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Development of Smart Health Screening System for Rural Communities in the Philippines

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Abstract: Philippines, surveyed as part of the 23 chosen countries worldwide, producing 80% of global mortality burden due to chronic diseases and 50% full disorder burden because of Noncommunicable diseases (NCDs) throughout the world. To prevent the growth of diseases, and in certain cases to prevent worsening of health conditions, screening is strongly recommended, identifying the symptoms while at their early stages. There is some laboratory test that a patient can undergo, if it is determined that a disease has emerged, further examinations will also be done to confirm the diagnosis. However, for people in rural areas, it is just additional burden because of the cost and time consumption. The aim of smart health screening system is to ease and enhance the quality of life in rural communities. The proponents introduced the system that screens specific health parameters related to cardiovascular system of an individual. The developed mobile application can monitor the patient's health parameters using commercially available medical devices and sensors integrated to the mobile application. The parameters include: Blood Pressure (BP), Heart Rate (HR), Oxygen Saturation (SPO2), Body Mass Index (BMI), Blood Glucose (BG), Cholesterol Level(Chol), and Uric Acid Level. An offline database of the gathered data was established for maintaining data privacy and for the admins to have access in medical records anytime.

Keywords: Smart Health Screening, Cardiovascular Disease, Remote Monitoring

1. INTRODUCTION

Technology, in conjunction with the developing world, is mainly considered to play an important role for various global advancements which also includes the evolution in health services. Combination of medical devices and sensors integrated with middleware and software that adjust to the current standard of the internet is the focal thought for the Internet of Things [1]. Sensors in the market are continuously being made smaller in size, cost-efficient but progressively being powerful at the same time. As competition arises, companies are being consistent in exerting a lot of effort in order to build sensors in maximum extent of development.

Noncommunicable diseases (NCDs) such as Cardiovascular Disease (CVD), Cancer, Diabetes, and Chronic Respiratory Disease (CRD), being the lead cause of global mortality rate, are responsible for the 41 million deaths annually which is also equivalent to 71% human deaths of the world. [2]. Cardiovascular Diseases (CVDs) are the leading cause of death internationally. [3]. Based from a 2016 report, an estimation of 17.9 million people is reportedly dead because of CVDs, equivalent to 31% of deaths worldwide and 85% are causes of Stroke and Myocardial Infarction (Heart Attack).

In Philippines, for the last 50 years, mortality rate due to NCDs became twice in number, including an estimate of 70% cases in association with the top 10 causes of deaths domestically [4]. Among the 23 surveyed international countries, Philippines contributes for about 80% of global mortality burden due to chronic disorders and 50% of full disorder burden because of NCDs [5].

In this paper, certain scenarios are presented where Smart Health Screening can be used effectively. Which are:

- When there are no medical personnel, people can easily operate this device because it is a user-friendly device.
- For the people in remote areas, it is very hard for them to visit hospitals to get a regular checkup cause hospital or any medical establishments may be very far

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from them, so this device could be beneficial for them by deploying this to their nearest barangay health centers.

- For the patients that prescribe to monitor their health for 24/7. By this device, they can afford to check their health status from time to time.

The researchers have been designing a system that can initially find to address the medical status of different health divisions in the Philippines, mainly in rural communities, by providing a cost-efficient and reliable medical screening and predictive disease system.

Three major functionalities comprised the whole system. First is to gather all required health parameters from the medical devices and sensors through a mobile application built for the system, including Blood Pressure (BP), Heart Rate (HR), Oxygen Saturation (SPO2), Body Mass Index (BMI), Blood Glucose (BG), Cholesterol Level (Chol), and Uric Acid Level along with the Medical Risk Assessment Questionnaires. Secondly, all parameter results can be viewed on a provided screen as it processes in the predictive system. All data will be saved offline the system's database. Lastly, the third part will give the result of the disease percentage and will also be viewed on the provided screen. For the users, printed copies of the summarized medical results will also be given.

The study also advocates to give a vision for health agencies in the government about advanced medical services especially for the lacking communities due to major reasons (far beyond their reach, expensive, lack of medical professionals in a location also time consuming). This will provide immediate diagnosis of a disease, which results to early prevention and to avoid a certain death. Another thing is that it raises the medical awareness of the people, leading the knowledge to be more on scientific. A knowledge excluding the subjectivism and superstitions, focusing mainly on scientific-based practices.

2. Related Works

Resembling the advances in Health Screening applications, various ventures of significant writings have been distributed. For example, an Android mobile application developed by Omer and AlSalihi, named as "HealthMate", functioning together with integrated health sensors for health monitoring. A web-based app was developed for medical practitioners. Jain and Arif [7] developed "HEMAN", aimed to use a software called LabVIEW, also for health monitoring and for the gathered health parameters to be analyzed.

For Smart Health Monitoring System that was developed by Khan and Chattopadhyay [8], it aims to utilize the health sensors that are integrated together with a microcontroller Arduino UNO for data reading in the Serial Monitor.

Mobile application and desktop software are both created to function as health monitoring devices. A system allowing medical professionals to monitor patients who are beyond of their reach in real-time, extending their capabilities to monitor multiple health status all connecte to a single device. It is a Real time Patient Monitoring System that was developed by Alam and Banu [9]. Another one, a low-cost smart wireless monitoring system in Android platform is proposed by researchers Kuman and Venkatesan.

Meanwhile, in [11], a system was developed that measured and correlated pH levels of sweat to an individual's pre-cognitive condition. The data is transmitted through LoRaWAN and Internet. In [12], a pH measuring device was created through characterization of a pH test strip based on LED optical absorbance. Potentiometric method was used in [13] to observe changes in hormonal balance due to ovulation in women.

On the other hand, image processing can be used in disease diagnosis. A fingernail image diagnostic device was developed in [14] that can detect circulatory diseases while a health evaluation device was constructed in [15] through tongue images. Images of microscopic urine constituents were analyzed in [16] and [17] using Prewitt operators and edge detection method for disease recognition. Skin images were analyzed in [18] for the diagnosis of skin diseases.

The referenced projects were added to build up the Smart Health Screening System in the early stage. In addition to the facts that, the results of these system were consequently utilized as a foundation plan to design and build up this system.

3. Development Of Smart Health Screening

The design of Smart Health Screening system is classified into three stages: Biomedical Data Acquisition; Data Processing and Communication; Display Panel as shown in Figure 1.

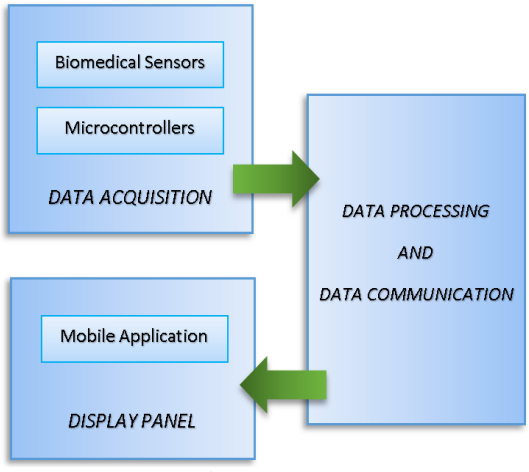

Figure 1. Overview of the Smart Health Screening System

A. *Data Acquisition*

The information to be procured relies upon the circumstance of the patient. However, the Smart Health Screening stage is intended to help an assortment of body parameters to be acquired to obtain the biometric information of the subject. This sensor stage is integrated directly to Raspberry Pi 3 and Arduino Mega 2560.

The system's work sequence covers the detection of health parameter through biomedical sensors and medical devices, microcontrollers for the acquisition of data, an Android application wherein allowing the user to input personal information and to provide their answers in the medical risk assessment questionnaires, and to analyze all given data to produce the predicted percentages of diseases through the implemented algorithms.

1) Sensors

In this system, the proponents used both noninvasive and invasive devices. The researchers utilized commercially available medical sensors and devices providing the required health parameters. Figure 2 shows a. HX711 and Load Cells, b. HC-SR04, and c. MAX30100 are the sensors integrated in the microcontroller.

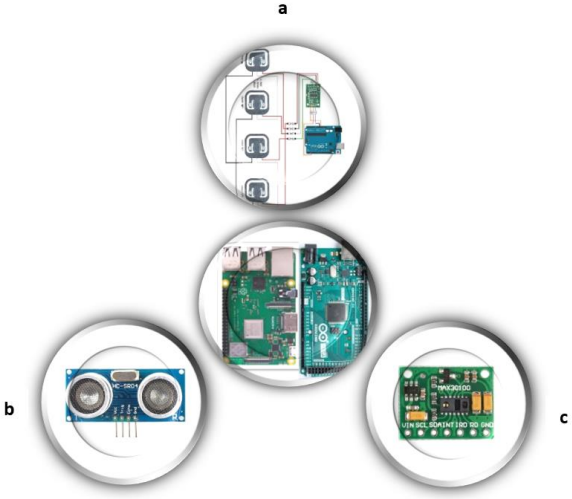

Figure 2. Sensors interfacing to Arduino

This system incorporates the following sensors and devices:

- EasySure GCU (Glucose, Cholesterol, Uric Acid)
- MAX30100- Pulse and Oxygen in Blood Sensor (SPO2)
- CK-101 Digital Blood Pressure device
- HC-SR04- Height Sensor
- HX711, Load Cells- Weight Sensor

In this Smart Health Screening platform, we interface the sensors to ATMega 2560 to utilize its connections which make it easy to operate. Sensors that are exhibited in the system principally imparts through digital, analog and serial protocols. Each one of these sensors are associated with the Microcontroller which gives the essential connectors and voltage level shifters to every sensor based on its specs.

2) Microcontroller

In Smart Health Screening system, we utilized the Arduino Mega microcontroller because of its memory space, greater size and more input and output pins. ATMega 2560 has an 8-bit board, 54 advanced pin MHz crystal oscillators, a USB association, reset button, an ICSP header, and a power jack. It is modified to interface all sensors and the printing of results in thermal printer. Arduino software (IDE) will be used to program microcontroller for connecting sensors, Bluetooth module and thermal printer to microcontroller. Arduino IDE is an open source Arduino software where you can write codes with an ease and upload it to the board. It runs in Linux, Windows and Mac OS X.

Smart Health Screening schematic diagram is shown in figure 3. This circuit includes height sensor, load cells, Bluetooth module, thermal printer, raspberry pi 3, Arduino mega and other miscellaneous components (USB header, etc). It shows the connection of sensors, thermal printer, Raspberry pi 3 and other miscellaneous components to ATMega2560

B. *Data Acquisition*

In the past few years, there are researchers that develops system and algorithms which enables to remotely monitor a patien by using sensors that is attached in patients' body and by using smart phones, laptops, desktop and so forth [6], [8], [10].

The Smart Health Screening System is designed to provide individuals a preventive measure by giving users an ailment analysis: allowing to give an automatic assessment by themselves on the most proficient method to deal with their conditions and react proactively to their interest in a manner that a user associating the system can interface to the included sensors and medical devices from the system and have it checked repeatedly.

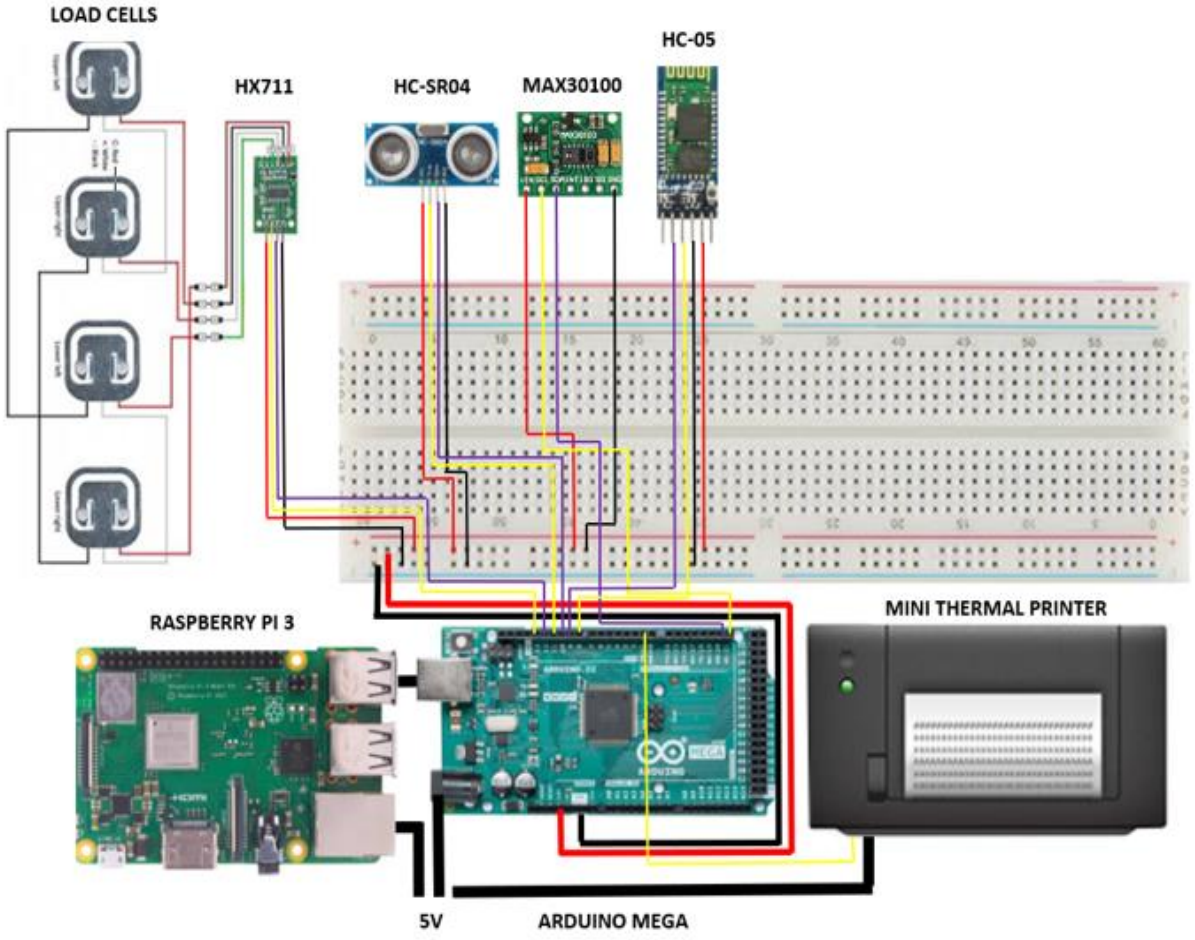

Figure 3. Schematic Diagram for Smart Health Screening

When there are no medical personnel, peoples in rural areas tend to ignore their disease even though they already have a symptom because having a medical checkup can be a little hassle for them. A mobile application is developed by the proponents which is based on Android platform using B4A-Bridge, which provides the app's interface for the medical sensors and devices. Their disease percentage will be also viewed on the mobile device therefore they can determine if they are in serious condition based from the acquired medical results.

Figure 4 shows the sequence of system communication. The data acquired from the sensors will be gathered by the Arduino Mega. Then by using a direct connection, the data gathered by Arduino will transferred to Raspberry Pi 3. In the connection of microcontrollers for the medical data to be displayed on the provided display device, Bluetooth (HC-05) is used.

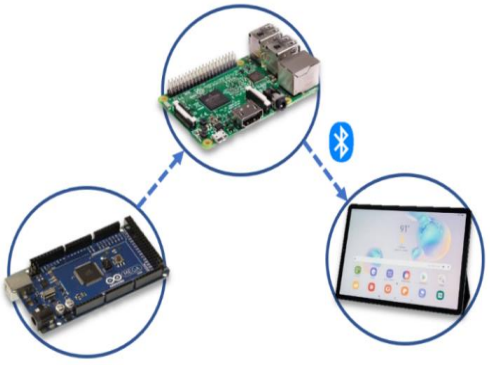

Figure 4. Data Communication Channel of the system

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B4A-Bridge is a simplest connection method, made up of two components. One is within a mobile device that allows the second component which is part of the IDE to connect and communicate with the device [19].

One of the microcontrollers that the researchers will be utilized is Arduino Mega. Because of its memory space, greater size and more I/O pins the researchers would like to use it. With 8-bit board, a USB association, 54 advanced pin MHz crystal oscillators, an ICSP header, a power jack, and a reset button. It is modified to interface all sensors and the printing of results in thermal printer.

The other microcontroller that the proponents used is the Raspberry pi 3. The primary motivation behind why the proponents used Raspberry Pi 3, because of its capacity for storing data and predicted output. Raspberry Pi 3 has a 1.2 GHz quad-core 64-bit ARM cortex A53 CPU and a memory size of 1GB and can expand to 40 general purpose input-output pins. Model B brings a more outstanding processor, around 10 times quicker than the other model of Raspberry Pi. It has a micro SD space for saving data and loading operating system.

The technique used in the mobile application is chaining inferences forward. With the help of this application, percentage of disease can be predicted by using an Android device as the media of communication between the system and the user.

C. Display Panel

As for the third part, it is the application that works for the prediction system and mediator between the system and the user. Once all the required data re gathered by the system, it can be displayed on the connected Android powered device. For the users, printed copies of the summarized medical results will also be given. It also includes the refence ID code. Since the database will be made offline, medical records will maintain its security supporting the Data Privacy Act that only the admins can have an access.

The application is made in Android platform simply because for the convenience and is built to be user-friendly. Also, an interface for both admin and patient is included for system's management purposes. They can both view personal data but as an admin, there will be added privileges.

Figure 5 presents all of the tabs included in the Android application. Each view of the tab has a different functionalities which includes a tab for getting the patient information, automatic averaging of data upon using the integrated medical sensors, manual input of medical parameters from other medical devices, medical risk assessment questionnaires, and display of results.

On the user interface, personal information and medical risk assessment questionnaires are required to be answered before proceeding to acquisition of required health parameters through medical sensors and devices of the system. A user can have a preview of own history when decided to view it again while for the admin's interface is capable of viewing all the stored medical records in the overall system.

It shows the display of patients result in Android application. The results obtained from medical devices and sensors, responses in the questionnaire, and patient information are shown.

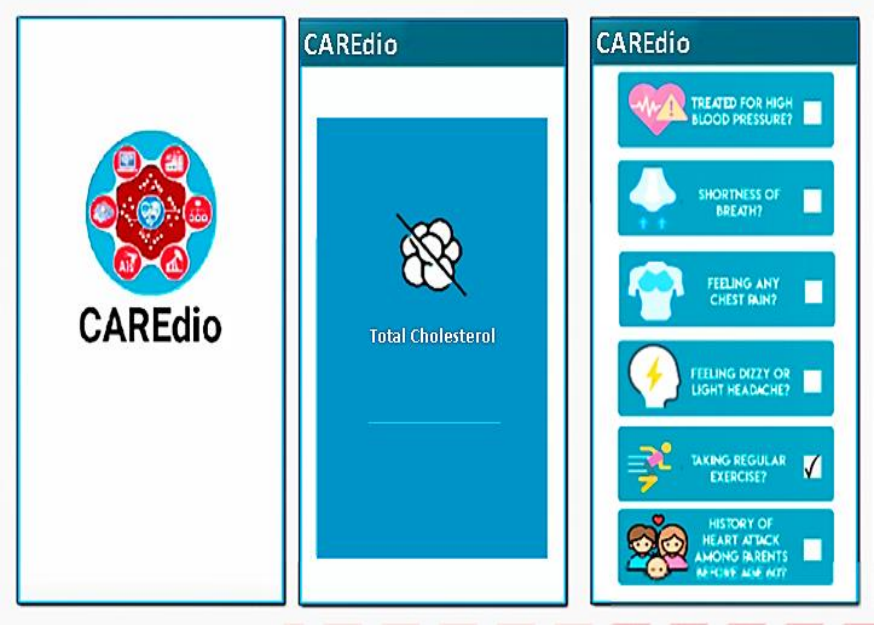

Figure 5. Smart Health Screening Android Application

After getting the result, the data of the patient will be forwarded to the database called MySQL and will be saved in csv file format. The database consists of timestamp, name of patients, age, health parameters and result percentage. MySQL is an open source relational database that can store and access data across multiple storage engines, like CSV and InnoDB. It can also duplicate data and sectioning tables for better durability and performance.

The patients can choose whether they want a hardcopy or not. This is an optional decision because sometimes the patient maybe doesn't have a smart phone to save their medication results. So, for printing output results of patient, a Thermal Printer is utilized. The thermal printer compatible with Arduino requires a 2.25" wide, 50ft or shorter thermal paper. With a printing speed of 50-80mm/s and a resolution of 8 dots/mm, 384 dots/line. It can operate in 3.3v to 5v TTL serial output.

4. CONCLUSION

In this study, the development of Smart Health Screening was successfully executed for the three of the most prevalent heart diseases in the Philippines. The system is screening the health parameters with the design that was composed of different health sensors and devices and analyzing the data collected from the patients to check the health parameters of the patient. The system is cost-efficient, having just a mobile application and the main prototype.

Therefore, Smart Health Screening has a user-friendly interface that can easily be used by a community health worker or GP doctor to screen for disease. Screening health system can act a vital role for community health workers in the prevention of having a disease due to disability of low resource areas. This system can help a community health worker or GP doctor in making decisions towards patient health risks. It generates results that make it closer to the real-life situations. This project could also be improved by using of additional medical sensors, this will increase the accuracy and sensitivity of the device. It is also recommended to use additional types of diseases for a wider scope which will make the project more useful. Thirdly, the researchers recommend that future researchers develop an application that will easily gather the readings of sensors and saving the file with .csv file format without the help of terminal.

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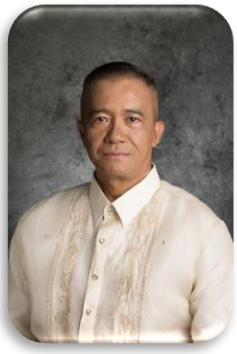

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