DESIGN AND IMPLEMENTATION OF AN AUTOMATED BAG VALVE MASK-BASED RESUSCITATOR

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Outline

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Introduction and Background

Fig. 1. Manual BVM resuscitation

- In Uganda, oxygen is supplied by oxygen cylinders, oxygen concentrators, and oxygen generators/plants. There are currently 17 medical oxygen plants[1]
- Bag Valve Masks (BVM) have been utilized as emergency manual ventilators in which the bags are pressed to deliver oxygen to patients.
- Research work has been done to automate the process of using BVMs for resuscitation, but still, with areas to improve.

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Problem Statement

The current reliance on manual operation of Bag Valve Mask(BVM) Resuscitators pose challenges in providing continuous and reliable ventilation to patients. The limited number of physicians further strains the manual usability of the BVM bags as they require continuous pressing to reliably deliver oxygen to patients. Human error, fatigue, inconsistency, and the need for uninterrupted care highlight the necessity for an automated system that can perform this life-saving task with a high degree of reliability and precision.

Justification

- In the Ministry of Health's Report on National Scale-up of Medical Oxygen Implementation Plan 2018-2022, Hypoxemia occurs in 20% of Neonates, 6% of children under 15 years, and 9% of adults admitted to hospitals in Sub-Saharan Africa.[1]
- In the assessment of the preparedness of the Ugandan healthcare system to tackle more COVID-19 cases, it was found that the doctor-patient and nurse-patient ratio is approximately 1:25000 and 1:11000 respectively.[2].
- Manikin-based studies for the evaluation of ventilation performance showed that all professionals tend to cause hyperventilation.[3]

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Objectives

Main Objective

To design and implement an automated bag valve mask (BVM)-based resuscitator.

Specific Objectives

1. To design and implement a mechanical unit responsible for the delivery of oxygen to the patient.
2. To implement a mechanism of synchronizing the pressing of the BVM with the breathing patterns of the patient.
3. To implement an electronic control circuitry.
4. To implement a wearable sensor to track the patient's oxygen levels.

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Methodology

Objective 1	▶ Make a 3-D design using SOLID WORKS. ▶ Integrate the parts, that is, a wiper motor, motor support, pressing arms, timing wheel, and BVM.
Objective 2	▶ Implement a contact switch that consists of fine wires, one of which is attached to the diaphragm. The diaphragm pushes the wire to close the switch as the patient attempts to breathe.

Methodology (cont'd)

Objective 3	▶ Design the schematics of the electronic control circuitry and user interface using Proteus software. ▶ Implement a PCB, integrate power supply, AC and DC ports, and ATmega328P.
Objective 4	▶ Design and print the oxygen sensor casing. ▶ Implement a physical port where to connect and disconnect the sensor.

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Scope

- The project does not involve the design or production of medical oxygen itself but focuses on the automated delivery system.
- The project work is not to serve as a substitute for the conventional high-end ventilators, but, as an emergency-based resuscitator to use in low-resource settings.
- It is to be used in various medical environments such as hospitals, ambulances, and disaster response units.

Expected Results

- At the end of the project, the system should mimic how trained medical personnel would manually press the BVM resuscitator.
- Deliver a regulated amount of clean oxygen at specific rates for different age groups.
- Regulate the pressures of the inhaled air to recommended levels.

Timeline

Fig. 2 shows how the tasks of the project will be done throughout the schedule.

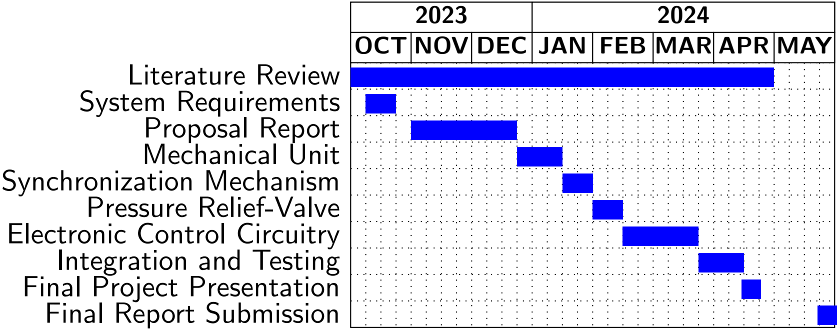

Fig. 2. Ghantt chart for project activities

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Budget

TABLE 1 PROPOSED BUDGET

Item	Quantity	Unit Cost	Total Cost
BVM	1	90000	90000
Wiper Motor	1	50000	50000
LCD screen	1	35000	35000
Acrylic sheet	1	140,000	212,000
ATmeg328P	1	16000	16000
12V, 10A adaptor	1	60000	60000
Laser Cutting			50000
MAX30100 Pulse Oximeter	1	10000	10000
Miscellaneous			100000
Grand Total			**UGX 623,000**

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References

[1] Ministry of Health, "National Scale-up of Medical Oxygen Implementation Plan 2018-2022" Jan. 12, 2023 [Online] Available: http://library.health.go.ug/sites/default/files/resources/MOH%20National%20Oxygen%20Scale%20up% 20Plan% 206% 20 April %202019.pdf

[2] E. E. Ajari and D. Ojilong, "Assessment of the preparedness of the Ugandan health care system to tackle more COVID-19 cases," *Journal of Global Health*, vol. 10, no. 2, pp. 020305, 2020. doi: 10.7189/jogh.10.020305

[3] F. S. Khoury, F. Sall, A. De Luca, A. Pugin, S. Pili-Floury, L. Pazart, and G. Capellier, "Evaluation of Bag-Valve-Mask Ventilation in Manikin Studies: What Are the Current Limitations?," BioMed Research International, vol. 2016, pp. 4521767-4521774, 2016. [Online]. Available: https://doi.org/10.1155/2016/4521767

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