IOT BASED ARTIFICIAL CPR DEVICE

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Abstract - *Cardio Pulmonary Resuscitation (CPR) is the first step in treating victims of sudden cardiac arrest (SCA). Though manual CPR has been prevalent for many years, mechanical CPR has proven to be easier for the rescuer, safer for the patient, and more effective in pumping blood through the body. Current mechanical CPR devices, such as the AutoPulse by Zoll, Inc., utilize a load-distributing band to apply circumferential chest compressions. However, it is very expensive and heavy, thus prohibiting its distribution to the general public. We propose to fabricate an automatic mechanical CPR device which will be cost-effective. The device will provide 2-inch deep anterior-posterior chest compressions to victims and will be able to be used in the hospitals.Material, electrical, and mechanical factors were taken into consideration when designing this device. The major components of the device include the board, motor assembly, microcontroller and power source. Upon completion of the project, it is expected that the device will be able to achieve the aforementioned goals of anterior-posterior displacement, easy application, and will be distributable to the various health care sectors. Remote health monitoring systems in hospitals or homes are required to reduce the overall healthcare cost and optimizing healthcare processes. The Internet of Things (IoT) technology is used in this project to monitor the cardiac waveforms and conditions from anywhere especially for inpatients and ICU patients. The project focuses on the automatic artificial Cardiopulmonary Resuscitation(CPR) for the ICU patients who suffer sudden cardiac arrest through a mechanical CPR for effectively pumping the blood to all the organs and simultaneously the activities can be controlled and monitored by the IoT. The motto of the project is to increase the survival rate of the cardiac arrest victims thus providing the high quality healthcare worldwide.*

Key Words: *Automated CPR, Cardiac Arrest, Mechanical Chest Compression, Resuscitation, Load-Distributing Band, Return of Spontaneous Circulation, Coronary Perfusion Pressure*

1. INTRODUCTION

Cardiopulmonary resuscitation (**CPR**) is an emergency procedure that combines chest compressions often with artificial ventilation in an effort to manually preserve intact brain function until further measures are taken to restore spontaneous blood circulation and breathing in a person who is in cardiac arrest.

CPR involves chest compressions for adults between 5 cm (2.0 in) and 6 cm (2.4 in) deep and at a rate of at least 100 to 120 per minute. The rescuer may also provide artificial ventilation by either exhaling air into the subject's mouth or nose (mouth-to-mouth resuscitation) or using a device that pushes air into the subject's lungs (mechanical ventilation). Current recommendations place emphasis on early and high-quality chest compressions over artificial ventilation; a simplified CPR method involving chest compressions only is recommended for untrained rescuers. In children, however, only doing compressions may result in worse outcomes, because in children the problem normally arises from a respiratory, rather than cardiac problem. Chest compression to breathing ratios is set at 30 to 2 in adults.

CPR alone is unlikely to restart the heart. Its main purpose is to restore partial flow of oxygenated blood to the brain and heart. The objective is to delay tissue death and to extend the brief window of opportunity for a successful resuscitation without permanent brain damage. Administration of an electric shock to the subject's heart, termed defibrillation, is usually needed in order to restore a viable or "perfusing" heart rhythm. Defibrillation is effective only for certain heart rhythms, namely ventricular fibrillation or pulseless ventricular tachycardia, rather than asystole or pulseless electrical activity. Early shock when appropriate is recommended. CPR may succeed in inducing a heart rhythm that may be shockable. In general, CPR is continued until the person has a return of spontaneous circulation (ROSC) or is declared dead.

1.1 DC MOTOR

A **DC motor** is any of a class of electrical machines that converts direct current electrical power into mechanical power. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor. Most types produce rotary motion; a linear motor directly produces force and motion in a straight line.

Figure 1 DC motor

DC motors were the first type widely used, since they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight motor used for portable power tools and appliances. Larger DC motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.

Working of DC motor

Under Electrical Motor, a DC motor in simple words is a device that converts direct current(electrical energy) into mechanical energy. It's of vital importance for the industry today, and is equally important for engineers to look into the **working principle of DC motor** in details that has been discussed in this article. In order to understand the **operating principle of dc motor** we need to first look into its constructional feature.

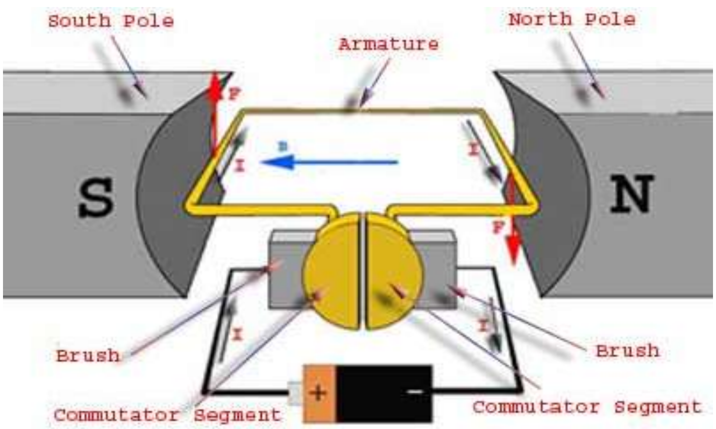

Figure 2 Construction of DC motor

The very basic construction of a dc motor contains a current carrying armature which is connected to the supply end through commutator segments and brushes and placed within the north south poles of a permanent or an electro-magnet as shown in the diagram below .Now to go into the details of the **operating principle of DC motor** its important that we have a clear understanding of Fleming's left hand rule to determine the direction of force acting on the armature conductors of dc motor.

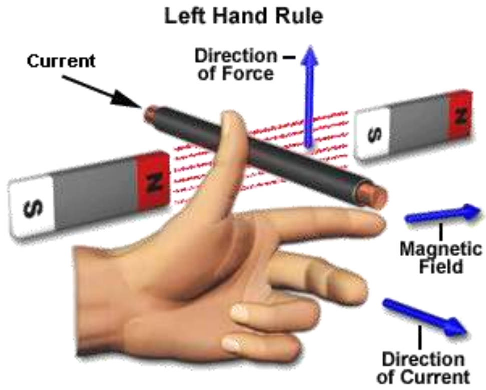

Figure 3 Fleming's left hand rule

Fleming's left hand rule says that if we extend the index finger, middle finger and thumb of our left hand in such a way that the current carrying conductor is placed in a magnetic field (represented by the index finger) is perpendicular to the direction of current (represented by the middle finger), then the conductor experiences a force in the direction (represented by the thumb) mutually perpendicular to both the direction of field and the current in the conductor.

Virtually no rotating torque acts on the armature at this instance. But still the armature does not come to a standstill, this is because of the fact that the operation of dc motor has been engineered in such a way that the inertia of motion at this point is just enough to overcome this point of null torque. Once the rotor crosses over this position the angle between the actual position of the armature and the initial plane again decreases and torque starts acting on it again.

1.2 MPLAB

MPLAB is a proprietary freeware integrated development environment for the development of embedded applications on PIC and dsPIC microcontrollers, and is developed by Microchip Technology. MPLAB X is the latest edition of MPLAB, and is developed on the NetBeans platform. MPLAB and MPLAB X support project management, code editing, debugging and programming of Microchip 8-bit, 16-bit and 32-bit PIC microcontrollers. MPLAB is designed to work with MPLAB-certified devices such as the MPLAB ICD 3 and MPLAB REAL ICE, for programming and debugging PIC microcontrollers using a personal computer. PICKit programmers are also supported by MPLAB.

MPLAB 8.X is the last version of the legacy MPLAB IDE technology, custom built by Microchip Technology in Microsoft Visual C++. MPLAB supports project management, editing, debugging and programming of Microchip 8-bit, 16-bit and 32-bit PICmicrocontrollers. MPLAB only works on Microsoft Windows. MPLAB is still available from Microchip's archives, but is not recommended for new projects.

MPLAB supports the following compilers:
MPLAB MPASM Assembler
MPLAB ASM30 Assembler
MPLAB C Compiler for PIC18
MPLAB C Compiler for PIC24 and dsPIC DSCs
MPLAB C Compiler for PIC32
HI-TECH C
MPLAB X is the latest version of the MPLAB IDE built by Microchip Technology, and is based on the open-source NetBeans platform. MPLAB X supports editing, debugging and programming of Microchip 8-bit, 16-bit and 32-bit PIC microcontrollers.
MPLAB X is the first version of the IDE to include cross-platform support for Mac OS X and Linux operating systems, in addition to Microsoft Windows.
MPLAB X supports the following compilers:
MPLAB XC8 — C compiler for 8-bit PIC devices
MPLAB XC16 — C compiler for 16-bit PIC devices
MPLAB XC32 — C/C++ compiler for 32-bit PIC devices
HI-TECH C — C compiler for 8-bit PIC devices
SDCC — open-source C compiler

Specifications

The input waveform is collected from a site available in the internet called Physionet. The reason why we go for this site is that, during the development of this project ECG waves from a live patient will be taken. Hence there is no problem of accuracy in the signals. But here to get a real time output ECG waveforms of some patients with normal and arrithymias conditions are taken.

The input ECG waveforms available from the internet are in the digital form so that it can be easily fed to the circuit. Thus the LabVIEW software is used to feed the input ECG waveforms to the circuit. The simulation for activating the automatic CPR device is given below:

Various virtual tools are used in the LabVIEW software here. It consists of two different panels for working. They are control panel and front panel. Tools selected in the function panel will be having corresponding icons in the control panel. The purpose of the LabVIEW design is to receive the waveform data and activate the mechanical device only when it is lowered below a particular range.

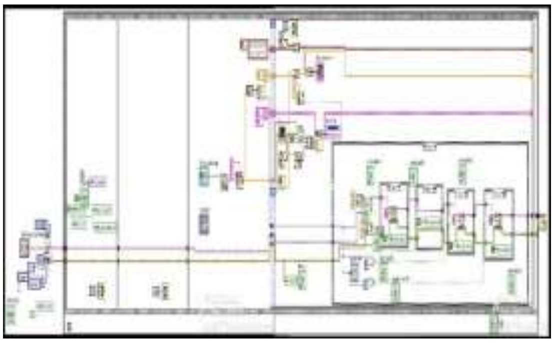

Figure 5 Image of the function panel of the LabVIEW simulation.

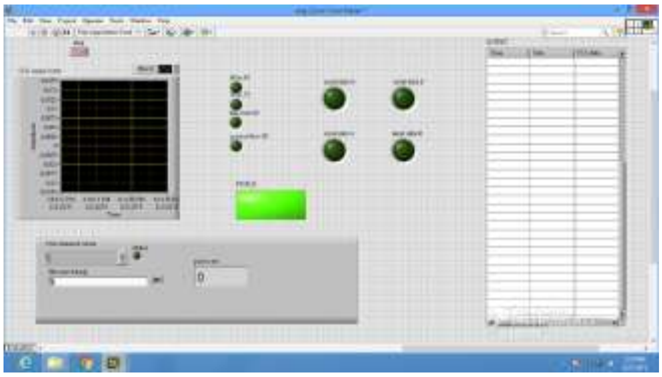

Figure 4 The control panel

Explanation of tools

The heart rate that is obtained as the output from the LabVIEW simulation determines the switching ON of the relay in the circuit. As per this simulation the relay is switched to ON condition only when the range of the ECG waveform is below the 60. The value obtained from the software is transferred to the circuit via the USB to UART port. Here the PC should be carrying the USB to UART application for the transmission of the serial data. The value of the heart rate is carried to the PIC microcontroller and the IC is programmed such that it switches the relay to ON condition only if the heart rate is below 60.

2. Output mechanical compression

The mechanical setup starts to work when it receives the signal of the required range. The setup can be divided into two portions i.e, the DC motor and the Crankshaft. Initially the DC motor rotates when the relay switches on the setup and the Crankshaft model which is attached to motor also starts to move.
The Crankshaft model will be consisting of the two components. One is the circular disk and another one is the long shaft. As the motor rotates the Crankshaft produces the longitudinal movements (up-down) which produces the compressions on the chest of the patient. The motor which

acts as the center for the mechanical setup drives the crankshaft mechanism. The efficiency of the motor and the programmed controller decides the number of strokes produced by the shaft onto the patient chest.

The average number of compressions that are needed for the first aid of a cardiac arrest victim is 100 compressions per minute with a depth of 2 to 2.5 inches. This automatic CPR device produces about 120 compressions per minute with 2.5 inch depth. The compressions of the shaft are continued until the ECG of the patient becomes normal that is above the danger level. Here it is 60 beats per minute.

When the data for the normal patient is given in the LabVIEW software during the running time of the device it does not affect any of the actions and the device automatically stops its compressions detecting the normal signal that is received from the controller. The mechanical setup is stopped because the relay is switched to OFF condition.

The mechanical setup can be adjusted depending on the need of the patient. The vertical stand can be adjusted in 360° so that the device can be moved away from the patient for the further treatment. The horizontal stand that carries the DC motor and Crankshaft model can also be adjusted horizontally as per the need of the patient and the position in which the patient is lying.

IoT INDICATION USING CAYENNE APP

IoT consisting of the four modules: the assest module, data acquisition module, data processing module and communication module. The purpose of using IoT is to indicate the condition of the patient. Here Cayenne App is used to indicate the person using mobile phone by blinking a light in it. Initially the heart rate which is monitored by the circuit reaches the IoT kit and it is acquired. The acquired data is converted to the digital form that can be manipulated by the computer. Then comes the data processing module which processes the data and send it to the cloud. The data processing unit is having a sufficient memory as per the requirement of the application. The final block is the communication module that connects the cloud of IoT to the mobile phone app. Here wireless communication is used to transfer the data. When the patient is abnormal the CPR is given automatically and this can be seen through the indication generated by the Cayenne App. If the patient again reaches the normal condition or another patient data is given through the software means the device stops the compressions and the blue light indication of the IoT is also disappeared.

3. CONCLUSION

The application of this technology in the hospitalised patient bed side provides the improved efficiency of the treatment for the cardiac patients which symbolises the high quality therapy given to the patients worldwide. This technology in place teach people how to administer effective CPR. But in emergency situations a trained person may not be available. Our application uses a smartphone to monitor the ECG waves and activate the CPR. The PIC microcontroller acts as the central control of the whole unit to control both the monitoring phase and the mechanical phase. The software provides the application with the abnormal cardiac wave of the patient. This is can be replaced by the ECG waves of the patient under continuous monitoring when this application is used in the hospitals

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