A Medical Kiosk System for Clinics

Darhene Donna Jean S. Polo[1], Ivan Gem M. Sumpay[1], Mia Joy E. Marquizo[1], Randy E. Angelia[2]

[1] *Electronics Engineering Program, College of Engineering Education*

[2] *Computer Engineering Program, College of Engineering Education*

University of Mindanao, Matina Campus, Davao City, Philippines

[1]darhenepolo@umindanao.edu.ph

[1]ivansumpay@umindanao.edu.ph

[1]miamarquizo@umindanao.edu.ph

[2]randy_angelia@umindanao.edu.ph

***Abstract*—With the busy and fast-moving life, every second counts, and even with little delays, the economy weakens. Daily traffic, long queues in banks and payment centers, or even long waiting-time for medical appointments are a few examples of loss of human productivity. This study evolved in developing a system that allows the clinic's patients to schedule an appointment by utilizing identification cards and biometrics. Specifically, to design and develop a system that can automate patient appointments to lessen the waiting time. The system is split into two: the kiosk system, where the user can access their accounts, and the administration system, where one administrator can control the queuing of appointments. The whole device is operated by Raspberry Pi 4B mini microcomputer with interconnection with Radio-frequency Identification (RFID) and biometrics device as well as a Global System for Mobile Communication (GSM) dongle for messaging and a thermal printer for issuance of queuing numbers. The functionality test reveals excellent results with 92.56 percent precision and 93.33 percent functional accuracy.**

***Index Terms*— Queuing system, RFID, Biometrics, Raspberry Pi, GSM module, Medical kiosk.**

I. INTRODUCTION

Community health centers are safety-net clinics that provide underserved and uninsured communities with primary care [1]. Nowadays, human beings are anxious about the state of their health; people from all walks of life keep their health conditions in check as much as possible, even with their busiest schedules. Unattended appointments, or "no-shows," are a burden in a fast-paced society where every second count, and having to waste any of it have consequences [2-3]. Appointment scheduling problems may result in minimizing patients' average waiting time, machines' or doctors' average idle time, overtime, and cost [4], because of increased spending on healthcare and an ever-increasing demand for healthcare services. To improve the profitability of their activities, hospitals face an ongoing challenge [5]. Therefore, countless attempts have been made in recent years to create new planning or patient methods for entry [6]. Healthcare centers are integral to life, providing first-aid medical services to individuals suffering from various common illnesses [7]. The clinics must also keep track of their day-to-day operations and the records of incoming patients. While electronic and mobile healthcare systems have many advantages, hackers often jeopardize access to health data [8].

A synthesis of 105 research on no-shows to appointments, for instance, indicated that distance to clinics is a pervasive problem adversely affecting the attendance of healthcare appointments. Socio-economic status, insurance status, and younger patient age were other determinants of absenteeism [9]. The development of efficient healthcare systems has become more critical for two main reasons in the last few decades. First is the rapid rise in healthcare spending in more developed countries and the simultaneous increase in demand for healthcare services and service quality demands of patients [10]. Outpatient clinics have become more critical in healthcare systems in recent years due to the focus on preventive medical procedures, shorter hospital stays, and outpatient provision of services. The appointment method is a significant component of successful treatment delivery in outpatient clinics [11].

A system protecting confidential information, or items of value, puts intense security demands on the identification. Biometry provides a user-friendly method to identify and become a competitor for current identification mechanisms, especially for electronic transactions [12]. With the frame-based biometric authentication, the researchers have also developed strictness for doctors and patients based on finger placement in the biometric scanner. To determine or verify the unique identity of an individual, a biometric is the automated use of unique human behavioral characteristics [13-14]. Lastly, the researchers have also developed an application that integrates Frame-based biometric methodology and RFID and GSM for access to records in a secure way [15]. Each area fingerprint scanner (sensor) has a unique scanner pattern that can distinguish one scanner from another. The design results from imperfections in converting the signal acquired from the object, applied to the scanner, into a digital image [16]. GSM Modem alerts the user by sending an SMS with the link using Global System for Mobile communication (GSM) modem controlled by simple AT commands. GSM sim900 is an ultra-compact and reliable wireless module [17].

This study designs an automated Medical Kiosk for a raspberry pi-based system that will function through a scientific and technical approach by developing a plan that would accommodate the patients most efficiently. In this study, the researchers achieved the following: (a) design a medical kiosk system for clinics that would allow the patients to schedule in queuing, (b) develop a program for the raspberry pi to run the physical network for the medical kiosk that the admin and the patients can access, (c) present the cost of the device, (d) perform functionality test for the registration process, accessing the medical results, scheduled appointments, and text alert.

Significantly the project is designed for the clinic customers or patients to provide better service and convenience. Creating a state-of-the-art customer service system will improve the clinics' service and the repository of clinical records.

The research study is designed and limited to scheduling medical appointments and consultations using the developed kiosk. Given the importance of medical data and privacy, only biometrics and RFID are used in user authentication. Moreover, the system will only store medical appointments, patient queuing, and laboratory results are taken from the clinic.

II. MATERIALS AND METHODS

A. Conceptual Framework

Exhibited in Fig. 1 is the conceptual framework of the project. Parameters such as patient data like basic personal information and contact numbers, biometrics, and RFID codes are the inputs of the study. Acquired data is processed and profiled by the system for possible utilization, such as queuing and repository of laboratory results. With the creation of the software and building up of hardware, the medical kiosks system for clinics materialized.

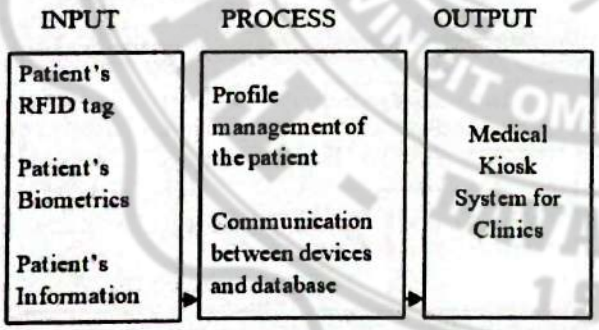

Fig 1 Conceptual framework

B. Functional Block Diagram

The Raspberry Pi minicomputer is the centrepiece of the system. It is used to fetch data from attached data acquisition devices and store essential data. Moreover, it is also responsible for providing feedback or outputs of the system. With the versatility of the Raspberry Pi minicomputer, the Medical kiosk is aimed to be flexible and portable.

Depicted in Fig 2 is the block diagram of a system. With the data acquisition devices, specifically RFID reader and Biometric acquisition devices, the Raspberry Pi processes the request of the acquired patient data. After processing, the GSM will be activated or send notifications, print information to the attached thermal printer or append queuing number of the system.

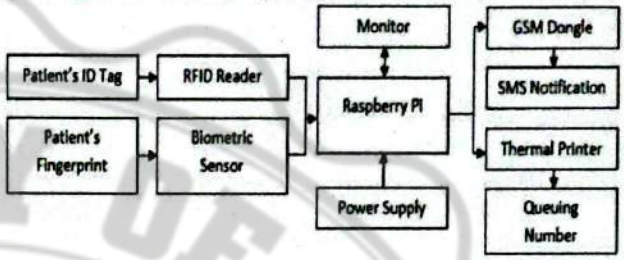

Fig 2 Functional block diagram of the study

In placing a patient appointment, it is a requirement to register to the system and RFID data and biometric information. The patient can put in doctor's appointments if all required data are provided. Then, the user will receive a printed copy of their queuing number. Thus, as a text message is sent to tell the user it is time for their appointment, they can now go somewhere to wait for their work.

C. Materials and Resources

The Medical kiosk consists of various components to make the system functional. This research used the Raspberry Pi 4 Model B computer manufactured by the Raspberry Foundation in China. The two-primary security of our study is the MFRC522 BXF RFID reader & tag version 1.0 manufactured by Shenzhen BXF Electronic Technology Co., LTD at, Guangdong, China. R307 Fingerprint sensor module manufactured by Raj Guru Electronics Private Limited in Maharashtra, India. For the input, the researchers used a P15 monitor 15.6" manufactured by ZSCMALL touchscreen monitor. Lastly, the output comprises the printer HOP-H58 Hoin Thermal Printer manufactured by Shenzhen Hoin Electronic Technology Co., LTD, and the GSM Huawei E173 3G USB dongle. The radio frequency identification module is connected through raspberry pi 4's general-purpose input/output pins. Simultaneously, the biometric sensor, thermal printer, and sim dongle are connected in ttyUSB0, ttyUSB1, ttyUSB2, and ttyUSB3 of the raspberry pi 4, respectively.

D. Product Design and Construction

The proposed study provides a multilayer of access to the system by enhancing the security levels to increase the privacy welfare of the patient's account. It also establishes a secure verification for the patient and the other individual's authentication.

Presented in Fig 3 is the proposed hardware plan for the medical kiosks. The kiosk has front measurements of about

50.8 cm x 60.96 cm x 13.97 cm and houses the 15.6" touchscreen monitor in the center.

The body of the medical kiosk is made up of a 0.375 cm inch thick plyboard. The frame of the medical system is podium-like, where the total height is measured at 127 cm, the top is 60.96cm, and the tube measures 63.5cm x 22.96cm. The RFID reader, RFID tag, fingerprint sensor module, and thermal printer are on its side. Inside its box, Raspberry Pi, USB dongle GSM, connectors, and extension wire drives the system were situated.

The box was designed to be closed and secured to protect the valuable electronic components. However, due to the required temperature of the components, a small 5volts computer box exhaust fan was mounted to maintain the temperature to its optimum level.

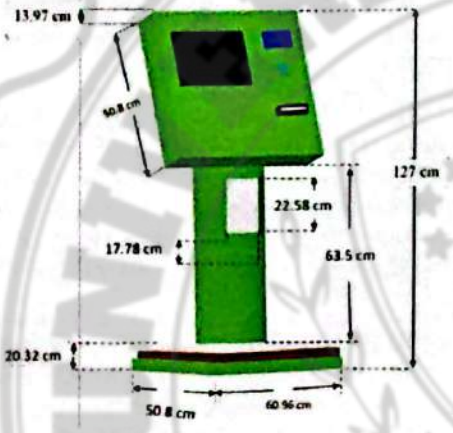

Fig 3 Medical Kiosk System for Clinic

A python flask interlinks the various components to the database. The input transferred to the Raspberry Pi 4B from RFID readers and biometrics is then processed through a JavaScript application to be stored in a database. This study utilizes MySQL for its database. The complete design and dimensions of the medical kiosk. A standard plug voltage of 220V powers this kiosk system.

E. Methods and Procedures

On the kiosk system, upon registering, a user must input necessary information like name, birthday, address, contact number, height, weight, and emergency contact number and then tap the RFID card to the reader. The card's hash or a string of unique code is then added. After that, the user's fingerprint is obtained by pressing a finger on the biometrics scanner, which generates a unique hash to be added to the user's profile. Pressing the "Save" button on the interface saves all the data the user has inputted. A prompt will then pop-up to signify that the user is now registered. If a registered user wants to see their profile, tap the "Authenticate" button. Then a prompt will pop up to indicate that the user must tap their RFID card and fingerprint to verify if the user accessing the profile is the valid owner of the account. After successfully opening the user's history, the verified user can access their profile. The user can now schedule an appointment by tapping the "Create Appointment" button, and it will automatically be queued according to the available number. A queuing number will then be printed. Users can also edit their profile by tapping the "Update" button on the interface's upper right side.

Fig 4 presents the kiosk system flowchart. This is to develop a workflow and understand how to execute a procedure upon accessing or registering a user and the user's options.

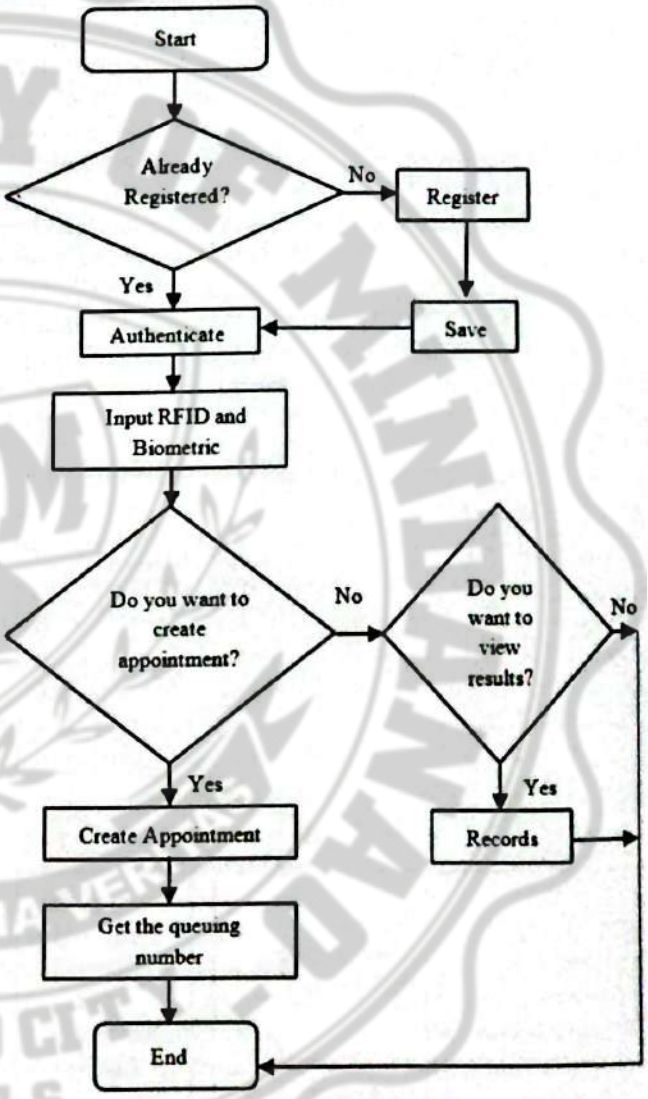

Fig 4 Kiosk System Flowchart

The administrator can access the profiles saved in the database on the admin system. The administrator can cater to the next patient by tapping the "Next Patient" button only in the admin system. By clicking the "Next Patient" button, A text message will be sent to the following user's phone number informing them that they are the next patient to be served. An administrator can also upload the test results in the user's profile or update the face upon the user's request.

III. RESULTS AND DISCUSSIONS

A. Prototype Design

Shown in Fig. 5 is the final device of the system. They are composed of three (3) main components in the kiosk interface: the RFID sensor located in the upper left and the biometric acquisition below it. Also, it showcases the main interface or the monitoring screen of the whole device. All other system components are securely placed at the rear portion of the kiosk and secured with security keys. Exhaust fans are mounted to maintain the ideal temperature of the electronic components.

Fig. 5 Front view of the actual design of the Medical Kiosk System for Clinic

B. Software Development

There are two systems to consider to attain the desired final product: the kiosk application and the backbone application, which is the administrator's application. The kiosk is where the user can register their profile and make an appointment. This system will let the users set their medication schedules and records at the booth. Users can also update their existing profiles on the system. In contrast, the administration course is where the clinic personnel can upload the results and queue and disorder the patient's appointment. The system lets the admin access the profiles saved into the database; it can also update a user's face upon a request when the user loses the RFID card given or the user forgets what fingerprint was saved in their profile. The system uses JavaScript and python to make the program for the user interface and connect to the hardware.

Exhibited in Fig 6 is the primary unit interface of the kiosk. This system will let the patients set their medical appointment and consultation at the booth. Also, patients can update their existing profiles on the system.

The Medical Kiosk mainframe served as the center point in all transactions in the clinic. This is also the information hub of the clients with the current marketing in the clinic.

Fig 6 Kiosk's Mainframe

Depicted in Fig 7 is the primary unit interface of the administrator system. In this part of the system, only the administrative or clinic personnel manipulate such us can upload photos and check and update the user's profile. Moreover, the admin personnel also used the said system in uploading the laboratory results of the patients.

Aside from managing patients' information, the application is also used to trigger the queuing of patients thru the admin software.

Fig 7 Admin's Main Frame

C. Functionality Testing

After completing the hardware set-up and completing the software applications for the project, it was tested to measure the device's functionality. All primary functions of the systems were tested and evaluated.

To consider if an attempt is successful during the functionality test, the user needs to register their basic information needed successfully, an RFID card given, and their biometrics. In determining if the user is registered, authentication is required.

Exhibited in Fig 8 is the authentication of the patient's ID and biometric. To proceed with the transactions, both should satisfy the condition to move to the patient's profile. Such a method is necessary for validating and identifying the identity of the patient or client.

Fig 8 Authentication

Depicted in Fig 9 is a sample printed copy of the queuing number of the patient. The client can only be queued to the system if the complete information was provided upon accessing the system.

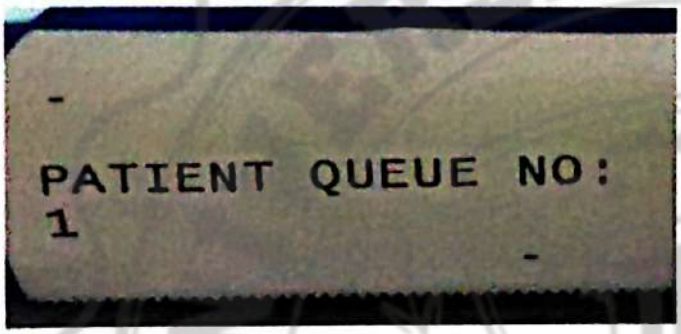

Fig 9 Printed Queuing Number

Fig 10., exhibited an actual SMS notification generated by the system and sent by the user. The SMS will notify the clients served and the succeeding client to be catered to. As shown in fig 2, patient 2 is null since no more patients are to be done.

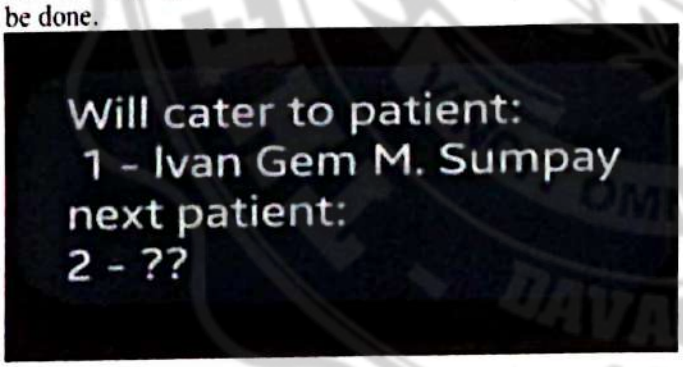

Fig 10 SMS Notification

D. Data Gathering

After completing the device, as part of the study, proponents should gather their data to check its functionality. Several factors were considered for testing the system. Researchers were able to conduct testing to check the functionality of the system. This study used a confusion matrix to analyze the data gathered. There are two possible outcomes in the process: "Yes" means that the user's RFID card and biometrics were recognized, and "No" means either the RFID card, the biometrics were not identified, or the GSM failed to send a message. To define the basic terms used for the classifier: TP (True Positive) applies to the predicted successful attempt and is ultimately successful. TN (True Negative) indicates that the anticipated failed attempt is finally a failure. FP (False Positive) suggests a predicted successful attempt but eventually fails. FN (False Negative) means an expected failed attempt but is finally successful. The researchers tested the system by sampling thirty accounts.

Presented in Table 1 is the result of the confusion matrix analysis conducted. The proponents utilized 27 registered accounts and three unregistered accounts. Out of 30 trials, the researchers predicted three failed and 27 successful attempts. In reality, 25 shots were successful, and five failed.

Using confusion matrix calculation, it was concluded that there was a 93.33% chance that the predicted success attempt would be success

TABLE I

TESTING RESULTS

n = 30	Predicted: No	Predicted: Yes
Actual: No	TN = 3	FP = 2
Actual: Yes	FN = 0	TP = 25

IV. CONCLUSIONS AND FUTURE WORKS

Completing the medical kiosk for clinics study is a testament to maximizing productivity through technology. Integration of new approaches and technology like SMS, Biometrics, and RFID has proved its worth in securing pertinent patients' information and valuable approaches like the queuing system.

It has been proven through the functionality test that the system is excellently performing well with 93.33 percent accuracy. It became successful in its proper programming structuring and correct algorithm though a 6.77 percent chance of inaccuracy can be improved by adding another layer of security and error trappings.

Nonetheless, this study can still be improved with much more advanced technology. The researchers highly recommended using IoT (Internet of Things) in innovating this study. More so, in this pandemic period, people tend to do indoor activities, and going to medical institutions and staying there for a prolonged period is not advisable. The proponents proposed making a version of this program into an IoT-based project to ensure the patients' safety.

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