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Design and Development of a QR-based Flashcard Trainer with Audio-Visuo-Tactile Feedback

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Abstract: This study discusses the design and development of a Quick Response (QR)-based flash card trainer with audio-visuo-tactile feedback for learning. The prototype comprises a QR flashcard reader with audio feedback as the master module. It serves as a learning tool to mitigate the negative impact of digital addiction on children. It also sends or transmits signals to two submodules that produce visuo-tactile information to help the visually impaired and sign language display for the hearing impaired, respectively. The visuo-tactile module has lighted tactile pins when activated. The unique feature of this visuo-tactile display is the lighting up of the activated pins to help the teachers of visually impaired students see the patterns immediately. Moreover, the module for the hearing impaired could display sign languages corresponding to the flashcard's information.

Key Words: QR, flashcard reader, audio-visuo-tactile feedback

1. INTRODUCTION

"Digital drugs", "digital heroin", "electronic cocaine", and "digital addiction" are some descriptions of the inappropriate or too much screen time of babies and children who are using digital media, such as cell phones, tablets, online games, harming children's ability to process sensations (Kardaras, 2016 and McLendon, 2024).

Babies and children need to develop skills to effectively communicate their thoughts, emotions, and basic needs, and to adopt positive behaviors. Teaching children to develop these skills can be challenging especially when the children have not yet developed functioning vocal-verbal skills or have special needs. Learning tools can help babies and children in communication and behavior development while also providing support for the children's parents and caretakers, who can use the tools to communicate with, understand, and care for the children under their care, thereby reducing frustration and stress for both the child and the caregivers.

This study aims to mitigate or combat digital addiction by introducing a QR-based flashcard trainer with audio-visuo-tactile feedback. QR code is very popular in online payments. To the best of our knowledge, this is the first time to use a QR code in a flashcard trainer. The reprogrammable QR-based flash card reader can be used to teach a toddler how to recognize different letters, shapes, and numbers with audio feedback in the form of the voice of the mother or the caretaker. Because of its programmability, the module can be used to teach other age groups such as students who want to learn the different traffic signs, object identification and classifications, narrator, and review voice assistant. The audio recording or voice recording can be in the form of an MP3 or WAV format.

Moreover, the prototype in this study offers additional learning tools for visually impaired and hearing impaired individuals. The whole system prototype comprises a card reader configured to read a Quick Response (QR) code on a card. The card reader further decodes and processes information stored in the QR code and then transmits a signal corresponding to the decoded and processed information. The signal is received by at least one actuator, which then generates feedback based on feedback data corresponding to the information stored in the QR code. The feedback can be visual, tactile, auditory, or a combination of the foregoing. Visual feedback may be an image or a video. Tactile feedback may be conveyed through a pattern that can be discerned through touch. Auditory feedback can be a sound, such as a recording of a word, number, or statement being spoken.

The reprogrammable QR-based flash card reader can be treated as the master module that can expanded to send signals to multiple tactile modules and multiple sign-language display modules within a classroom setting.

Moreover, the visuo-tactile display is not restricted to a 2x3 matrix or Braille display but can be expanded to a 4x4 or higher resolution tactile display. The LED can also be multicolor or RGB-type where we can display an embossed image that can be touched. The unique feature of this tactile display is the lighting of the activated pins to help the teachers of the visually impaired to see the patterns immediately. This device could help not only the visually impaired, but also many teachers who are teaching the visually impaired students in their tactile learning sessions.

Furthermore, the main module can also transmit a signal to a visual actuator or LCD module for the hearing impaired to see the sign language of the corresponding image on the flashcard inserted in the main module. The sign-language pictures can be in the form of JPG, PNG, GIF, or BMP.

This paper is organized as follows: literature review in section 2, followed by the design and construction of the prototype in section 3, results and discussion in section 4, and conclusion in section 5.

2. RELATED LITERATURE

An example of a learning tool specially designed for children with special needs is the BecDot, an educational tool or toy that is used to introduce braille at an early age to children who have visual impairments, are blind, or have been diagnosed with conditions that will eventually cause blindness. The BecDot device includes a reader that detects when an object having a pre-programmed near-field communication (NFC) tag is placed on it. The BecDot device further includes four braille pads that react when an NFC-tagged object is detected. In particular, dots on the braille pads are raised in response to an object being detected. Depending on how a user programs the device, the braille pads could be configured to spell a word corresponding to the detected object or to provide other information. The individual dots on the BecDot braille pads are driven by an Arduino Uno. The BecDot also includes an internal speaker that can play sounds corresponding to the detected object.

Other learning tools include the system for braille learning disclosed in US11514817B2, the braille learning machine taught in CN102881195, and the system of language learning in US11810475.

US11514817B2 describes a completely digitized, smart, interactive, and connected system for braille learning that a user interfaces with through audio-tactile input and output modules. The input modules include a braille keyboard that helps a user learn how to type in braille, and a digitized version of a braille slate and stylus that helps a user learn how to write in braille without the need for paper. The output modules include a plurality of enlarged and regular braille display cells. The enlarged braille display cells help a beginner or early braille learner identify the braille dot patterns for different characters. The user then advances to reading on the regular braille display cells. The output modules help a user learn to read braille by developing tactile sensitivity in their fingertips.

The braille learning machine taught in CN102881195 comprises a core control microprocessor that reads braille teaching materials and audio files stored in a system memory of the machine, a braille display module that displays braille patterns for a user's tactile recognition, a random access memory (RAM) for operating a system program, a memory card interface for adding auxiliary data, a liquid crystal display for displaying a system running state and learning information, a pronunciation module that sounds out the character displayed on the braille display module, and a power supply. A user of the braille learning machine touches the braille pattern on the braille display module and at the same time hears from the pronunciation module the sound of the character being displayed. Through repeated exercise using this approach, the user's braille learning is accelerated.

In US11810475, a computerized system of

teaching uses curriculum materials having printed symbols. The system comprises a computer, a camera, and a transceiver. The computer includes computerized memory and a processor executing imaging software and decoding software in the memory. The camera includes an image reader assembly configured to generate pixel data from encoded indicia on a respective curriculum material. The imaging software processes the pixel data to generate digital pixel data and stores the digital pixel data in the memory. The processor executes decoding software by receiving the digital pixel data from the memory and generates a data set from the encoded indicia. A transceiver is in bi-directional communication with the computer and a server on a network, and the server has access to augmented reality image data. The transceiver transmits the data set to the server over the network, and the server is configured to receive the data set and transmit it to the computer-selected augmented reality image data that corresponds to the data set. The computer uses the processor to show the augmented reality image data on a display. The system is designed particularly to employ augmented reality platforms to increase efficiencies when teaching students who are fully immersed in a new language at school.

Some learning tools use flashcards, which are versatile teaching tools useful for teaching new words, pictures, or concepts to children, especially those with special needs. Additionally, because most children learn best visually, flashcards containing vibrant pictures are more likely to grab their attention. Flashcards can help children learn to start conversations and replace incorrect behaviors with more suitable ones.

One example of a learning system that may be used with flash cards is the interactive system described in US20090286210, which is designed to provide many different learning experiences. One specific use relates to sign language learning and acquisition for deaf children. The interactive system comprises a body portion, an input receiver adapted to detect and recognize a code on an object representation, an output display adapted to visually represent interactive content associated with the object representation, and a microprocessor. In a preferred embodiment, the body portion may be in the form of a toy, such as a stuffed animal, that a user can bond with and take anywhere they go. It may also be a flat screen that can display an interactive video game or other medium. The object representation may be a flashcard or an array of reference points and may further comprise a radio frequency identification (RFID) tag or a barcode. The input receiver may further comprise an RFID reader or a barcode reader. The output display may be a screen and the interactive content may be a video, such as a video display of a sign language gesture.

3. CONSTRUCTION OF THE PROTOTYPE

3.1 System Overview

The block diagram of the whole system, as shown in Fig. 1, comprises the wireless flashcard trainer with a QR code reader, an audio actuator or audio feedback through the speaker, and an HC-12 transceiver module for wireless communications. Moreover, aside from audio feedback, the system has a visuo-tactile actuator and visual actuator. The different modules will be discussed in the following sections.

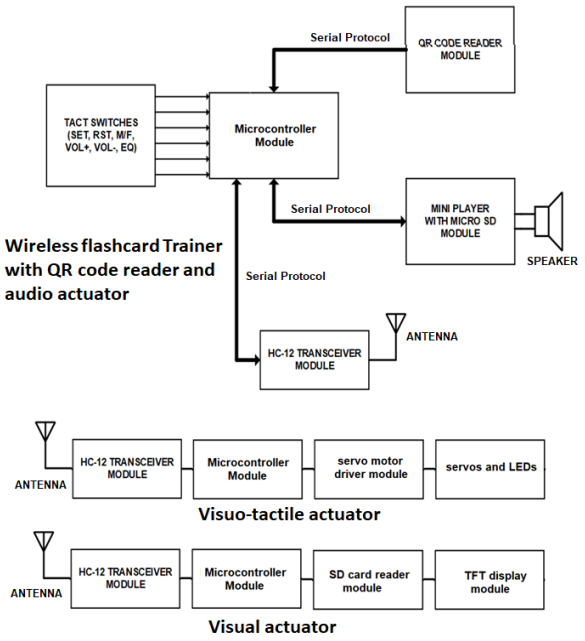

Fig. 1. Block diagram of the whole system.

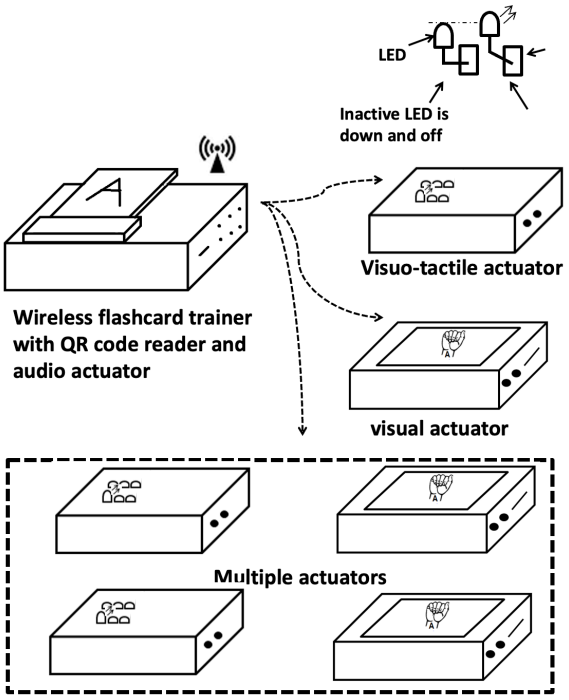

Fig. 2. The 3D system structure.

3.2. Wireless flashcard trainer with QR code reader and audio actuator

This module can also be called a reprogrammable QR-based flash card reader module and has a memory unit that stores quick response (QR) codes corresponding to learning information and feedback data corresponding to the learning information. Audio files or voice recordings of parent or guardian in MP3 or WAV format are stored in the memory unit corresponding to the learning information on the flashcard. Voice recordings that sound familiar to the child using the device might help in the motivation and learning process.

The flashcard reader is configured to read a QR code on a card. The card reader further comprises a processor and a transmitter. The processor is functionally coupled to the memory unit and is configured to decode the learning information corresponding to the QR code on the card. The transmitter is functionally coupled to the processor and is configured to transmit a signal corresponding to the decoded learning information.

The module has a flash card holder on its top cover and a control panel on one side, while the power connector and on/off switch are on the other side. The control panel has an SD card slot where the SD card containing the different audio or voice recordings is inserted.

Moreover, there are different buttons in the control panel for the volume up or down, equalizer, voice selection for male or female, and the set and reset functions. If the flash card holder is removed, the transparent plate will be visible. This clear plate will enable the QR code attached to the back of the flashcard to be read by the QR reader/scanner. When the top cover of the module is removed, the control board can be seen. The control board has a power connector, on/off switch, microcontroller, speaker, wireless module, QR code reader/scanner, MP3 player and control panel, and SD card reader. When a flash card is put on the cardholder, the QR code reader scans the QR code at the back of the flashcard and the microcontroller matches the code to the corresponding audio or voice stored in the SD card. An audible sound is produced through the speaker. Furthermore, a corresponding signal is also wirelessly transmitted to the tactile module to activate the corresponding tactile actuators and to the reprogrammable LCD module for sign language display.

3.3 Visuo-tactile actuator

The visuo-tactile actuator is a portable module that can communicate with the flash card reader module using a wireless module. This module has tactile pins arranged in rows and columns and is made from LEDs that light up and move up when activated. This visuo-tactile module gives tactile feedback by moving LEDs up and down and also visual feedback by lighting the activated LEDs. This module is made from small servos with a servo driver and LEDs on their arms that can be moved up or down and are controlled by a microcontroller similar to the "A Portable Braille Refreshable Display Using Micro Servos" of Muntasir Rahman, A. M., et al., (2018) but their tactile pins do not light up and the purpose of their device is only for the visually impaired.

On the other hand, the visuo-tactile module has a USB connector that can be connected to a USB

charger or USB power bank. It has also an on/off switch near the USB connector. It is configured to receive the transmitted signal and to generate tactile feedback based on the tactile feedback data corresponding to the learning information. In one embodiment, as shown in Fig. 2, the visuo-tactile actuator further comprises an array of tactile pins. Each tactile pin is independently switchable between deactivated and activated state. The tactile feedback data is a tactile pattern with certain tactile pins in an activated state and the remaining tactile pins are in a deactivated state. In one embodiment, the learning information comprises letters of the English alphabet and Arabic numerals, each QR code corresponds to one letter or one numeral, and the tactile pattern is a Braille pattern corresponding to the letter or the numeral, such that the activated tactile pins correspond to raised dots in a Braille pattern. In one embodiment, each tactile pin further comprises a light source configured to emit light when the tactile pin is in an activated state.

This visuo-tactile module could help not only the visually impaired, but also the teachers who are teaching the visually impaired students in their tactile learning sessions. The device might help the teachers and students of the "SLU-Inclusive Education Resource Center."

3.4 Visual actuator (LCD module)

The visual actuator is a reprogrammable LCD module. This module displays images or pictures for sign language corresponding to the flash card inserted in the QR flash card reader. This module has an LCD controlled by a microcontroller. An SD card containing different sign language pictures can be inserted into a slot of an SD card reader module. This module has a power button and a USB connector that can be connected to a USB charger or USB power bank.

The visual actuator is configured to receive the transmitted signal and to generate visual feedback based on the visual feedback data corresponding to the learning information. In one embodiment, the visual actuator further comprises a screen configured to display the visual feedback data. The visual feedback data comprises an image stored as an image file. The image corresponds to the learning information associated with the QR code read by the card reader. In one embodiment, the information comprises letters of the English alphabet or Arabic numerals, each QR code corresponds to one letter or one numeral, and the image is of a sign language hand gesture corresponding to the letter or the numeral.

4. RESULTS AND DISCUSSION

The actual prototype of the wireless flashcard trainer with a QR code reader and audio actuator is shown in Fig. 3. The flashcard with the letter "A" is shown in Fig. 3a with a QR code at the back of the flashcard as shown in Fig. 3b. When the flashcard is inserted to the module, a pre-recorded voice enunciating the letter "A" can be heard through the speaker within the module.

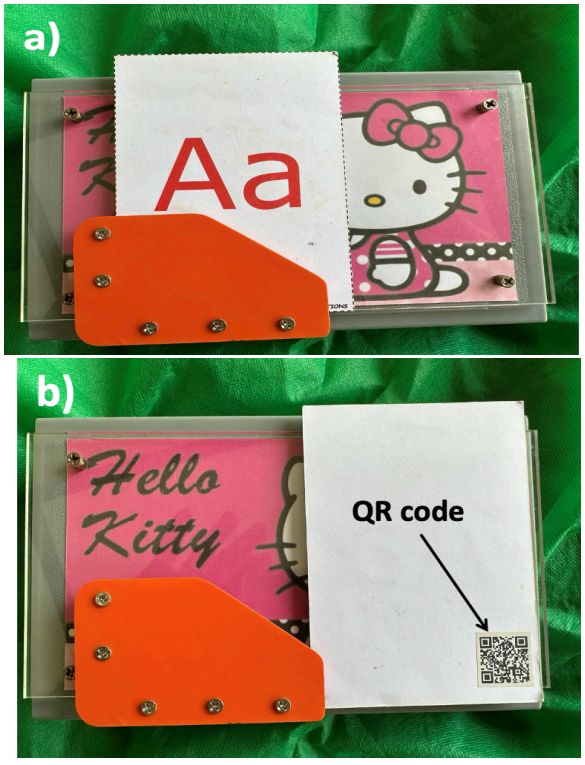

Fig. 3. Wireless flashcard trainer with QR code reader and audio actuator.

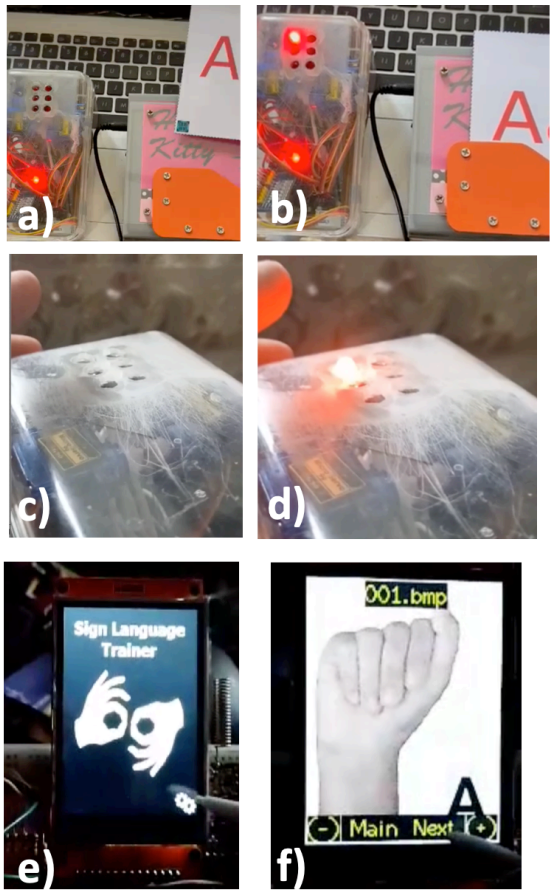

Fig. 4. Actuator modules: a) visuo-tactile actuator with no activated tactile pins, b) visuo-tactile actuator with one tactile pin activated showing the Braille pattern for letter "A", c) and d) show another perspective of a) and b), e) default screen of the visual actuator or the LCD module, and f) American Sign Language of the letter "A" as shown in the LCD.

The visuo-tactile module side-by-side with the QR-based flashcard reader is shown in Fig. 4.a) to Fig. 4.d). All 26 letters of the alphabet and numbers 0-9 were tested. The test videos can be found in this link. When the tactile pins are not activated, the user can only feel the holes, as shown in Fig. 4.c). When a pin is activated, it can be felt by the user and can be seen by the teacher because the activated pin lights up, as shown in Fig. 4.d).

Fig. 4.e) and Fig. 4.f) show the welcome image and sign-language image of the letter "A" corresponding to the flashcard in Fig. 4.b), respectively. The LCD is a touch screen where the user or teacher can adjust the brightness and/or contrast. The display module has an SD card where the images are stored, a microcontroller, and a wireless receiver module to receive the signal from the master module or the QR-based flashcard reader.

5. CONCLUSION

This study discussed the design and development of a system for learning for educational purposes that comprises a memory unit, a card reader, and one or more actuators, including a tactile actuator with lighted-tactile pins when activated, an audio actuator, and a visual actuator. A memory unit stores audio and image files corresponding to the decoded QR code information that further corresponds to feedback data comprising tactile feedback data, audio feedback data, and visual feedback data. The card reader further comprises a processor and a wireless transmitter and is configured to read a QR code on a card, decode the information of the QR code on the card, process the corresponding feedback data, and transmit a signal corresponding to the decoded information. Each of the actuators, tactile actuator, audio actuator, and visual actuator is configured to receive the transmitted signal and generate the corresponding feedback. The prototype offers a learning tool to mitigate the negative impact of digital addiction on children, as well as a visuo-tactile module for the visually impaired, and a display module for the hearing impaired.

6. ACKNOWLEDGMENTS

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7. REFERENCES

Kardaras, N. (2016, Aug. 27). It's 'digital heroin': How screens turn kids into psychotic junkies. https://nypost.com/2016/08/27/its-digital-heroin-how-screens-turn-kids-into-psychotic-junkies/

McLendon, R. (2024, Jan. 22). Screen Time Could Have a Surprising Effect on Our Children's Ability to Process Sensations. https://www.sciencealert.com/screen-time-could-have-a-surprising-effect-on-our-childrens-ability-to-process-sensations

Memoriesforbecca (2017, Sept 25). THE BECDOT. https://memoriesforbecca.com/2017/09/25/introducing-the-becdot/

Muntasir Rahman, A. M., et al., (2018). "A Portable Braille Refreshable Display UsingMicro Servos," in 2018 Joint 7th International Conference on Informatics, Electronics & Vision (ICIEV) and 2018 2nd International Conference on Imaging, Vision & Pattern Recognition (icIVPR), Kitakyushu, Japan, pp. 212–217, Jun. 2018, doi:10.1109/ICIEV.2018.8641028.

SHAIKH, S. A. S. A., RAMESH, D., DAWLE, S. A., & SRIVASTAVA, A. K. (2022, November 29). Smart interactive system for braille learning. (U.S. Patent No. US11514817B2). U.S. Patent and Trademark Office. https://patents.google.com/patent/US11514817B2/fr

杨晓慧褚国兴李国琳姜俊海左思源金豆张彤 (2014, Aug. 6). Braille learning machine. China Patent CN102881195. https://patents.google.com/patent/CN102881195A/en?oq=CN102881195

Smith, S. A., Maria Soledad CarloSanghoon ParkHoward Kaplan (2022, Dec. 12). System of language learning with augmented reality. (U.S. Patent No. US11810475B2). U.S. Patent and Trademark Office. https://patents.google.com/patent/US11810475B2/en?oq=US11810475

Spreen, K., Jesse SmithKevin HuangMary Frances Jones (2009, Nov. 19). Methods and Systems for Providing Interactive Content. (U.S. Patent No. US20090286210A1). U.S. Patent and Trademark Office. https://patents.google.com/patent/US20090286210A1/en?oq=US20090286210