through other mechanisms such as haptic and audio cues. This learning system can be thought of the supporting wheels on a bicycle, which are attached while a child learns to ride, in order to prevent him from falling. However unknowingly soon enough the child learns to naturally balance the bicycle and once the wheels are removed, he realizes that he has learnt the art of

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balancing the bicycle and thus, doesn't fall. This is the kind of implicit learning and skill development that is aimed by virtue of this device (Zukin & Snyder, 1984).

The proposed system is the final outcome of many design considerations such as camera (Kinect) based implementation, which was highly costly. The glove device is a product of multiple iterations. Detailed feedbacks were collected on the regular basis from users, based on the level of comfort, long term usage, level of invasiveness, and any impact on the natural movement of the hand. The objective was to create the least invasive design, in the lightest possible form factor. The current system is lightweight fingerless glove which is effective and economical solution for quick PHL typing training for the visually impaired. Also, being connected to the mobile application, the system can adapt to the skill level of the user and thus is able to adapt and optimize its level of difficulty/dexterity.

Passive Haptic Learning and Related Work

In the realm of interfaces with haptic cues, multiple devices have appeared in the modern era. A novel system based on multimedia has been proposed by (Eid et al., 2007) for learning to write and correctly pronounce the alphabets and characters in varied languages. The system provides visual, auditory and haptic cues in accordance to the desired character selected by a user. (Grindlay, 2007) proposed to study the impacts of physical guidance on learning percussion. The system is called the FielDrum, which employs a combination of electromagnets and permanent magnets to guide a player's drumstick through the different movements involved in the performance of arbitrary rhythmic patterns. Another system called the Haptic Guidance System, uses a servo motor and optical encoder pairing to provide precise measurement and playback of movements involved in snare drum performance. In the year 2008, multiple experiments (Bluteau et al., 2008) were piloted to enhance the visio-manual tracking of Arabic and Japanese letters and ellipses based on the two types of haptic guidance control, in position (HGP) or in force (HGF) – based on psychophysics laws of movement production. In the year 2010 great strides were taken in the areas of Human- Haptic collaboration by (Chellali et al., 2010) to understand how haptic information is exchanged between a user and a computer enabled system. They introduced a new paradigm of WYFIWIF (What You Feel Is What I Feel). This paradigm is based on a hand guidance metaphor. The model facilitates users to create a common frame of reference by allowing a direct haptic communication between the user and the system. Tanya Markow showcased in her doctoral research that how Passive Haptic Rehabilitation (PHR), (Markow, 2012) is possible using vibrotactile stimulation of the hands in persons classified as tetraplegic due to incomplete spinal cord injury. More recently, a training aid (Daniel et al., 2015) is introduced to facilitate the learning of touch typing. The system also uses electro-neural finger stimulation to enhance learning of the correct finger key associations. (Caitlyn et al., 2014) have proposed a specialized device for helping the blind to type. Further, (Caitlyn et al. 2015) showed that passive stimulation is more effective to teach piano pieces with both hands instead of training the left hand and then the right hand. Recently, (Caitlyn et al., 2017) developed a randomized numeric keypad to track the enhancement of speed of PHL affectivity.

Moreover, (Chang, 2006) described how technology can be used and adopted by the people. Vast range of examples is being covered to show how Web Service Testing for Mobile Learning can be carried out. Further, (Gupta et al., 2014) deployed a system which reads emotional state detected by EEG brainwaves and helps in enhancing the text as sometimes people are not able to express themselves properly on social media. A new perspective of technology is being forwarded by (Chang, 2018), where cloud computing technology can be used for brain segmentation. The system captures data for each brain segment and explains some segments of brain are more active than others.

(González et al., 2018) used the virtual reality as an educational tool for medical training. Various efforts have been made to get ready the young people to face the real world changes using digital technology, (García-Peñalvo, 2018a, 2018b; Vázquez-Ingelmo et al. 2018).

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