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Medicine Identification System with Near Field Communication Technology

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Abstract: Elderly people who suffer from declining memory are likely at risk of forgetting the functions or dosage of their prescribed medication. Accidental consumption of wrong medicines may have fatal consequences. Near-Field Communication (NFC) based medicine identification systems have the advantage of being relatively fast, reliable and cost-effective. The proposed NFC-MedIDS endeavors to provide an easy and effective solution to ensure the elderly gets the accurate information either on their smartphones or Television (TV) screens prior to consuming it. The NFC-MedIDS consists of the NFC-MedID box which work with the NFC chip-embedded medicine bottles, NFC-enabled smartphones and/or a large display such as the TV. Information on medicines can be instantly retrieved by tapping the medicine bottle on the NFC-MedID box or the NFC smartphone. The information helps the elderly to ensure they take the right medicine in the right dosage every time.

Key words: Communication, field, medicine, information, smartphones

INTRODUCTION

The number of elderly people is on the rise: from 8% in 1950-11% in 2009 and is expected to reach as much as 22% in 2050. This phenomenon of aging population has profound implications on all facets of life, notably the economic growth and the social spheres. Many of the elderly face the problem of declining memory (Brickman *et al*., 2009). This may cause some of them unable to remember the functions and/or dosage of a medicine. Consumption of wrong medicine or dosage of medicine may lead to premature death if left unchecked (Wang *et al*., 2014). Through the advance of technology, various medicine identification systems have surfaced to help the elderly in identifying medicines. For example, Xiankleber introduced the use of visual feature matching using camera for visually-impaired people to identify medicines (Benjamim *et al*., 2012). One of the drawbacks of using cameras, however is the large amount of time it takes to process the images. This results in slow responses which may discourage the elderly from using the system. Besides that, a bright environment is required for the camera approach to work effectively.

Near Field Communication (NFC) based systems have been proposed as a faster and more reliable way for medicine identification (Harjumaa *et al*., 2011; Mareli *et al*., 2014). For instance, information on the medicine is conveyed to users using audio when a reader device is tapped on the medicine bottle. However, the audio information may not be suitable to the elderly as most of them may suffer from hearing loss or have bad hearing (Cruickshanks *et al*., 1998). To address the gap in the literature, a low-cost NFC Medicine Identification System (NFC-MedIDS) is proposed. The proposed system uses NFC and Single Board Computer (SBC) technology to prevent elderly with impaired or declined memory from taking the wrong medicines. The objective of NFC-MedIDS is to assist the elderly in identifying medicines through the display of NFC-enabled smartphones or the display of TV. The design of NFC-MedIDS is specifically tailored to meet the needs of the elderly where a simple tap-to-identify interaction is proposed for easy operation.

NFC (Coskunet *et al*., 2013) is a wireless and invisible technology that can initiate communication between devices. It is based on Radio Frequency Identification (RFID) communication scheme that operates on 13.56 MHz frequency with a data rate of up to 424 kilobits per second within an operating range of up to 10 cm (Coskunet *et al*., 2013). Three main modes of operation are available for NFC which is reader/writer, peer-to-peer and card emulation. All these modes require

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two devices to operate: an initiator and a target. An initiator starts the communication while a target acknowledges the requests made by the initiator. In the reader/writer mode, an initiator reads data from the target which is usually an NFC device or NFC tag. The initiator can also write data onto empty target. The standardized format used to store data on tags is the NFC Data Exchange Format or NDEF. The applications of NFC are increasing rapidly as the availability of NFC compatible devices is vast (Chattha *et al*., 2014). Many contemporary smartphones are now equipped with NFC technology. Raspberry Pi (RPI) (Chattha *et al*., 2014) is a small and in expensive credit card-sized SBC developed with the initial goal of inspiring young programmers to learn basic programming in schools. There are two versions of RPI available in the market: RPI 1 and 2. RPI 1 runs on a Broadcom BCM2835 700MHz processor whereas RPI 2 runs on a Broadcom BCM2836 900MHz quad-core ARM cortex-A7. RPI is capable of performing the tasks that a desktop computer can while its GPU is fast enough for High Definition (HD) videos playback. Although, RPI is note quipped with VGA output, it supports HDMI connection which is more commonly used nowadays. Due to RPI's capability to interface with different devices via its GPIO, it has been adopted in a wide range of applications.

Related work: The related work and technologies are discussed in this section with reference to the proposed tap-to-identify interaction paradigm for medicine identification that uses NFC and/or SBC technology to disseminate information of medicine to the elderly at home. A desktop application was presented by Marja *et al*. 2010, Sanchez *et al*. (2009) that used NFC technology to identify medicines and convey its related information to the user through a computer. By tapping the NFC-enabled medicine box to the NFC reader attached to a computer, audio information of the medicine will be retrieved from a server and play back through the computer. In 2014, an NFC medicine identification system for illiterate patients to obtain medicine information using NFC smartphones was proposed by Mareli *et al*. (2014). By tapping their smartphones on an NFC-tagged medicine container, the corresponding audio file will be downloaded to the phone and play back the information on the phone. Instances of usage of SBC in health care include a system using RPI with third-party sensor shield and equipment for patient monitorin (Maksimovic *et al*., 2015) and the e-Health smart networked system that uses RPI with e-Health Sensor Shield to measure the patient's physical parameters. The invisibility and proximity natures of NFC technology coupled with the advancement of SBC technologies allows researchers to develop a more compact and cost effective platform for the elderly to identify medicine in a simpler and easier way. Given this backdrop, an inexpensive, fast and accurate tap-to-identify medicine identification system for the elderly utilizing NFC and RPI is proposed. Although, researchers have been using NFC technology to identify medicine, as far as we have surveyed, there are no previous reports of combining NFC smartphone, RPI and TV as a method to identify medicine via tap-to-identify interaction paradigm.

MATERIALS AND METHODS

System design: The system architecture of the proposed NFC-MedIDS is shown in Fig. 1. The objective of the

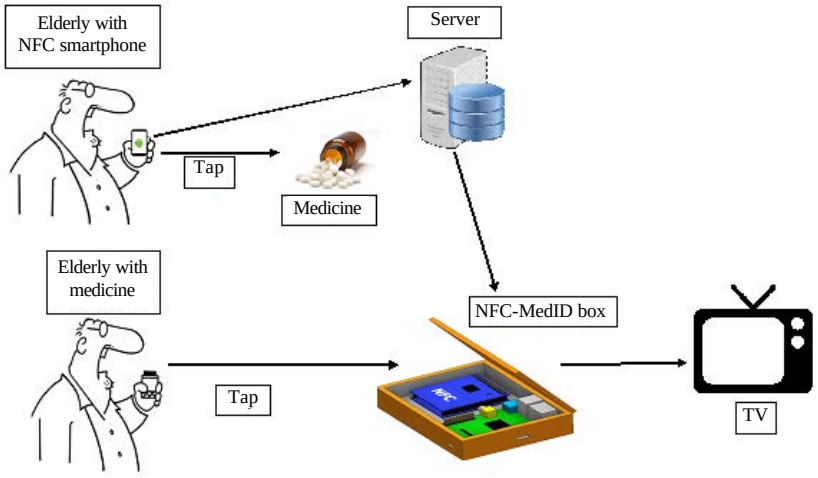

Fig. 1: System architecture of the NFC-MedID

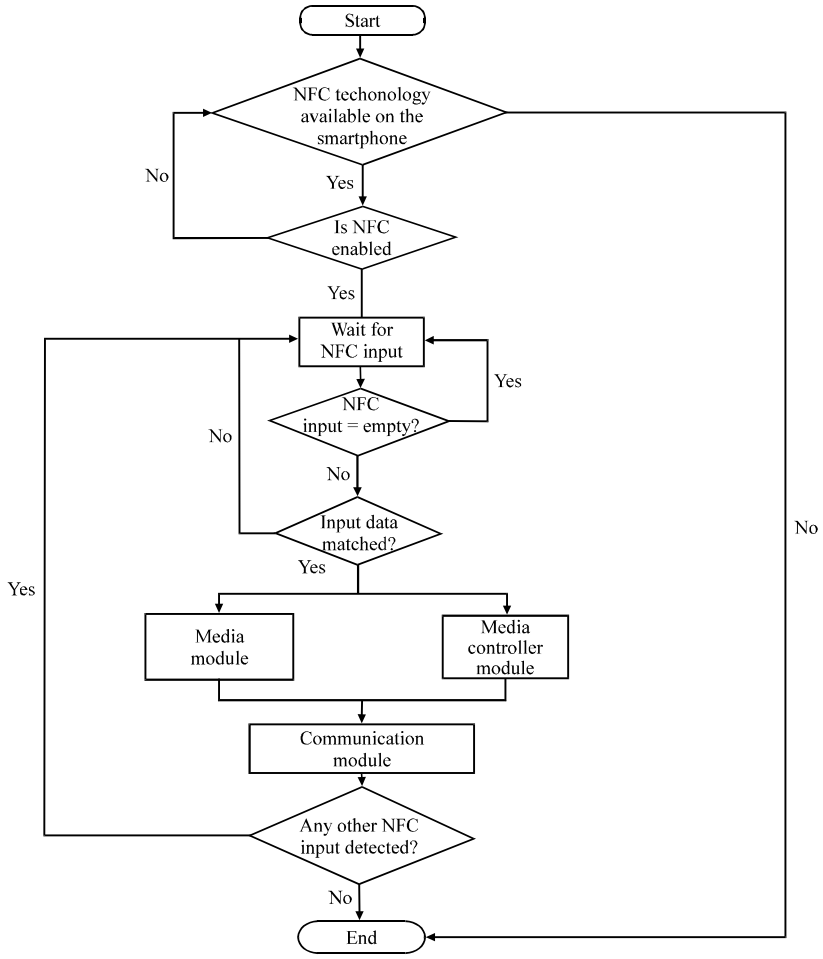

Fig. 2: Flow chart to identify medicines via NFC smartphone

system is to assist the elderly in identifying medicines to ensure they take the right medicine in the right dosage every time. NFC-MedIDS provides two ways for the elderly to identify medicines: using an NFC smartphone or NFC-MedID box. The invisible and close proximity characteristics of NFC technology are exploited in the NFC-MedIDS to facilitate the tap-to-identify interaction that is simple to operate. The proposed NFC-MedIDS allows the elderly to identify a particular medicine and if they so please, obtain further information about it, prior to consumption. A smartphone application is designed to allow the elderly identify medicines using NFC smartphone. Figure 2 shows the flow chart of the smartphone application which identifies various medicines when the NFC smartphone are tapped on an NFC-embedded medicine bottle. The main modules of the application are the media module and media controller module. Whenever data that is read from the NFC tag is valid, the media module will decode and display the corresponding medicine information such as name, usage and dosage on the smartphone's screen.

The media controller module is responsible for controlling the displaying of medicine information such as stopping, pausing and resuming a video, in the case of a video playback. To cater to the elderly with poor eyesight and to improve the readability of the medicine information, NFC-MedID box is designed to provide option for the elderly to view the information on a TV with a larger screen, using the same android application. This is achieved by sending dedicated control signals from the NFC smartphone to the XMPP server. The server temporarily holds the signal prior pushing it to the NFC-MedID box.

For elderly people who are not comfortable using or do not possess any NFC smartphones, they can use the NFC-MedID box as standalone system to identify medicines. They just have to tap the NFC-tagged medicine bottle on the NFC-MedID box to obtain the medicine information on the large display of a TV. The inspiration for the NFC-MedID box comes from the conventional medicine boxes that store daily-intake pills. It is however, equipped with RPI, Arduino and NFC

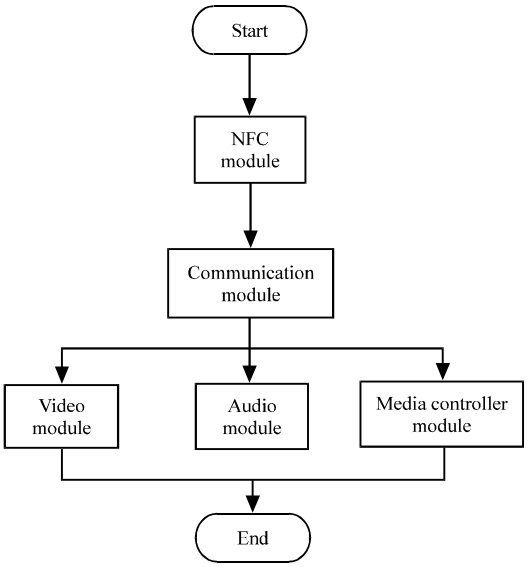

Fig. 3: Flow chart to identify medicines via the NFC MedID box

shield to support the functionality of identifying medicines. Arduino and NFC shield are used to read the information stored inside the NFC tag which is embedded in the medicine bottles whereas RPI is used as the processing unit to process the data read and information playback on TV. Data read from the NFC tag is first passed to the NFC decoding module. Then, the decoding module generates the corresponding command to trigger the video module to initiate playback of the associated medicine information obtained from the internal repository. The information is then displayed on a TV through HDMI connection.

The flow chart of the NFC-MedID box application is shown in Fig. 3 that consists of the NFC module, communication module, video module, audio module and media controller module. The role of the NFC module is to read data from the NFC tags whereas the communication module checks and receives control signal from the smartphone application through the cloud server. The video and audio modules are responsible for the playback of the medicine information on a TV. The media controller module handles the control operations of the medicine information.

RESULTS AND DISCUSSION

A prototype of the NFC-MedIDS is successfully implemented and tested for the elderly to identify medicines at Faculty of Engineering (FOE), Multimedia University (MMU), Malaysia. The use of NFC technology in the system is to simplify the process of searching for specific medicine information. Each of the NFC tag stores unique data which represents a particular medicine. This greatly assists the elderly in identifying their medicines. Through the system, elderly need not search for the medicine information online which may not be easy for them and time consuming. They only need to tap the NFC smartphone on the NFC embedded medicine bottle to conveniently identify the medicine. The interaction required between the system and the elderly is simple, minimal and hassle-free. Besides using an NFC smartpphone, the elderly can also use the NFC MedID box as standalone medicine identification system. Instead of tapping the phone on the bottles, the elderly need only to tap the NFC-enabled medicine bottles on the NFC-MedID box. The interaction required to access information on the medicines in the form of video, audio and photo through a TV is similarly simple and minimal. The hardware implementation of the NFC MedID box is shown in Fig. 4. It consists of an RPI model B that is integrated with an Arduino along with an NXP Explore NFC shield.

A miniature WiFi dongle is connected to the system via a USB hub WiFi dongle to check and receive control signals from the cloud server. The USB hub allows other USB devices such as Bluetooth Low Energy (BLE) dongle, mouse and keyboard to connect to the system easily. A micro USB power supply of 5 V at 1 A is used to power up the NFC MedID box. The NFC Antenna from the NFC shield is used to read the data from various NFC tags attached to medicine boxes. RPI is employed to process the data read from the NFC tags and subsequently display the associated medicine information on a TV via HDMI connection. TV is selected as the display which provides better visuals for the elderly. The reasons are the size of the screen is much bigger than any NFC smartphones and it is commonly available in all homes. The software that drives the NFC-MedID box comprises a set of modules developed with Python scripts that run on Raspian operating system. Its functions include reading and decoding the data from the NFC tags and initiating the playback of relevant medicine information through OMX player.

Comparing with the existing medicine identification systems that use camera, the proposed NFC-MedIDS provides faster response and does not require sufficient lighting for optimal operation. Since, it does not rely on audio playback to relay the retrieved medicine information, unlike the systems that use audio, declining or impaired hearing of the user will not be an issue. The possible issue of declining eyesight among the elderly is overcome by the system's ability to use a TV display with a relatively large screen.

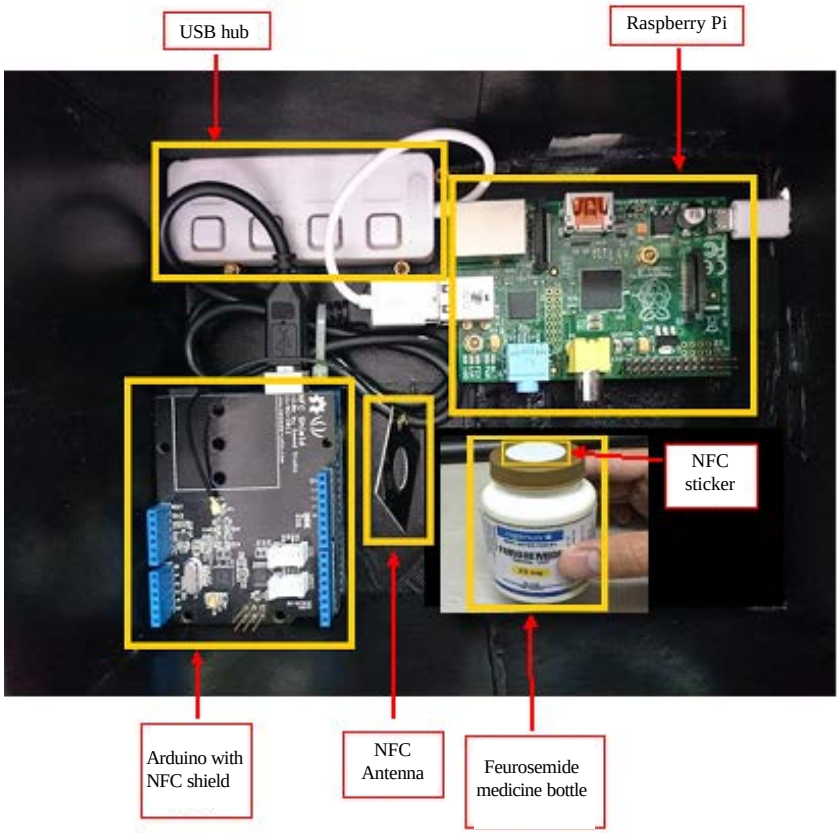

Fig. 4: Prototype of the NFC MedID box

CONCLUSION

The design canvas of medicine identification system has been expanded through the use of NFC and RPI technologies via a cost effective implementation of the NFC MedIDS. The proposed system strives to achieve an important step in assisting the elderly in identifying medicine in two ways: using the NFC smartphone to provide maximum flexibility for the elderly to easily identify medicine through tap-to-identify interaction that is simple to operate; using the cost-effective NFC MedID box, the elderly can view the medicine information on a large TV display simply by tapping the NFC tag-embedded bottle to the NFC MedID box. The fast and easy approach of the proposed NFC MedIDS could potentially transcend the conventional way of identifying medicine.

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