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Managing Healthcare Records via Mobile Applications

Eileen Y.P. Li, C.T. Lau and S. Chan

Abstract – **In this paper, a mobile application that facilitates users in managing healthcare records is proposed. Patient's important medical information such as measurements of vital signs can be easily captured and automatically uploaded to the care-giver's medical information system. The application is able to readily capture vital readings such as blood pressure, pulse rate, blood glucose level and body temperature using 3 approaches: (1) Bluetooth connectivity, (2) Optical Character Recognition, and (3) Voice Input Recognition. The benefits of using this application include time saving, ease of use, improve data entry accuracy, reduce medical records storage and reduce cost.**

Index Terms – self-management healthcare. mobile healthcare.

I. INTRODUCTION

STUDIES have shown that human error is a primary cause for contributing to many disasters and accidents in industries such as aviation, space exploration and medicine [1]. In the healthcare industry, human error includes errors in recording measurements taken from monitoring devices. In addition, improper documentations, similarly named medications, inadequate nurse-to-patient ratios, and illegible handwritings are also known as contributing factors to erroneous medical records.

Despite advances in Information Technology, the health care industry has been slow in implementing a fully integrated digital medical information system. Many healthcare service providers such as hospitals and clinics are still recording patients' medical information including vital signs measurements and medication prescriptions manually on papers. Usually the nurses and healthcare providers are required to manually record readings and plot graphs which show the trend of the patient's medical conditions. However, the nurses and healthcare providers have hectic schedules to follow, and often over-worked due to under-staffed in this profession, mistakes in recording the vital signs can occur and graphs may be erroneously plotted. This may result in patients not receiving appropriate medical attention. In this paper, a mobile application which is able to capture important medical information such as vital signs measurements automatically using 3 approaches such as Bluetooth connectivity, optical character recognition and voice recognition is proposed. The proposed mobile application allows the nurses and healthcare providers to record patient's vital signs information effectively and accurately. All recorded data can be further processed to obtain useful indicator on the assessment of acute illness such as the National Early Warning Score [2]. The mobile application can also readily be used by the user for self-monitoring of medical measurements.

The organization of this paper is as follows. Section II provides information on some existing applications related to this context. Section III provides a brief introduction of the android framework on which this mobile application is built. The detailed description of the proposed mobile application is provided in Section IV. Section V presents the surveys and the experiments done regarding the proposed mobile application and finally, the concluding remarks are given in Section VI.

II. RELATED WORK

There are many existing mobile applications in the market that can capture vital signs measurements and record these data in the mobile phones. Many of them also further process the recorded readings to obtain the statistical parameters and the graphical trends for better visual appeals. Some of the examples are as follows. The Blood Pressure Diary [3] is a blood pressure tracking and analysis tool. This application is intended to support regular blood pressure tracking for conducting the treatment led by a physician or performing preliminary self-analysis. The Blood Pressure (BP) Watch [4], which aims to help the user to get the most out of blood pressure monitoring. The Diabetes Monitor [5] is another tracking and analysis tool but is used for Diabetes patients.

Typically, these applications in the market focus on tracking a type of vital signs and further process the data gathered into statistic and graphs for nurses and healthcare providers to make use of when monitoring patients. However, the data entry for the existing mobile applications is done by manually typing them into the textboxes provided in the applications. Although the data are captured into the electronic systems, this is also a possibility that the user may enter incorrect vital signs measurement values. In addition, existing mobile applications target to capture only one type of vital signs. In the hospital or clinic environment, it is often required to take different kinds of vital signs measurement for each patient.

Although the existing applications are able to store and process medical data electronically, it does not provide options for the nurses and healthcare providers to automatically transfer vital sign measurements from healthcare devices to the existing applications. This automatic transferring of data between healthcare devices and mobile application is important in order to avoid

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manual input of values into the applications such as typing, and it is also able to cater to many different types of vital signs measurements within the same application.

III. ANDROID PLATFORM

The proposed mobile application has been developed based on Android platform. The android platform was chosen mainly due to the fact that it is a freely available open source platform and its flexibilities during the processing of development as compared to other platforms. Android is a Linux based open source operating system designed mainly for mobile devices with touchscreen user interface. The open source code allows the developers in the communication to be able to develop their own applications. It comes with a Java Virtual machine and various tools including a compiler, a debugger and a device emulator. An Android Development Tools (ADT) is made available to facilitate programmers in developing mobile applications using the freeware Integrated Development Environment (IDE) known as Eclipse [6].

A. Android Architecture

The Android Architecture layers are depicted in Figure 1 below:

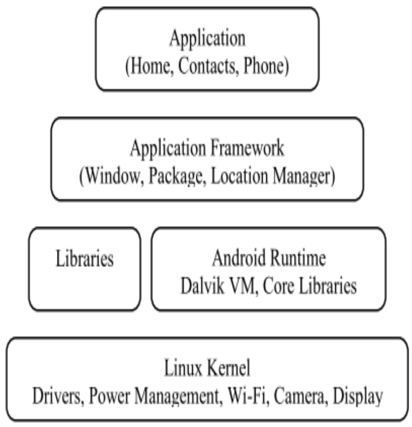

Figure 1: Android Architecture

B. Applications Layer

Android application layer includes a core set of built-in applications. These include the common useful applications such as Email Client, Short Message Service, Calendar, Maps, Internet Browser, Contacts, and many others.

C. Application Framework

Being an open source development platform, Android offers developers the ability to build extremely innovative applications. Developers can take advantage of many of the device built-in applications and also have access to the same framework application program interface (API) used by the core applications to develop an application according to their creativity. The architecture is designed in a way to simplify the reuse of components and beneath all applications is a set of services such as: (1) a rich and extensible set of user interface components that can be used to build an application, which includes lists, grids, text boxes, buttons, and others, (2) content providers that enable applications to access data from other applications, (3) a Resource Manager, providing access to non-code resources, (4) a Notification Manager that enables all applications to display custom alerts in the status bar (5) an Activity Manager that manages the lifecycle of applications. All these services are reusable and readily called upon by an application.

D. Android APIs

Android also provides developers a large set of APIs and methods that can support the developers in implementing their desired applications. These APIs and methods can be found in the official Android website [7].

IV. SYSTEM DESIGN

This project aims to develop a healthcare mobile application that is able to automatically (or manually with minimum operation) capture vital sign measurements from healthcare devices through 3 approaches: (1) Optical Character Recognition, (2) Bluetooth connectivity, (3) Voice Recognition. These functions will allow its user the ease of entering measurement values. Bluetooth Connectivity is readily available on devices such as Omron blood pressure device (model 708BP) which conforms to the guidelines defined by the Continua Health Alliance. For devices that are not Continua guidelines compliance or with no Bluetooth wireless communication function, the approaches (1) and (3) can be used. The Optical Character Recognition (OCR) fulfilled this automatic transfer of data through capturing the images of the measurement readings on the devices. The measurement results are then extracted from the images through some backend processing and the readings are presented in text format. The voice recognition does it by requesting the user to speak out the measurement results, and it converts the voice of the user into text format.

A. Optical Character Recognition

OCR allows automatic recognition of characters through an optical mechanism. OCR can recognize printed text, such as measurement results on healthcare devices. However, the accuracy of the results produced by OCR is directly dependent on the image quality of the input documents. OCR is designed to process the images that consist almost entirely of text, with very little non-text cluster obtain from the image that is captured by mobile camera. In this project, Google's open-source OCR engine, Tesseract [8], has been used.

Images captured often have defects which make it difficult for most OCR applications to correctly recognize the text represented. This give rises to the need of pre-processing before the recognition process is performed. The OCR engine, Tesseract, has been chosen because of the widespread approbation, its extensibility and flexibility. The following sections will discuss the details on the Tesseract architecture and the key steps of the OCR function in the proposed application.

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Tesseract Architecture

Figure 2 illustrates the various stages of the OCR engine that are required to recognize a text from within an image.

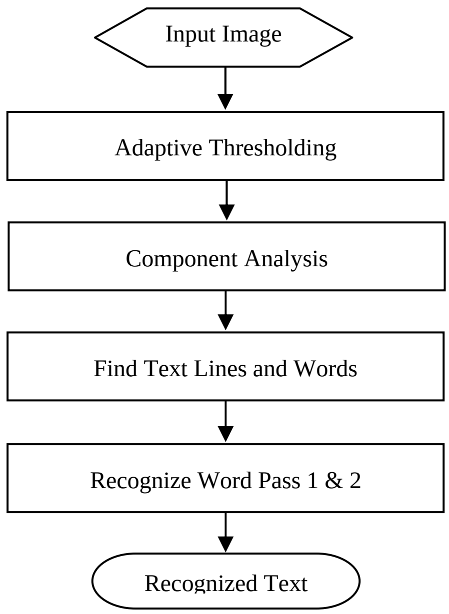

Figure 2: Tesseract Architecture

The outlines of the components of the input images are first collected. Next the nesting of the outlines is carried out on the gathered outlines in order to form a large binary object. These objects are then formed into text lines which are then used to analyse for fixed pitch and proportional text. Following that, they were broken into separate words by analysis according to the character spacing.

The process is followed by performing several activities to recognize the words. The recognition activities are mainly divided into two phases. The first phase tries to recognize the words of a given input image. Then the word that is satisfactory will be passed to Adaptive Classifier as training data, used for training, which will subsequently be used for the recognition of the desire text accurately. In the second phase, the words which were not recognized well in phase 1 are put through the test and recognition again. Finally Tesseract resolves the fuzzy spaces and returns the results of the recognized text extracted from the input image.

Implementations

This section describes the procedures implemented for the OCR functionality of the proposed application. The sequence of steps are as follows:

i. Scanning image captured from camera

ii. Segmentation of texts and images

iii. Pre-processing to remove noice

iv. Recognition for final texts output

Scanning

The proposed application uses the Android mobile camera to capture the images of the measurement readings on a healthcare device. This process is also known as the scanning process. Scanning comes with thresholding which makes the image taken as black and white image, also known as a binarized image. Thresholding is the process which converts multi-level image into binary image or black and white image [9]. Fixed threshold level is defined in thresholding. For each pixel, if the gray levels are below the threshold level, it will be identified as black. Otherwise the pixel's gray level is above the threshold level and it will be identified as white.

Segmentation

The process of locating regions of the text is called segmentation. Segmentation differentiates text from figures and graphics within an image. When segmentation is applied to the input images taken from the mobile's camera, it isolates characters or words from the image.

Pre-processing

Before performing the recognition process, some pre-processing is done on the image captured to clear some noise within the image. This consists of smoothing and normalization. The contrasts and brightness of the images taken were also adjusted to improve the OCR results. Further pre-processing were identified and executed if necessary to obtain a clearer image.

Recognition

The proposed application works with Tesseract algorithm which recognizes characters. Tesseract identifies characters in foreground pixels, which are known as blobs (large binary objects), and then it locates and identifies lines. Following that, word by word recognition of characters is done throughout the lines. The process of recognition involves converting these images into character streams representing letters of recognized words. In another word, for this stage, the algorithm extracts text from the images taken by users on their measurement readings displayed on the healthcare monitoring device.

B. Bluetooth Connectivity

Bluetooth technology has been a good choice for short-distance communication between devices and computers. Many newer models of the healthcare devices are Bluetooth enabled as well. The Bluetooth connectivity function in the proposed application is specially catered to the Blood Pressure monitoring devices which are compliance with the Continua guidelines. The Bluetooth health device profile (HDP) is used for this function. It uses the IEEE 11073-20601 [10] data exchange protocol as transport content, in order to standardize health device communication. HDP has two roles, operating as a sink and a source. As a source, the device transmits medical data; for example the blood pressure device. In this project, the blood pressure monitor used is Omron 708BP. While operating as a sink, the device receives the medical data; such as Android smartphones. There are 3 important procedures which are required for

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proper communication. They are, association procedure, configuring procedure and operating procedure. When the application is first started, Bluetooth must be enabled and registration must be done between the mobile application and the OMRON device. After the registration, the user can start to measure blood pressures using the OMRON device. Whenever a measurement has been taken, it can be transferred to the application via the Bluetooth link by pressing the "upload" button on the OMRON device. This measurement is then captured and displayed on the proposed application, and is available for further processing when necessary. The user interface of this function is as shown in Figure 3.

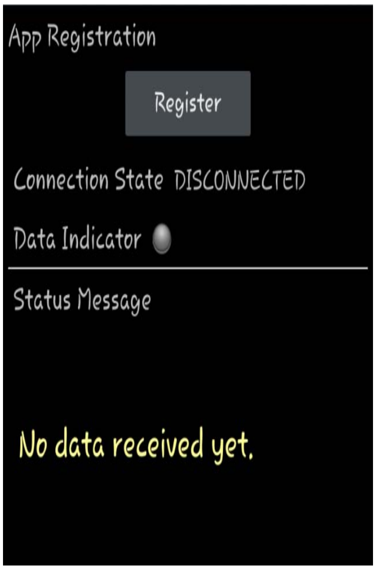

Figure 3: Bluetooth connectivity function

C. Voice Recognition

The voice recognition functionality for the proposed application is done on the Google server, using the Hidden Markov Model (HMM) algorithm. This functionality integrates direct speech input enabling user to record spoken measurement results from the healthcare devices as text message, and store in it the database for further references or processing. Once the application is started, the user interface of the application shows button which initiates voice recognition function as illustrated in Figure 5.

When speech is been detected, the application opens up the connection with Google's server and starts to communicate with it by sending blocks of speech signal. At the same time, the figure of waveform is generated on application's user interface for display. Speech recognition of the received signal is preformed on server. This is as illustrated in Figure 6.

When process of recognition is over, user can see the list of possible recognized text. Then they can choose the most appropriate recognized text and store it as a vital sign measurement value. This Process can be repeated by clicking on the "microphone" image button. This function can cater for various types of vital signs measurements.

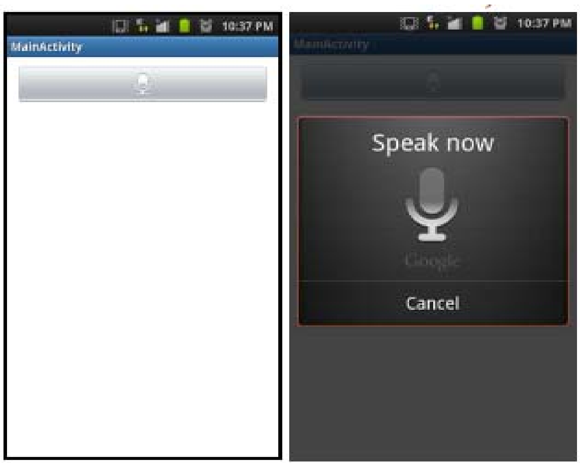

Figure 5: Voice recognition functionality

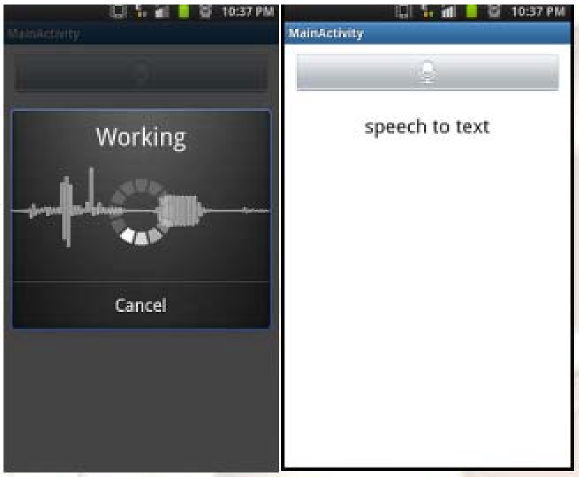

Figure 6: Processing input voice and output text result

V. RESULTS AND DISCUSSION

The evaluation of the mobile application has been carried out to obtain user's feedback on the 3 functionalities provided by the proposed application. The survey mainly focuses on the following aspects of the proposed applications: (1) the amount of time saved in recording medical information, ease of use of the application, data entry accuracy provided by the application.

Ten users comprising of 5 middle-aged adults and 5 adults in their early 20s participated in the evaluation and gave their feedbacks through the survey conducted. Results obtained show that the users are generally satisfied with the application in most aspects. The users find it time saving to allow the application to automatically record medical information for them, and the data entered were very accurate. However, most of the middle aged users find that the user interface of the application can be made much friendlier by reducing the number of selections involved when taking measurements. The feedbacks from these users are recorded as shown in Table 1. The number of user in each rating is presented in terms of percentage.

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Table 1:
Survey Results

<table>
<tr><th rowspan="2">Aspects</th><th rowspan="2">Age Group</th><th colspan="5">Ratings 5-Highest, 1-lowest</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr>
<tr><td rowspan="2">GUI Design</td><td>20-30</td><td>0</td><td>0</td><td>10</td><td>40</td><td>50</td></tr>
<tr><td>31-65</td><td>0</td><td>0</td><td>30</td><td>40</td><td>30</td></tr>
<tr><td rowspan="2">Ease of use for Bluetooth</td><td>20-30</td><td>0</td><td>0</td><td>0</td><td>20</td><td>80</td></tr>
<tr><td>31-65</td><td>0</td><td>10</td><td>10</td><td>20</td><td>60</td></tr>
<tr><td rowspan="2">Ease of use for Voice inputs</td><td>20-30</td><td>0</td><td>0</td><td>0</td><td>30</td><td>70</td></tr>
<tr><td>31-65</td><td>0</td><td>0</td><td>20</td><td>10</td><td>70</td></tr>
<tr><td rowspan="2">Accuracy of data entered</td><td>20-30</td><td>0</td><td>0</td><td>0</td><td>10</td><td>90</td></tr>
<tr><td>31-65</td><td>0</td><td>0</td><td>10</td><td>10</td><td>80</td></tr>
<tr><td rowspan="2">Clear instruction provided</td><td>20-30</td><td>0</td><td>0</td><td>20</td><td>0</td><td>80</td></tr>
<tr><td>31-65</td><td>0</td><td>0</td><td>40</td><td>60</td><td>0</td></tr>
<tr><td rowspan="2">Time saving</td><td>20-30</td><td>0</td><td>0</td><td>0</td><td>20</td><td>80</td></tr>
<tr><td>31-65</td><td>0</td><td>0</td><td>20</td><td>30</td><td>50</td></tr>
<tr><td rowspan="2">Comments</td><td>20-30</td><td colspan="5">• Bluetooth connection between BP monitor and application is convenient and fast
• Application is easy to use
• Medical information captured is accurate
• Time saving</td></tr>
<tr><td>31-65</td><td colspan="5">• It will be better if the number of selections is reduced when entering inputs through various ways.
• Convenient and interesting idea.
• Time required to get familiar with the application</td></tr>
</table>

VI. CONCLUSION

In summary, this paper studied 3 approaches, namely: Bluetooth connectivity, OCR, and voice recognition of the proposed application, to gather vital signs measurements automatically in order to reduce human errors. The benefits of using this application include time saving, ease of use, improve data entry accuracy, reduce medical records storage and reduce cost.

The Bluetooth connectivity is currently available for communication with Continua certified BP monitoring devices. Further implementation can be done to include Bluetooth connectivity link between other Continua certified medical devices such as the glucose meter and thermometer. Further studies can also be done on improving the accuracy of both OCR and voice recognition functionality for better user experience.

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