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IOT Based Ambulatory Bag Mechanical Ventilator

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Abstract: The IoT-based Ambu bag mechanical ventilator is a ventilator that automates the process of hand press mechanism using the rack and pinion mechanism. The circulatory motion of the rack is converted into linear motion which helps to press the Ambu bag. The proposed project works on three modes of operation that is child-adult and elder which is set wrt to the breaths per minute. There are two states of operation one normal state where the normal working is evidenced whereas the other operation mode is emergency where the buzzer is themed on in case of emergency. All the parameters are displayed on LCD and connected to the IoT cloud to communicate remotely in the end device
Keywords: Ambulatory Bag, IoT network, Rack and Pinion mechanism, Manual resuscitator, mechanical ventilators.

I. INTRODUCTION

The fact of scarcity of ventilators not only in remote places but also in cities has made a prominent impact due to the ongoing pandemic. A more makeshift version is a manual resuscitator like the Ambulatory Bag (AMBU bag) which consists of a Bag valve mask (BVM). This works when a healthcare worker manually presses the bag to force in the air to the patient who has difficulty in breathing. As manual pressing cannot happen for a long duration, a mechanical smart device is attached to this simple medical equipment to automate the process and to connect it to the internet to make monitoring and diagnosis easy and affordable. An ambulatory bag mechanical ventilator is proposed as a solution for this problem. In this paper, we will discuss a solution to this problem employing automation to a manual resuscitator and upgrading it into a mechanical ventilator

A ventilator is a device that provides ventilation by taking over the breathing functionality of a person who has difficulty breathing or is unable to breathe. Modern ventilators with complex architectures are generally used in a case of a serious condition. There are many ways and techniques present today due to exponential growth in the fields of both technology and medicine [1]. Modern ventilators are quite complex to work with and require professionals to work on them. The scarcity of ventilators had been in rural places mainly due to their remote locations. This issue got more serious when the ongoing pandemic took the severely infected, straight to the ventilators. As the numbers increased the scarcity began even in developed cities.[2] An immediate and quick solution was required for this problem. So, we considered a simple hand-operated Ambulatory bag, a manual resuscitator, and decided to automate the process thereby being an asset in both temporary solutions as well as resource management. The idea is to automate the randomly pressed ambulatory back at specific time intervals and long duration. Once the automation is done, then the system could be made into a smart device by connecting it to the internet to make it more useful and enable remote monitoring.

II. HISTORY

A. The advent of positive pressure ventilation

Positive pressure ventilation is a form of respiratory therapy that involves the delivery of air or a mixture of oxygen combined with other gases by positive pressure into the lungs. As gas enters the lungs, the interalveolar pressure increases until a change in flow or pressure are detected by the machine delivering the mixture, or the set volume of gas was delivered to signal the end of a breath. Expiration of air happens passively secondary to the build-up of pressure in the alveoli that escapes into the less pressurized conductive airways.[4]

This method was comparatively better than the already present negative pressure ventilation. In the late 19th century, ventilation was delivered using sub-atmospheric pressure delivered around the body of the patient to replace or augment the work being done by the respiratory muscles, and was known as negative pressure ventilation.[3]

Over the past few years, many technical aspects of ventilators have dramatically improved concerning flow delivery, exhalation valves, use of microprocessors, improved triggering, better flow delivery, and the development of new modes of ventilation [3].

III. RELATED STUDY

In this paper, we shall discuss the usage of the manual resuscitator and automate the process to convert it to a smart mechanical ventilator. A resuscitator is a device that follows positive pressure to inflate the lungs of an unconscious person who is not breathing, to keep them oxygenated and alive. There are three basic types:

A manual version (also known as a bag valve mask) consisting of a mask and a large hand-squeezed plastic bulb using ambient air, or with supplemental oxygen from a high-pressure tank.

The second type is the Expired Air or breath-powered resuscitator.

The third type is an oxygen-powered resuscitator. These are driven by pressurized gas delivered by a regulator and can either be automatic or manually controlled.

A mechanical ventilator is a machine that helps a patient breathe (ventilate) when they are having surgery or cannot breathe on their own due to a critical illness. The patient is connected to the ventilator with a hollow tube (artificial airway) that goes in their mouth and down into their main airway or trachea. They remain on the ventilator until they improve enough to breathe on their own.

A. Existing system

Define The existing system that we would improve on would be the simple BVM or the Ambulatory bag. In BVM ventilation, a self-inflating bag (resuscitator bag) is attached to a nonrebreathing valve and then to a face mask that conforms to the soft tissues of the face. The opposite end of the bag is attached to an oxygen source (100% oxygen) and usually a reservoir bag. The mask is manually held tightly against the face, and squeezing the bag ventilates the patient through the nose and mouth.[5].

Studies are done extensively in this area due to the extensive need and urgency of the situation. Although some products are under progress, clinical trials are worked upon until it is made available for use.

IV. DEVICE DESIGN

A. Automation of Handpressing

1) The concept of automation considered her involves a system of two gears namely Rack and Pinion.
2) A circular gear connected to a motor controlled by an H-bridge directed by a micro-controller (Arduino mega in our case).
3) The clockwise and Anticlockwise movement of the circular gear is converted into forwarding and backward motion. This motion is used for the automation part.
4) The control is given to the system either by manual input of knobs or by a secure IoT server.
5) A display is present in the dashboard of the system with knobs and switches for the operation.
6) The control of the pressing is given to the user as three modes of working which have fixed standard values of Tidal volume, Respiratory rate, and other parameters.

B. Internet of Things implementation.

The concept of the internet of things is used.[7] is a system of interrelated computing devices, machines, or objects with unique identifiers and the ability to communicate the data over a network or Internet without requiring human intervention. Internet of Things offers many applications today that help in making life easier. Making an IoT product is the act of connecting any physical object to the Internet or local network to collect and share data and performing some physical activity according to available data. Preparing the prototype is the first step in building an Internet of Things(IoT) product. An IoT prototype consists of the user interface, hardware devices including sensors, actuators and processors, backend software, and connectivity. A smartphone app or web frontend may work as a user interface. A sensor may measure a physical phenomenon and transform it into an electric signal. An actuator takes an electrical input and turns it into physical action. The processor unit of IoT systems is generally a microcontroller (MCU) which is responsible for processing data and run software stacks interfaced to a wireless device for connectivity. Through connectivity, the hardware is connected with the backend and the backend with the user interface. Backend software implements business logic and data storage. IoT microcontroller unit (MCU) or development board is a prototyping solution that features low-power processors which support various programming environments, collect sensor data using firmware and transfer it to a local or cloud-based server[7].

1) NodeMCU is used as the interface between the sensors and the sever.
2) NodeMCU has two modes of operation:
   a) Station mode, where the NodeMCU device joins an existing network.
   b) Access point (AP) mode, where it creates its network that others can join.

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Wireless access points are better for businesses because of their broad transmission range, high users access, and stronger signal sending and receiving capabilities. Wireless APs also have a better safety performance, which is essential for any business.
In Access Point(AP) mode, the NodeMCU acts as a router by itself. This makes it possible for high security compared to station mode. A server is set and the NodeMCU creates a website to display values.

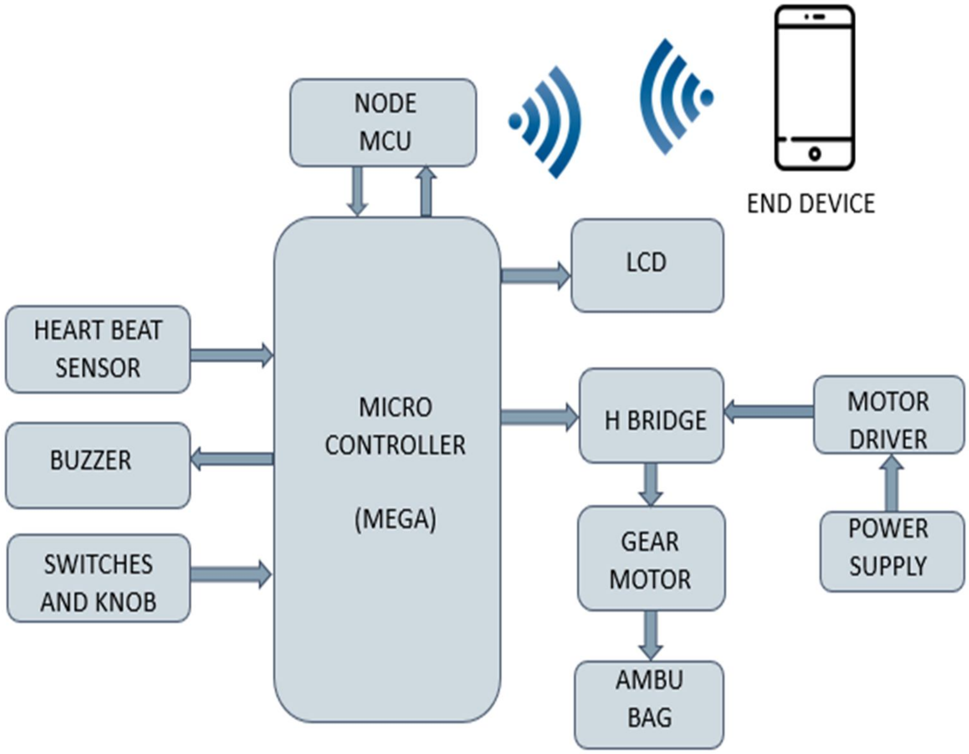

Fig. 1. Block Diagram of the proposed system.

This block diagram gives insight into the connections as well as interfacing of sensors. The directions included gives the direction flow of energy/data. Circuital connections are made according to this block diagram. As the diagram states, Arduino Mega acts as the brain of the entire system. The NodeMCU on the other is in charge of remote monitoring and control. Thereby properly distributing functions and maintaining accuracy and precision in real-time.

V. OPERATION

The dashboard consists of the LCD 20x4 display, potentiometer knobs, and switches.

A. LCD Display

The display shows the following parameters:
1) *Line1*:Name of the ventilator.
2) *Line2:Mode:* This consists of three modes of operation like Child, Adult, and elder mode.
3) *Line3:BPM:* Heart Beat Per Minute is displayed from measuring using the Thumb Heart Beat Sensor.
4) *Line4:Status*: Status is either Normal or changed to Help.

B. Input Methods

Input is given specifically on the device. It is advised to do so all the time as a healthcare person must be always around a person requiring the help of a ventilator. But the ability to control the internet is given to the person with access to both the name and the password of the ventilator NodeMCU. Although the control is limited to the person on the premises, it is done so help is always close by in case of any medical emergency. An emergency switch is also given to the patient to call for help. Apart from that, the main switch is present to stop the operation of the device completely.

C. Components Used

All the components sourced are off the shelf and easily available components. Thereby making the entire project cost-effective. Given below is the list of the components used.

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TABLE I. Table of components

Sl No	Components	
	Name of the Component	Quantity
1	Arduino Mega	1
2	NodeMCU	1
3	Ambu Bag and accessories	1 Set
4	DC Motor (12v 92.8 rpm)	1
5	Thumb heart beat Sensor	1
6	Gears	2
7	L298N : H-bridge Motor Driver	1
8	Potentiometer and knobs	2
9	Buzzer	1
10	Switch	2
11	Preassure transducer	1
12	A2D Converter Hx711	1
13	20x4 LCD Display	1
14	Power Supply 12v adapter	1
15	PCB, Breadboard, Wires and resistors	Misc
16	Acrylic Fabrication	Misc

VI. RESULT

The result of this implementation is a perfectly working model of an IoT-based ambulatory bag mechanical ventilator as shown in Fig 2. Three modes of operation with real-time sensor values are recorded in real-time.

The IoT system is user-friendly web widgets. The entire system is an overall efficient system that not only works in three standard modes with 12, 16, and 20 breaths per min, with beats per minute reading.

Apart from the on-device LCD, the web interface is made to facilitate the operation to be approved by a certified person for the usage of the ventilator as well as to abide by the rule that states that a healthcare worker must be present at all times near the patient in the ventilator. Remote monitoring is added mainly to serve this purpose.

This device not only connects the patient to the health care worker but also would help in managing the workforce. Therefore the IoT-based ambulatory bag mechanical ventilator would be the right solution.

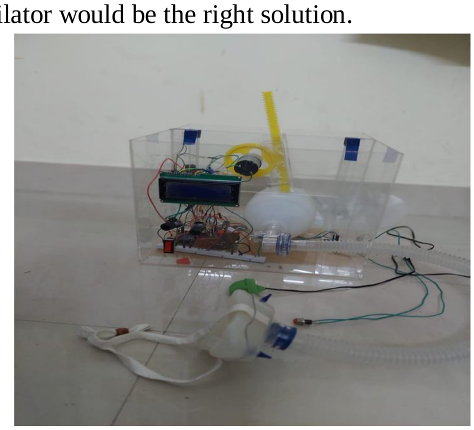

Fig. 2. Completed project image

VII. CONCLUSION

A specific path was taken after a complete survey and was experimented with. All the surveys conducted, and the experiment implemented assisted in obtaining the required result. The final product is an efficient IoT device.

The device overcomes the problem statement of required hand pressing operation for long durations, helps in remote monitoring and control to facilitate proper workforce management, the simple mechanism coupled with required components make the device accurate and reliable.

To conclude, this device tackles all the objectives thereby making a suitable to aid the health care worker by reducing contact as much as possible and also acts as a device of last resort in case of unavailability of a critical care mechanical ventilator. Although the objectives of this device are met, it is to be noted that, this cannot be a replacement for a complex mechanical ventilator but serves the purpose when the complex ventilator is unavailable and also for minor cases.

REFERENCES

[1] Abdul Mohsen Al Husseini, Heon Ju Lee, Justin Negrete, Stephen Powelson, Amelia Servi, Alexander Slocum, Jussi Saukkonen, "Design and Prototyping of a Low-cost Portable Mechanical Ventilator" Proceedings of the 2010 Design of Medical Devices Conference DMD2010 April 13-15, 2010, Minneapolis, MN, USA.

[2] Rajeev Chauhan, Raman Sharma, Nidhi Chauhan, "Automatic AMBU bag operating device: creating a boon for high volume centers in low-income countries "Article in BMJ Innovations · July 2020.

[3] Arthur S. Slutsky, "History of Mechanical Ventilation. From Vesalius to Ventilator-induced Lung Injury". Am J Respir Crit Care Med 2015 May 15;191(10):1106-15 DOI: 10.1164/rccm.201503-0421PP?

[4] Iordan Potchileev; Maksym Doroshenko; Asif N. Mohammed "Positive Pressure Ventilation". 2021, StatPearls Publishing LLC.

[5] Dorothy Habrat, DO, "How To Do Bag-Valve-Mask (BVM) Ventilation" Department of Emergency Medicine, University of New Mexico School of Medicine. Aug 2019.

[6] Cuno Pfister, "Getting Started with the Internet of Things: Connecting Sensors and Microcontrollers" Maker Media, Inc., 2011.

[7] A. Khoury, S. Hugonnot, J. Cossus, A. D. Luca, T. Desmettre, F. S. Sall and G. Capellini, "From Mouth-to-Mouth to Bag-Valve-Mask Ventilation: Evolution and Characteristics of Actual Devices— A Review of the Literature," BioMed Research International, vol. 2014, 27 May 2014.

[8] S. Fludger and A. Klein, "Portable Ventilators," Continuing Education in Anaesthesia, Critical Care & Pain, vol. 8, no. 6, pp. 199-203, 2008.

[9] M. Harrison, R. Muckel, C. Freeman, M. Revekant, D. Fenton, D. Zielinski, K. Kong, D. Engell and E. Welch, "PORTABLE EMERGENCY VENTILATOR," in Multidisciplinary Senior Design Conference, Rochester Institute of Technology, Rochester, New York, 2013.

[10] R. L. Vicenzi and T. R. Findlay, "portable lightweight completely self-contained emergency single patient-ventilator/resuscitator". USA Patent 4,905,688, 6 March 1990.

[11] C. Chopin, "L'histoire de la ventilation mecanique: des ´ machines et des hommes," Reanimation ´ , vol. 16, pp. 4–12, 2007.

[12] Bag Valve Mask (BVM). Firefighter Medic, http://www.firefightermedic.com/wiki/bag-valve-mask-bvm/. [11] A. C. F. De Godoy, R. J. Vieira, and R. J. Vieira Neto, "Oxygen outflow delivered by manually operated self-inflating resuscitation bags in patients breathing spontaneously," Jornal Brasileiro de Pneumologia, vol. 34, no. 4, pp. 212–216, 2008.

[13] B. J. Munford and K. J. Wishaw, "Critical incidents with nonrebreathing valves," Anaesthesia and Intensive Care, vol. 18, no. 4, pp. 560–574, 1990.

[14] P. M. Fenton and G. Bel, "The patient inflating valve in anesthesia and resuscitation breathing systems," Anaesthesia and Intensive Care, vol. 41, no. 2, pp. 163–174, 2013.

[15] S. Payne, R. Tully, and R. Eltringham, "A new valve for draw over anesthesia," Anaesthesia, vol. 65, no. 11, pp. 1080–1084, 2010.

[16] B. Al-Shaikh and S. Stacey, Essentials of Anaesthetic Equipment4: Essentials of Anaesthetic Equipment, Elsevier Health Sciences, 2013.

[17] D. K. Kim, Y. Y. Kim, J. S. Yi, H. S. Lim, and D. C. Kim, "The malfunction of self-inflating bag resuscitator due to misassembly—a case report," Korean Journal of Anesthesiology, vol. 55, pp. 731–735, 2008.

[18] C. Schmitt, "Possibilite de raccordement incorrect de certains ´ filtres respiratoires au segment expiratoire de la valve de non-reinhalation Ambu," ´ Annales Franc¸aises d'Anesthesie et de ´ Reanimation ´ , vol. 19, pp. 205–208, 2000.

[19] P. Tandon and G. H. Meakin, "Mis-assembly of Laerdal resuscitator valve," Anaesthesia, vol. 63, no. 3, pp. 324–325, 2008.

[20] T. P. Aufderheide, G. Sigurdsson, R. G. Pirrello, et al., "Hyperventilation-induced hypotension during cardiopulmonary resuscitation," Circulation, vol. 109, no. 16, pp. 1960–1965, 2004.

[21] Y. C. Cho, S. W. Cho, S. P. Chung, K. Yu, O. Y. Kwon, and S. W. Kim, "How can a single rescuer adequately deliver tidal volume with a manual resuscitator? An improved device for delivering regular tidal volume," Emergency Medicine Journal, vol. 28, no. 1, pp. 40–43, 2011.

[22] T. P. Aufderheide and K. G. Lurie, "Death by hyperventilation: a common and life-threatening problem during cardiopulmonary resuscitation," Critical Care Medicine, vol. 32, no. 9, supplement, pp. S345–S351, 2004