



GSM Enabled Patient Monitoring System Using Arduino Application for Cardiac Support

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Abstract. This paper focuses on designing a system to provide the patients with supplemental oxygen to prevent hypoxia for and covid patient. The decrease of oxygen in the tissues in patients with heart diseases, lung related-diseases and elderly people result in hypoxia. During this covid-pandemic, number of the patient died due to poor monitor system and mainly due to insufficient of the oxygen. The main goal of this article is to develop a system to deliver oxygen supplement automatically to patients when required. This system is portable, does not prevent the patients from their life style and gives freedom of mobility for patient. This device can be used both on hospitals and also in houses for patients with not so critical condition to be monitored. The system is designed to read the heart rate in the body using a heartbeat sensor. As the heart-rate decreases eventually the SpO₂ levels in the organs start diminishing thus leading to hypoxia. Here the Arduino Uno operates a solenoid valve using a relay to regulate the required oxygen supply automatically. It also has a temperature sensor to record the body temperature. The system uses a portable light-weighted oxygen cylinder to deliver the oxygen via nose. The system uses LCD device to display the readings recorded. This system also uses GSM to communicate with others in case of emergency. The system is provided with a buzzer to intimate the patient in case of emergency.

Keywords: hypoxia · supplement oxygen · heartrate sensor · SpO₂level · GSM

1 Introduction

Till the present day, eminent countries in the world are suffering from different types of diseases. The number of patients struggling illness are increasing day by day. Common diseases, inherited diseases, diseases due to stress, lifestyle etc., affects the person physically and psychologically. Unhealthy lifestyle, irregular food habits and stress due to personal and work-related matters affect the people with chronic illness which may lead to heart disease, lung related disease etc., from young to elderly people irrespective of the age. People living in rural areas or countryside suffering from heart diseases cannot reach the hospital early in case of emergency if the hospital is located far. Thus, making the continuous monitoring of heart patients not possible [1]. At this pandemic situation, many people died due to insufficient oxygen and poor monitoring.

The heartbeat rate plays a major role in maintaining the saturated oxygen level in the blood. If the heart beat rate is reduced, the pumping of blood by the circulatory system is slowed thus the oxygenated blood flow is also reduced. As time passes by, the organs and the tissues will be deprived of blood thus causing hypoxia. SpO₂ or oxygen saturation is one of the vital parameters that concerns a body's most basic. The SpO₂ level refers to the blood oxygen saturation. Oxygen saturation (SpO₂) is defined as the ratio of oxy hemoglobin to the total concentration of hemoglobin [2]. It is the percentage of oxygen present in the blood... The normal SpO₂ level should be about 90–100%. If it is reduced below 90 it leads to hypoxia. If it further decreases below 80% it may lead to organ dysfunction such as heart failure etc.

Hypoxia is a medical condition where a particular organ or the entire body is seized of adequate oxygen source at the tissue level. Hypoxia is mainly sorted into two categories. They are generalized and local. In generalized whole body is affected and in local, only a part or an organ of the body is affected. An example of generalized hypoxia is altitude sickness [3]. An example of local hypoxia is ischemia. Hypoxemia and anoxemia is distinctive from hypoxia... Hypoxia are a state of shortage in oxygen source hypoxemia and anoxemia is a state of zero arterial oxygen supply. Anoxia is a state of hypoxia where total oxygen supply is deprived. Hypoxia is of 4 different types.

Ischemic hypoxia refers to insufficient blood flow to a tissue which may occur due to trauma to the tissue. Hypoxemic hypoxia refers to the insufficiency in arterial blood oxygen supply which may occur due to carbon-monoxide poisoning, altitude, hypoxic breathing gases etc., Anemic hypoxia results due to haemoglobin deficiency. Hemoglobin plays an important role of carrying oxygen throughout the body. Histotoxic hypoxia are refers to the defect in cells where the cells are unfit to use the oxygen [4].

“Heart rate is defined as the number of times the heart beats per minute”, which can also be determined by the pulse. The pulse and heart beat are not much different from each other as the pulse is determined by the heart contractions that causes rise in the blood pressure [5]. The heart rate or the heart beat rate is the straight measure of pulse.

Temperature is expressed in three common scales, Celsius, Fahrenheit and Kelvin. It can express both heat and cold Temperature is used in all day-to-day activities such as cooking etc., It is used in various departments like natural science, medicine etc., Temperature is more important in the medical field as fever or chillness is the most common symptom of various diseases [6].

Temperature is not vital function, but can complement vital function sensors and, based on body temperature and information such as heart rate, determine the load on organism [7]. The normal body temperature in humans is determined to be between 36.5–37.5 °C. Temperatures below or above the normal range indicates illness. The internal body temperature is regulated or maintained by the circulatory system.

In this system, we are developing a module to monitor the heart rate and temperature of the person and deliver supplement oxygen when necessary. It is designed to be portable and an automatic system [8]. It is also designed to notify the doctor or the person's family through an emergency SMS. It is programmed in such a way that when the heart rate reduces below a certain range it supplies with supplement oxygen. Supplemental oxygen dose can greatly help relieve an individual from hypoxic stress [9].

2 Materials and Working Methodology

In the proposed system we are designing an automatic delivery of supplement oxygen to patients with heart disease, lung related problems, elderly people and hypoxic patients in case of emergency. It is designed to intimate the person of interest of the patient through the GSM [10].

It encompasses of heart beat sensor and temperature sensor which is the input module section where as the GSM, LCD, buzzer and the solenoid valve is the output module. The powersupply is given through a powersupply-board [11]. The Arduino uno board is secured to the power supply. The heart beat sensor is secured to the input of the Arduino uno board and to the power supply board [12]. The temperature sensor is also secured to the input of the Arduino board and to the power supply. The relay is connected to the power supply, output of Arduino uno and to the solenoid valve. The buzzer is secured to the output pin of the Arduino uno board [13]. The LCD is secured to the output pins of the Arduino uno. The GSM module is connected to the Ardu ino uno and to the power supply [14] (Fig. 1).

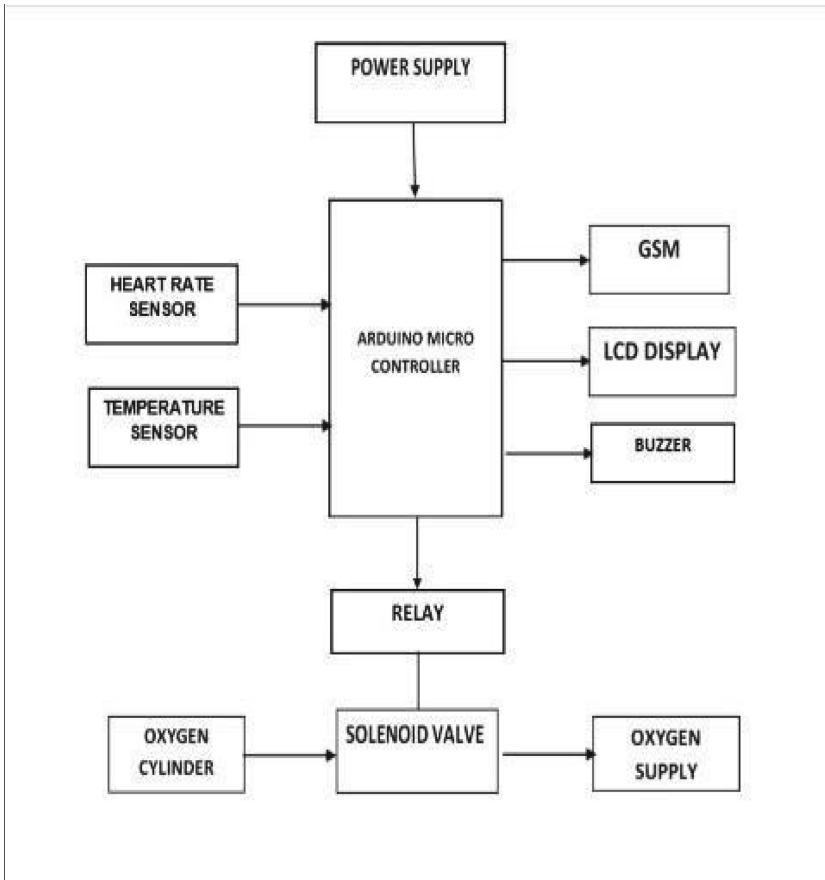


Fig. 1. BLOCKDIAGRAM

2.1 Power Supply

The power supply is an electrical device used to convert electric current from a source to the appropriate voltage, current, and frequency. Electric power converters are a synonym for power supply circuits. Different kinds of power supply circuits are distinguished based on the amount of energy used to supply circuits or devices. There are switching, unregulated, and regulated circuits.

The power supply used here is regulated power supply. In order to operate electronic devices most of the electronic devices requires the unregulated AC to be converted into constant DC. The electronic circuits inside the devices should be able to supply a constant DC voltage not beyond the power supply limit. The electronic equipment may break down easily if the supply from the main is fluctuating and not-properly limited.

2.2 Arduino Uno

The Arduino Uno is developed by Arduino. It is based on microchip ATmega328P open-source microcontroller. The latest revised version of Arduino Uno is Arduino Uno R3. The microcontroller board used here is Arduino Uno Rev3.

The Board is Equipped with 20 digital input/output pins. Among these 20 pins 6 can be used as Pulse width modulation (PWM) output pins and 6 can be used as input analog pins. The board is powered up by connecting it directly to the computer using a USB cable or by connecting it to a power supply through a AC to DC adapter or using a battery (Fig. 2).

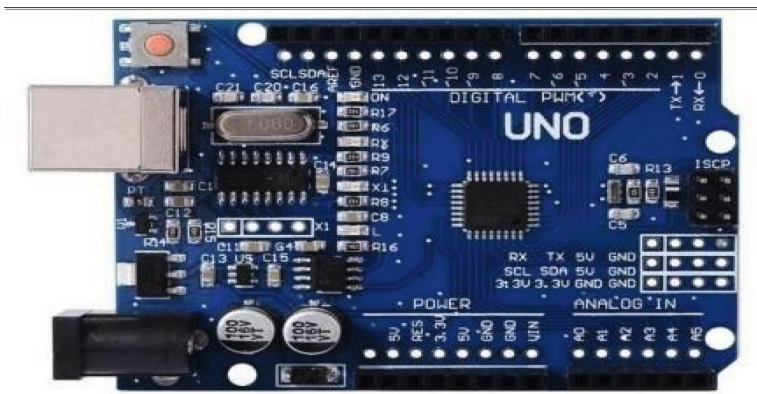


Fig. 2. ARDUINO UNO R3

2.3 ATmega

ATmega328 belongs to the mega AVR family and is a single chip microcontroller. It was created by Atmel but was later acquired in Microchip Technology in 2016. It has 28 pins in total among which 6 are analogue pins which belongs to the C port. It has 14 digital

2.6 Relay

A relay is an electrically operated switching device and a primary protection for most of the equipment. As a switching device it is used to change one state of the electric circuit to another state. Wherever one signal is necessary to control several circuits or a separate low power signal is required to control a circuit relay can be used.

Relays are classified based on the operating principles. The most common relays use electromagnet to mechanically operate the switch. Based in the operating principles the relays are classified as Electromagnetic relays (A Cor DC), Solid state relays, Thermal relays, reed relays, hybrid relays etc.

The relay used here is the Single Pole Double Throw relay. The SPDT relay has one general terminal and two contacts in separate configurations i.e., when the coil is applied with DC voltage, the terminal T is associated to contact 1 allowing the current to flow through fan 1 and fan 2 is closed and when the coil is applied with DC voltage, the terminal T is associated to contact2 allowing the current to flow through fan 2 and fan 1 is closed (Fig. 4).

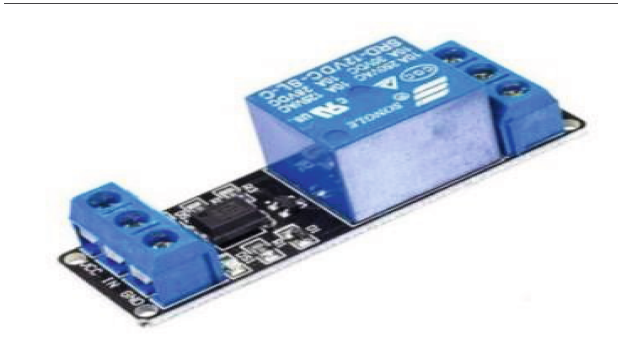


Fig. 4. RELAY

2.7 Solenoid Valve

“A solenoid valve is an electromechanical device.” The solenoid profits electric flow to actuate attractive field and works a system which controls the opening of fluid surge in a valve. There are unmistakable kinds of solenoid valve. In view of the attributes of the electric flow utilized, quality of the attractive field produced, the instrument used to manage the liquid, and the sort and qualities of the liquid they control, the solenoid valve varies.

Solenoid valves are generally administered to direct components in fluidics. Solenoids provide rapid and secure exchanges, high consistency, a long service life, minimal control power, and a compact design. One-way or two-way solenoid valves are applied in this context.

2.8 GSM

GSM module stands for Global System for Mobile Communication module. It is a digital mobile network that establish communication between the computer and the GSM module. GSM is an architecture used widely by mobile users in Europe and other parts of the world. GSM was first utilized in Finland in 1991. It is a standard that was established by the European Telecommunication standards Institute (ETSI). Since 2014, GSM became the Global Standard for Mobile Communication and is operating in over 193 countries and territories (Fig. 5).



Fig. 5. GSM

2.9 LCD Display

It is an electronic gadget balanced optically utilizing the light regulating properties of fluid crystals. These fluid crystals can't transmit light legitimately and utilizes the back-drop illumination as a source to deliver pictures.

The working principle behind the LCD is it enables light to go through as the crystals wind and untwist at modifying degrees. If no voltage is passed through the liquid crystal, polarized light is allowed through the 90-degree twisted LC layer. If voltage is passed through the liquid crystals, polarization is altered when the liquid crystal sun twist thus blocking the light's path.

The LCD display used here is the 16×2 LCD module. It has 16 rows and 2 columns thus having 32 characters in total. Each character is of 5 × 8-pixel specks. In this manner each character will have 40 pixels and the all-out 32 characters will have 1280 pixels.

2.10 Buzzer

A buzzer may be a mechanical, electromechanical or piezoelectric device used for audio signaling. A buzzer or beeper are used as alarming device, timers or as key strokes etc.,

The buzzer used here is the piezoelectric buzzer also called as piezo buzzer. “The piezo buzzer is based on the principle of reversing of piezoelectric effect.” The main component of the buzzer is the piezoelectric element. All piezo elements express phenomenon like piezo electric effect and reverse piezo electric effect. When mechanical strain is applied on the piezo electric element, the material develops an electric field and vice versa.

Therefore, as the name piezoelectric buzzer suggests when the piezoelectric material is exposed to mechanical strain it produces an electric field and vice versa. The buzzer comprises of piezo-crystals put between two conductors. At the point when electric tension is involved, the crystals push one conductor and tug the other. This push and tug create a soundwave.

2.11 Arduino Compiler

The Arduino IDE stands for Arduino Integrated Development Environment. The Arduino IDE is a software that is used as a compiler for the Arduino board. It is a cross – platform application used in Windows, macOS and Linux.

2.12 Embedded C

The most mainstream programming language in the software field for creating electronic contraptions is Embedded C. In electronic systems each processor used is linked with embedded software. Certain functions performed by the processor is programmed by embedded C.

Electronic devices used in day-to-day life such as mobile phone, washing machine, digital camera etc., work based on microcontrollers that are programmed by embedded C-code programming is preferred in embedded systems because it is easy to understand with high reliability and it is portable and has high capability.

3 Result and Discussion

The heart beat sensor and temperature sensor detect the pulse and the temperature individually. The buzzer provides alarm when sensing the heart rate. The oxygen will be delivered to the patient when the heart rate is less than 65 bpm by the solenoid valve. When the heart rate and temperature is sensed, it automatically generates SMS (Short Messaging Service) to representative user phone through GSM (Global System for Mobile Communication). The input modules and output modules are connected to the Arduino Uno using connecting wires as per the given construction and heart rate will be displayed on the LCD (Liquid Crystal Display).

The research is presented to provide better diagnostic and therapeutic aid for the heart disease patients and Hypoxia patient. Hypoxia is the condition, which occurs due to low concentration of oxygen in blood vessels, which means absence of the blood O₂ in the patient’s body which leads to fall of heart rate.

So, the treatment for hypoxia patient is to provide enough oxygen supplement to the body by sensing the heart rate. The heart beat sensor costs low and it can be used for

long time if not damaged. It is of simple construction. It is user – friendly module where everyone can use. It can be used both in hospital and house care for heart disease patients and it prevents the patient from acquiring Hypoxia. This research alerts the concerned person about their heart rate through Global Mobile communication system.

4 Conclusion

This research is useful for heart patient because it performs both therapeutic and diagnostic aid in this device. This system gives heart rate and temperature as input and the output will be given by buzzer (when it sensed), automatic oxygen supply to the patients, SMS to the concern person by displaying heart rate and temperature. The module also displays the output in LCD to provide assistance to the surrounding person

References

1. Lim, M.J., Jun-Kim, H., Jung, D.K.: Cloud networking based patient risk detection monitoring system. *Int. J. Intell. Syst. Appl. Eng.* **10**(1s), 121–124 (2022)
2. Kiruthika, R., Ramya, E., Prabha, R., Harinarayanan, M., Divakaran, S., Iswariya, R.: IOT based patient monitoring system. In: 2022 8th International Conference on Advanced Computing and Communication Systems (ICACCS), vol. 1, pp. 165–168. IEEE (2022)
3. Rajpoot, N., Bansal, S., Dhir, S.: IoT based vital monitoring and bed availability system using Arduino. In: Transformation in Healthcare with Emerging Technologies, pp. 231–248. Chapman and Hall/CRC (2022)
4. Jain, A., Prasad, J., Velho, D.B.D.V.: covIoT: integrated patient monitoring and sanitization system. In: 2022 International Conference on Communication, Computing and Internet of Things (IC3IoT), pp. 1–6. IEEE (2022)
5. Geetha, S., Ramachandran, V., Kanna, R.K., Vasuki, R.: Patient monitoring system in hospital. *Indian J. Public Health Res. Develop.* **10**(5) (2019)
6. Pantawane, R., Jyoti, A., Sheoran, S., Uikey, Y., Sonarkar, S., Thakare, R.: Implementation of IoT-based health care and saline monitoring system using Arduino UNO. In: Shaw, R.N., Das, S., Piuri, V., Bianchini, M. (eds.) *Advanced Computing and Intelligent Technologies*. LNEE, vol. 914. Springer, Singapore (2022). https://doi.org/10.1007/978-981-19-2980-9_41
7. Agriesti, C., De Cinque, M.I., Carloni, F., Santambrogio, M.D.: ROH-BOT: an IoT wearable and inclusive health device for remote patient monitoring with different alarm systems. In: 2022 IEEE 7th Forum on Research and Technologies for Society and Industry Innovation (RTSI), pp. 68–73. IEEE (2022)
8. Ramachandran, V., Kanna, R.K., Geetha, S., Vasuki, R.: Automatic insulin analyser. *Indian J. Public Health Res. Develop.* **10**(11) (2019)
9. Ali, S., Parveen, S.: IoT-based smart healthcare monitoring system: a prototype approach. In: Rajakumar, G., Du, K.L., Vuppapalapati, C., Beligiannis, G.N. (eds.) *Intelligent Communication Technologies and Virtual Mobile Networks*. LNDECT, vol. 131. Springer, Singapore (2023). https://doi.org/10.1007/978-981-19-1844-5_34
10. Kasiselvanathan, M., Prasad, J., Sekar, G.: Arduino UNO controller and RTC-based medication reminder and monitoring system. In: Goyal, V., Gupta, M., Mirjalili, S., Trivedi, A. (eds.) *Proceedings of International Conference on Communication and Artificial Intelligence*. LNNS, vol. 435. Springer, Singapore (2022). https://doi.org/10.1007/978-981-19-0976-4_17
11. Geetha, S., Subhalakshmi, N., Kanna, R.K., Vasuki, R.: Automated implantable cardioverter-defibrillator. *Drug Invent. Today.* **11**(11) (2019)

12. Edwan, E., Altubji, M., Jedyan, A.A., Alghwiri, A.: Android-Arduino platform for detecting and monitoring obstructive sleep apnea (OSA). *J. Natl. Sci.* **24**(01), 24–39 (2022)
13. Visvesvaran, C., Karthikeyan, N.K., Kumar, I.J.B., Kaviya, P., Kaviya, S.: Advanced patient monitoring and alert system with auto medicine suggestion using machine learning. In: 2022 3rd International Conference on Electronics and Sustainable Communication Systems (ICESC), pp. 829–833. IEEE (2022)
14. Kanna, R.K., Banappagoudar, S.B., Helen Shaji, J.C., Kangeswari, P., Uma, V., Gupta, M.: Nursing assist module compact patient monitoring system using Iot application. *J. Pharmaceut. Negat. Results*, 236–239 (2022)
15. Varghese, A., Muthukumaraswamy, S.A.: An IoT-based health monitoring system for elderly patients. In: Bhateja, V., Mohanty, J.R., Flores Fuentes, W., Maharatna, K. (eds.) *Communication, Software and Networks. LNNS*, vol. 493. Springer, Singapore (2023). https://doi.org/10.1007/978-981-19-4990-6_29