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Pillbox: Medicine Recognition System for Chronic Patients using Raspberry Pi

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Abstract: Chronic disease has become important threat to be handled in today's date. As per WHO the millions of people suffering from this disease and most of them are older ones. Overall death rate in country is effecting due to chronic disease. The main reason of increased number of chronic patients is nothing but having lot of medications because of having number of health conditions as well as increased percentage of drugs in patient's body. So, the system introduced successfully works to reduce death rate as well as to minimize drug intake in patient's body. The system comprises of raspberry pi based pill recognition device namely "Pillbox", Apache cloud based platform and android based mobile application.
Keywords: Medicine Recognition, Chronic Disease, REST API, Raspberry Pi, ssd_mobilenet_v1_coco model.

I. INTRODUCTION

Chronic disease is currently posing a rising threat around the world. Chronic disease is described as a condition that affects a person for an extended period of time. It causes rapid death as well as disability to the patients with this disease. As a result, all physicians and health organizations are facing a challenge. The most recent WHO study provides insight into the growing prevalence of chronic disease. According to WHO surveys, chronic illnesses like hypertension, Blood sugar, cancer, heart disease has leaved an impact in lives of many people. It's not only getting spread in high income countries but also in lots of lower and middle income countries. Overall 20% deaths are causing in higher income countries while the rate of deaths in lower income countries is 80%. WHO also gives a report about rate of deaths in 2005 year Globally 58 million deaths caused from that 38 million deaths are caused by chronic disease WHO also throws prediction that the rate of deaths in upcoming 10 years will be increase about 17% in because of chronic disease. Because of their weakened immune systems, this disease is mainly found in the elderly, who have become easy prey for this threat. As a result, it has been riskier for elderly patients, resulting in a higher mortality rate. To address this problem, the system will assist patients in taking the appropriate medications at the appropriate times. As a result, the number of deaths is reduced, as is the opioid content in the patient's medication intake. This system consist of an android mobile device with one application to notify patients family members about patients daily medication intake, one cloud platform nothing but amazon web services for storing patients overall data. Also system contain one recognition device which can help patients to take medications on time. Recognition device assembled using Raspberry pi board's version 4 and model B which is quicker and chipper board. Also one 5 MP raspberry pi camera to capture the current medications of patients. It also consist of one amplifier speaker unit to dictate patients about the medications dosage. The device would aid in the monitoring of the patient's drug behaviors on a regular basis. It asks patients to keep their drugs in front of the camera, which it then captures and sends to a database via Raspberry Pi. The Raspberry Pi and the cloud are connected via Wi-Fi, and the mobile device is connected to the cloud platform via the mobile device's 4G network. After that, the machine compares the drug images to the images stored in the database, and then uses voice prompts to direct the patient through the medication intake process. It also notifies the patient's family members about drug intake and sends a regular report via a mobile device application. The system results in 100% accuracy in medication recognition also this method will successfully work to minimize the amount of medication taken by chronic patients that are taking the wrong medications. It can also assist physicians in determining whether or not the patient is taking the proper drugs. As a result, the machine would be useful in lowering the death rate.

II. LITERATURE

Usability and sensor interface interoperability are two major technical obstacles to the widespread introduction of patient tele monitoring services for chronic condition care. Since a large number of chronic patients are also aged, the system's accessibility must be tailored to their needs. This paper outlines a series of design criteria to resolve these problems and explains the resulting device, which is based on a wireless sensor network and includes a node as a custom-made interface that adheres to the specified usability design criteria. A validated usability questionnaire was used to assess this device, which was assessed with 22 users. The results are fine, and they outperform those of other TV or smartphone-based systems. [1]

Using a three-staged approach, this paper introduces a novel approach to the challenge of medicine box identification. The algorithms for each stage are presented, including barcode recognition, text recognition, and feature matching techniques. The system's ultimate aim is to use a camera mounted on an Android smartphone to properly locate prescription boxes and then give accurate information to people with disabilities. This study found that labelling boxes using their barcodes or running an OCR to detect the drug name had an 80 percent success rate. In the case of function matching, the success rate is higher, but the evolved approach is sluggish in its current state. [2]

Per year, about 6,000 to 8,000 people die around the world as a result of taking a pill incorrectly. Pill recognition schemes based on form, color, and other characteristics have also been suggested in some studies. The author proposes a pill attribute extractor to distinguish pills based on form and color in this paper. The function extractors were evaluated using three classifiers (KNN, SVM, and Bayes). The results show that CoforDes is an outstanding function extractor for extracting drug pill photographs, and that because of its speed, it can be used in real-time applications. [3].

The Internet of Things has seen a lot of press in recent years because of its ability to relieve the pressure about healthcare services brought about by an ageing population and an increase in chronic disease. Since standardization is a major roadblock to advancement in this field, this paper suggests a blueprint for use in potential Internet of Things healthcare systems. The state-of-the-art research relating to each region of the model is then presented in this survey report, which evaluates their capabilities, shortcomings, and general suitability for a wearable IoT healthcare system. Security, safety, wear ability, and low-power activity are among the challenges that healthcare IoT faces, and guidelines for future research directions are made. [4].

To hypothesis object positions, state-of-the-art object detection networks depend on area proposal algorithms. This paper introduces a Region Proposal Network (RPN) that shares full-image convolutional features with the detection network, allowing region proposals to be virtually cost-free. An RPN is a completely convolutional network that predicts object bounds and scores at each location at the same time. The RPN is qualified from start to finish to produce high-quality area proposals that Quick R-CNN uses for identification. [5].

The customer satisfaction identification method is detailed in this article. Speech and the user's facial expression are the two graphical contents that would be reviewed. There will be three outputs for the satisfaction results: satisfied, not satisfied, and indifferent. As a result, this paper employs digital media to gather customer feedback. Just voice and photographs are used as signs. The user's voice and facial image are collected, then sent over the cloud network for analysis. Interactive media sensors are used in an integrated home to receive signals. The outcome will be communicated to the relevant stakeholders. In terms of happiness identification, the device is 93 percent accurate. [6].

Poor drug adherence endangers a person's wellbeing and accounts for a significant portion of medical expenses in the United States each year. Author created a smartwatch program that gathers data from integrated inertial sensors, such as an accelerometer and gyroscope, to detect a set of behaviors that occur during an individual's drug intake in order to increase medication adherence rates and provide timely reminders. They were able to preprocess high frequency sensor data and implement a random forest algorithm using these methods, resulting in high frequency and recall of the aforementioned behavior. [7].

For intelligent healthcare, human activity tracking may be useful for remotely monitoring the condition of patients or elderly people. The paper introduced a new deep learning framework called the recurrent 3D convolutional neural network (R3D) for extracting efficient and discriminative spatial-temporal features to be used for action recognition. The R3D architecture allows for the capture of long-range temporal information by aggregating the 3D convolutional network entries to serve as an input to the LSTM architecture. The experimental results showed that the proposed method, which can be used for remote healthcare monitoring, is successful. [8]

Rapid advancements in sensor and information technologies have resulted in the creation of instruments and approaches for customized health tracking. In this article, we recommend an integrated framework for monitoring elderly people's health. This system is designed to provide physicians and community nurses with computer-assisted decision support so that they can quickly track and assess an elderly person's overall activity and vital signs using a portable fitness tacker and an all-in-one satiation-based screening method, resulting in a cost-effective approach with less human error. [9]

The use of symptom checkers, which are online wellness apps that offer diagnostic information about users' health, has grown in popularity as the public's interest in healthcare has grown. However, since current symptom checkers depend on manually built information models, their diagnostic accuracy remains limited. The proposed methodology uses two well-established ontologies for diseases and symptoms, as well as a large-scale medical bibliographic archive and an open biomedical library, to automatically produce a human disease diagnosis ontology. The suggested approach also delivers medical improvement information to the patient, and can be used to detect or control disease progression by taking into account improvements in symptoms over time.[10]

More Cyber-Physical Systems (CPS) implementations in the linked health sector have been created by recent developments in Wireless Sensor Networks (WSNs), physical sensors, and the Internet of Things. This paper describes a shared sensing technique-based non-invasive drug compliance control scheme. A medicine bottle is included in the device, which contains a transfer sensor, a MEMS accelerometer, a load cell, and a wireless interface. The aim of this paper is to look at the viability of collective sensing in order to reduce total energy consumption while ensuring versatility in order to improve user acceptability and usability. [11]

III. METHODOLOGY

A. *Basic Concept*

This technology will recognize pills instantly and assist patients with chronic conditions in recognizing prescription dosages and other related material, reducing the risk of patients taking the wrong medication. We suggest an intelligent medicine recognition system namely "Pillbox". Which is built on deep learning technologies to solve the challenges faced by patients with chronic diseases. The block diagram is shown in Figure 1 below.

This System works in several steps as follows:

1) *Step I*- User Log in First user goes through the verification process for successfully log in to his or her account. After successfully log in user can scan QR code on the medicine packet after clicking on the QR code scan option for getting the medication information.

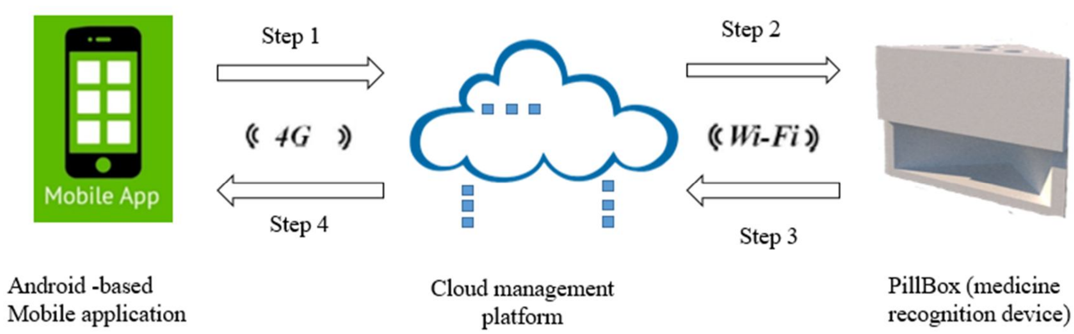

Figure 1: System Block Diagram

2) *Step II*- Connection between mobile app and cloud management platform. Second step is to connect android app to cloud platform through 4G network. The scanned QR code data will be then uploaded to the cloud through this 4G network. The medicine details like the name of medicine, time to take medicine and medicine dose available to check on website.
3) *Step III*- Connection between cloud management platform and medicine identification device. The cloud platform will transfer the medicine information scanned by QR code to the medicine identification system using Wi-Fi network. Then pillbox will throw voice reminder to patients through amplifier unit. Then patient will place the medicines in front of 5 MP camera attached to the raspberry pi module in the identification device. After successfully recognition the result will be announced by voice prompt to the patient and then patient can take correct dosage of medicine in the right time.
4) *Step IV*- Sending result back to the cloud. After successfully recognition the recognition device sends the result to the cloud platform through wide fidelity network. So the one who is using android app can get the status of daily dosage taken by the patient as well as can keep the record of the patient's medicines.
5) *Step V*- Send feedback to the android app from cloud over 4G network. After getting result from medicine device the cloud platform sends feedback to the android app about the patient's medication record. So that family members can take care about the chronic patient's health.

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B. Mobile Application

The application namely Pillbox is designed to establish communication with recognition device also to get the current status of patient medicines. It is going to help patient's relatives to track patient's daily medicine activities. Application is having QR code scanning to connect to the recognition device (Pillbox), list of medicines, medicine time reminders, and other functions are among its capabilities. The application name is Pillbox which is going to instruct patients to take respective medicines as per the timing given by doctors. The user first need to login into the application by using the ID and password provided by the developers or device owners then he can ready to add all the information of patients using Device and Patients options given in application as shown in fig.2 and 3 below.

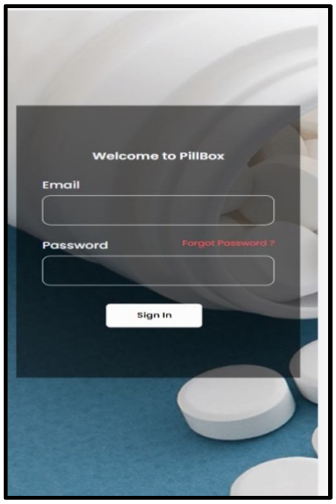

Figure 2: User Login

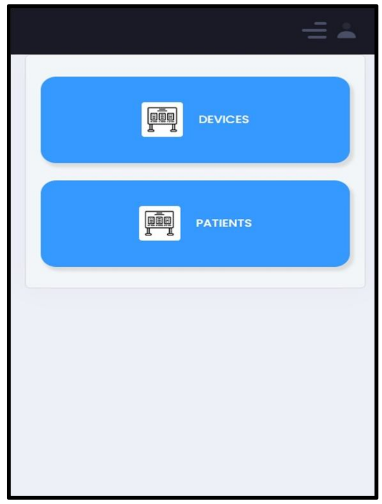

Figure 3: Application first page

The first page of application is consist of two options namely Devices and Patients the device option is having the information about the device assigned to the user. Device is having one unique ID nothing but a one random number and device name assigned by the developer. So we can add and assign device to the user as shown in figure 4 And 5 Below.

The following are the steps involved in the proposed mobile device app's operation.

First of all, the user add medicines for the patient by scanning QR code on a medicine wrapper .then by using QR code scan option the drug details are passed to our Apache cloud platform, the information such as drug name and prescription time As shown in figure 6 and 7. Drug information is also essential for recognition system to do medicine comparison and determine whether the medication are correct or not and when they can be taken by patients. After successfully scanning of QR the name of medicines appears on the screen and after submitting the medicines are get added in the patient's medicine table in cloud management platform site.

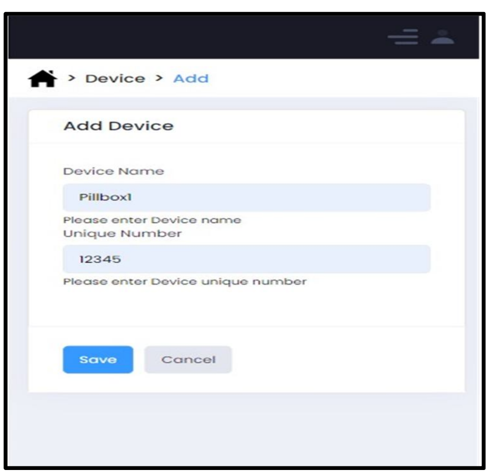

Figure 4: Adding Device

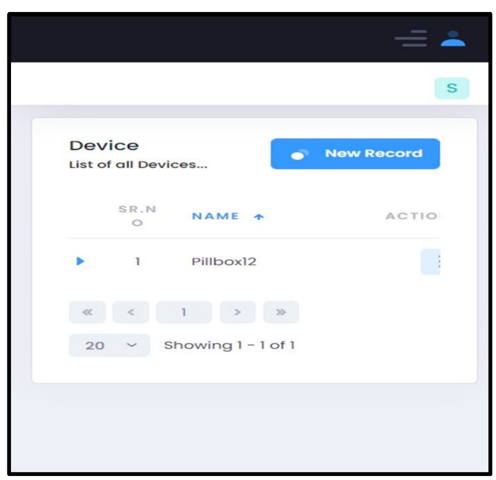

Figure 5: Device Added

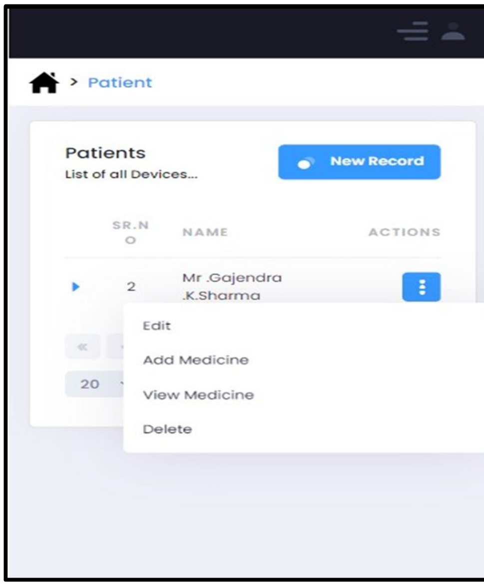

Figure 6: Add Medicine

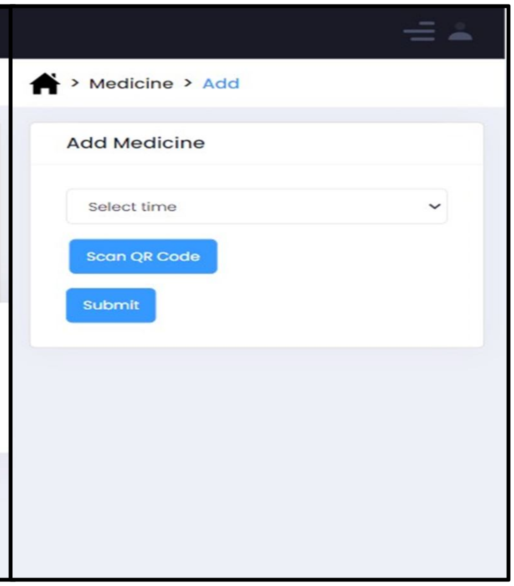

Figure 7: QR Code Scan

C. Pill Recognition Techniques

As our deep learning development framework in this paper, we use Google Tensor Flow. In terms of CPU performance, Google Tensor Flow lags behind other frameworks, but it outperforms them when it comes to GPU computing

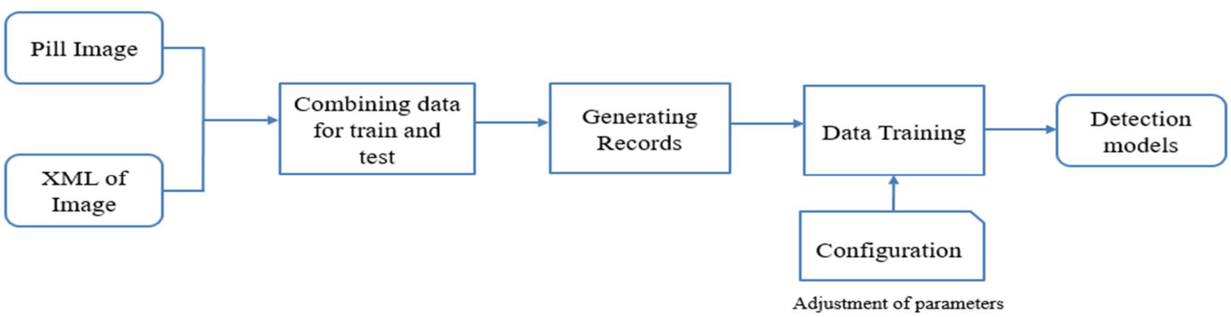

Figure 8: Flow chart of training process

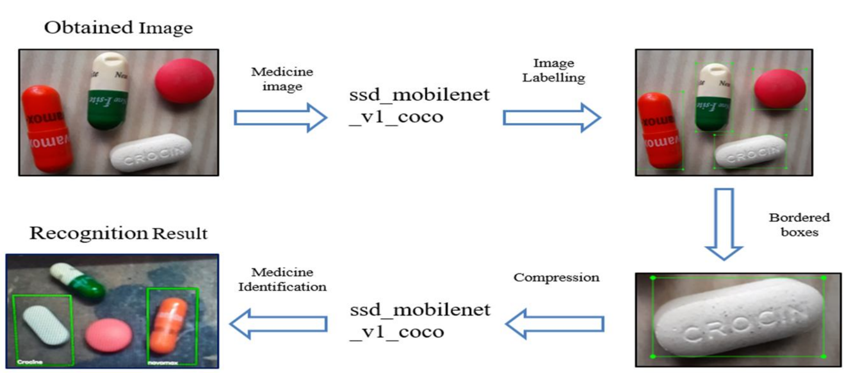

Figure 9: Medicine Recognition Flowchart

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For object identification, the open-source ssd_mobilenet_v1_coco model is utilized, which is based on the Tensor Flow framework as shown in figure 8 For training, medicines XML files and medicines original images are translated in the form of “TFRecord” , and altered Configuration file is loaded. For generating xml files of the medicine images the image labelling is done using LabelImg as shown in figure 10. LabelImg is a tool for annotating graphical images. It's developed in Python and has a graphical user interface built using Qt. Annotations are recorded as XML files in the PASCAL VOC format, which is the same format that ImageNet uses. It also supports the YOLO and Create ML file formats.

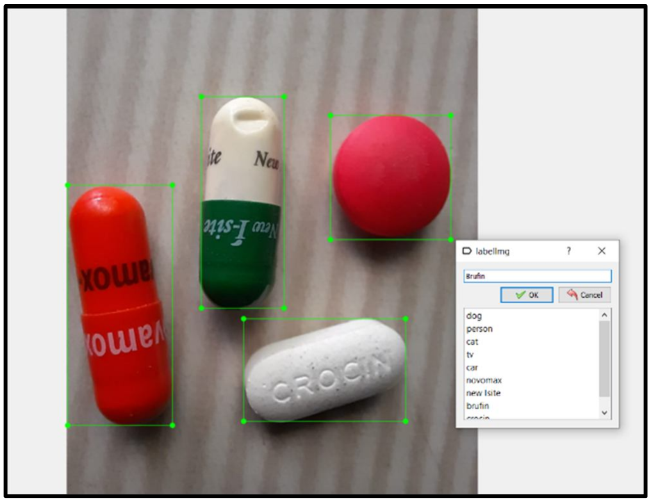

Figure 10: Image labelling

D. Pill Recognition Device: Pillbox

The Pillbox consist of Raspberry Pi 4 model B as heart of project , then 5 MP Camera for taking images , 15 W amplifier speaker unit as audio outlet, one Push button control to on-off purpose and one Android device with internet connection.

1) *Raspberry pi 4 Model b Board:* An information this is a small sized Pi that was inspired by the BBC Micro in 1981 and is primarily intended for educational purposes. The Raspberry was released in 2012 and included a SOC architecture based on the Broadcom BCM2835 CPU, a tiny but powerful mobile CPU frequently seen in mobile phones.

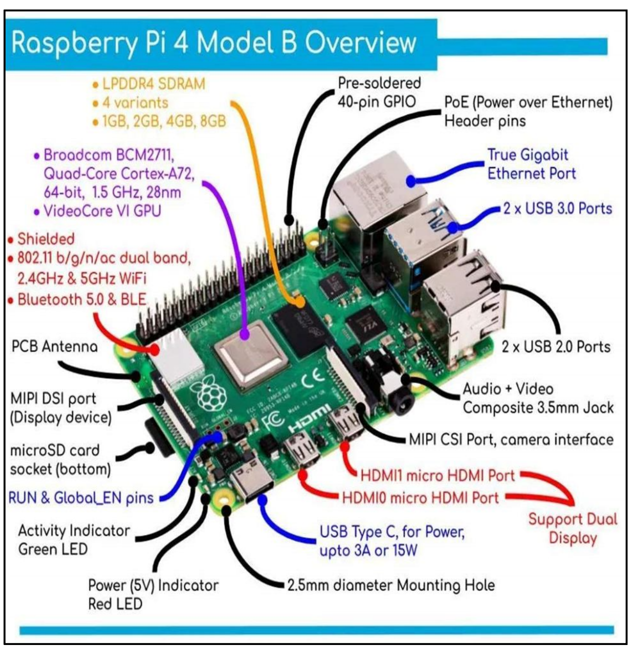

Figure 11: Raspberry Pi Module

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2) *Pi camera: 5 MP:* The camera is made out of a compact board that linked to the Raspberry Pi's Interface bus namely CSI bus instrumentation through lightweight ribbon wire. A mounted focus lens with a native resolution of 5 megapixels may be used as the image sensor element of the camera. This 5 megapixel sensor, in combination with the OV5647 camera module, can shoot 1080p video and still images and attaches straight to your Raspberry Pi.

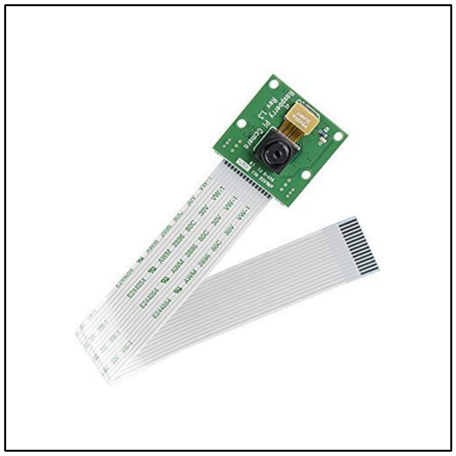

Figure 12: Raspberry Pi Camera Module

3) *Amplifier Speaker Unit*

Figure 13: Amplifier Speaker Unit

In this system the speaker unit used is nothing but wireless Bluetooth speaker type. Wireless speakers accept audile waves from radio waves instead of audile cables. A variant of WLAN IEEE 802.11 is one in all the foremost common RF frequencies for audio transmission to wireless loudspeakers, some on the other hand, rely on Bluetooth to transfer audio data to the receiving speaker.

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4) Raspberry Pi USB power supply

Figure 14: Raspberry Pi USB power supply

A USB power supply is a device that injects energy into a secondary cell or rechargeable battery by using electric current. The kind and size of the battery influence the charging process. Some battery types are resistant to overcharging and can be charged again by connecting to a stable voltage and current source, depending on the battery type. This type of chargers need to be unplugged using one's hand for the conclusion of the charge cycle. Certain battery types, on the other hand, may need or use a timer to switch off charging current at a set time, roughly when charging is completed.

IV. EXPERIMENT AND RESULT

This section is all about Result for medicine addition after QR code scan in application and the medicine recognition results collected for different medicine with maximum accuracy 80%.

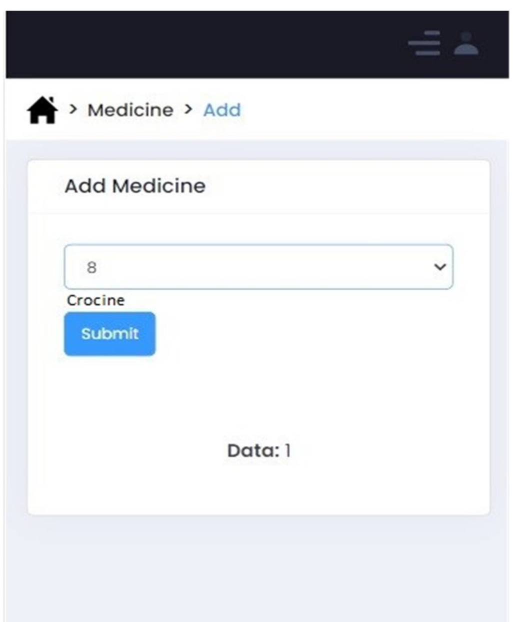

Figure 15: Medicine Added

Figure 16: Medicine Recognition Result

V. CONCLUSION

Chronic disease currently acts as dangerous threat for elderly people and results onto the death of patients. It's also affecting death rate of country so to minimize the death rate and to help elder peoples the system successfully recognize the medicines as per doctor's instructions and guide patients to take right medicines at right time and avoid wrong ones. Device also help patients to reduce drug intake in their body and to reduce overall death rate increasing because of chronic disease.

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