A SIMPLE SMART MEDICINE BOX FOR AGED USING LOCAL MATERIALS A SIMPLE SMART MEDICINE BOX USING LOCAL MATERIALS

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Abstract

Medicine administration always tend to have adverse effects on the health of patients when taken out of schedule. Alzheimer's disease is a disease likely to cause these effects on the patients due to their inability to recall their day-to-day activities. In this case, their ineffectiveness to comply to their medication as a result of memory loss and as such requires the best attention and quality health care to help improve their life span. In other to achieve this, a proposed system is designed to help the early diagnosed Alzheimer's patients take the required medicine in the right dosage and at the right time. The basic ideology is integrating an alarm clock with a liquid crystal display (LCD), an Arduino, a multilingual software and an ultrasonic sensor, sensing on a normal pill. To make this box more effective, it has a GSM module for alerting the patient when it is time to take the drug, the family member of the patient and medical personnel if or not the patient has taken the drug. This will help provide improved quality health care and ensure the effective reminder of medication for the early diagnosed Alzheimer's patients.

Key words; Alzheimer, Disease, Display, Ultrasonic, Sensor, Dementia, liquid crystal display (LCD), and Global System for Mobile communication (GSM)

1.0 Introduction

Medicine has not always been the precise science which we know nowadays, in fact, throughout history the vast majority of maladies and afflictions would have resulted in probable death. Fortunately, medicine has experienced a great development in the last century, resulting in an increased life expectancy and the possibility to cure a great quantity of diseases and health disorders [1]. Pills are one of the pillars of medicine, being used as direct treatments of some sort of illness as to assuring some medical condition remains stable (people with organ transplants or patients suffering from a chronic disease such as HIV). The fast-paced life of people has always taken a toll on the people. The irony is that the new medicines are found for the never-ending chain of diseases. These new diseases often require timely medication and course therapy for curing [2], often the busy life schedule of the people let down and they don't fellow the best procedure for their medications. Most common reason for the failure of a method of cure is the failure of the patient to administer the dosage in the right proportion and at right time. It is important for the patient to follow a precise plan when managing one or multiple medications during a treatment of an illness. Almost all medicines today have been

specialized with specific targets in our bodies. These targets can be inner organs, hormones etc. This makes our medicines much more complicated than before and patients are therefore required to take multiple aspects into consideration when using a certain medicine. Some of these important aspects are to take a proper and precise dosage, not taking some medicines together or exactly after or before meals, etc. The other aspect which also is very crucial during a treatment is the time interval between the medications. Both short-term and long-term impacts of a medicine are strongly correlated with these time periods. The time interval that is predetermined should be followed strictly where the dosage of a specific medicine has been taken into consideration. In most cases, the long-term impact of a chosen treatment needs to be studied. Thus, it is also necessary to know how well a patient has been following a given plan. Memory disorder has been a common part of aging with most of our population, though there are some young people suffering from it and this affect the ability for one to recall or remember an event or instruction, in this case the ability for them to remember their drugs prescriptions and take them on time is forgotten. Examples includes Alzheimer's disease, Amnesia, Agnosia, Huntington's disease etc.

Alzheimer's is a serious health disease that affects the older people, and prevents their brain from functioning very well causing loss of memory, loss of ability to speak clearly etc. Over 60-80% of the world's population suffers from the Alzheimer's disease. This disease is mostly found in people between that age of 65 and above and less than 4% below the age of 65 suffer from this disease. Alzheimer is the common cause of Dementia found in the older ones. Some of the early symptoms includes; memory, repletion, disorientation etc. With this disease, there are three general stages in which it progresses such as mild (early stage), moderate (middle stage), and severe (late stage)

As people grow old the human body tends to malfunction and the number of pills the average person has to take when certain age is reached greatly increases, where, according to [1] more than 40 percent of Americans age 65 and older take five medications a day. Usually, they are a wide range of different pills an elderly has to take at different times. Keeping track of taking the right pill at the right moment each day can become a challenging experience for the elderly, as it is not as easy as it could be for a younger person. This fact is easily explained when we understand that many of the abilities such as sight, memory or logical capabilities tend to decrease in a proportional way to age once human beings have entered old age, making it difficult for them to remember which pill to take at the correct time, remembering to take them or confusing one pill with another as the person may not be able to distinguish one from another due to their decreased sight as well as the similarity in the pills forms and colors [3]. This problem will most surely be a cause for concern for the people surrounding the pill-taker, because as he or she not taking a pill at the correct time can cause severe problems (such as organ rejection in a patient with organ transplant or heart attack in patients suffering from grave heart conditions).

As the pace of living is increasing, diagnosed Alzheimer's patients is on the rise. Due to this disease, the day-to-day life style of these patients are compromised such that they tend to forget to take their medications. As a result, they require constant monitoring and this cannot be fully achieved using the old technique of drug administration where nurses have to go to the patient's bed two or three times per day to give medicine to the patients. Using this method, lots of time is exhausted and it's difficult for the nurses to monitor the patients properly because they lack the time to do so. There is a need to monitor the patients and how compliant they

are to their medications to avoid the disease transgressing to the next stage. To overcome these issues, a smart medicine box was designed. Smart Medicine Box is a device that monitors the intake of drugs by the elderly, displaying the appropriate time and indicating the number of drugs to be taken. It is a portable system which can be programmed and set up by the user, making of alarms, saving, sending and showing the data on its display needed. Using embedded programmable devices like microcontrollers and microprocessors is really inevitable. The designed prototype smart medicine box will monitor and ensure the effective reminder of medication by Alzheimer patients. [4] invited medicine box with LED placed the box. When the voice says that to take a vitamin tablet immediately LED glows where the vitamin tablet is. So, it would be easy for the illiterates. Alarm system is also used. The usage of it is if the person is sleeping alarm reminds them to take a tablet. It reminds whenever the tablet is taken. Frequency of an alarm is set between 1 and 3 KHz. The advantage of using this is there is no need to remind by the people. It's also portable and affordable system supports elderly patients, mainly the illiterate has been designed which helps to take their medicine at proper time. In this device it reduces this type of negligence towards health, a system is developed in a paper instead of programming it to help the people for reminding to have their medicine on time. [5] developed system that can also use to monitor the patient parents as it will be linked to a phone application. This application was used to configure the medical box by calculating the weight of each pill, setting the schedule of medical intake, alarming the user of the number of remaining pills, generating alarms whenever the patient does not take the required number of pills or do not take them at all. [6] presented a Smart Medicine Box to users who regularly take drugs or vitamin supplements, or nurses who take care of the elderly patients. This medicine box is programmable such that it reminds the nurses and users which specific pill to take at particular times of the day and serves at those times each day. It consists of three separate boxes. The nurses and users can set information for three different pills. This device was designed using an ARM7 LPC2148 Microcontroller, LED, Keypad, an LCD, a speaker module, and a Real time clock. It was stated as one of their recommendations for the future to develop strategies and modify the device based on the user's evaluation results. This include using a metal or a plastic box to cover the entire circuity placing switch and LCD displays on the surface of the box using the pill boxes. This implementation, though small and simple, will be a very great and useful step in the field of medicine.[7] came up with a Smart medicine box for users who regularly take drugs, and prescription of their medicine is very long for patients to remember and also for their care giver. The device was designed by setting up time tables. The present time was saved in RTC module and notifications will be saved in EEPROM. Therefore, at the time of taking medicine, system generate notification sound and display the Bright light in certain pill boxes. Another advantage of their system was the sensing capability if the patient tries to postpone the time of taking the medicine by suddenly opening and closing the medicine boxes to stop the sound. The final result of their device provides fast curing of patient health. A limitation of this device observed was its inability to notify the medical personnel or family member if the patient fails to take the prescribed dug at the particular time through GSM. [8] proposed the basic idea of automatic medicine reminder based on ARDUINO, which will help the patients to take their medicines at the prescribed time. The system is not just helpful for an individual but can also have major contributions in hospitals. The system was designed, using an LCD (liquid crystal display), keypad (push button), ARDUINO module, RTC system and alarm system. As stated in their future scope, the medicine reminder can be updated using GSM module, such

that there is feedback to the medical personnel or family member on the status of the patient if the patient took his or her drug or missed it. And a major limitation shows that the device was not able to notify the patient the amount of drug to be taken at a particular time. [9] designed and developed a patient medication reminder, which helps in medication administration and monitoring. This system consists of an ATMEGA328P microcontroller with an inbuilt EEPROM and a real-time circuit. The system is driven by an embedded program that inputs predefined parameters, which are processed based on the input variables entered via a user interface device such as the keypad. All the entries made on the keypad are displayed on the LCD panel of the device. It was seen as one of their limitations the absence of a GSM module, which alerts the person in charge of the patient whether the patient has taken his medication or not. It clears from the previous works done that lots of innovations have been made to provide effective medication compliance of patients to better their lives, makes them live comfortably and help reduce the mortality rates. However, most of the devices lack the GSM, LCD and Buzzer combine together in a single device. The idea of this work is to design a medicine box by incorporating a multilingual software and hardware which consists of an LCD which displays the number of pills to be taken, with a sound system also notifying the patient when it is time to take the drug, a keypad used to input the information needed, an Arduino which is the microcontroller of the system and a GSM module that alerts the patient when it is time to take the drug, the nurse and family member when the patient has taken the drug or not. These modifications will enhance or improve the lives especially the elderly and will help improve the health of patient suffering from Alzheimer's which is a serious health disease that affects the older people, and prevents their brain from functioning very well causing loss of memory, loss of ability to speak clearly.

2.0 Methodology

2.1 Materials

The various electronic components used for the realization of the smart medicine box are listed below:

S/N	COMPONENTS	TYPES	QUANTITY
1	Micro Controller	ATMEGA 328	2
2	Diode	IN4007	5
3	Transformer	TRAN-2P3S	1
4	Electrolytic Capacitor	470µF	1
5	RTC Module	DS1307	1
6	Liquid Crystal Display	16x2	1
7	Resistors	1.5kΩ	2
8	Voltage Regulator	LM7809	1
9	I^2C Serial Communicator	PCF8574	1
10	Df player		1
11	GSM Module	SIM800L	1
12	Ultrasonic Sensor	HC-SRO4	4

13	Buzzer		1
14	Led		1
15	Keypad	4x4 matrix keypad	1

Table 1. Showing the various component used

2.2 Principal Electronic Components

The electronic components integrated into a smart medicine box are considered for their specific functions in the device which are briefly explained below.

2.3 Atmega 328p Microcontroller

A Microcontroller is a control device which incorporates a microprocessor or it is a single chip microprocessor system. The microcontroller used for this design is the Atmega328p which serves as the center for processing all activities thereby acting as the brain of the design, it is an all-purpose general, open-source microcontroller from the AVR group which can be programmed using C/C++ based programming language. Atmega328 is used in many device and self-driven systems where a simple low-powered and low-cost microcontroller is needed.

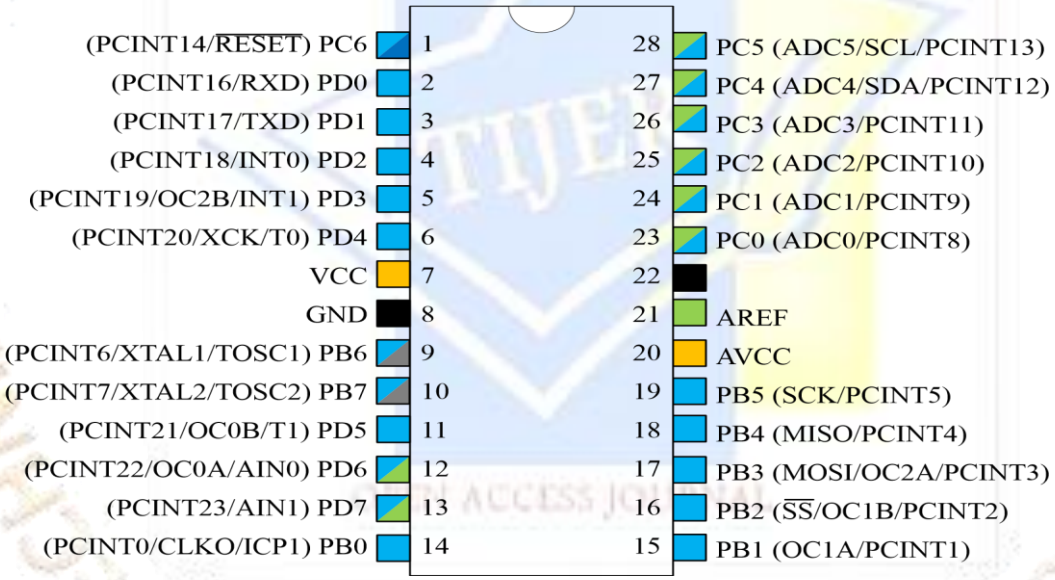

Figure 1. Atmega 328p Pin configuration (www.pivotell.co.uk)

2.4 Transformer

A transformer is a passive electrical device that transfers electrical energy between two or more circuits through electromagnetic induction. The transformer in the device is used to step down voltages from 230volts to 15volts.

2.5 Liquid Crystal Display (LCD)

The LCD is used to display the number of drugs to be taken from each box and enables input of command through the keypad. The size is 16x2 capable of displaying 32 characters (16 characters in two lines), it uses a power supply of 5V. In the input data, 4-Bits and 8-Bits interface are available. The LCD screen is used to display the number of drugs to be taken at a given time.

2.6 Resistors

Resistors are electronic passive components which have a specific electrical resistance resisting the flow of electron through a circuit. They are passive components, meaning they only consume power or allow power pass through them but cannot generate it. Resistors are added to circuit where they complement components like Op-Amp, microcontrollers and other integrated circuit. There are two resistors used in the design of which are 1.5k Ohms each. They act as pull up resistors.

2.7 Real Time Clock (RTC) Module

The RTC module is a handy module that keeps accurate time for years using a tiny coin-cell. The DS1307 serial real-time clock (RTC) is a low-power, full binary-coded decimal (BCD) clock/calendar plus 56 bytes of NV SRAM. Address and data are transferred serially through an I^2C, bidirectional bus. The clock operates in either the 24-hour or 12-hour format with Am/Pm indicator. The DS1307 has a built-in power sense circuit that detects power failures and automatically switches to the backup supply. The RTC module was be used to keep track of the prescribed time for the drugs in each of the containers.

2.8 I^2c Serial Communicator (Pcf8574)

The complexity and cost of this device must be kept at its minimum. The system must be designed in such a way that will not cause slowing down of the system. An I^2C chip was used to minimize complexity in this system, this chip is used to allow multiple slave circuit to communicate with the master chip which is the LCD.

2.9 GSM Module

The GSM module used in this study is a SIM800L. This is a GSM/GPRS-compatible Quad-band cell phone, which works on a frequency of 850/950/1800/1900MHz and which can be used not only to access the Internet, but also for oral communication (provided that it is connected to a microphone and a small loud speaker) and for SMSs. It consists of two antennas and its ON board LED displays connection state (no network coverage – fast blinking, logged in – slow blinking). The GSM module was used to send message to the doctor to inform him of the fact that the drugs have either been taking from the box or not.

2.10 Dfplayer

Dfplayer Mini is a serial MP3 module that provides the integrated MP3, WMV hard ware coding. While the software supports TF card driver, supports FAT16, FAT32 file system. It uses simple serial commands to specify music playing, as well as how to play music and other functions. This module was used to communicate to the user that it's time to take his or her drugs.

2.11 Ultrasonic Sonar Sensor

An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves. The ultrasonic sonar sensor allows to measure distance from 2cm to 400cm with an accuracy of up to 3mm. The HC-SR04sonar sensor comprises of an ultrasonic transmitter, an ultrasonic receiver and a control circuit. The 4-pin connection corresponds to power 5v, trigger pulse (input), Echo pulse (output), and 0v (ground). The ultrasonic sensor was used to detect if the person has taken the drugs from the container or not and send that information to the guardian through the GSM module.

2.12 Buzzer

It's an electromechanical device which produces sounds. The buzzer used in this design operates with DC voltage and minimal current. They generate a buzzing sound in the frequency range 300 to 500 Hz. When an electrical signal is passed through the coil inside the buzzer; it reduces a fluctuating magnetic field which vibrates the disk at a frequency to that of the drive signal.

2.13 LM7809

The LM7809 is a 9V voltage regulator that restricts the voltage output to 9V and draws 9V regulated power supply. The 7809 is the most common, as its regulated 9-volt supply provides a convenient power source for most TTL components.

2.14 Electrolytic Capacitor

An electrolytic capacitor (e-cap) is a polarized capacitor whose anode or positive plate is made of a metal that forms an insulating oxide layer through anodization. The oxide layer acts as the dielectric of the capacitor. A solid, liquid, or gel electrolyte covers the surface of this oxide layer, serving as the cathode or negative plate of the capacitor. Due to their very thin dielectric oxide layer and enlarged anode surface, electrolytic capacitors have a much higher capacitance-voltage (CV) product per unit volume compared to ceramic capacitor or film capacitors, and so can have large capacitance values producing smooth signals when filtering.

2.14 Keypad

The four by four (4x4) keypad features give a total of 16 buttons in matrix form. The keypad is connected to a 5volts. The 16-button keypad provides a useful human interface component for many microcontroller project examples of which is the Intelligent Infant incubator with security system. It is a membrane keypad with no moving parts. It uses a combination of four rows and four columns to provide button states to the microcontroller in the system. Underneath each key is a push button which is connected to one row and the other end connected to one column. It basically uses the principle of multiplexing.

Specifications

1. Weight: 8g
2. Mount style: self-adherence
3. Insulation specification: 100M ohms,100v
4. Maximum circuit rating: 24vDC, 30Ma

2.15 Flow Chart Methods

The diagram in figure 2 explains the selecting of the required component, their stability, constructing of the system, its testing and implementation.

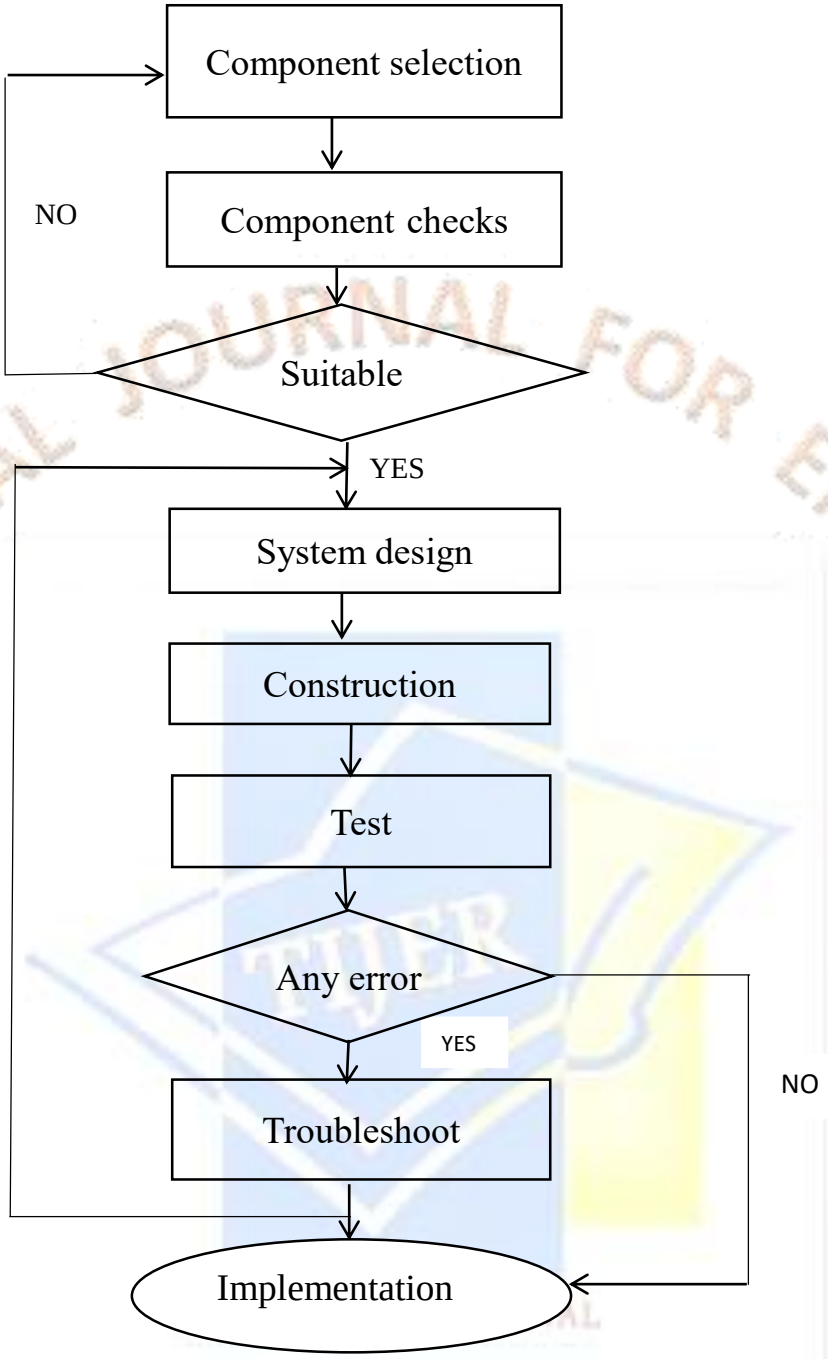

Figure 2 Flow Chart of Methods

2.16 Flow Chart Method Description for System Design

The flowchart above shows the process of building the system. First thing to is to know the specification and requirement which will be used in selecting the components. It was check if the component's selected are suitable, if not we go back and make corrections to ensure that the required components are selected, if yes, the process proceed to design the system which involves (circuit designing, implementing software and packaging of the system). The system is then tested to ensure that it corresponds to our expected results. Errors may be likely to occur, if there is any, the system will undergo troubleshooting thereby starting all over again and be tested. This process continues until a good system is obtained. Afterwards the system is implemented on the target population.

2.17 Block Diagram of the Device

Various units are integrated for realizing a smart medicine box (SMB). The integration of the various units is shown in figure 3.

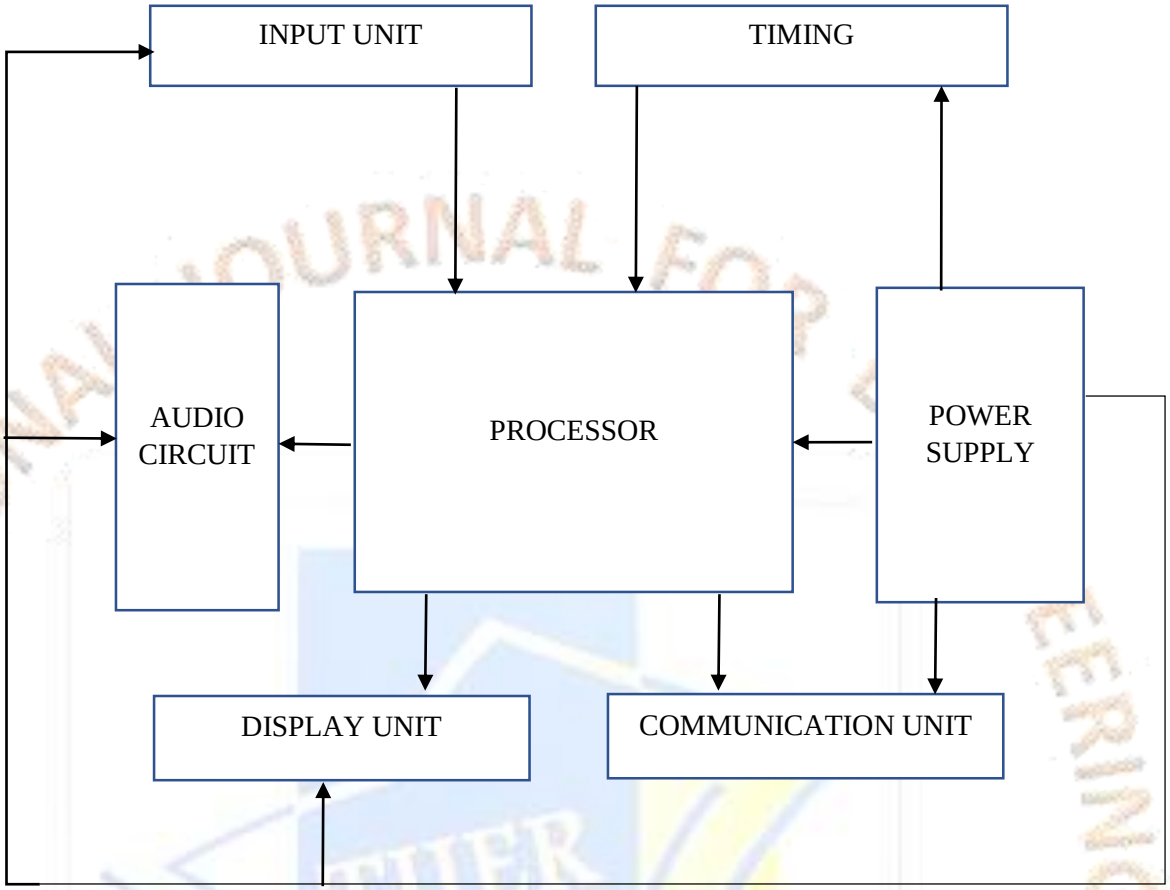

Figure 3 Block Diagram

2.19 Block Diagram Description

The block diagram consists of various units such as the processor unit, power supply unit, communication unit, display unit, audio unit, input unit and timing unit. The system has a central processing unit that consists of two Atmega 328p arduino microcontrollers. At the input unit, the system uses four ultrasonic sensors to give readings of intrusion to the central processing unit, and also has a keypad to enable input of data to the system. The system uses a Real Time Clock to give accurate track of time to the central processing unit at the timing unit of the block diagram. Signal is sent from the central processing unit to the audio unit to enable it send audio information (buzzing or speaking voice) to the user. The display unit uses an LCD screen to show the information sent from the central processing unit, while the communication unit receives and sends information to user's phone using a GSM module. The block diagram comprises of a power supply of 230V of AC current and it is converted to a 12v DC. The 12-voltage direct current is regulated by a voltage regulator to ensure that there is a steady 9 voltage direct current that goes to power the various unit of the system.

2.20 System Flow Chart

The figure 4 below shows the flow chart for the smart medicine box.

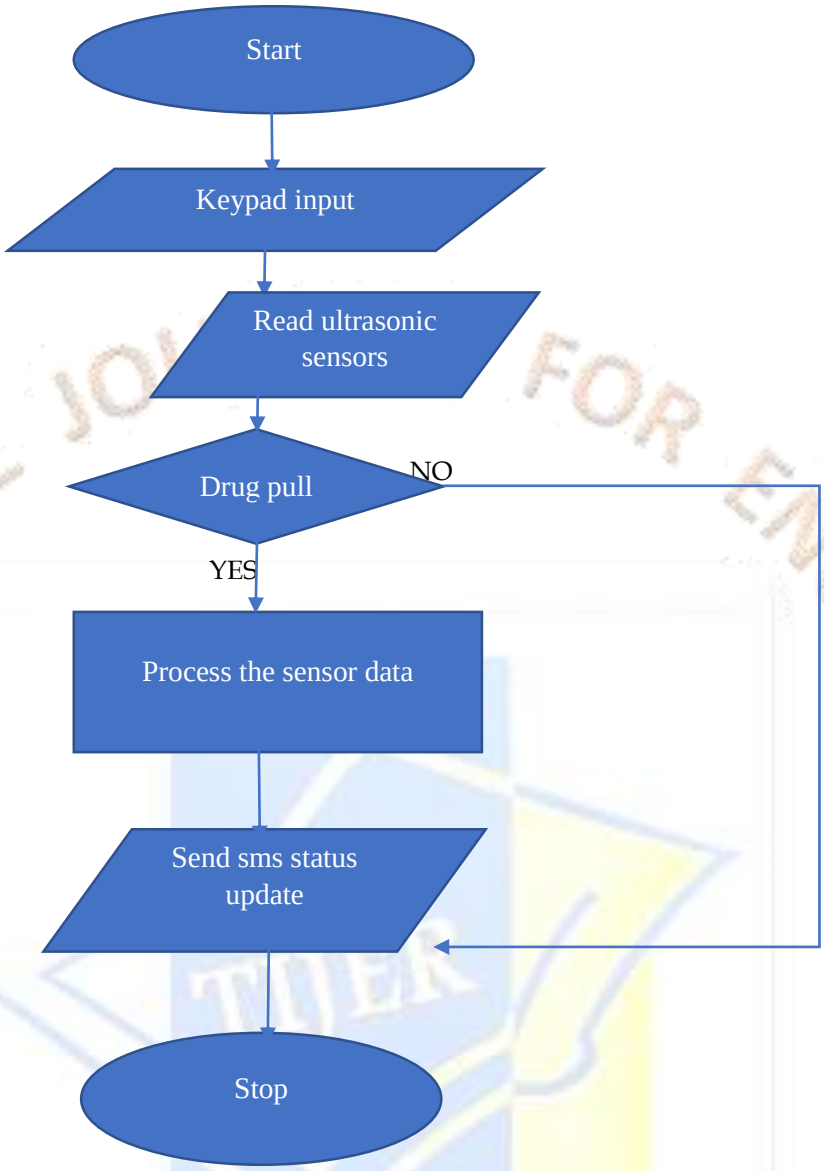

Figure 4 System Flow Chart

2.21`System Flow Chart Description

The flow chart above describes the operation of the system. The system is turned on and all the components are initialized. A prescription is entered into the keypad after the various drugs has been placed in the medicine box. The ultrasonic sensor detects motion in the medicine box and if the medicine is taken at a time that was not prescribed, the system would send message to the doctor and guardian to inform them of the fact that the drugs are taken out of the prescribed timeline. The system buzzes when it is time to take prescribed drugs and the ultrasonic sensor is on standby to detect motion, if the patient takes the medicine, it would send a signal for a positive status update and if the patient doesn't take the drugs, it would send a signal for a negative status update to the doctor and guardian.

2.22 System Design

An assembly of circuits consisting of power supply, processor, display, transceiver and sound. The assembly of circuits forms an overall circuit shown in figure 5 below.

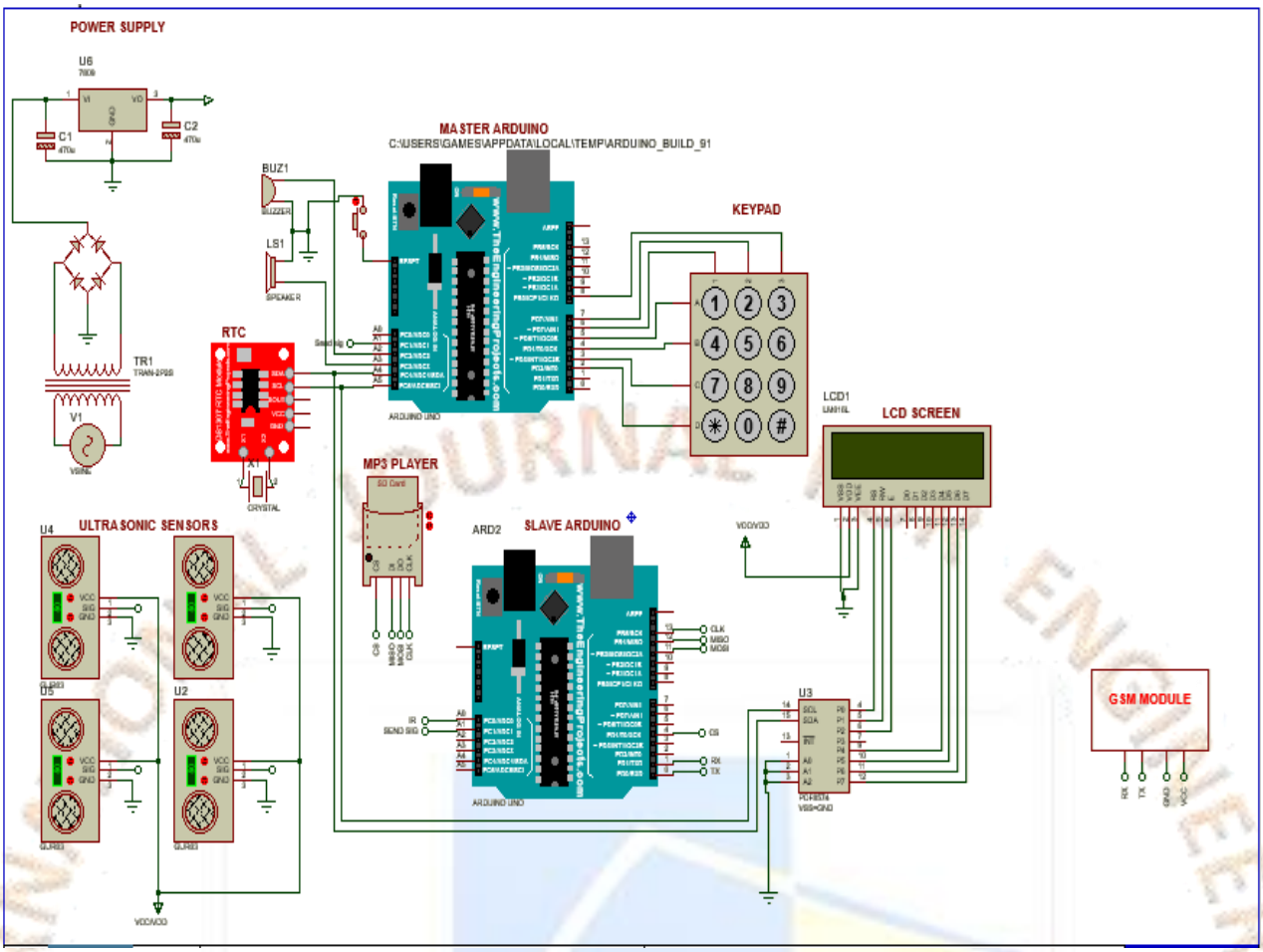

Figure 5 Circuit Diagram

2.23 PRINCIPLE OF OPERATION

The circuit diagram is shown in the diagram above. The circuit needs a 9volts steady direct current for the running and operation of this circuit. The power supply is gotten from the wall socket or any alternating current source available. This source gives us 230volts of alternating current and this 230volts AC would have to be converted to 12volts DC, in other for the Arduino to work. A transformer is used to reduce the 230volts AC to 12volts AC base on input/output ratio, and a rectification process (using a full bridge DC converter which uses four diodes) is used to convert the AC to DC. The voltage coming out of the transformer and converted to DC has a direct relationship with the AC mains that is coming from the socket and if there is a low AC current at the main source, there would also be a low DC current as the transformer uses ratio to step the current down. A voltage regulator is used to ensure that we have a constant 9volts DC for the Arduino to run, regardless of the output current from the transformer. A capacitor was used to filter some of the ripples that was left after the conversion before sending it to the voltage regulator and after the signal leaves the voltage regulator, it is filtered to avoid signal interference. The two Arduino boards, the RTC module, MP3 module, and ITC LCD module communicates to each other through the I^2C bus. The ITC bus is a type of communication bus that allows a maximum connection of 127 devices on the same line using two wires (which are the clock and data lines). In this bus we have the master (one of the Arduinos) and the slaves. The master gives a command using an address system and the device with that address would respond by carrying out that command. A standard mode of I^2C bus is used together with a pull up resistor of about 1.5kohms and the

standard mode has a frequency of about 100kb per second, indicating that we would have a data communication speed of 100kb per second. The Arduino request takes input from the keypad (the keypad is a metrics of wires which have points of contact and it uses the IC protocols). The ultrasonic sensor sends a sound wave and waits for the reflection of that sound wave to be able to use that reflection to detect if someone has dipped his/her hands into the medicine box. The MP3 player is a module that has an amplifier on its board. The master Arduino issues a command to the mp3 player and the MP3 player would play the pre-recorded voice saved on an SD card through the amplifier circuit to the speakers to enable the user to hear this sound. The SIM800L model is a GSM model that supports GPRS and GSM transmission (that is 2G and 3G network). The master Arduino would send a signal to the GSM module to send a text through a sim card inserted in the GSM module to the end users (the patient, guardian and doctor).

3.0 Results and Discussions

The results obtained after several performed experiments on both the simulated version and hardware. The testing of the simulated version and hardware were conducted and observations were duly noted.

3.1Testing

The testing was first of all carried out in the simulation software (Proteus 8) and the various scenarios or procedures with which the device would be operated were tested. The second phase of the testing was the testing of the hardware. The device was not tested on the desired population due to lack of ethical clearance. The various modules such as the GSM module, sensors, RTC module were tested and the desired feedback was gotten as an indication that the device is working.

The Smart Medicine Box Designed contains one power supply unit (, 230vAC), pill boxes, the GSM module, the Keypad, LCD, 2 Arduino Uno (Master and Slave). RTC module, DF player, Buzzer, Ultrasonic sonar sensor, IR sensor. There's a beep sound once the device is switched on, indicating that there is power in the system. The Keypad, LCD, RTC module are mounted on the body of the device. The LCD screen displays a green light, the GSM module has a blue LED that blinks fast when powered on showing it is searching for network and after 1-2 minutes the speed of the light slows down showing that it is now connected to the mobile number.

3.2 Hardware Testing Results

Although the device was not tested with an Alzheimer's patient, it was tested by simulation and some volunteered student for trial whether the hardware is working. Hence, this hardware reads, measures and monitors the patient's compliance to his or her medication. The LCD was able to display the number of drugs to be taken, the sensor detected if the patient took the drug or not and the GSM module sent an SMS to the patient, medical personnel and a family member.

3.3 First Patient's Result

Table 2: Results for first patient

Boxes	Time (am)	Buzzer Alert	Screen Display	Voice Output	Was The Drugs Taken	SMS Output
Box 1	9:00:20	Yes	Take one drug	Yes	Yes	Drug was taken
Box 2	9:00:20	Yes	Take two drugs	Yes	No	Drugs were not taken
Box 3	9:00:20	Yes	Take one drug	Yes	Yes	Drug was taken
Box 4	9:00:20	Yes	Take two drugs	Yes	No	Drugs were not taken

3.4 Second Patient's Result

Table .3: Results for second patient

Boxes	Time (pm)	Buzzer Alert	Screen Display	Voice Output	Was the Drugs Taken	SMS Output
Box 1	3:00:10	Yes	Take one drug	Yes	Yes	Drug was taken
Box 2	3:00:10	Yes	Take two drugs	Yes	Yes	Drugs were taken
Box 3	3:00:10	Yes	Take one drug	Yes	Yes	Drug was taken
Box 4	3:00:10	Yes	Take two drugs	Yes	Yes	Drugs were taken

3.5 Third Patient's Result

Table 4.: Results for third patient

Boxes	Time	Buzzer Alert	Screen Display	Voice Output	Was The Drugs Taken	SMS Output
Box 1	6:00:20	Yes	Take one drug	Yes	Yes	Drug was taken
Box 2	6:00:20	No Prescribed Drug	No Prescribed Drug	No Prescribed Drug	No Prescribed Drug	No SMS was sent
Box 3	6:00:20	Yes	Take one drug	Yes	Yes	Drug was taken
Box 4	6:00:20	Yes	Take two drugs	Yes	No	Drugs were not taken

4.0 Discussion

The above results were the output gotten from the testing of the simulated version and hardware of the smart medicine box. The simulated version was tested based on the functionality of the various components of the smart medicine box and the output shows that the entire component available to the software were responding and carrying out their basic functions.

The hardware was tested on three volunteers, and the test was conducted on various scenarios. The patients were to take their prescribed drugs at various time intervals for a whole day. This document accounts for the outcome of each patient (volunteer) per interval of that day. The first patient skipped his drugs in box two (2) and four (4), whiles box one (1) and three (3) were taken. The second patient (volunteer) took the drugs in all four boxes and good feedback was sent to her guardian/doctor. The third person took her drugs from all the boxes except from box two (2); this is because there were no prescribed drugs for box two. The device sent possible feedback to the guardian/doctor.

4.1 Conclusion

A simple smart medicine box prototype was designed with locally made material using wood box and a test was done on the hardware prototype of a smart medicine box to help ensure the effective compliance of medication by the patients. These was done e to ensure the functionality of the smart medicine box to be able to remind patients to take their drugs at the accurate time, and also show them the number of drugs they are supposed to take from each of the medicine box. The box uses the common and local language to inform them that it's time for them to take their drugs. The device logic structure is made up of three major stages, which are the user initialization stage (where the user enters the correct time intervals and pill information), comparison stage (the system compares the pill information for each of the sub-box with the time counted by RTC module), and reminder stage (once the information entered by the user matches the RTC time, the system will jump out of comparison stage and enter reminder stage).

4.2 Recommendations

The designed smart medicine box could attain a high efficiency of reminding patients of stipulated times for taking their drugs. The outcome should be further improved by the involvement of care-giver in their patient's drug reminding through a text message. However, the smart medicine can be modified to enable other applications such as being able to accurately determine the number of drugs in the system and the amount taken by the patient to avoid drug over dose. An advanced simulation should be done with software that supports all the components of the device, to reduce the assumptions made during the simulation test. The aesthetics of the device should be more appealing for easy access. A rechargeable battery can be added.

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