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IoT Enabled Ventilator Monitoring System for Covid-19 Patients

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IoT Enabled Ventilator Monitoring System for Covid-19 Patients

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Abstract. The use of the IoT protocol on medical equipment is expected to provide protection for medical personnel in dealing with Covid-19 patients, especially when medical personnel are monitoring and setting up an equipment. This study aims to (1) produce a monitoring and control system for a breathing apparatus (Ventilator) based on the Internet of Thing (IoT), (2) test the ventilator control function, (3) test the data transmission function with the IoT protocol. The method used is Define, Design, Develop, and Disseminate (4D). Data collection is done through (1) Testing and Observation (2) Limited field test. This research produces a control and monitoring system for mechanical ventilators. The mechanical ventilator consists of a gripper motion mechanism driven by a dc motor. The movement of the gripper creates pressure and releases pressure on the ambu bag. The depth of pressure exerted by the gripper is measured as the volume and pressure of the air delivered to the lungs. The rate of pressure exerted is measured as the velocity of air flowing into the lungs.

Keywords: Ventilator, IoT, Covid19

1. Introduction

We currently face a disease pandemic that known as Coronavirus Disease 2019 (Covid 19). Covid 19 is transmitted through droplets and spread very quickly in humans. This virus attacks the human airways. If infected with this virus, a person will experience a high fever and difficulty breathing. One of the medical equipment that is needed to treat corona patients is a ventilator. A ventilator is a device used by medical personnel for patients who experience respiratory distress. The need for ventilators today is very high globally. This is because the number of corona patients has increased very sharply while the number of ventilators is very limited[1].

The ventilator serves to exhale gas (in this case oxygen) into the patient's lungs and helps strengthen the work of the respiratory muscles[2]. The working phase of the ventilator is shown in the Figure 1[3].



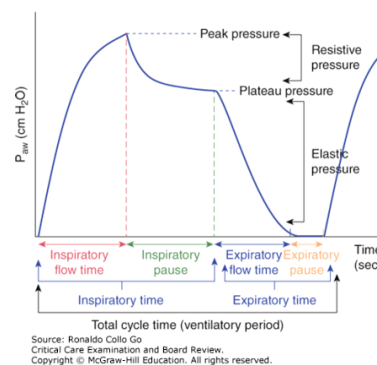


Figure 1. Expiratory and Inspiratory Phases of the Ventilator

The role of the ventilator is vital and is needed in the handling of covid19 patients. However, with a limited amount, not all patients can be treated using this equipment. As reported by several print or electronic media, transmission of covid19 virus is through droplets (small droplets) that come out of the patient's body and transmission can also be through the air. Covid19 transmission mechanism like this requires us to maintain a physical distance (physical distancing) of at least 1-2 meters when talking with others.

Medical staff (nurses, doctors and other health workers) are people who are at high risk of **contracting** this virus. This is caused by the frequency of interaction between medical personnel and patients that very high. To prevent and reduce the possibility of medical personnel contracting by the viruses from patients treated, medical personnel need to be equipped with Personal Protection Equipment (PPE). The use of PPE does not always guarantee that medical personnel are free from contracting this virus. This is evidenced by the high number of medical staff who died due to **contracting the covid19 virus**. Then, it is necessary to look for ways that can prevent medical personnel from contracting covid19. One of the ways is to reduce interaction and maintain distance between medical personnel and patients treated.

1.1. Medical Internet of Thing

Internet of Things (IoT) is a concept that aims to expand the function of the internet network. The functions and benefits of internet networks such as sharing data, remote control, and so on can connect objects in the real world, so that objects in the real world can communicate with each other. In general, the IoT architecture can be divided into three layers, the first is the application layer, the second is network layer and the third is the sensing layer. One form of application layer is service, which includes health service and emergency service.

IoT technology provides convenience features for remote control. The control network can use Bluetooth, WiFi, or the internet. With IoT technology, it is possible to implement a remote monitoring and control system. From the problems outlined above, this study aims to create an IoT-based ventilator monitoring and control system, which is expected to help prevent the transmission of the Covid19 virus and deal with Covi19 patients who have difficulty breathing.

One of the fastest-growing Internet of Things application is in medicine. Medical IoT (MIoT) is a term that refers to the application of IoT to medicine [4][5][2]. The rapid development of technology in the area of IoT has enabled for pervasive monitoring of health[6][7]. IoT has filled the gap in the integration of wearable sensors, mobile phones, smart devices and cloud platform so that remote monitoring of individual's health has been possible to perform [8][9][10].



Figure 2. An Architecture for Open IoT Services

As proof of how important MIoT is, during the pandemic of Coronavirus 2019 (Covid-19) in China, IoT application called nCapp has been proposed to be used by chinese experts for Covid-19 intelligence diagnosis, treatment assistant program and online monitoring system[11] According to the the consensus results, nCapp has obtained warm welcomed from specialists and even managers at all levels of hospitals, local community development corporations, and public health centers.

nCapp has helped diagnosis process of Covid-19 patients and classified the severity level into mild, moderate, severe and critical pneumonia. For patients with pneumonia who have respiratory failure and require mechanical ventilation, they are categorized critical pneumonia. Furthermore, the patients will be monitored online and the system will send an alarm to remind the medical staff to take corrective measures when the data exceed the normal value or emergency occurs. However, it is likely that the proposed system didn't considered to monitor the ventilator it self whereas it is important to make sure the ventilator working well and the setting is suitable with the patient condition.

1.2. An Alternative Ventilator Monitoring System .

The function of installing Ventilator equipment for patients is to improve oxygenation, help eliminate carbon dioxide, and help the respiratory muscles work.

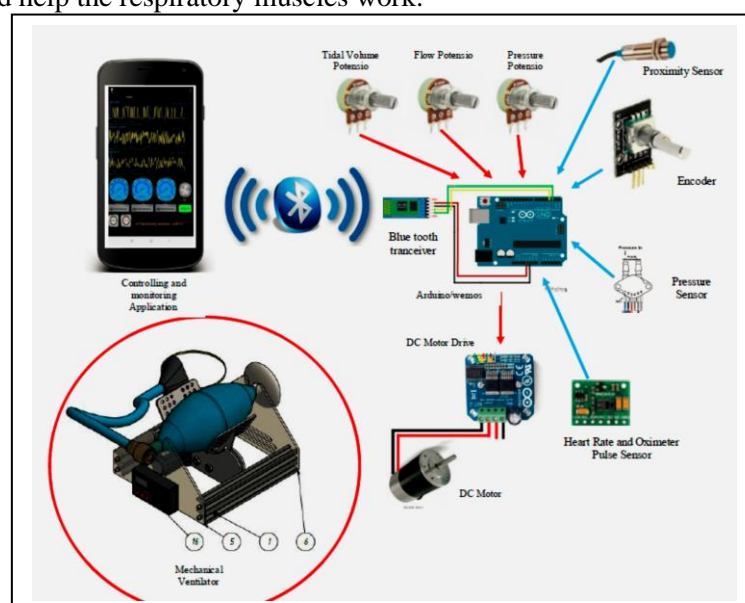


Figure 3. The Ventilator Monitoring System Component Diagram

The ventilator control system uses pwm controlling system, with the main control chip using the WEMOS LOLIN32 ESP32 chip. The use of the ESP32 chip aims to control IoT (Internet Of Thing)-based ventilators with bluetooth communication. So that in the process of monitoring and controlling the ventilator for COVID-19 patients, it will be possible to do it at a certain distance (Physical Distancing). In addition to the IoT-based monitoring and controlling function, the ventilator can also be adjusted with several control buttons provided near the system. The setting button consists of an inspiration button, an expiration button, and a pause button. Refer to the figure 3, some of the sensors used in this system are lung pressure sensor, blood oxygen levels sensor (oximeter), air flow sensor (flow sensor), current sensor, proximity sensor, and angular position sensor (encoder).

2. Method

The research was carried out in the Industrial Electronics laboratory, Faculty of Engineering, Yogyakarta State University. The object under study is the IoT Enabled Ventilator Monitoring System for Covid-19 Patients. A product that can be used by medical personnel or doctors to monitor patient data without having to approach the patient and the ventilator unit.

The research was conducted through 4 stages, starting from 1) Define, 2) Design, 3) Develop, and 4) Disseminate, as shown in Figure 4 below:

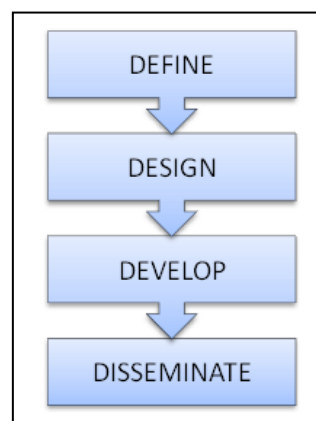


Figure 4. Research Method

The Define stage conducting needs analysis, and conducting literature study. Design Phase Designing ventilator hardware and software, determining programming algorithms, compiling programs, and conducting Simulations. Develop Phase validating the product by experts, product revision based on expert suggestions, conducting limited trials, and doing revision of test results products. at the Disseminate stage, implementation and product diffusion have been carried out. Result and Discussion.

The iot enabled ventilator monitoring system for covid-19 patients is a device to facilitate the transport of oxygen and carbon dioxide between the atmosphere and the alveoli for the purpose of improving lung gas exchange which can be monitored for measurement parameters via smart devices with a dedicated IoT network (Internet of Thing). for Covid-19 patients.

Medical staff need to be equipped with Personal Protective Equipment (PPE). So it is necessary to find ways that can prevent medical personnel from contracting COVID-19, one of which is to reduce interactions and maintain a distance between medical personnel and patients being treated.

IoT technology provides convenience features for remote control. In the implementation of the tool using bluetooth, with the consideration that monitoring and control devices do not need to have a very long distance, but enough distance is maintained between medical personnel and patients as a condition for meeting health protocols.

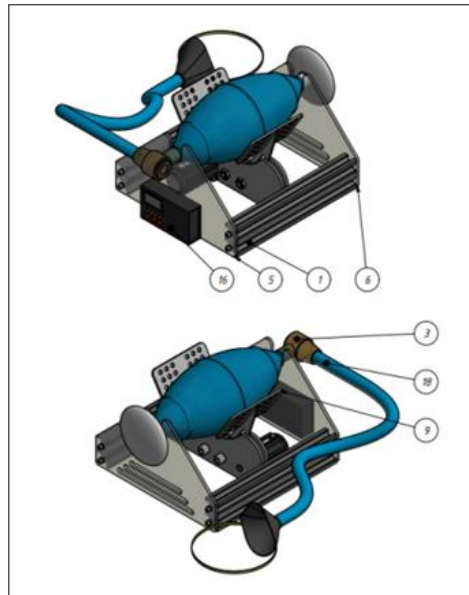


Figure 5. The Design of Mechanical Ventilator

The designed ventilator has several parts consisting of: mechanical hardware consisting of a gripper mechanism which is driven by a DC motor. The gripper functions to apply pressure to the ambu bag to provide inspiratory and expiratory pressure. The mechanical design uses a Gripper model that can apply pressure to an ambu bag.



Figure 6. Prototype of Ventilator Monitoring System

The prototype IoT Enabled Ventilator Monitoring System has been functionally tested at a lab scale. The motion function of the gripper ambu bag has worked as expected, the motion control system of the gripper is obtained from the DC motor control circuit. Speed control using PWM programmed on arduino/wemos esp32.

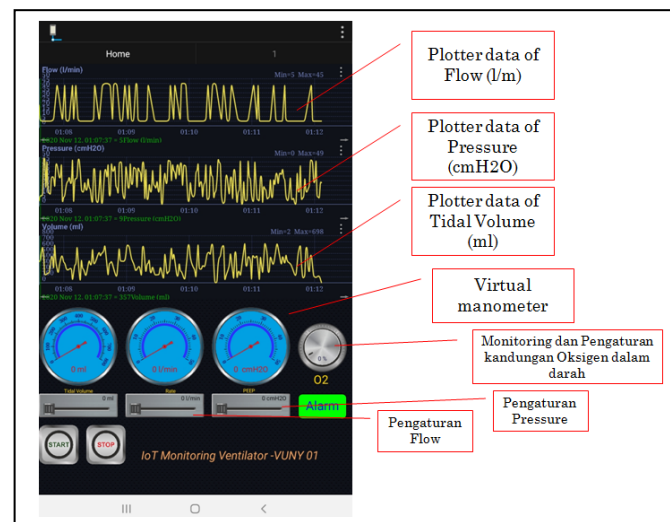


Figure 7. User Interface of Mechanical Ventilator Using Virtuino

At the application level this product uses Virtuino. Virtuino is an HMI platform for IoT servers, Arduino ESP and so on. Virtuino is installed on Android to monitor sensors or control the ventilator, with the aim of being the client side of the smartphone. The measurement parameters and ventilator settings are displayed on the smartphone screen. Besides that, monitoring and control are also provided on the hardware side of this ventilator device.

3. Conclusion

This research produces a control and monitoring system for a mechanical ventilator. The mechanical ventilator consists of a gripper motion mechanism driven by a dc motor. The motion of the gripper creates pressure and releases pressure on an ambu bag. The depth of pressure exerted by the gripper is measured as the volume and pressure of air delivered to the lungs. The rate of pressure exerted is measured as the velocity of air flowing into the lungs.

The control and monitoring system uses Arduino components as the main control. The bluetooth-based android application chosen is Virtuino, because it has a user-friendly interface and can work efficiently with Arduino to control and monitor variables on the ventilator via smart devices. Arduino is programmed to interact with the Virtuino application. The bluetooth module, alarm, air pressure sensor, blood oxygen level sensor (SpO2) and speed sensor will be connected directly to Arduino.

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