Intelligent Cardiac-Arrest Rescue Technology Incorporating Autonomous Vehicle Control System

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Abstract:

The number of car accidents that occur world-wide because of cardiac patients phenomenally rise as the days go by. So, in this paper, we will be presenting a relatively new idea for a system, along with its implementation with an algorithm, which ensures the safety of the passengers on-board and the vehicles being driven nearby. A cardiac pulse monitor mechanism, an emergency stop-assistant system and a communication telematics system were used for achieving our goal. These three systems were interfaced with open-source hardware and observations were made.

1-Introduction:

Loss of motor control during driving due to a cardiac-arrest can prove fatal not only for the passengers in the vehicle, but also the surrounding traffic. In this paper, we have devised a method that not only saves the lives of the passengers and the surrounding traffic, but can also save the life of the driver who is struck by the cardiac distress. The fundamental basis of this idea is on vehicular telematics. Although there are many potential applications in the field of vehicular telematics, we will focus only on one. In this paper, we will be focusing on mainly 3 aspects in order to achieve our goal mentioned earlier:

1. Cardiac Pulse Monitor
2. The Emergency Stop-Assistant System.
3. Communication Telematics System.

An algorithm for combining the three aforementioned systems by means of hardware is also mentioned in the further sections.

The idea is elaborated in following sections of the paper, which are organized as follows. Section 2 gives the working of the cardiac pulse monitor, section 3 gives the working of the emergency stop assistant system, section 4 deals with the working of the communication telematics system, section 5 gives the co-coordinated implementation of the three systems working in conjunction by means of a microcontroller by the proposed algorithm and the conclusion of the paper is given in section 6.

2-Cardiac Pulse Monitor:

The use of a wireless sensor that measure pulses on the driver's wrist is incorporated. The device transmits the data continuously in real-time by means of a Bluetooth transmitter. An effective range of up to 10 meters can be achieved through this system. Two kinds of electrodes are used, namely: the central electrode(which provides artificial grounding) and the exploratory electrode(which measures the pulse). This data is continuously transmitted to the ECG unit which is interfaced with the hardware circuitry.

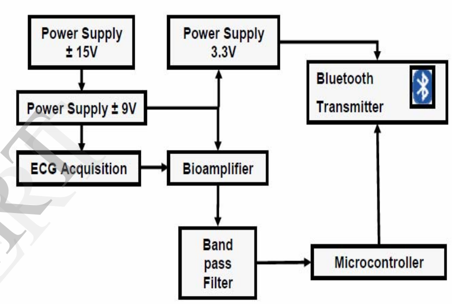


Figure 1:Processing Module within the Sensor

One of the heart conditions that leads to a heart attack is called as fibrillation. It is defined as the rapid and irregular contraction and relaxation of the heart muscles. The type of fibrillation that we are focusing on detecting in this paper is called as atrial fibrillation. It is an arrhythmia characterized as irregular, disorganized, electrical activity of the upper chambers (atria) of the heart. The atria quiver instead of regularly beating which causes them to move around 300-600 times a minute (instead of 60-80 times a minute). Because the upper chambers are quivering so rapidly, the blood is not allowed to completely empty and causes pooling in the atria.

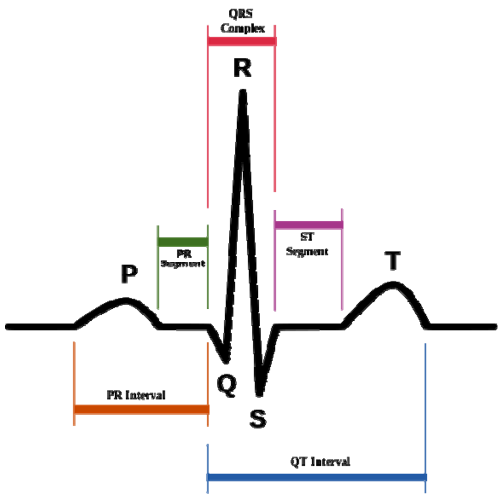


Figure 2: Regular ECG Wave

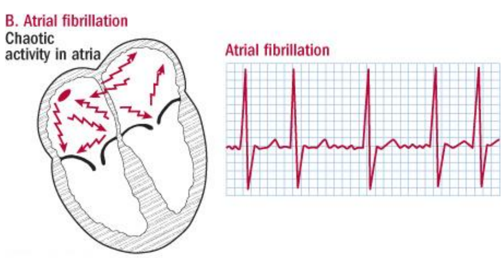


Figure 3: Atrial Fibrillated ECG Wave

From figure 2 and figure 3, the difference between a regular ECG wave and an atrial fibrillated wave can be observed. Atrial fibrillation can be characterized by the irregular spacing between the subsequent ECG pulses. The ECG pulses are continually monitored by the pulse monitor. Thus, the occurrence of atrial fibrillation is indicated by the increase in the heart rate to more than 300 beats per minute. Whenthis problem is detected by the unit, the system send a signal to the hardware circuitry which will control the remaining action.

3-The Emergency Stop-Assistant System:

The Emergency Brake Assistance idea used in our system is a version based on existing technology - Autonomous Emergency Braking. When the emergency break assistance system is initialized, the control unit calculates the object's position, the relative speed and the relative acceleration in relation to itself. This is done by the use of proximity sensors which are fitted at the front, rear and the sides of the car. As the primary step, when the Emergency Break Assistance System is activated, the hazard lights of the vehicle are turned on. Simultaneously the proximity sensors located on the sides monitor the speed of the vehicle relative to the traffic flow on the sides and if the vehicle on the side is at a higher/identical velocity than itself,the control unit calculates the amount of brake pressure to be applied and the corresponding break pressure is put and the vehicle is slowed down. The next step is the maneuvering of the vehicle to the side. This is achieved by the modification of the Automatic Parking algorithm. When a vehicle is detected by the sensor, brake pressure is applied and the car is decelerated and it is made to move forward till it finds an available space, after which it places itself in that position. Thus the vehicle is brought to a halt.

3.1-Working of the Proximity Sensor:

The proximity sensor is based on radar mechanism. The system's radar sensor has a range of up to 200 metres and a beam angle of 12 degrees. The radar sensor and control unit are combined into a single unit which is located. Using the signals from the radar sensor, the control unit computes the distance to the vehicle ahead and your car's speed relative to it. It also works out its lateral position on multi-lane roads. If there are several vehicles within the sensor's field of coverage at the same time, this information is used to select which of the vehicles the system should track. The radar sensor is not capable of detecting stationary obstructions, such as the end of a tailback or crash barriers, however. If approaching a slower vehicle ahead or if another vehicle cuts in front, the Emergency Brake Assistant System slows down the car by initiating corrective controls in the engine management by applying a suitable brake pressure.

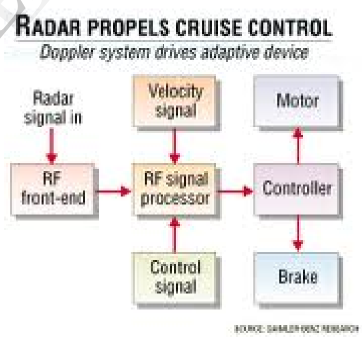


Figure-4: Block Diagram of the Proximity Sensor

Figure 4 shows the proximity sensor employed.

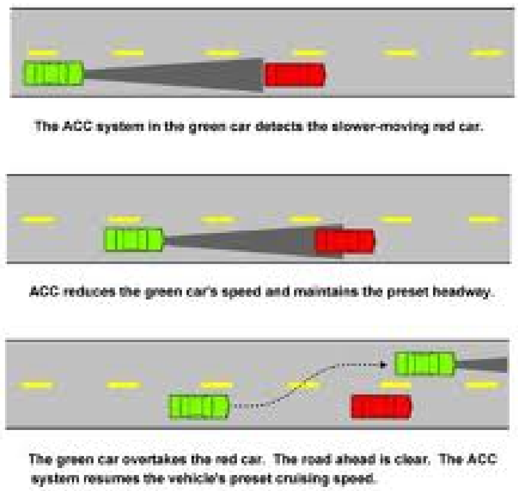


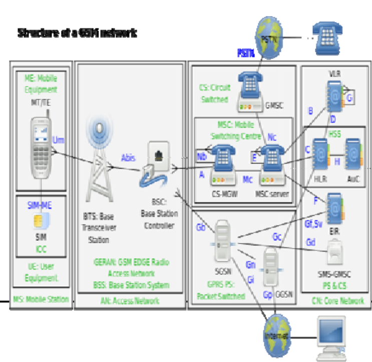
Figure-5: Adaptive Cruise Control

Figure 5 show the adaptive cruise control technology which uses proximity sensors employing radar mechanism

4- The Communication Telematics System:

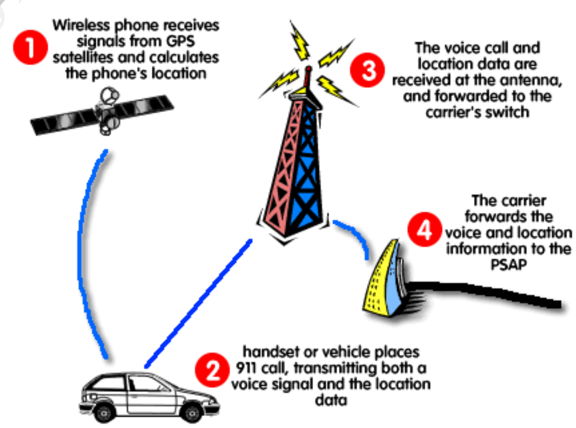
i) GSM: distress message transmission

Once the car is parked the system connects with the user's mobile to send a emergency text message containing the details of the driver such as the name and time and condition of distress to the most nearby hospital. This is done by the basic components of the gsm network. Where the user's mobile transmits the data to the base transceiver station. A base transceiver station (BTS) is a piece of equipment that facilitateswireless communication between user equipment (UE) and a network. The transmitted data is then sent to the base station controller. The base station controller (BSS) is the section of a traditional cellular telephone network which is responsible for handling traffic and signaling between a mobile phone and the network switching subsystem. From this stage the message can be transmitted in various forms but the most efficient method is the connection through SGSN network which is the network used to facilitate the mobile internet of handheld devices. Thus finally the connection is facilitated to the personal computer of the hospitals via internet connection to display the distress message.



ii) Location of the driver& hospital- GPS

In this stage our main area of concentration is to find the location of the driver and nearby hospital. Then to transmit the location data of the driver to that nearby hospital located. To locate a mobile telephone geographically, there are two general approaches. One is to use some form of radiolocation from the cellular network; the other is to use a Global Positioning System receiver built into the phone itself. Out of these GPS is more accurate and has fewer disadvantages. Radio resource location services (LCS) protocol (RRLP) applies to GSM and UMTS Cellular Networks. It is used to exchange messages between a handset and an SMLC in order to provide geolocation information; e.g., in the case of emergency. (SMLC) Serving Mobile Location Center.The SMLC is a network element in GSM Networks that resides in the BSC (Base Station Controller) which calculates network-based location of mobile stations (handsets). The SMLC may control several LMUs (Location Measurement Units) which measure radio signals to help find mobile stations in the area served by the SMLC. It can calculate location using the TA (Timing Advance) method. Thus by implementing this technique we will be able to accomplish our two main criterions, namely (i) location of the distressed driver and (ii) location of the nearby hospital. Thus by combining these two data we will be able to efficiently manage the positioninginfomatics aspect of the device.



5- Hardware Implementation:

For the hardware implementation, we make use of a microcontroller. The three units are interfaced within this circuitry, as shown in figure.

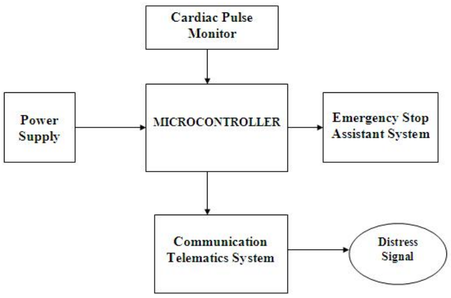


Figure : Hardware Circuitry of the System.

One typical open source hardware that can be used for this purpose is the Arduino UNO which is based on the ATMega328 microcontroller.

From the figure, it can be seen that the input is coming from the pulse monitor to the microcontroller, thus, when there is a possibility which indicates atrial fibrillation, this is detected by the microcontroller and the control switches to the emergency stop assistant system. This system,typically measures the position and speed of the oncoming vehicle by using state of the art radar and relays the information to the adaptive cruise control circuit which controls the speed of the vehicle and steers it in the most safest path such that there is no collision with the nearby vehicle. One should remember that this system acts to only slow down the vehicle and by no means does not increase the speed in any way.

Simultaneously, the microcontroller also activates the communication telematics system. This system has a built-in GPS, GSM module and a Real-Time Circuit (RTC) interfaced in it. Thus, once the signal from the microcontroller is detected, the system obtains the present location from the GPS, present time from the RTC and combines them in the form of an encoded message containing the details. This message is transmitted to the nearest hospital or health facility by means of the GSM module. The nearest hospital/health facility location is obtained from the GPS.

Conclusion:

Thus the various sections namely, (i) cardiac pulse monitor, (ii) emergency stop system and (iii) communication telematics when brought together in the most versatile form gives us the

'Intelligent Cardiac-Arrest Rescue Technology Incorporating Autonomous Vehicle Control System'.

With this system we have incorporated safety measures along with user friendly technologies to create a dynamic piece of equipment which on overall enhances the safeness of the user to a whole new level.