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IOT-based Hospital Bed

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Abstract

In this era of globalisation, smart devices have slowly overcome the traditional version of devices where everything is just on the tip of our fingers. The proposed IoT-based hospital bed aims to bring more convenience to the patients and also the guardians. ESP32 microcontroller is used to connect to the handset through Wi-Fi and then control the bed using a handset. ESP32 will trigger the relays to send the signal to each movement when the handset button is pressed. It allows the patients to control the height of the whole bed as well as the adjacent angle of the head and leg over a handset; the bed can also be controlled by using the default wired remote controller. Both methods can be used simultaneously. By using Blynk, the bed can be controlled in multiple movements at the same time, which is better than the default remote controller. Blynk. Besides that, an emergency call button is provided at the interface of Blynk in the handset, where the patient can seek a guardian's help simply by pressing it. An e-mail will be sent to that guardian when the button is pressed. The bed is then tested, and it is verified that it can be operated as expected using the handset.

1. Introduction

The hospital bed is an imperative medical instrument in that the bed's position can be conveniently adjusted by the patient using the controller connected to the bed itself. It is a piece of medical gear carefully selected to fit the patient's unique demands for optimum comfort and healing [1].

Nowadays, hospital beds are not only used in hospitals or as healthcare facilities but are also commonly used in home care settings [2]. Homecare hospital beds have proven particularly beneficial for elderly patients with impaired mobility. The ongoing COVID-19 pandemic has disrupted traditional healthcare methods and prompted the adoption of IoT technologies to enhance safety and improve care delivery [3]. The Internet of Things (IoT) has revolutionised various industries, including healthcare. The Internet of Things (IoT) has revolutionised various industries, including healthcare. IoT refers to a vast and massive network of interconnected things or devices and people that collect and share data about their usage and the surrounding environment [4]. In the context of hospital beds, the IoT system typically consists of sensors or wearable sensors that collect data [5], which is then transmitted wirelessly to a mobile application. To ensure the efficiency of the transmission, a wireless network connection of 4G or higher is typically required.

2. Literature Review

Innovative eye-controlled technology for a distinct hospital bed is discussed in the article [6]. The control mechanism, interpreting user eye movements, specifically winking, utilises an affordable web camera with an

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infrared filter. Infrared pupil images are captured and processed through LabVIEW VI and Arduino 2560, allowing intuitive bed control via a graphical user interface. The compact homemade hospital bed model, measuring 45cm in length, 20cm in width, and 13cm in height, aims to empower bedridden patients to adjust positions effortlessly through eye movements, enhancing future comfort and autonomy in healthcare settings.

The creation of a Next Generation Medical Care Bed [7] was undertaken with a focus on cost reduction and healthcare services for patients, particularly the elderly and those with special needs. Objectives encompassed weight capacity analysis, high-quality component selection, and the incorporation of voice-activated controls. The bed's mechanics, including height, head, foot, and temperature adjustments, are controlled through buttons, voice commands, and mobile applications. Embedded sensors monitor patient health, and the hardware utilised Arduino UNO, EasyVR Shield 2.0, sensors, and relays, with voice commands executed through the EasyVR 2.0 module.

3. Methodology

This chapter explains the methodology used in this project in detail to give a better overview of the whole project. The general system flow of ESP32 board implementation and the IoT-based hospital bed architecture are presented. The project is done with the following objectives.

1. To develop a wireless-controlled IoT-based Hospital Bed for several movements using a handset.
2. To provide an emergency button that can call for help from a guardian using the handset.
3. To verify the IoT-based hospital bed in terms of its functionality.

3.1 Block Diagram

Once the power is on or the battery supply is at optimum, the ESP32 will connect with the handset through Wi-Fi, enabling it to seamlessly connect to a local network hotspot and communicate or be controlled between ESP32 and the mobile application, Blynk. Furthermore, the mobile Blynk also provides control functionality. The user can send control signals or commands through Blynk, which are then transmitted to the ESP32 via the Wi-Fi connection hotspot from the local network. These signals or commands can be used to actuate the actuator nodes of the bed responsible for raising and lowering the bed to different positions. The actuators will be in the head section, foot section, and the stent of a hospital bed, in which there will be eight types of positions.

In addition, notifications or alerts can be sent by Blynk to another mobile handset through the Wi-Fi network when the emergency button is pressed. This notification can include an update on the user's status, such as the user or patient-facing problems or difficulties. Besides, it allows the medical officer or guardian to be informed about the patient's needs and issues while alone, allowing the connection between the patient and the caregiver or guardian [8]. The notification will be sent as an e-mail to the medical officers and guardians, which has been registered on the user's handset. Fig.1 shows the block diagram of this project.

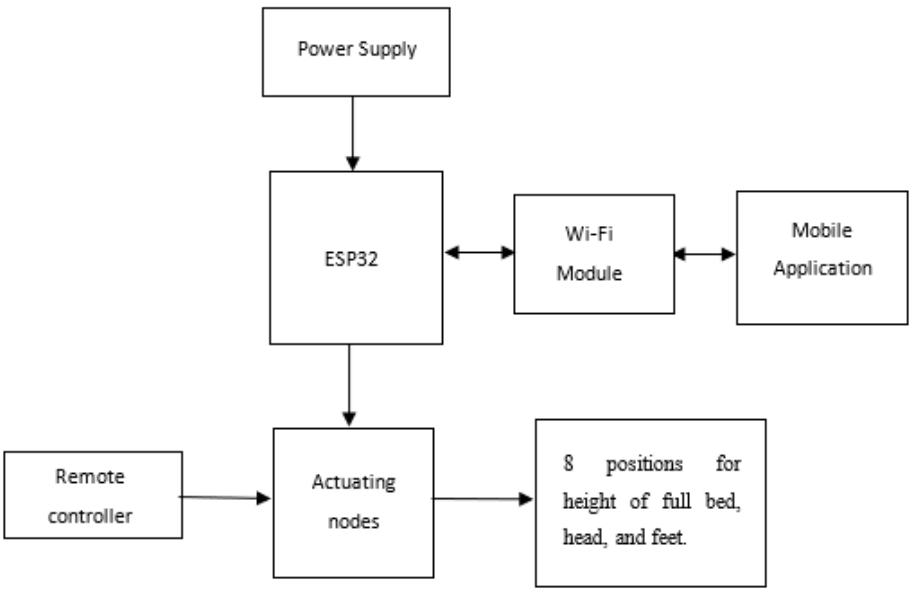
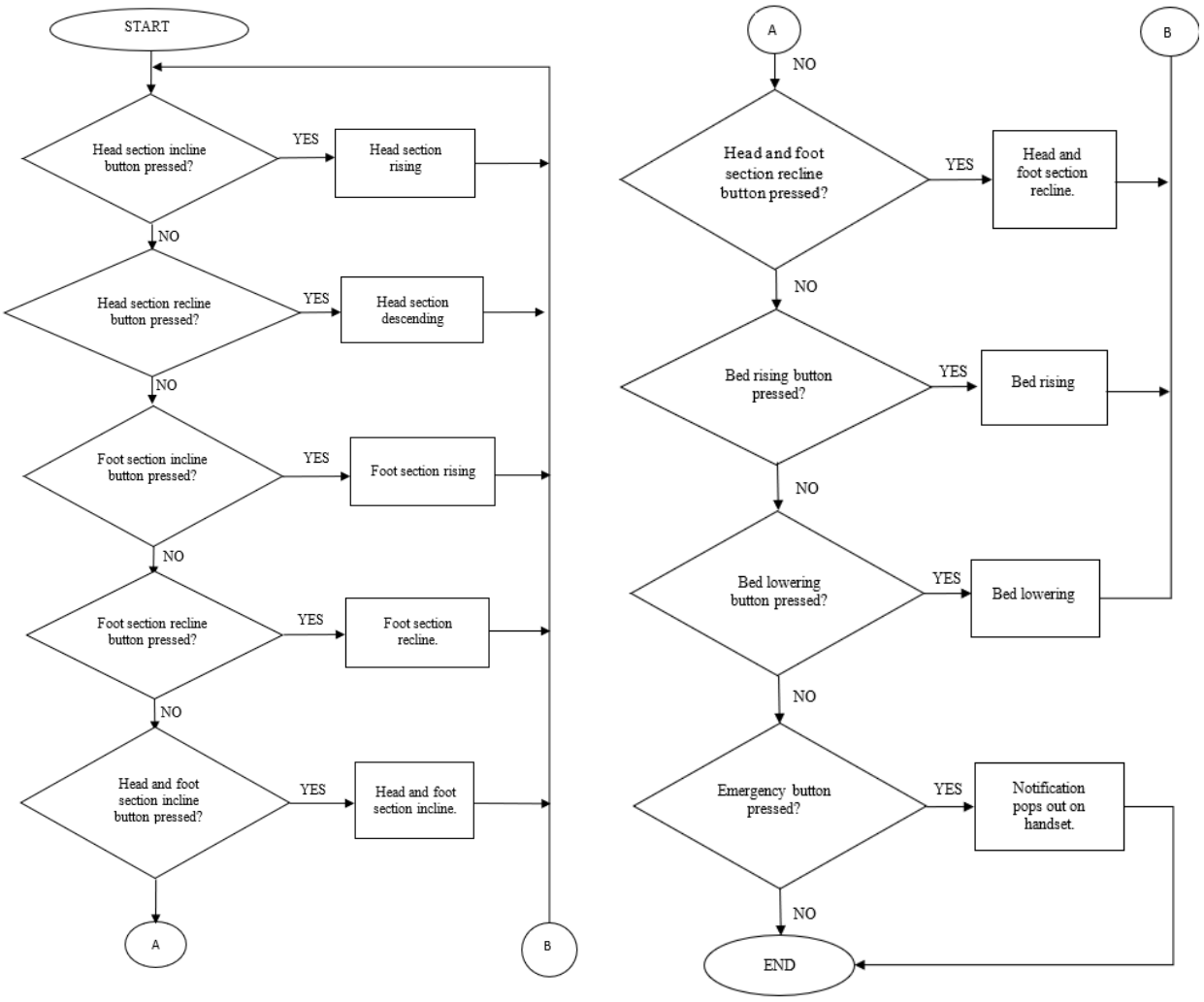


Fig. 1 *Block diagram of the system of IoT-based hospital bed.*

3.2 Flow Chart

There are a total of nine buttons displayed, encompassing functions such as head section rising, head section descending, foot section rising, foot section descending, simultaneous incline of head and foot sections, simultaneous recline of head and foot sections, full bed incline, full bed recline, and an emergency call button.

Upon pressing any of these buttons, the relay in the microcontroller is triggered to transmit a signal to the hospital bed, activating the respective actuator or motor for position adjustment. Continuous triggering of the relay by the ESP32 board occurs if the corresponding button remains in an active high state. The system halts only when the button is returned to its active low state or toggled. The ESP32 board remains on standby, ready to receive interruptions from the emergency call button on Blynk. Upon pressing this button, Blynk sends a notification via e-mail to the caregiver or guardian, alerting them that the patient requires assistance. The project's flow chart is depicted in Fig. 2.



(a) **(b)**

Fig. 2 *General IoT-based hospital bed flow (a) upper part; (b) bottom part.*

3.3 Entire System Architecture

The hospital bed is equipped with a remote control connected to the bed's control box. The remote-control cable is severed in half, and each side is affixed to a female-male 8-pin connector, as illustrated in Fig. 3(a). The female side of the connector is connected to both the bed and the controller system of this project, while the male connector is linked to the remote control.

The commons are connected to the ground, and each output is associated with specific function wires from the remote control. Specifically, relay one is connected to the head-up signal, 2 to the head-down signal, 3 to the

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leg-up signal, 4 to the leg-down signal, 7 to the full bed-up signal, and 8 to the full bed-down signal. Relays 5 and 6 are connected to two diodes, one for the lifting action of the head and leg and the other for the lowering action, as evident in Fig. 3(b).

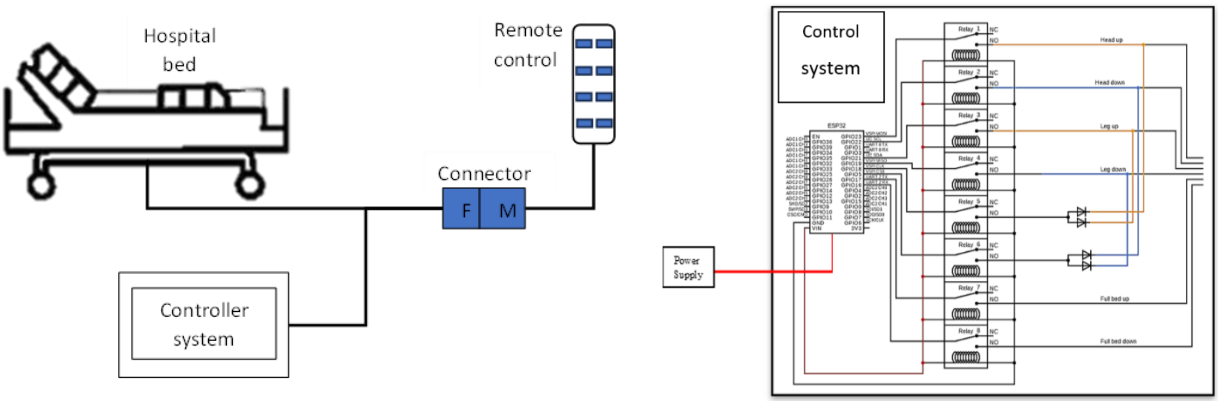


Fig. 3 *(a) General diagram of the system; (b) Schematic diagram of the control system.*

4. Results

This chapter discusses the results obtained after modifying the hospital bed's remote controller and verifying the wireless control function over the handset.

4.1 Control System

The Blynk mobile interface, illustrated in Fig. 4(a), provides a comprehensive control system featuring eight buttons for seamless on and off functionality and a dedicated emergency notification button. In Fig. 4(b), the finalised control system incorporates a backup supply battery that can be recharged when it runs low.

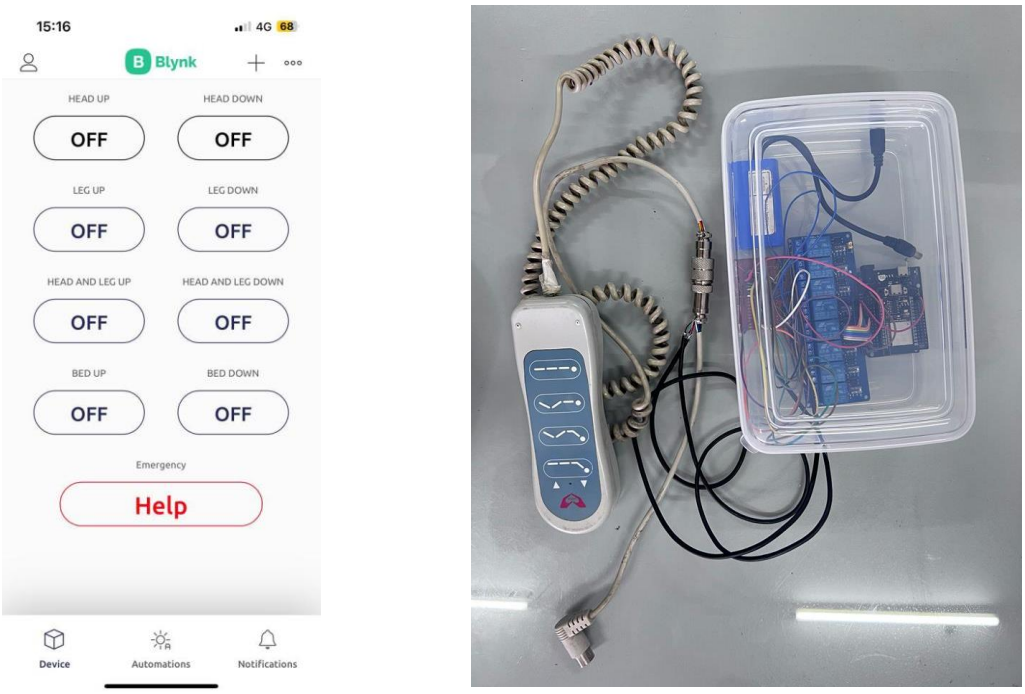
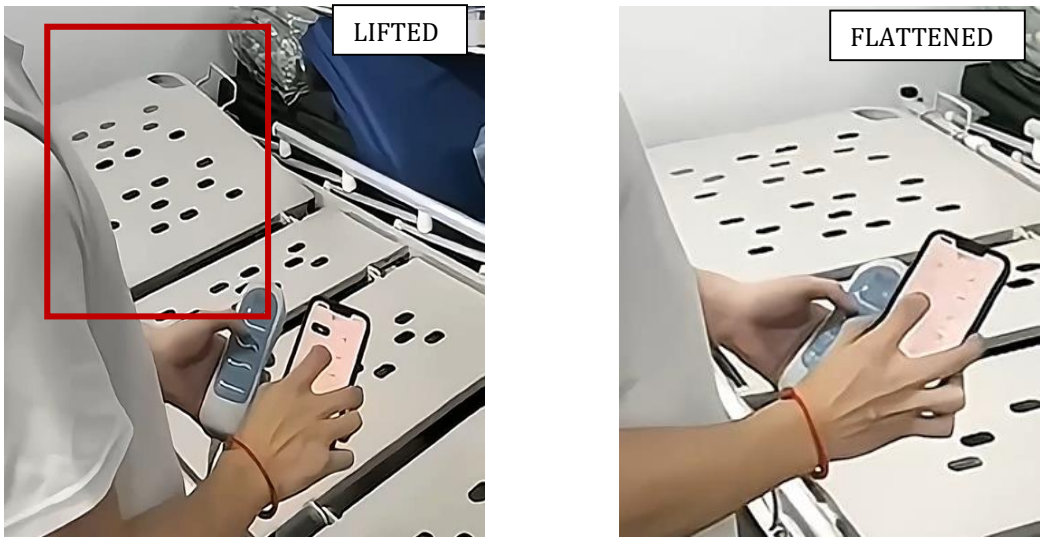


Fig. 4 *(a) Blynk interface on the handset; (b) Control system with remote controller.*

4.2 Functional Verification

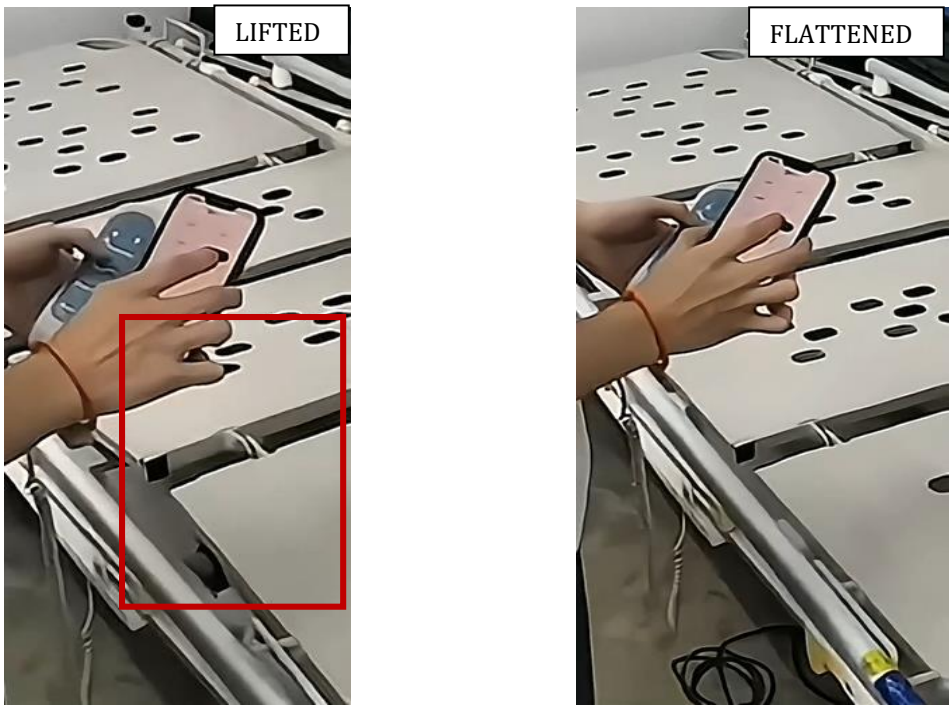
The buttons on Blynk are set in switch mode, ensuring that each button remains pressed even after the finger is released. The relays are triggered by the ESP32 microcontroller in response to the pressing of the corresponding button, facilitating the necessary movements. Fig. 5 demonstrates the upward and downward adjustments of the head section when the head-up or head-down button on the phone is pressed.



(a) **(b)**

Fig. 5 *(a) Head up; (b) Head down.*

Similarly, Fig. 6 exhibits the lifting and lowering of the leg section when one of the leg-up or leg-down buttons on the phone is pressed.



(a) **(b)**

Fig. 6 *(a) Leg up (a); (b) Leg down.*

Pressing both the head and leg up buttons concurrently will elevate both sections, while the head and leg down buttons lower them, as depicted in Fig. 7.

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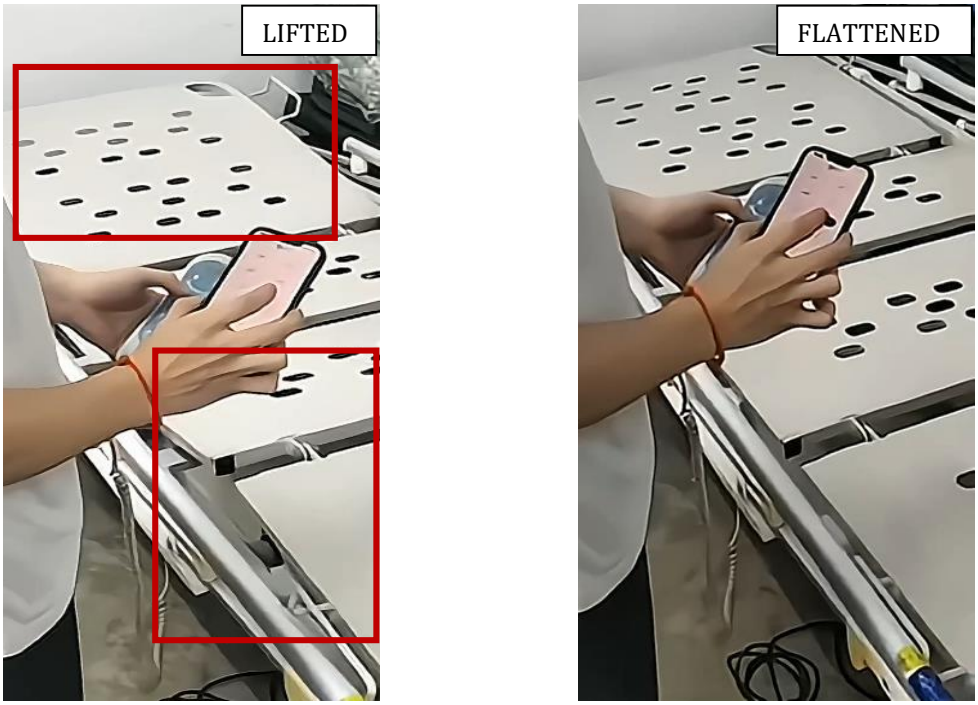


Fig. 7 *(a) Head and leg up; (b) Head and leg down.*

Additionally, the entire bed-up button raises the bed to a specific height, and the entire bed-down button lowers it, as shown in Fig. 8.

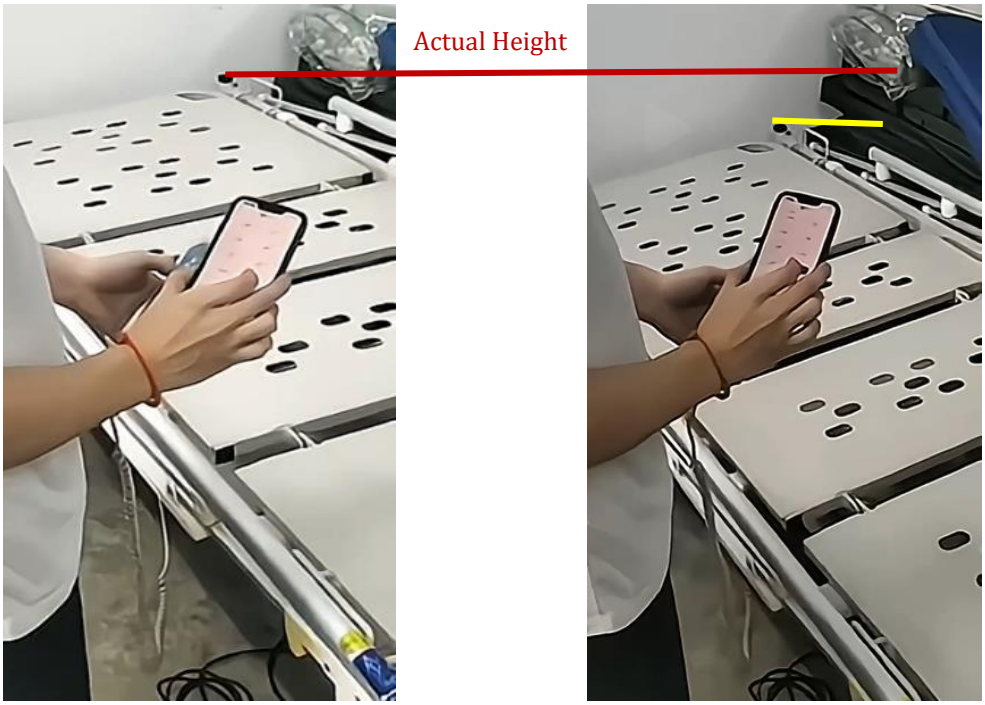
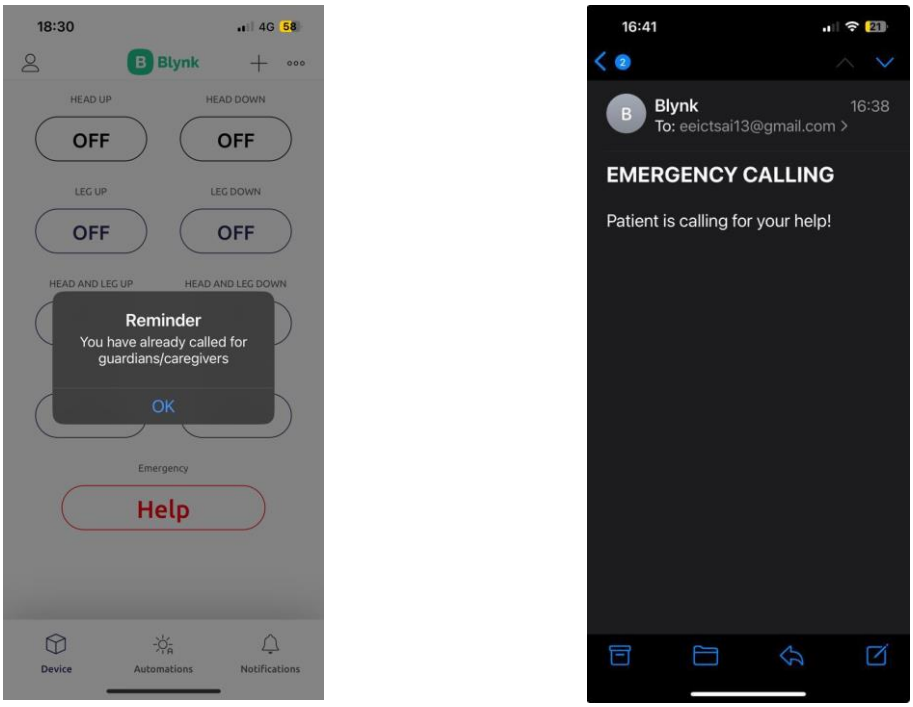


Fig. 8 *(a) Full bed up; (b) Full bed down.*

Furthermore, Blynk on the phone provides a call function, allowing patients to press the call button to request assistance from their guardian or caregiver. A notification will appear on the phone, indicating that the patient has sought help, and an e-mail alert will be sent to the guardian or caregiver, as shown in Fig. 9.



(a) **(b)**

Fig. 9 *(a) After pressing the help button; (b) Email notification received.*

The IoT-based hospital bed is completed and is further verified and tested to where it can really perform the movement on the height of the whole bed, head, and leg section of the bed, as well as the notification provided to seek help from the guardian or caregiver.

5. Conclusion

The aim of the project was to create a hospital bed based on IoT technology. The bed is equipped with an emergency call button that can notify the caregiver in case of an emergency. Additionally, the bed has been innovated to allow for eight up and down movements, which can be controlled via a handset. A Blynk interface is also provided on the handset, which includes an emergency help button. Patients or users can press this button to call for help from their guardian or caregiver when they need assistance. Blynk will send an e-mail to the targeted person when the button is pressed. Furthermore, the bed is verified where it can perform adjustments on the height of the entire bed, head and leg based on the user's desire, and the emergency help button will send an e-mail to the person targeted.

Recommendation for future work in the project involved enhancing the Blynk application on the IOS handset. Instead of sending e-mail notifications to the desired person, IOS Blynk should have the same features as Android Blynk, which can send pop-up notifications to the shared Blynk user. This would significantly improve the chance of being noticed by the guardian or caregiver. Moreover, ESP32 can also be connected over WI-FI rather than connecting to the mobile hotspot. Mobile hotspots rely more on Internet coverage in the area; thus, they will provide a better experience for the user.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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