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IOT Based Smart Portable Ventilator

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Abstract: Electrical ventilation, or assisted ventilation, is the medical term for artificial ventilation where Electrical Motor is used to assist or replace spontaneous breathing. This may involve a machine called a ventilator, or the breathing may be assisted manually by an Electrical Motor by compressing a bag valve mask device. Logically, for the realization of any project, engineering and architectures must be governed by current regulations. However, we must ask whether the parameters required by regulations are sufficient or not. From this point, this is where intelligent ventilation comes into play. It makes no sense, from a logical and economic point of view, to practice the same levels of ventilation, for example, in a gym at night when it is completely empty than during the day when users use their services.

Keywords: Internet of things, portable devices, Arduino uno, Microcontroller, raspberry, analogue to digital

Introduction

Respiratory diseases and disorders are a major public health problem in both developed and developing countries. There are two types of ventilation units. One of them simply mechanically pushes a volume of air into the lungs, regardless of whether the patient wants to push into his body. Most of these devices are based on the use of traditional bag valve mask. A BVM is a plastic bag that clinician can manually operate with their hands, providing an inexpensive and easy way to force air into the lungs. The second type is more advanced and are currently used to treat patients with Covid-19 and others because these ventilators are smart enough to be able to tell if the patient is trying to breathe or expel air and then help the patient achieve the desired action. Such a ventilator has many sensors that interact with the human body, and the air is deliberately and precisely supplied to the patient based on sensor data. For example, the Puritan Bennett 900 mechanical ventilator, a top-of-the-range high-performance ventilator, offers advanced timing tools that the clinician can use to customize the ventilator for each patient’s unique needs and provide adequate support throughout the breath. However, these devices have very complicated parts. A ventilator is a machine that provides mechanical ventilation by moving breathable air into and out of the lungs, to deliver breaths to a patient who is physically unable to breathe or breathing insufficiently.

Modern ventilators are awfully expensive. These ventilators are so expensive that for a country of 1.3 billion people there were only 47,000 ventilators. The few of the ventilators that are available are working overtime and are very susceptible to malfunction. Most of the government hospital have very low budget so they cannot be equipped with ventilator. They have a very high maintenance cost. These machines look very small but are very expensive. And if they are not maintained properly, they can be more of a death sentence than a life saver. This IOT based portable Ventilator is a concept to realize the advancement in health monitoring system of human beings due to the COVID-19 pandemic, the medical facilities have been scares and are required by a lot of people. As we all are aware of COVID-19 causes respiratory distress due to which patients face difficulty in breathing and because of which ventilators are used, which help them breath. This project describes a prospective solution of low cost ventilators with a wireless monitoring feature. The goals and advantages of the prospective solution are: - Fight COVID-19 in countries with poor healthcare systems - Provide low-cost and low-resource ventilation devices. Help hospital staff to monitor operational functionality and parameters of ventilators with affordable and reliable Internet of Things (IoT) technology - Support Patient Management via User Interface - Compensate lower reliability of low-cost ventilators by supporting human supervision - Reduce the need for medical staff by monitoring several ventilation devices at the same time - Save Personal Protection Equipment (PPE) such as masks by reducing patient contact.

Literature Survey

[1] The stepper motor used in the Ambu-Bag compression mechanism is connected to the MSP430 microprocessor, which serves as the device's brain. A 15 watt solar panel is used to charge a battery that is helpful in trucking camps, military installations, and rural areas. For the purpose of connecting to the internet and receiving real-time affected person requests from the cloud, the microcontroller and the Wi-Fi module communicate verbally in serial. The apparatus has [2] This work details the assessment and testing of a straightforward, inexpensive alternative ventilator that makes use of a cutting-edge pressure-sensing methodology and control algorithm. This is intended to provide low-cost, portable positive-pressure mechanical breathing while independently monitoring patient status and critical safety metrics. An anesthetic test-lung was used as a patient surrogate in the construction and evaluation of a prototype ventilator. We looked at compliance and resistance change detection, as well as ventilation pressure waveform circuit leak detection, using a digital pressure sensor and a

customizable test-lung. The prototype system demonstrated acceptable pressure waveform parameters during intermittent positive-pressure ventilation to the test lung: all simulated circuit leaks with a size of ≥ 6 mm2 were detected; compliance changes were noted between 10 ml.cmH2O−1, 20 ml.cmH2O−1, and 50 ml.cmH2O−1; and resistance changes were noted throughout the available simulated range. These findings demonstrate that this prototype system can offer safe emergency ventilation without requiring sophisticated digital sensors or software, and that substantial cost and complexity savings are possible due to its clever construction and design.

[3] A plastic air tank, two plastic or wooden circles (movable and stationary discs), a flexible wire, two check valves, a DC motor, and a support box (guide cylinder) are the components of this idea. The higher circle's center is where the motor is fixed. When the motor is in the ON state, it rotates the top circular in a single direction. The wire bends as a result of the motor's action. The bottom circle is drawn upward as a result, pressurizing the air within the tank. As a result, the check valve directs this compressed air into pipes. This condition is associated with the inspiration stage. When the motor is turned off, it is freed. The bottom circle then descends as a result of its own weight and the wire's tension being released, returning it to its starting position. The gadget will take air from the patient's lungs since the pressure in the lungs is greater than the pressure in the air tank. As a result, the expiry phase and the OFF state coincide. Breathing is induced by the ON/OFF state cycle. Alternatively, the flexible wire's return to its starting location. The battery may be recharged by using the engine as a dynamo to produce power. As a result, the initiative would be less dependent on outside funding.

[4] This study reports on the design and development of a mass casualty and resource-poor environment-friendly portable mechanical ventilator. By compressing a traditional bag-valve mask (BVM) with a rotating cam arm, the ventilator is able to administer breaths without the need for a human operator. The first version weighed 9 pounds (4.1 kg) and was constructed from acrylic. It measured 11.25 x 6.7 x 8 inches (285 x 170 x 200 mm). It has an electric motor that runs on a 14.8 V DC battery, and it can be adjusted to have a maximum tidal capacity of 750 ml. You may adjust the tidal volume and breaths per minute using easy-to-use input knobs. The prototype also has an alert to signal that the system is overpressurized and an assist-control mode. A controllab le inspiration to expiration time ratio, an LCD panel, a pressure relief valve, and PEEP capabilities are all planned for future revisions of the device. The ventilator is expected to cost less than $200 in mass manufacture, with a prototype cost of around $420.

[5] This study assessed the triggering, battery life, delivered tidal volume (VT) accuracy, delivered FIO2 accuracy, and gas consumption of four portable ventilators: Impact EMV, CareFusion LTV

1200, Newport HT70, and Hamilton T1. A microprocessor driven breathing simulator was used to evaluate triggering. It used muscle pressures of −2, −4, and −8 cm H2O, respectively, to replicate a mild, normal, and vigorous inspiratory effort. Accuracy of delivered VT and FIO2 was assessed in a variety of operations. The ventilators were connected to an E type oxygen cylinder and ran at a FIO2 of 1.0 until the tank was empty in order to measure gas consumption. Each ventilator was run at a FIO2 of 0.21 until the device shut off in order to assess the battery's endurance. There are still variations amongst the devices in a few areas of the testing procedure. The range of gas consumption was 9.2 to 16 L/min. The battery had a duration of 101 to 640 minutes. Using the quickest and slowest rise time options, the triggering performance varied throughout devices but remained constant breath to breath within the same device. With one device, the FIO2 accuracy ranged at the low end on the 50 mL VT setting and at the high end on both the 50 mL and 500 mL VT settings.

[6] The portable and small HP gas ventilator shown in this article combines all the gas supply and physiological monitoring features needed for high-resolution 3D hyperpolarized 129Xe imaging. Driven by low-cost microcontrollers with open source code, this ventilator is compatible with both MR and HP gases and enables fine control over the tidal volume and breathing cycle in perorally intubated mice and rats. We use the apparatus to exhibit data collection throughout many breath-holds, whereby lung movement is halted to provide fine-grained 3D visualization of both gas-phase and dissolved-phase 129Xe inside the lungs. We image a healthy rat at 7 Tesla and a lung cancer-prone mouse model longitudinally at 2 Tesla to highlight the ventilator's mobility and adaptability. We also report the observation of small spectroscopic changes overlaid on larger respiratory cycle-related variations, and in phase with the heart rate. The goal of developing this ventilator was to speed up preclinical 129Xe MRI research by facilitating duplication and gaining widespread acceptance.

[7] For respiratory failure, non-invasive positive pressure ventilation, or NIPPV, is a successful therapy. Patients who are acutely hypoxemic may potentially benefit from continuous positive pressure (CPAP). Extra oxygen is often required in both systems. On the other hand, it is uncertain what inspired oxygen fraction (FiO2) a portable ventilator delivers. This study's primary goals were to determine the highest FiO2 that these devices could produce and to examine the variables that influence FiO2. A BiPAP ST30 ventilator equipped with a nasal mask, expiratory port, and single-limb circuit was used to assess ten healthy participants. At the proximal and distal connection locations, 15 L/min of oxygen were given. Every participant performed a CPAP (10 cmH2O) and an NIPPV (inspiratory pressure 20 cmH2O [1.95 kPa]—expiratory pressure 8 cmH2O [0.78 kPa]).

[8] A portable gas-powered ventilator's performance was assessed twice. In order to replicate both healthy and sick lungs, the ventilator was evaluated at various compliance and airway resistance combinations using a mechanical lung model. The ventilator's effectiveness was then evaluated in twenty individuals who had been given anesthesia. When the ventilator was in airmix mode, the tidal volume it provided ranged from -20 to +30% of the predetermined tidal volume. The mechanical lung model's compliance and airway resistance were tuned to typical adult values. When the ventilator was configured to provide 100% oxygen, the corresponding number fell between -22 and -7% of the planned tidal volume. In the mechanical lung model, the ventilator's performance dropped as compliance or airway resistance rose; this impact was more pronounced in airmix mode. When the ventilator was used in airmix mode, the delivered tidal volume ranged from -19 to +12% of the current tidal volume in the group of anesthetized patients. The anesthetized patients' performance on the ventilator was within acceptable bounds, and it was dependable and easy to use. Nonetheless, the article advises that if a severely sick or anesthetized patient is transported using a portable ventilator, a method of confirming the ventilation's sufficiency should always be used.

[9] In order to address the shortage of respiratory ventilators for COVID-19 patients, a low-cost portable ventilator with performance analysis has been designed and examined in this work. Pneumatic piston, revolving disc, and DC motor are the components that make up the system. The patient's heartbeat is the system's input, and the amount of air that is delivered to their lungs at a customized breathing rate is the system's output. Depending on the patient's heart rate, this ventilator modifies the breathing rate. Full State Feedback H2 controllers and Proportional Integral Derivative (PID) have been used in the performance study of this system. A promising outcome was successfully assessed after the system and the suggested controllers were compared utilizing a step change and a random modification of the patient's heart rate.

Research Methodology

While the ventilators used in modern Indian hospitals are functionally and technologically advanced, their acquisition costs are the same (up to Rs. 5,00,00), expensive for use in resource-poor areas. In addition, these machines are often fragile and susceptible to continuous use, which requires expensive service contracts from the manufacture like sharing ventilators between hospitals and buying less reliable, refurbished units. As medical resources in this country is concentrated in the main urban centers, rural and peripheral areas are in some cases inaccessible. Hence, the need for an inexpensive portable ventilator is paramount. We are designing IOT Based Smart Portable Ventilator.

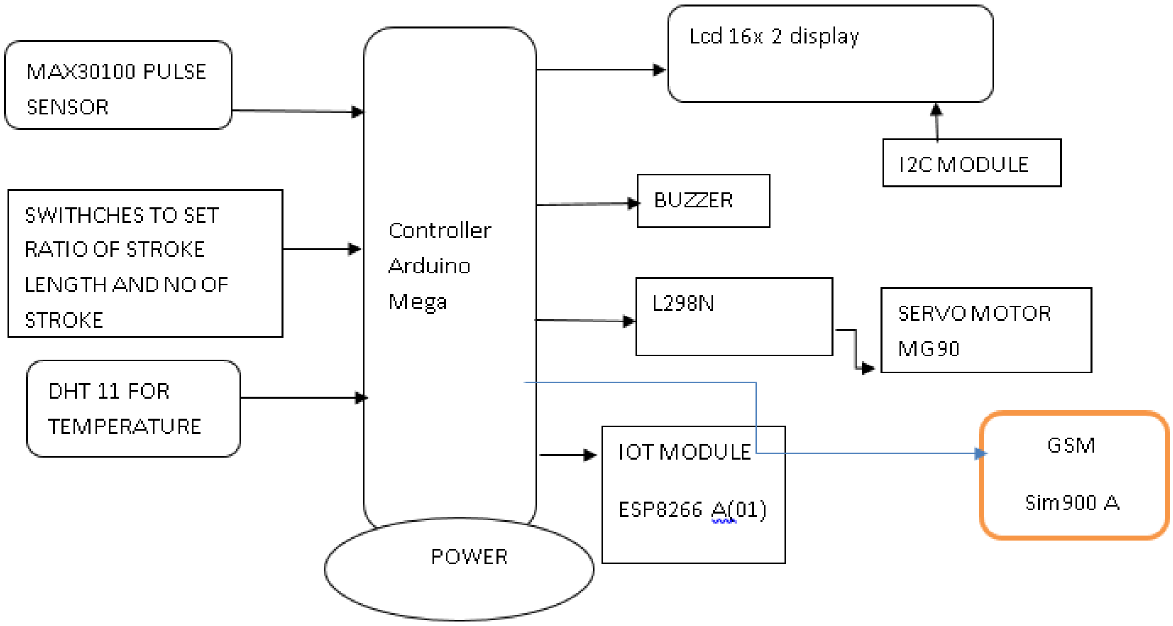

Figure 1 : proposed system architecture

The flow chart shows the process of IOT Based Smart Ventilator. The system works as follows:

- Sensors detects the pulse rate and temperature Firstly, sensors detect the pulse rate and temperature to determine health condition.
- Read values from all sensors Arduino uses analog to digital convertor to read the values from all sensors.
- Condition : If the readings of sensors are higher than threshold value then we conclude that health condition is not quite good.
- Values displayed on the LCD Values detected by the sensors will display on the LCD module.
- Alert message : As sensors value are

Conclusion

Thus a portable ventilator prototype is proposed and its development is explained in this project report. An Ambu bag is used here to produce the oxygen needed for the patient. An LCD display is produced along with a user- friendly knob, so that the operator can adjust the amount of BPM or Breaths-Per-Minute needed according to the patient's needs. To compress the Ambu bag, the Cam mechanism is followed here by converting rotary motion into linear motion and a lever compresses the bag according to the input from the ventilator's operator. In this report, a highly innovative ventilator design is proposed. The concept is still under development. Future iterations will include changes induced by the results of our prototype testing. It will incorporate an adjustable inspiratory /expiratory ratio that will be displayed on a LCD screen. Many cost-effective and precise sensors that interact with the human body and ensure that air is administered deliberately and accurately will also be added. Our goal is to provide a new and inexpensive solution. Finally, the ventilator must be tested on test lungs and various patient's respiratory tracts to compare its performance with conventional ventilators before the ventilator can be actually used on human bodies.

References

[1] Al Husseini, A. M., Lee, H. J., Negrete, J., Powelson, S., Servi, A. T., Slocum, A. H., & Saukkonen, J. (2010). Design and prototyping of a low-cost portable mechanical ventilator. Transactions of the ASME-W-Journal of Medical Devices, 4(2), 027514.

[2] Darwood, A., McCanny, J., Kwasnicki, R., Martin, B., & Jones, P. (2019). The design and evaluation of a novel low-cost portable ventilator. Anaesthesia, 74(11), 1406-1415.

[3] El Majid, B., El Hammoumi, A., Motahhir, S., Lebbadi, A., & El Ghzizal, A. (2020). Preliminary design of an innovative, simple, and easy-to-build portable ventilator for COVID-19 patients. Euro- Mediterranean journal for environmental integration, 5, 1-4.

[4] Kerechanin, C. W., Cytcgusm, P. N., Vincent, J. A., Smith, D. G., & Wenstrand, D. S. (2004). Development of field portable ventilator systems for domestic and military emergency medical response. John Hopkins Apl. Tech. Digest, 25(3).

[5] Charles, R. A. (1985). Coping with life on a portable ventilator. Home Healthcare Now, 3(2), 27-33.

[6] McCluskey, A., & Gwinnutt, C. L. (1995). Evaluation of the Pneupac Ventipac portable ventilator: comparison of performance in a mechanical lung and anaesthetized patients. British journal of anaesthesia, 75(5), 645-650.

[7] Holets, S. R., & Davies, J. D. (2016). Portable ventilators and their role in ambulance and transportation. Respiratory care, 61(6), 839- 853.

[8] Samolski, D., Antón, A., Güell, R., Sanz, F., Giner, J., & Casan, P. (2006). Inspired oxygen fraction achieved with a portable ventilator: determinant factors. Respiratory medicine, 100(9), 1608-1613.

[9] Virgincar, R. S., Dahlke, J., Robertson, S. H., Morand, N., Qi, Y., Degan, S., ... & Nouls, J. C. (2018). A portable ventilator with integrated physiologic monitoring for hyperpolarized 129Xe MRI in rodents. Journal of Magnetic Resonance, 295, 63-71.

[10] Revill, S. M., Singh, S. J., & Morgan, M. D. L. (2000). Randomized controlled trial of ambulatory oxygen and an ambulatory ventilator on endurance exercise in COPD. Respiratory medicine, 94(8), 778- 783.