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A Design and Implementation of IoT-Based Blind Inpatient Monitoring System

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Abstract: In this study, we designed a blind inpatient monitoring system connected to Raspberry Pi 2 that supports the IoT (Internet of Things) based on windows. The proposed inpatient monitoring system helps the doctors to make effective rounds. Especially, patients with blindness can press the button connected to the Raspberry Pi to store their condition in the patient database. We designed blind patients to communicate their condition to a doctor or nurse through four buttons. All patients have one Raspberry Pi, so they communicate with buttons, microphones and earphones connected to the Raspberry Pi. We designed doctors and nurses to check the status of patients through the Android app in real time. We also added a macro function in our system to easily register frequently-sent messages from patients. In this system, patients can register daily status by individual date and doctors can access the web server and monitor the patient's condition in real time through the web and the app. Therefore, it is designed to enable stable system operation.

Key words: IoT (Internet of Things), Raspberry Pi, macro functions, inpatient monitoring system, designed

INTRODUCTION

IoT technology raises significant challenges that could stand in the way of realizing its potential benefits in various domains (Sanders and Stappers, 2008; Jang *et al*., 2016). It refers to scenarios where network connectivity and computing capabilities extends to objects, sensors and everyday items normally considered as computers allowing these devices to generate, exchange and consume data with minimal human intervention (Joonseok *et al*., 2017). In addition, with the use of IoT technology, the population using smartphones continues to grow. As that result, many people are using Health Care Applications for their health care (Seong-Bum *et al*., 2017). U-healthcare service which collects patient's information and monitors their activity can be provided due to the development of ubiquitous computing technology. Some hospitals utilize this service to monitor and manage in-patients real-time (Lee and Park, 2010). Doctors make rounds every morning to check on patients. If doctor did not have any information on patients and saw patient in order from patient 1-7 was in danger because doctor was running late from rounds, this indicates that patient management system is ineffective in this hospital. Therefore, there is a need for an effective patient management system so that doctors can be more effective going rounds and patient can alert the professionals about their condition by entering their own data into the system. Since, the blind cannot communicate well compared to the normal population, we had one actor as the blind and the system was designed accordingly. Each patient has one raspberry pi and they are able to communicate digitally with their physician and nurse via microphones, earphones and buttons attached to the Raspberry Pi.

With the rapid growth of the internet, more and more advanced devices or sensors have been used into it for performing the desired work (Saumya *et al*., 2016; Hyoung-Ro and Chi-Ho, 2016). The blind's button is made with braille keyboard. The system recognizes their voice through microphone so patient can use the system and also record their voice daily in a diary form. So, it helps them to be more independent and active in their community.

Recent studies confirm that writing is an effective psychological therapy to control one's emotions and improve relationships with others as well as a positive effect on boosting immunity and fighting illness. Based on these findings, we seek to maximize the healing effect by utilizing raspberry pi and voice recognition.

There are several buttons in this system: braille keyboard, send button, function change button, restroom button, meal button, medication button and emergency button. The restroom, meal and medication buttons let health professionals know whether if the patient defecated/urinated, ate and took medication or not which

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are three fundamental questions they ask the patients. Moreover, the emergency button alerts doctors and nurses right away and allows them to handle the situation quickly. All the actions in the system are sent to the web and Android so that doctors and nurses can view patient's information promptly.

In this study, we propose a blind inpatient monitoring system based on Raspberry Pi. Since, the proposed system is designed using Raspberry Pi which is a microcontroller, it is easily accessible to anyone and it is easy to store data using compatible devices on Raspberry Pi.

MATERIALS AND METHODS

Related technology

Raspberry Pi: The Raspberry Pi is a series of credit card-sized single-board computers developed in the United Kingdom by the Raspberry Pi Foundation to promote the teaching of basic computer science in schools and in developing countries. The original model became far more popular than anticipated, selling outside of its target market for uses such as robotics. Accessories including keyboards, mice and cases are not included with the Raspberry Pi. Some accessories however have been included in several official and unofficial bundles. Each Raspberry Pi located at each patient's bed sends data to Web and Android via Wifi dongle.

Android: A signal from patient is sent to web and the information can be viewed using Android. Doctors and nurses can check patient's message and their condition via Android frequently at any time.

STT (Speech to Text): Speech Recognition (SR) is the inter-disciplinary sub-field of computational linguistics which incorporates knowledge and research in the linguistics, computer science and electrical engineering fields to develop methodologies and technologies that enables the recognition and translation of spoken language into text by computers and computerized devices such as those categorized as smart technologies and robotics. It is also known as "Automatic Speech Recognition" (ASR), "computer speech recognition" or just "Speech to Text" (STT).

STTis a system that converts voice into text so it can be sent to web. It is easy to convert voice to text in English but not for Korean. Therefore, we had to use Google APIs to carry out this function in Korean. First of all, the frequency of patient's voice is recognized and converted into flac file. Google APIs then catch the exact frequency and convert into text.

TTS (Text to Speech): Speech synthesis is the artificial production of human speech. A computer system used for this purpose is called a speech computer or speech synthesizer and can be implemented in software or hardware products. A Text-to-Speech (TTS) system converts normal language text into speech; other systems render symbolic linguistic representations like phonetic transcriptions into speech. It is also hard to apply Korean into TTS system, so Google APIs are necessary to carry out the function. A text is converted back to voice file via Google API's Translate_Tts.

Macro function: Entering Braille alphabets one by one is slow compared to normal typing. In order to increase the speed, Macro function was added to frequently sent messages. If the button were pressed, the patient's saved macro message would be directed right away to doctors and nurses.

RESULTS AND DISCUSSION

Components of blind inpatient monitoring system

Raspberry Pi as IoT: Internet of Things (IoT) is a proposed development of the Internet in which everyday objects and people have network connectivity, allowing them to send and receive data. Raspberry Pi is an "open-type platform" based on IoT. Raspberry Pi is a small board consisting of hardware, hardware-controlling software and development tool. Since, a circuit diagram is open to public, anyone can buy the components and assemble or buy a completed board at cheap price. The operation of Raspberry Pi's sensors is trickier than Arduino. However, since computer and circuits are easily manipulated, Raspberry Pi is useful in constructing a product that interacts with the surrounding environment (Fig. 1).

Wifi dongle: Wifi dongle is iptime 802.1, helping Raspberry Pi to recognize Wifi without any previous installations and send data to server via the Wifi.

Input buttons: There are several buttons such as Braille keyboard, send button, function change button, restroom button, meal button, medication button and emergency button. Patients can send their message using Braille keyboard or speaking through microphone. The restroom, meal and medication buttons let health professionals know whether if the patient defecated/urinated, ate and took medication or not which are three fundamental questions they ask the patients. Moreover, the emergency

Fig. 1: Raspberry Pi 2 Model B

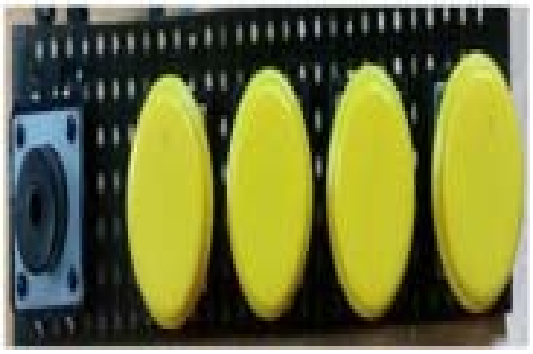

Fig. 2: Function change, restroom, medication, meal, emergency buttons

button alerts doctors and nurses right away and allows them to handle a similar emergency situation promptly (Fig. 2 and 3).

Eclipse and Terminal shell: Since, Raspberry Pi is a microcomputer, Eclipse can be installed. With Eclipse, Java socket is programmed to recognize patient's signal and socket is sent to web. Patient's signal and voice recognition are programmed with terminal shell.

Android studio: Android studio is the official Integrated Development Environment (IDE) for the Android platform.It was announced on May 16, 2013 at the Google I/O conference. Android Studio is freely available under the Apache License 2.0. It is a developmental tool that is used to create Android in which doctors and nurses use to check on their patients. New features are expected to be rolled out with each

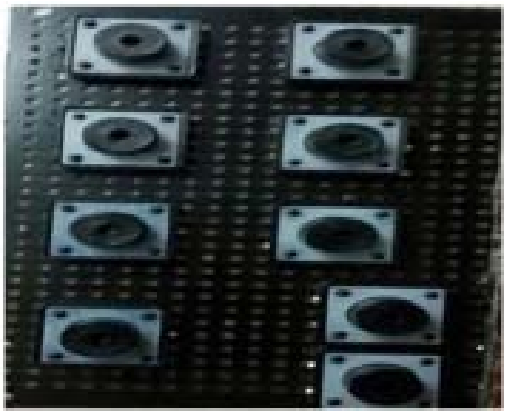

Fig. 3: Braille keyboard

release of Android studio. The following features are provided in the current stable version (Honig, 2013; Dobie, 2013):

- Gradle-based build support
- Android-specific refactoring and quick fixes
- Support for building Android Wear apps
- An Android virtual device that is used to run and debug apps

Google API: Both STT and TTS use Google API. Since, Google provides API to all countries, there are traffic issues and operation of the system can sometimes be less efficient.

Implementation of system: Figure 4 shows the configuration of the proposed system. The main processor used Raspberry Pi and connected the braille keyboards buttons and microphones. A web server was built to transmit and store sensed data and the data received by the web server can be stored in a database and monitored by a doctor or a nurse's PC or smart device.

Figure 5 shows the flow of the implemented system. Doctors and nurses use the Android app to check the patient's condition in real time. The patient stores his or her status in this system using the braille keyboard buttons and microphones associated with the Raspberry Pi. If the patient is typing on the keyboard, pressing a button or speaking a microphone, the data is sent to doctors and nurses. The patient's condition is entered using the button whether the patient is taking the restroom, taking medicine or eating the meal. The emergency call button is used when calling a nurse or doctor. All data is stored in the patient information database reflecting the patient's individual daily state in the system. Doctors can monitor patient status by viewing patient daily data. Next is the scenario.

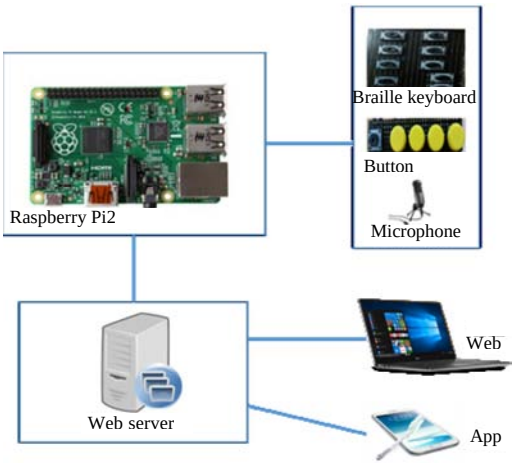

Fig. 4: System configuration

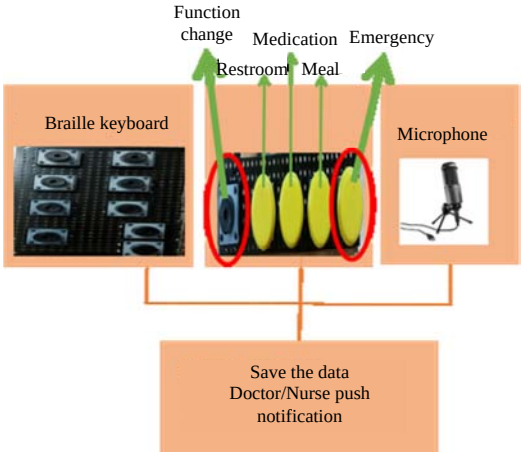

Fig. 5: System flow

A blind inpatient uses Raspberry Pi to communicate with doctors and physicians. Whenever patient defecates, he presses the restroom button and then doctors and nurses check the frequency of defecation to analyze his physical condition. When patient presses meal button, nurses can check if patient ate on time or not. If a patient does not eat after a certain time, nurse gets a list of patients who did not eat on their Android so that the nurse can take care of them. After 30 min after the meal, if patient does not take medication, the system alerts patients to take it as soon as possible. If patient does not take medication even after the alarm, the signal is sent to doctors and nurses so that those kinds of patients can be taken care of separately.

In a patient's point of view, if the neighbor patient is being loud, patient can let nurses know by sending the message using braille keyboard. Moreover, if the patient has pain but not enough to press emergency button, they can voice record their condition on the system. They can record the condition daily and also track previous records if they want.

CONCLUSION

This system allows patients to communicate directly with doctors and nurses using Raspberry Pi 2 Model B. Patient's conditions are gathered using various buttons and braille keyboard and updated quickly on the Web and Android. In this modern time of IoT, blind inpatient monitoring system should be convenient and also be easily accessible to patients and patient's guardians. This system uses Beacon and all cellphones in the hospital are controlled according to the hospital environment. Moreover, various sensors in Raspberry Pi are utilized to recognize patient's signal. This system is rather passive.

Future research topics are finding methods for Beacon to be operated automatically and designingalgorithm that allows doctors and nurses to handle emergencies and check patient's condition in real-time. Therefore, there should be an improvement where attending doctors and nurses get the signal automatically in emergency situations.

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