IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 7, July 2016

Automatic Pill Dispenser

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Abstract: Geriatrics rely on their medications to keep them healthy, but complex medication schedules can lead to mistakes like missing doses, taking incorrect amounts, or taking medicines at the wrong times. These mistakes could lead to unnecessary doctor or hospital visits, illness and even death. Hence there is a need to design a Medication Dispensing Device that can help Geriatrics to take medication on schedule. This would prevent unplanned hospital or doctor visits related to incorrect medication use. This paper proposes a design of a smart device which dispenses the medications on the prescribed schedule.

Keywords: Microcontrollers, Driver Circuits, Stepper Motor, Medicines, Medications.

I. INTRODUCTION

As the people getting busier these days, they tend to forget to take their medicines at prescribed schedule. As a consequence of this Geriatrics are facing unnecessary disposure of themselves into the hospitals. Hence a device or a system is to be designed in such a way that it can dispense the pills at preset time. Since the target audience of the device are the Geriatrics, it must be user friendly, handy, safe to use, light in weight. To build a working prototype we made use of famous Engineering Design Approach where we followed different steps to achieve different attributes. Before we begin with the actual implementation of the prototype we listed down different attributes for the device. We took feedback from many patients and we found there is a huge need of this device in medicinal field. We started working according to the feedback given by the patients and the attributes and finally we were successful in designing a smart pill dispenser device. This paper explains different steps to be followed to design above said device using Engineering Design approach. The reader is expected to have sound knowledge in Electronics behind stepper motor and different interfacing techniques with microcontroller Atmega 328P.

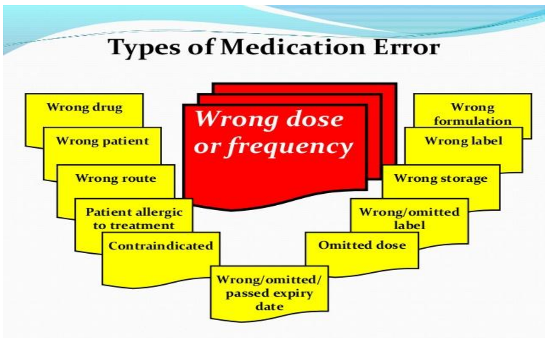

Fig. 1 Different medication errors

Consider fig.1 shows different types of medication errors which could be seen in Geriatrics.

II. LITERATURE SURVEY

According to a survey carried out by patient's safety authority of India, 74% of total death count in the hospital is caused due to overdose or under dosage of the medicines. Fig.2 stands in support for the above statistics.

Table 1. Top Five Medication Error Event Types Associated with Wrong Weights (n = 448)

EVENT TYPE	TOTAL	% OF TOTAL REPORTS (N=479)
Wrong dose/ overdosage	208	43.4%
Wrong dose/ underdosage	102	21.3%
Wrong rate (intravenous)	47	9.8%
Extra dose	12	2.5%
Other	79	16.5%

Fig.2 Reports of different medication errors.

Clinical analysts reviewed 479 event reports submitted to the Indian Patient Safety Authority from June 2004 through the end of November 2008 that specifically mentioned medication errors resulting from breakdowns in the process of obtaining, documenting, and/or communicating patient weights. The shocking news from the statistics is that of the 479 reports, 448 (93.5%) represent the five most common medication error event types, with the most commonly reported event type being wrong dose/over dosage (43.4%) and wrong dose/under dosage (21.3%).

DOI 10.17148/IJARCCE.2016.57107

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III.PROPOSED IDEA

The principal idea that needs to be attended to solve above mentioned problem is to design a self pill dispensing device which needs no human intervention. This project makes use of the concept of circular step wise motion of the compartment which is meant to store the pills.

Step wise motion of the compartment is achieved using stepper motor. There is a provision for alarming system built in with the device which consists of a buzzer and LED to indicate the time of medication.

IV.ENGINEERING DESIGN APPROACH

As discussed earlier, we have made use of Engineering Design approach to design the device. After collecting feedback from the patients of different hospitals we listed down different attributes to be considered during actual implementation. These attributes were further been classified as Objectives, Functions, Means, Constraints.

Objectives are the attributes essential to achieve the prescribed function. Means are the ways of achieving the attributes. Fig.3 shows the classifications of different attributes listed for our project.

Attributes	*O*	*F*	*M*	*C*
Device should be safe.	Y			
Device must be shock-proof.				Y
Device should be light in weight.	Y			
Device should contain good battery backup.				Y
Device must be eco-friendly.	Y			
Must be made from rust free material.				Y
There should be less human interference.			Y	
It must withstand change in climatic conditions.	Y			
It should require less maintenance.	Y			
Device must be wired or wireless.			Y	
Device should be user-friendly.	Y			
Device should be durable.	Y			
Device must be rigid.	Y			
Device must meet ISO requirements.				Y
Device may be battery operated.			Y	
Device may be round in shape or box.	Y			
It must contain proper casing.	Y			
Alarm and LED glowing should be simultaneous.		Y		
Should have good notification display		Y		
The sound of notifications must be pleasant.	Y			

Fig.3 OFMC Chart.

A. Objective tree
Objective tree is the classification of different objectives and their sub objectives. It basically consists of different nodes which signify main objectives and the sub nodes signify sub objectives of the concept. Basic purpose of using such classification is to understand different functions to be achieved. Fig. 4 shows the objective tree for the given problem statement.
Here the main objectives are safety, Portability, Durability and Accuracy which are shown as nodes of the tree and these nodes have different twigs which symbolize sub objectives.

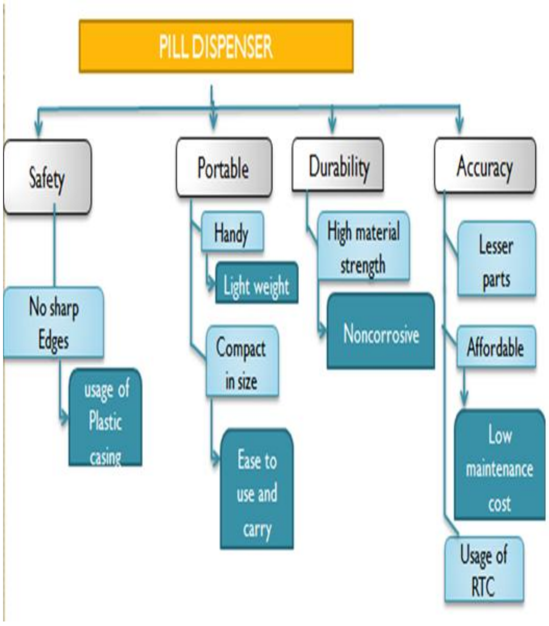

Fig. 4 Objective tree

B. Pair wise comparison chart
The pair wise comparison chart is a tool for ordering the relative importance of objectives. It facilitates comparison of each objective with the remaining objectives. In this method each objective is compared with other objectives and given a specific number which symbolizes the relative importance. Usually the objectives present at the nodes of objective tree are considered while preparing this chart.

At the end of each row the total score of each objective is written and the objective with highest score is given highest priority. It is helpful in determining which objective is to be given more preference in a given set of objectives. Fig.5 shows the Pair wise comparison chart for our project.

GOALS	ACCURACY	PORTABLE	DURABLE	SAFETY	TOTAL
ACCURACY	###	1	1	0.5	2.5
PORTABLE	0	###	0	0.5	0.5
DURABLE	0	1	###	0.5	1.5
SAFETY	0.5	0.5	0.5	###	1.5

Fig.5 Pair Wise Comparison Chart

From the above table it is clear that accuracy has got highest score among all the objectives. Hence we can conclude that the device to be designed should be accurate.

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V. DETAILED DESIGN

Detailed design is the type of design which gives detailed specification of each block used in the project in Engineering design approach, we use different tools like black box, white box, morphological chart etc. to define specification of each blocks used.

A. Black box

A Black Box is a graphical representation of a design illustrating inputs, outputs and transformation between them. It consists of set of inputs and outputs which specify the operation of the final prototype. It gives only overview of the operation but not detailed operation. Fig. 6 shows the Black box for this project.

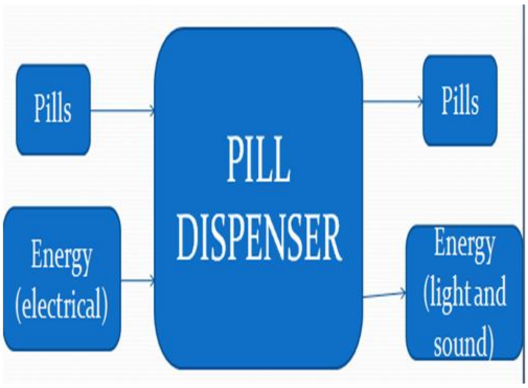

Fig. 6 Black Box

B. White Box (Glass Box)

It is a testing methodology used to ensure and validate the internal framework, mechanism, objectives and components of application. This gives the information of all the operations to be performed by the final prototype as well as work flow from different inputs to the different outputs. The work flow inside the box is denoted by dot lines to show that the operation is done by the microcontroller. Fig. 7 shows the white box structure of our project.

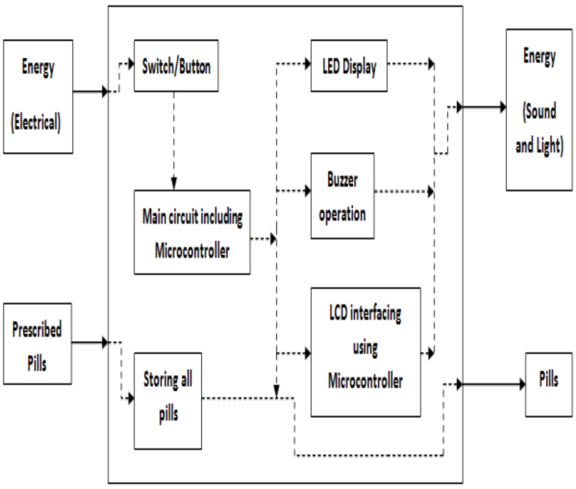

Fig. 7 White Boxes

C. Function Means tree

After designing black box and glass box, it is necessary that one should derive the relation between different functions and means to achieve them. This relation can be established by preparing Function means tree. Here the function and means should be represented in different geometrical symbol to differentiate between them. Each tree should start with a root and the root must be Function. Fig. 8 shows the diagram of function means tree.

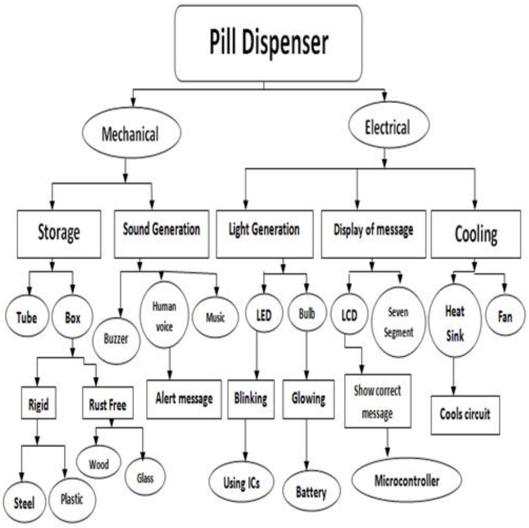

Fig. 8 Function Means tree

As we have discussed earlier, in F-M tree functions are written in rectangles whereas different means for a particular function is written inside a spherical structure. The last nodes in the function means tree would be representing the means to be implemented in the final implementation of the prototype.

D. Morphological Chart

The morphological chart is a method to generate ideas in an analytical and systematic manner. Usually functions of the product are taken as starting point. It is a visual aid used to come up with different ideas. The main purpose of using this chart is to define the functions of the final prototype. It has different options as the columns and different functions as rows. Fig. 9 shows a typical morphological chart for the project.

Functions	Option 1	Option 2	Option 3
1.Storing Pills	Plastic Box	Wooden Box	Plastic Tube
2.Sound Notifications	Buzzer	Music System	Human voice
3.Light Notification	LED	Bulb	---
4.Pill Dispensing	Manual	---	Using Stepper Motor
5.Time Display	Digital(LCD Display)	Analog	---
6.Power source	Battery	Solar	Charging
7.Cooling Unit	Heat Sink	Using Electric Fan	---
8.Prevention from rust	Usage of plastic materials	Usage of Glass casing	Wooden casing
9.Remainder for Non-pill conditions	Speaker module	---	Buzzer
10.Display messages	2x16 LCD module	2x8 LCD module	---
11.Setting Time	Using 3x4 keypad	Using 4x4 keypad	Inbuilt Software

Fig. 9 Morphological Chart

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E. Concept Screening

It is an effective tool of engineering design approach in which each objective of the prototype of each alternative designs is compared with the objectives of the ideal product available in the market. If the objective is almost equally effective the score is given as 0. If it is more effective, it is given with + signs and if it is less effective, it is given with – sign. Further these scores are added together and the average is being considered. The top three deigns with maximum scores are being considered for the final evaluation in the concept scoring tool. Fig 10 is the chart for concept screening.

Objectives	Design 1	Design 2	Design 3	Design 4	Design 5	Design 6	Design 7	Reference
Safe	-	-	+	+	-	0	+	0
Portable	+	0	0	+	+	-	0	0
Cost efficient	+	-	+	-	0	+	-	0
Power consumed	+	-	-	-	0	0	+	0
Accuracy	+	+	+	-	+	-	+	0
Efficiency	-	0	0	-	+	-	0	0
Automatic	0	0	+	+	-	0	0	0
Marketable	0	-	-	-	-	-	-	0
Rust free	+	+	-	0	0	0	+	0
Pluses	5	2	4	3	3	1	4	
Same	2	3	2	2	3	4	3	
Minuses	2	4	3	4	3	4	2	
Net	3	-2	1	-1	0	-3	2	
Rank	1	6	3	5	4	7	2	
Yes/No	Yes	No	Yes	No	No	No	Yes	

Fig. 10 Concept screening

F. Concept Scoring

Concept scoring is the extended version of Concept screening where we eliminate the other two designs to define the specification of the final prototype. Here different selection criteria are being defined to decide which the best design is. Each criterion is given some weights and score of each design is being calculated. Below is the calculation made in concept scoring tool

Selection criteria	Weightage	Solution A		Solution B		Solution C		Reference
		Rating		Rating		Rating		
Ease of handling	10%	4	0.6	2	0.3	4	0.6	3
Cost efficient	5%	3	0.3	1	0.1	1	0.1	3
Power consumption	5%	2	0.1	3	0.15	2	0.1	3
Efficiency	10%	2	0.2	2	0.2	4	0.4	3
Safety	10%	3	0.6	2	0.4	1	0.2	3
Accuracy	40%	2	1	1	0.5	3	1.5	3
Portability	10%	4	1	2	0.5	4	1	3
Marketability	10%	4	0.4	2	0.2	2	0.2	3
Total	100%	4.2		3.35		3.2		3

Fig. 11 Concept Scoring

G. Reverse Engineering

We carried out most popular Reverse Engineering of two existing products Pill Minder and ePill Med-Time to know working of each part in them. We used some concepts and principles of such products and implemented the same in our prototype.

VI. SPECIFICATIONS

After carrying out different steps of engineering design and analysing the working of the prototype iteratively we were able to finalize some of the specifications of the final prototype.

A. Block Level Specifications

This specification describes the operation of each block to be used in the final prototype. Fig. 12 is the list of block level specification.

Blocks	Specifications
1.Keypad	Takes the time to be set by the user and send information to RTC.
2.LED	To notify whether specified time is reached.
3.LCD Display	To display "Time to take pills".
4.Speaker/Buzzer	To notify the user about the medication for the specified time.
5.Audio Amplifier	Amplifies the audio signals of MC since the o/p frequency of MC is too small.
6.Microcontroller	Controls keypad, LEDs, Buzzer and LCD display.
7.Pill boxes	Stores the prescribed pills.
8.Battery	Acts as the power supply for the Microcontroller.
9.Interface	Converts assembly level language to Machine level language.
10.Compiler	Compiles builds and used to run the codes.
11.Real Time Clock (RTC)	Sets the specified time .It reads the keypad value and sends the information to buzzer/speaker.

Fig. 12 Block level specifications

B. Engineering Specifications

Engineering specifications are used to provide the physical measurements of the final prototype. Hence we need to decide each and every measurement carefully before final implementation. Below is the sketch of different engineering specifications.

Metric	Specifications
1.Weight	<1.5Kg
2.Dimensions	160x160x80
3.Manufacturing cost	<2000 Rs
4.Effeciency rating	>92%
5.Material used	ABS, Acralite
6.LCD used	16x2
7.LED used	3 volts
8.Microcontroller	Atmega-328
9.Battery	12 Volts
10.Speaker	45-120dB
11.Simulater used	Arduino 1.6.6

Fig. 13 engineering specifications

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VII. DISCUSSION OF RESULTS

In this section we have discussed about results of the final prototype, Simulations, CATIA Models and cost for the manufacturing.

A. CATIA models

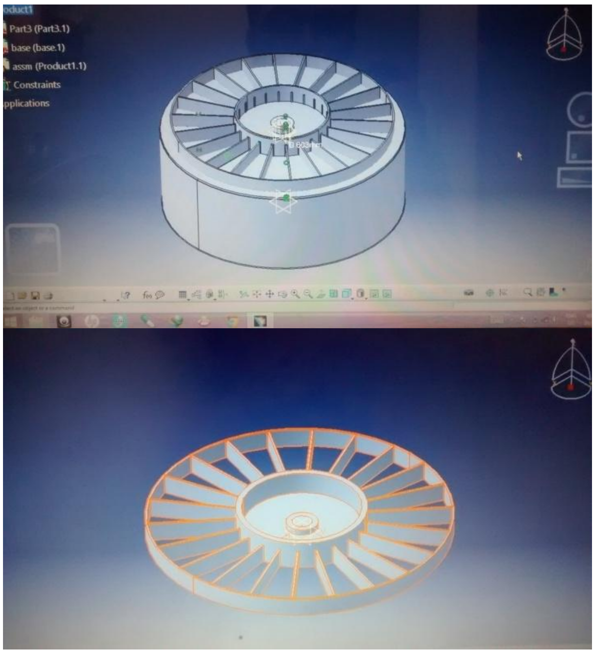

Fig. 14 CATIA models for upper plates.

B. Simulations results

We used Proteus simulation model to simulate the code before actual implementation. Here are some snapshots of the same.

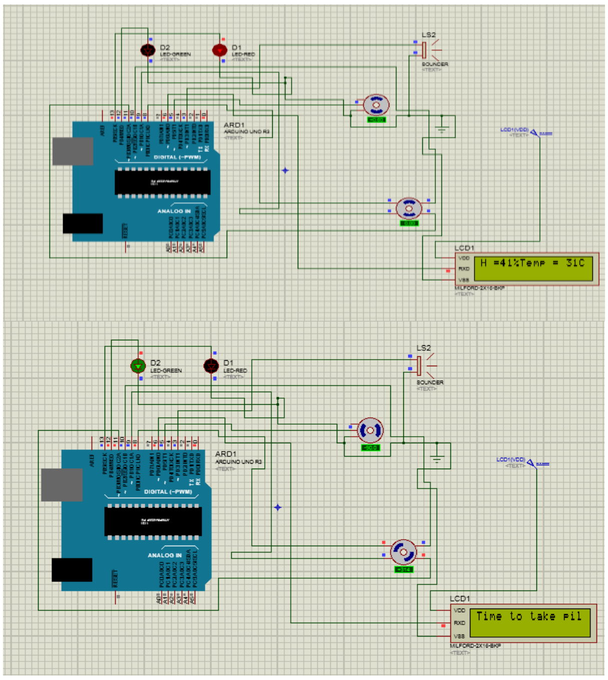

Fig. 15 Simulation of the results

C. Manufacturing cost

Components	Quantity	Cost (Rs.)
1.Pill box	1	70
2.Seven segment LED display	1	10
3.Microcontroller(Atmega 328P)	1	300
4.Speaker module	1	25
5.16x2 LCD module	1	85
6.3x4 Keypad	1	55
7.PVC box	1	200
8.2 pin jumpers	14	28
9.Arduino Board	1	700
10.Opamp-LM 386	1	20
11.Resistors(470,10k)	2	5
12.Capacitors(10u,0.1u,100u)	3	10
Total	31	1645

Fig. 16 manufacturing cost

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