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Design and Development of a Voice Actuated Hospital Bed for Patient Care

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Abstract: ***In the recent twentieth century, medical beds are subjected to advanced techniques particularly in the domain of making it intelligent for patient care. The past fifteen years have brought out various changes in the smart-bed technologies concept but no legit proof for existence of the project were shown. These and other earlier systems more often utilize at least one pushbutton or pressure-sensitive type switches to enact the different correspondence and control capacities. The proposed aim is to build a prototype bed which can respond to basic commands and helps the user to recline, incline and command for a food table which also monitors the minimum spacing required for the bed to incline or recline using a simple mechanism and therefore, sends a feedback to the system warning about the spacing between them. The voice recognition (VR3) module is used to detect the keywords for the trained voice when the user is passing commands to perform any of the actions such as Inclination, Reclination, Upward, Downward etc. Functions like bedroom necessities, turning on appliances and various other activities can also be carried out as an extended function.***

Keywords: Arduino UNO based Voice Actuated Hospital Bed, Smart Med-Bed, Voice Recognition (VR3) Module.

I. INTRODUCTION

Hospital beds are the place most patients spend most of their times which need firm awareness regarding help patients remain safe while keen capacities help attendants investigate data and improve patient care. A definitive goal is to give patients a specific independency accordingly, enabling them to take some indispensable activities when nurses or care-takers are late or inaccessible. Therefore, such solutions help most of the patients when their conditions are inevitable and require sudden change in their movements.

The accessibility of good medicinal assistance in hospitals turns into a critical issue. The two fundamental purposes behind that are the expanding cost of therapeutic consideration and the decrease in the number of guardians, (for example: medical caretakers). Such an issue turns out to be increasingly critical if the patient is experiencing lock-in disorders. Dealing with those patients requires a great deal of exertion and concern. In this manner, it is essential to give specialized answers for assistance guardians of those patients in homes or hospitals. In this paper, a hospital bed is proposed for patients with full powerlessness to move, patients who experience the ill effects of the secured disorder, long term coma, quadriplegia, clinical demise and so on. These patients require exceptional consideration since they can't move by any stretch of the imagination. Moreover, rotating each a few hours implies that somebody ought to be every now and again accessible to carry out the responsibility; including at the times of night. The project scope is to build a smart intelligent bed in such a way that it is prompt in responding to the user's instructions using voice commands to achieve desired outputs and is mainly concentrated on a small-scale prototype which can be scaled on a larger proportion if found effective.

The principal aim of the proposed framework is to streamline the way towards dealing with a patient who can't move and enduringly lies on a bed. The continuous lying on a bed for a long time get various medical issues.

II. LITERATURE REVIEW

[1], This paper represents a clear view on electronic medical beds, which is defined as "smart beds", as part of an increasingly protective patient-care habitat. Raspberry pi is interfaced with a stepper motor using a motor driver circuit and is then brought forward with an audio input. The accuracy for detecting the voice commands was found to be troublesome. Wireless communication can be a hinderance to the patient.

[2], This paper talks about the plan of voice-controlled automatic wheelchair-using Arduino. The structure is made with a voice acknowledgment framework, which empowers the physically incapacitated individual to control the wheelchair by voice direction who have issues near to improvement as a result of the loss of motion or loss of movement for joystick-controlled wheelchairs.

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In the proposed arrangement the discourse preparing is done only with the coordinated module of voice recognition (VR3) which takes out the requirement for any bulky complex extra processing modules. Moreover, the proposed plan is relatively less complex and more affordable to execute with the all-around accessible electronic gadgets interestingly with other existing structure which impacts under developing nations. [3], The main aim of the proposed model is to simplify the way toward dealing with a patient who can't move and for all time lies on a bed. The proposed medicinal bed is to automate it when required; to be specific, a bed that rotates by itself every a few hours. The electrical buttons of the bed control the moving parts and been pre-programmed for the desired positions.

[4], This paper represents the plan and execution of a minimal effort solar-power oriented controlled wheelchair for physically disabled individuals. The required signal for the motion of the wheelchair is acquired by the muscles of the hand utilizing surface Electromyography (sEMG) framework. To obtain the essential characteristics for the production of the control signals for the automatic movement of the medical bed the raw sEMG signals are gathered from the muscles in the upper limb which is then processed, characterized and classified.

[5], In huge medical clinics, the attendant's contribution inside certain periods can be an authoritative factor in a patient's recuperation and might provoke noteworthy and irreversible results. MedBed-the smart digitalized bed which is assembled to determine the most significant and testing issues beneficially from time, space and commonsense conclusion. A definitive objective is to give patients a particular independency along these lines, empowering them to take some urgent exercises when attendants are late or difficult to reach. The main feature of the framework is that it can be executed in the hospitals and medical centers with the least infrastructural modifications.

[6], Evolution of a voice acknowledgment based smart wheelchair system for physically impaired people who can't handle the wheelchair by their hand is spoken in this paper where the patient can drive the wheelchair-using voice instructions and the region of the patient can be pursued using the GPS module in the wheelchair that trails and sends the information to mobile phone application by methods for Firebase. Voice recognition module VR3 is used to record the user's voice and see that voice to hold fast to the bearings of the patient. As this system simultaneously offers voice-recognized wheelchair, motor speed control, hindrance area, and the GPS following of the user utilizing the android application in a perfect world, it will be a fruitful system for the handicapped people the world over.

[7], Recent advanced trends and technologies have brought a huge presentation of new medical equipment, empowered with profoundly created intelligent and embedded controlled functions in it. The previous two decades have additionally carried changes to theoretical systems, regarding the item structure and assembling forms (measures), just as the patient (points of view on patient-care environment and availability). This introduces a condition of-workmanship review on automated smart-medical beds, addressing what is portrayed as "Smart beds", as an element of the progressively comprehensive patient-care condition.

[8], A patient-care mechanical assembly includes a control system, a receiver designed to recognize a signal from the identification when the emitter is proximate the patient-care module, and a voice recognition module arranged to give inputs to the control system to control in any event task of the patient-care device.

[9], The Gesture Recognition Interactive Technology (GRiT) Chair Alarm intends to keep patient tumbles from seats and wheelchairs by seeing the signs of a patient attempting to stand. Patient tumble is probably a big reason for injury in hospitals. Present-day bed exit and chairs caution system is deficient given inadequate notice, long trigger delays, and high false-alarm rate. The pressure sensors and capacitive proximity sensors in GRiT chair alert caution users by making a guide of sitting position, and also using gesture recognition algorithms whether a patient is trying to stand and alerting the care-takers. Hospitals existing wifi network is integrated with the GRiT system to notify and approximately get the patient's location through nurse call systems.

[10], The advancement of the Patient Data Management System (PDMS) and its voice data entry unit are depicted. The PDMS relies upon an IBM PS/2 interfaced to a LAN for procuring of real-time information of the patient. By giving progressively regular methods for physically entering information, promising use of speech generation and recognition in intensive care units.

III. SYSTEM ENGINEERING APPROACH FOR SYSTEM DEVELOPMENT

Systems Engineering (SE) approach is used to build the Smart Bed as per specification so that a balanced system is developed. SE approach makes sure that the subsystems are properly selected as per requirement and no unnecessary wastage in cost and time is incurred. It helps in developing the best system with cost, schedule and performance optimization.

It deals with identifying different subsystems available that constitutes concept exploration phase with divergent thinking for problem solving. The concept selection then involves convergent thinking to arrive at the best subsystem and hence, a balanced solution. The functional requirements are listed down along with hardware, software and mechanical requirements.

A. Hardware Requirements

The following subcomponents are required to carry out the required functions.

- Speech Processing Chip – REES52.
- Microcontroller – Arduino UNO board to execute the control.
- Motor Driver Circuit – L298N dual H- Bridge for Bidirectional control of the motor • DC Geared motors – 12V, 10 RPM, 11.25 kgcm.
- Battery of 12V, 3000 mAH.
- Adapter for Arduino UNO – 5V, 2A
- LED’s
- Jumper wires – Male to male, female to female and male to female
- Resistors of various specifications

B. Software Requirements

- To control the microcontroller, embedded C logic is used to control the motors simultaneously.
- To design the mechanical bed, Fusion 360, Solidworks and AutoCAD are used.
- To simulate the electronic components, Proteus and Fritzing are used.
-
- To train the voice commands, Access port and UNO are used.

C. Mechanical Requirements

There are three mechanical design requirements for this bed. The main structure is to be conceptualized and designed

- For the free movement of the smart bed, the wiper mechanism was chosen such that the rod rotated according to the user's needs.
- For the framework, the base is designed after performing the required analysis using various analytical methods.
- To ensure the loading capability, fine adjustment measures while designing are taken into consideration.
- The mechanical designs are precisely carved to ensure quality testing.

IV. ELECTRONIC SYSTEM LEVEL BLOCK DIAGRAM

The electronic system level block diagram is given in figure 1. The voice which is to be trained is received from the user via a mic to the voice recognition chip i.e., REES52 and the port is accessed via USB to UART converter by setting the baud rate at 9600. The voice commands are then converted to the ASCII character. This speech recognition chip will transmit the data to the microcontroller enabling the motor driver circuit pins and entering into the desired mode of operation of the driver circuit and then the motor driver circuit will send the signal to the motor terminal to rotate in the specific direction.

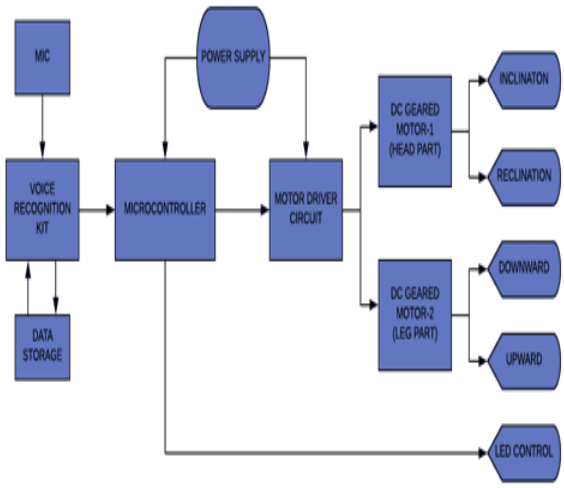

Figure 1: Electronic System Level Block Diagram

V. SOFTWARE DEVELOPMENT AND TESTING

A few tests were kept running at home and school conditions (for example study hall, research center) with low commotion where the created plan worked superbly three out of five times. In actuality, while testing it in a normal louder area (for example swarmed places or traffic blocked places) it was hard to control the bed now and again. Upcoming research is engaged in to make the plan work in a loud and bawling condition by including speed processing filters and classifying methods. The voice which is to be trained is received from the user via a mic to the voice recognition chip i.e., REES52 and the access port software using USB to UART converter by setting the baud rate 9600. The voice command is then converted to the ASCII character and if the ASCII character is stored and the LED light indication will turn ON which is given in the 16th GPIO pin with a delay of 4 second. And if the ASCII character is not received i.e., no voice is been trained which turns OFF the LED light which is given in the 16th GPIO pin. The trained data is then stored in the registers which are assigned to it. Voice commands are the main inputs to activate Johnson motors for setting the bed in motion. Since wireless technologies are limited in a hospital environment, the whole concept of using speech processing chip came into existence instead of using wireless modules. The user is first subjected to train his/her voice to get the system activated for secured operation. The speed control of the DC motor is achieved by controlling the input voltage using the motor driver circuit. A dual H-bridge L298N motor driver is used which helps in direction and speed control of the two DC motors simultaneously, and the circuit drives a DC voltage between 5-35V and the maximum current up to 2A. The pulse modulation technique is used to control the speed of the DC motor. The technique allows adjusting the value of the voltage to its average value which is going to the motor driver circuit by turning the power on and off at quick rates. The average value of the voltage relies upon the duty cycle, or the measure of time the signal is ON versus the measure of time the signal is OFF in a period.

To give the patient the best care is still a hot topic under discussion which can boost up the hospital's reputation when a successful model is invented. The principal goal of the project is to build a smart-Medbed which aligns itself based on the voice inputs or commands in our context and the same can be extended into a smart hospital room using socket programming techniques for automation of electrical appliances, nurse call and other functional requirements based on the user. Due to the misinterpretation of words, most of the softwares fail to recognize the voice accurately and therefore, produce errors because most of the programs don't understand the language the way humans do. For the current project being implemented the above-mentioned errors are taken care off by introducing a feedback system which can compare the voice inputs and trigger the controller to generate an output according to the end user. For the user to decide the angle of alignment, specific commands are chosen which makes the system more intelligent.

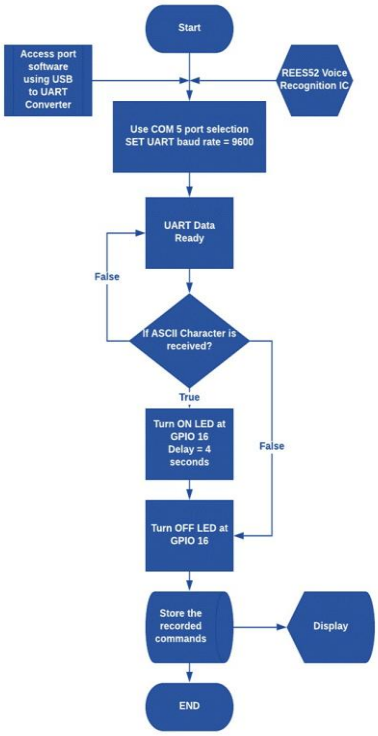

Figure 2: Main control algorithm flowchart

COM6

```
Elechouse Voice Recognition V3 Module "tra----
elp                     print this message
--------------------------------------------------------------------------------
Elechouse Voice Recognition V3 Module "train" sample.
--------------------------------------------------------------------------------
Usage:
--------------------------------------------------------------------------------
COMMAND     FORMAT                  EXAMPLE                 Comment
--------------------------------------------------------------------------------
train       train (r0) (r1)...      train 0 2 45            Train records
load        load (r0) (r1) ...      load 0 51 2 3           Load records
clear       clear                   clear                   remove all records in  Recognizer
record      record / record (r0) (r1)... record / record 0 79   Check record train status
vr          vr                      vr                      Check recognizer status
getsig      getsig (r)              getsig 0                Get signature of record (r)
sigtrain    sigtrain (r) (sig)      sigtrain 0 ZERO         Train one record(r) with signature(sig)
settings    settings                settings                Check current system settings
help        help                    help                    print this message
--------------------------------------------------------------------------------
```

Figure 3: Voice Training

```
vr
--------------------------------------------------------------------------------
All voice records in recognizer: 6
Valid voice records in recognizer: 6
VR is not in group mode.
VR Index        Record          Comment
0               0               Valid
1               1               Valid
2               2               Valid
3               3               Valid
4               4               Valid
5               5               Valid
6               Unloaded        NONE
--------------------------------------------------------------------------------
```

Figure 4: Voice Recognition Status

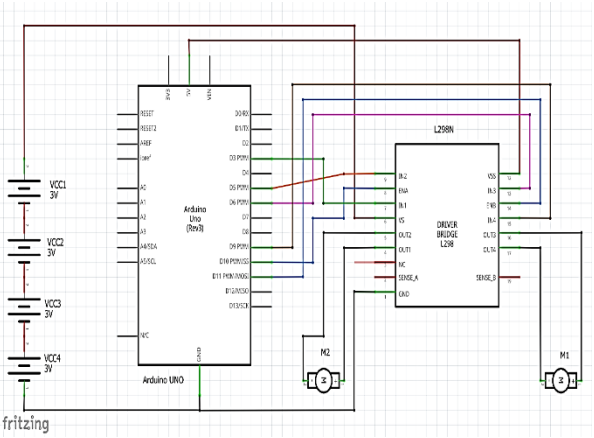

Figure 5: Simulation of Arduino-UNO with L298N and Johnson motors

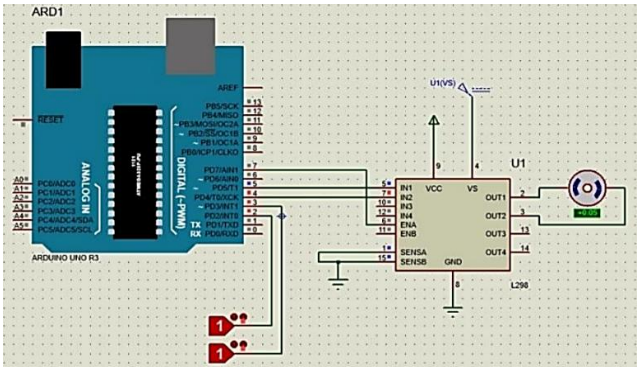

Figure 6: Simulation using Proteus

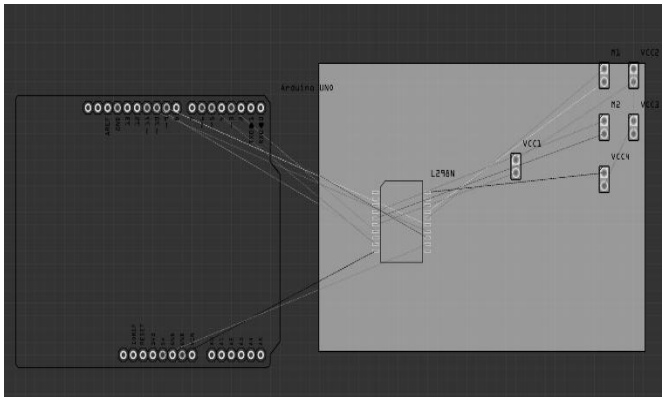

Figure 7: PCB Layout of the Developed System

VI. MECHANICAL SUBSYSTEM CONCEPTUALIZATION

On the mechanical aspect, an X Y Z Johnson motor base was to be designed in order to test if the product concept works. The concept was designed with two motors as the controller selected could support only two motors. The design of concept in Fusion 360 is as shown in figure 8, 9 respectively.

Figure 8: Assembled Structure 1

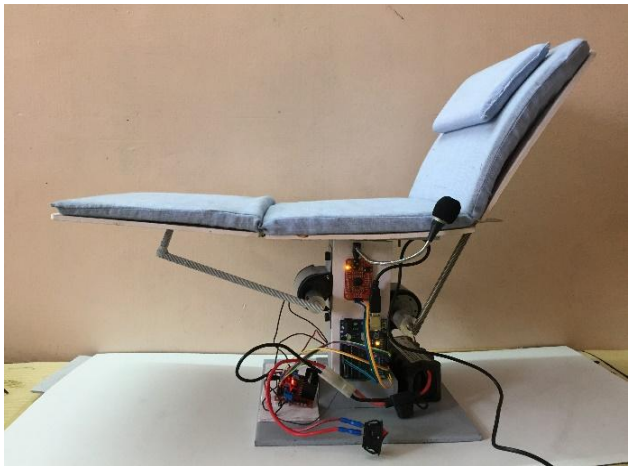

Figure 9: Assembled Structure - Head Inclination

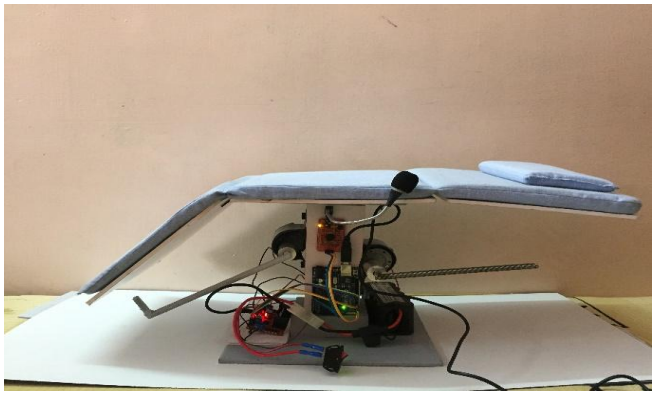

Figure 10: Assembled Structure – Leg Reclination

A. Voice Module Design

Voice commands are the main inputs to activate Johnson motors for setting the bed in motion. Since wireless technologies are limited in a hospital environment, the whole concept of using speech processing chip came into existence instead of using wireless modules. The user is first subjected to train his/her voice to get the system activated for secured operation. The VR3 module helps us achieve a Human-Machine Interface by facilitating natural and a convenient atmosphere and this module uses a HM2007 chip. According to our needs, the following commands were recorded:

- Incline (head movement)
- Recline (head movement)
- Upward (leg movement)
- Downward (leg movement)
- Lights on (led on)
- Turn off (led off)

Figure 11: Voice Module Chip

B. Hospital Bed and controlling the motion design

The mechanical bed was designed using Fusion 360 wherein all the dimensions were made clear to perform load and stress analysis, such that understanding of load placement was made easier. The whole system is fabricated of steel to reduce the complexity of the project, the above design is chosen which ensures rigid support and increases space for movement of the rods thereby producing the desired output. The driver used in this system is a H-Bridge l298N relay circuit which consumes a supply of 12V to control the motor for bidirectional operation of the bed and is achieved due to the conduction of current in both the directions. The motor used is a DC geared Johnson motor to lift the hospital bed and incline it to a desired angle. The Johnson Geared Motors are known for their massive torque-speed characteristic and compact size, And it runs smoothly at the speed of 10 RPM with the voltage between the range 6 to 18 V DC at 12V supply. The torque provided by this motor is of 11.7 kg-cm at 10 RPM.

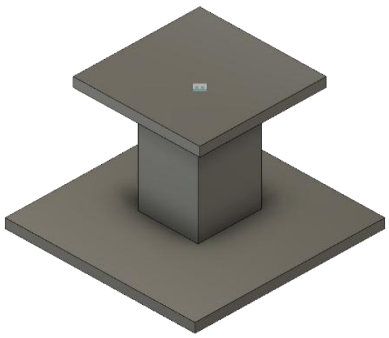

Figure 12: Hospital Bed Support Structure

VII. CONCLUSION

The developed intelligent bed actuated using voice commands, put the bed in a motion responding to the user's voice and also the bed inclined and reclined at precise angles. The methods and methodology for every procedure followed during the construction of this bed are discussed. With the help of stress and load analysis, the components requirements were understood though revisiting for conceptualization was necessary.

ATmega328 was used to control the logic level of this system which drove the motor driver circuit for every voice input from the user was initiated. In this project, the desired angles were already decided for easy development of the concept which could be further modified according to the user. The entire system functioned using C logic for which Arduino was compatible. Chip HM2007 is also Arduino compatible making the system a whole lot easier for implementation. This approach reduced the complexity of the project thereby decreasing the cost and increasing efficiency. Bugs and debugs were the common issues faced during the implementation of the Smart Bed which includes both hardware and electronic aspects. The Software requirements with a little team effort made us achieve the desired output. The load analysis of the entire subsystem consumed enough time due to the special mechanism introduced by us making the bed hassle-free and less complex. The challenges faced during the misalignment of the bed made us overcome about 80% of the problems. The cost estimation of the intelligent bed is nearly around Rs.8000/-. Most of the patients will be benefitted using this prototype since its simple, user-friendly and cost-effective. Extension of the same prototype will make it more advance and help us combat the disadvantages faced. Overall, our proposed prototype of the Hospital Bed is made eco-friendly without any signals which are hazardous for the Hospital environment even-after the system is wireless.

APPENDIX- FUTURE SCOPE

1. Increasing the precision of the motors for slow movement of the bed.
2. Introducing Neural-networks and Fuzzy logic to control the motion of the bed.
3. Introducing more Artificial Intelligence interfaced systems so as to avoid electronics on the whole which is a hazardous environment adding on to the disadvantages of the module.
4. The speech processing chip can be completely avoided and instead mind-ware controls can be introduced which overcomes the disability of speaking and other special disorders.
5. Advanced control systems like robots can be introduced for patient care.

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Patents: Sitaram Gupta, V. V. S. N. and Prajwal, K. T. "Method and System for Continuous Power Supply System from Multiple Energy Source Based on Demand Management", Indian Patent Application: 201741046744, December 27, 2017. Email: prajwal.ee.et@msruas.ac.in