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Advancing Patient Care: The Innovative Design Of Automatic Height-Adjustable Stretchers For Seamless Patient Transfer

Dr. Yuvaraj Velusamy[1*], Ezhilnithi T[2] , Meiyyazhagan J[3], Nitheesh P[4], Prem T[5]

[1*,2,3,4,5]*Associate Professor, Ug Scholar Be-Biomedical Engineering Vsb Engineering College, Karur, Tamilnadu, India*

***Corresponding Author:** Dr.Yuvaraj Velusamy*
**Associate Professor Ug Scholar Be-Biomedical Engineering Vsb Engineering College, Karur, Tamilnadu, India*

ABSTRACT
As per the current scenario, hospitals and healthcare centers are becoming more crowded and require more healthcare professionals. As the demands for manpower increase, the number of workers also increases. As part of our project, we are considering the transfer of patients from bed to stretcher and vice versa, as well as across wards for clinical procedures such as medical imaging, treatment concerns, and shifting to the operating theater. Patients may be affected or disturbed by these procedures or actions, which can make things more complicated. The stretcher's height will vary depending on whether it is in a ward or an operating room, depending on its location. In this project, we have designed an automatic sensor-based height adjustment stretcher. The sensors in the stretcher will recognize the height of the bed near them and adjust themselves accordingly to the bed's height. In this project, we have reviewed existing techniques such as rail-based moving or hover-based moving systems to improve patient transfer. We can use this automatic height-adjusting application not only in hospital beds but also in beds of CT and MRI machines and ambulances to hospitals, and vice versa. Furthermore, the height-adjusting stretcher, guided by automatic sensors, is designed to elevate the effectiveness of healthcare services by diminishing the need for manual labor in patient transfers. It promises a hassle-free and comforting encounter for both healthcare providers and their patients.

1. INTRODUCTION

Hospital beds used by healthcare professionals are operated manually in most cases, which requires some physical effort. In the last few decades, it is mainly focused on minimizing risks caused by among other mistakes and indisposition of the medical personnel occurring during the transport of patients in life-threatening conditions. Solutions include automation of bed movement by means of motorized devices, for both functional and transport purposes.
In addition, it concerns devices that will allow the transfer of a patient from one bed to another or from a bed to a wheelchair, devices providing periodic automatic change of a lying patient's position to prevent the emergence of bedsores, and advanced automated wheelchairs. The technical development of these kinds of devices and their application in the hospital environment are facing many difficulties and limitations. This

work presents a design solution for the hospital bed height adjustment mechanism developed within the objectives related to the requirements set for one of the hospitals.

A hospital bed specially designed for patients or others in need of some form of health care. These beds have special features both for the comfort and well-being of patient and for the convenience of health care workers. Common features include adjustable height for the entire bed, the head and the feet, adjustable side rails and electronic buttons to operate both the bed and nearby devices. While designing hospital beds the most important parameter is safety of patient.
The modern features of hospital beds are as follows: - wheels enables easy movement of the bed, either within parts of the facility in which they are located or within the room. Sometimes movement of the bed a few inches too few feet may be necessary in-patient care. Wheels are lockable, for safety wheels can be locked when transferring the patient in or out of the bed. Beds can be raised or lowered at the head, feet and the entire height. While on older beds this is done with cranks usually found at the foot of the bed, on modern beds this feature is electronic. Raising automatic level track and height adjustable stretcher.
The head (known as fowler's position) can provide some benefits to the patient, staff or both. The fowler's position is used for sitting the patient upright foe feeding or certain other activities or in some patients can ease breathing. Raising and lowering the height of the bed can help bring the bed to a comfortable level for the patient to get on and out of bed. Beds have a side rail that can be raised or lowered. These rails which serve as protection for the patient and sometimes can make the patient feel more secure can also include the buttons used for their operation by staff and patients to move the bed.
There are varieties of different types of side rails to serve different purposes. While some are simply to prevent patients fall, others have equipment that can aid the patient themselves without physically confining then patient to bed. Some advanced beds are equipped with columns which help tilt the bed tom 15-30degees on each side. Such tilting can help prevent pressure ulcers for the patient and help caregivers to do their daily tasks with less of a risk of back injuries. Many modern hospital beds can feature a bed exit alarm whereby a pressure pad on or in the mattress arms an audible alert when a weight such as a patient is placed on it, activating the full alarm once this weight is removed. This is helpful to hospital staff or caregivers monitoring any number of patients from a distance as the alarm will trigger in the event of a patient falling out of the bed or wandering off unsupervised. This alarm can be emitted solely from the bed itself or connected to the nurse call bell/light or hospital phone/ paging system, also some beds can feature a multi-zone bed exit alarm which can alert the staff when the patient start moving in the bed and before the actual exit which is necessary for some cases.

2. EASE OF USE

2.1. INTUITIVE INTERFACE:

The automatic height-adjustable stretcher is designed with a user-friendly interface and features intuitive controls for easy operation by healthcare professionals. These stretchers simplify the operating process, minimizing the need for extensive training and allowing medical staff to focus on patient care rather than equipment management.

2.2. SEAMLESS INTEGRATION:

These stretchers integrate seamlessly into existing healthcare infrastructure, ensuring compatibility with electronic medical records (EMR), patient monitoring systems, and other critical technologies. Plug-and-play functionality and interoperability improve workflow efficiency, enable seamless communication between different departments, and ultimately improve the overall patient experience.

3. PROBLEM STATEMENT, SCOPE, OBJECTIVE

3.1. PROBLEM STATEMENT

It is generally observed that, during a patient carrying on stretcher in inclined slope ramp, the stability of patient is not maintained. To overcome this problem, we are going to design and manufacture automatic position adjusting bed, to improve patients comfort and safety.

3.2. SCOPE FOR STUDY

Flat beds cause improper spinal alignment which causes great discomfort during movement in stairs. In some cases, viz. Slopes, irregular road surfaces, ups and downs on the corridors, bed becomes inclined. To make a

stretcher for the ease of transportation & to provide comfort during operation of patient.

3.3. AIM AND OBJECTIVE OF STUDY

The basic objectives of present study are as follows:

1. To study existing model's hospital beds and to analyse the components and functions of each.
2. To determine additional features that could be useful in a modern hospital bed and then begin the design process.
3. To improve quality, safety, efficiency and effectiveness and to provide safe and therapeutic environment.
4. To incorporate more flexible design to minimize the risk and impact of patient falls.
5. To provide stability and easy to use controls for the patient but is also built to satisfy the needs of patient.
6. To have a position convenient for resuscitation in case of emergency this ensures patients safety.
7. To improve the aesthetics of bed while maintain no additional costly components.

4. LITERATURE SURVEY

For the literature study purposes we have selected five close topic related research papers are as follows:

1. Sang, L., et al. (2019)[1] investigated and designed a novel wheelchair-stretcher assistive robot, which can meet the physiological needs of patients. The following tasks are conducted: (1) the mecanum wheel is adopted as the executive device of the walking mechanism, and its kinematics is analyzed in detail. (2) A five-link mechanism with a single degree of freedom is proposed to realize the folding motion of the robot. Through the minimum conclusive area method, the optimal sizes of the armrests link and the side link are 507.9, and 332.5 mm, respectively. Based on the force analysis of the linkage mechanism, six torsion springs and an RV (rotate vector) reduction motor are used as the driving device, which reduces the driving torque of the motor. (3) Based on the STM32 (STMicroelectronics 32-bits Microcontroller) chip, and combined with the theoretical analysis, the mechanical structure and the control system of the whole prototype are designed, and the feasibility of each module is verified by experimental research. The results confirm that the proposed robot has good performance and that the control algorithm for the walking mechanism and the lifting mechanism is suitable.

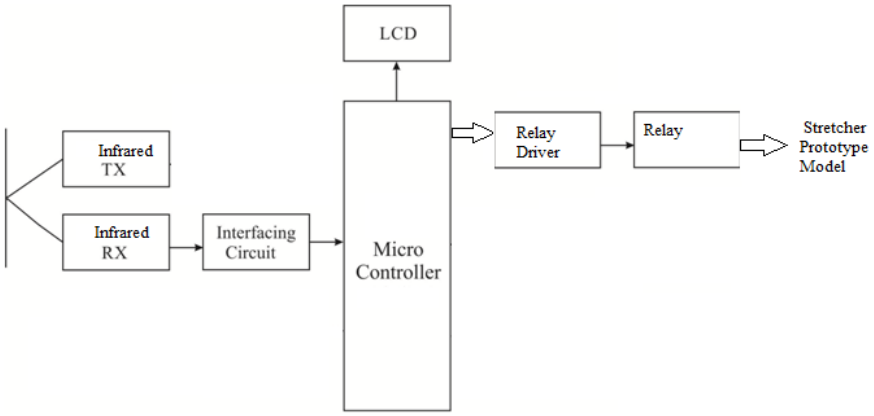
2. Deshmukh, P. V. M. (2019) [2] proposed the design of a smart stretcher. Nowadays, the lifestyle of a human being is becoming smarter due to smart electronics equipment for personal as well as domestic applications. The medical field is also powered by the use of advanced technologies in hospitals. Ambulances play a significant role to transport patients from home to hospital or from one hospital to another hospital. At the time of transportation of the patients, ambulances face many critical situations like heavy traffic, traffic signals, bad road including condition potholes, etc. Moreover, the patient in the ambulance bears the road conditions like up and down and the vibrations of the ambulance. Considering such facts, it is proposed to design the smart stretcher. The aim of the present research work was to reduce the effect of potholes on roads, road structures, and vibrations of an ambulance on a patient traveling on a stretcher in a typical ambulance. Vibrations are sensed by a smart sensor and the electronic system is designed to adjust the stretcher stand smoothly, hence the effect of potholes on roads, vibrations of ambulances are removed and it becomes easy for thehealthcare team to transport the patient. The electronic system consists of signal processing and actuators. The signal processing unit processed the sensed data from the signal and according to that, the output signal is produced to actuator. On implementation of the system, it is observed that the proposed system works satisfactorily.

3. Park, K. H., (2007) [3]introduced a new robotic smart house, Intelligent Sweet Home, developed at KAIST in Korea, which is based on several robotic agents and aims at testing advanced concepts for independent living of the elderly and people with disabilities. The work focuses on technical solutions for human-friendly assistance in motion/mobility and advanced human-machine interfaces that provide simple control of all assistive robotic systems and home-installed appliances. The smart house concept includes an intelligent bed, intelligent wheelchair, and robotic hoist for effortless transfer of the user between bed and wheelchair. The design solutions comply with most of the users' requirements and suggestions collected by a special questionnaire survey of people with disabilities. The smart house responds to the user's commands as well as to the recognized intentions of the user. Various interfaces, based on hand gestures, voice, body movement, and posture, have been studied and tested. The paper describes the overall system structure andexplains the design and functionality of some main system components.

4. Campos, A., et al.(2021) [4] studied portable mechatronic rehabilitation system easily adaptable to different situations— e.g., different body members, training modes, and physical spaces—using Internet of Things communication and designed applying a methodology based on user requirements, named SARPA, is developed. Bedridden patients, i.e., those who stay in bed for long periods, often have diseases due to immobility. Conventional rehabilitation to mobility recovery is conducted by therapists who present humanly limited strength characteristics (force, speed, etc.), mainly if the patient is overweight. Mechatronic rehabilitation systems aim to optimize comfort, cost, force, and time to the user, i.e., the patient and therapist pair. However, in general, these systems are conceived to execute just one training mode on just one determined body member in the lower or upper limb. Therefore, a different system is often required for a different training mode or body member. Using SARPA, users may select a body member (among lower or upper limb), an active (isokinetic, isotonic, or isometric), or passive mode and configure it according to a specific therapy. SARPA is configured through a Human Machine Interface based on the Internet of Things, with characteristics that may exceed the values of a human-made conventional rehabilitation. The SARPA flexibility allows several rehabilitation options using a single system. Through SARPA, it would be possible to program games or competitions among patients using the Internet of Things technology, improving their mood and autonomy level during therapeutic sessions. This paper, it is presented the SARPA system design methodology—based on user requirements, construction,and preliminary applications in a hospital.

5. Elsokah, M. M., et al. (2019) [5] presented a Medical Care Bed with the Internet of Things Solutions a bed designed specifically for patients in hospitals or other people who need some forms of health care that can be used with a button, voice commands and phone applications for control the Smart Bed System using sensors, to voice-controlled application, we are continuously trying to find a better way to control electrical and electronic devices to ease our daily life. Common features include adjustable height for the entire bed, head,and feet, adjustable, adjustable, temperature, pressure, voice command, and application to run both families using sensors and monitoring the patient's body temperature, measuring the proportion of oxygen in the blood and heartbeat using Arduino board. Thesefamily features are special features for both the ease and comfort of the patient and the comfort of health care workers. By referring to the above papers, we have fixed the strategy of our academic project.

5. BLOCK DIAGRAM



6. SYSTEM SPECIFICATION

6.1. HARDWARE SPECIFICATION

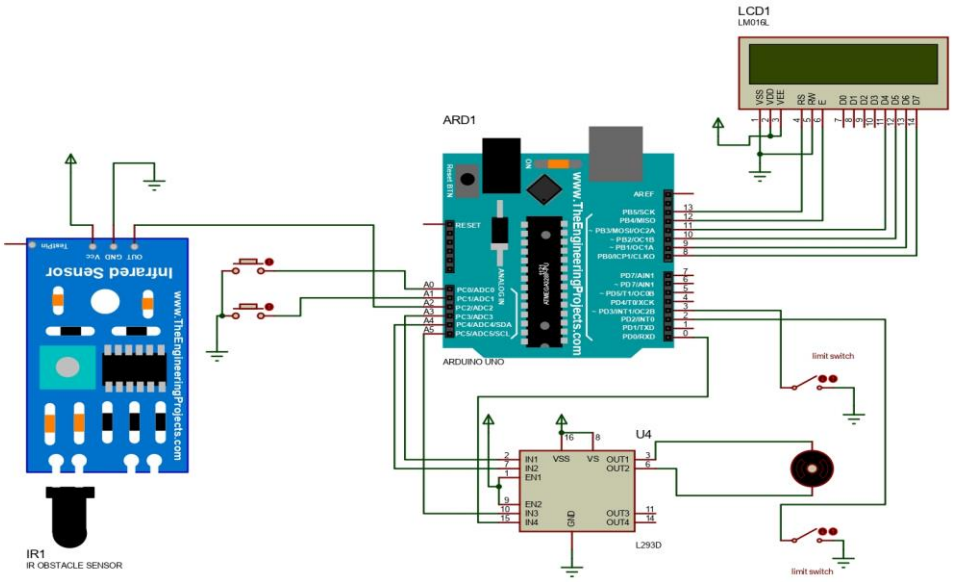
1. microcontroller
2. LCD
3. object sensor.
4. relays
5. dc motor

6.2. SOFTWARE SPECIFICATION

1. ARDUINO IDE ---Controller Side
2. ANDROID STUDIO---Mobile side

7. HARDWARE SPECIFICATIONS

1. **Microcontroller:** The system uses a microcontroller (MCU) as the central processing unit. The MCU is responsible for receiving sensor data, processing it, and sending control signals to the actuators based on programmed logic. Arduino boards or similar embedded development platforms are often chosen as MCUs due to their ease of use and programmability.
2. **LCD Display:** Integrated LCD provides visual feedback to medical personnel. The display shows the current height of the stretcher, any error messages, or any relevant information about system operation.



3. **Object Sensors:** Object sensors, such as ultrasonic sensors and infrared sensors, are used to detect the presence and height of the bed or other nearby objects. Sensor data is sent to the microcontroller for processing and automatic height adjustment.
4. **Relay:** A relay acts as a switch controlled by a microcontroller. These are used to adjust the power supply to the DC motor according to the desired direction and speed of the height adjustment mechanism.
5. **DC Motor:** The DC motor provides the driving power for the height adjustment mechanism. The direction and speed of the motor are controlled by a microcontroller via a relay, allowing precise positioning of the stretcher platform.

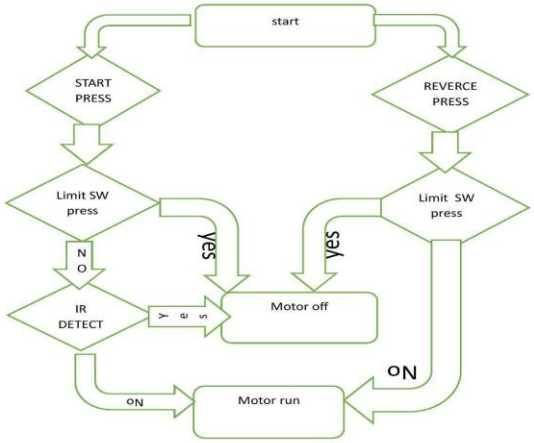
7.1. ADDITIONAL HARDWARE CONSIDERATIONS

1. **Linear actuator or hydraulic system:** Depending on the design chosen, a linear actuator driven by an electric motor or a hydraulic system with pistons and cylinders can be used to smoothly, and Powerful height adjustment can be made.

2. **Battery or power supply:** Electronic components and DC motors require a reliable power source, such as a battery or a connection to mains power, to operate.

8. SOFTWARE SPECIFICATIONS

1. **Controller-Side Software (Arduino IDE):** The Arduino Integrated Development Environment (IDE) is a popular platform for programming microcontrollers. The software defines the logic to interpret sensor data, control relays for motor operation, and possibly display information on an LCD screen.



2. **Mobile Apps (Android Studio) (Optional):** You can integrate Android applications developed with Android Studio into your system to add functionality. This app allows you to remotely control stretcher height adjustments, view real-time data, and provide user manuals and troubleshooting guides.

9. METHODOLOGIES

1. User-Centered Design (UCD): We have conducted focus groups and interviews with medical professionals (doctors, nurses, paramedics) to understand their needs and challenges regarding patient transfer and observed the patient transfers in real-world settings to identify pain points and opportunities for further improvement in the existing system. From the above information, we have developed a prototype with automatic height adjustment for the stretch

prototype dimension:

1.height = 2 feet

2.length = 3 feet

3.width = 1.5 feet

2. Engineering Design and Analysis: At first, we analysed the mechanical design of existing stretcher mechanisms and identified the areas for improvement in terms of automation, weight capacity, and stability. With the help of computer-aided design, we have software to create detailed models of the automatic height-adjustable stretcher, simulating its functionality and ensuring safe operation. Finally, we have conducted a structural analysis to ensure the stretcher can handle the weight of patients and medical equipment.

3. Performance Evaluation: After completing the initial processes, we have done a testing protocol to evaluate the performance of the automatic height-adjustable stretcher.
From that we have concluded the following factors:
1. Speed and accuracy of height adjustment.
2. Stability during movement
3. Ease of use for medical personnel
4. Patient comfort during the transfer

4. **Safety and Regulatory Compliance:** We have researched important medical device safety standards such as those established by the authorities like US Food and Drug Administration and the International Standard of Organization. Based on that we have designed an automatic height-adjustable stretcher and made sure that no chance of harm to the patients as well as the medical staff handling the stretcher.
5. Cost-Effectiveness Analysis: Further, we analyzed the cost of developing, manufacturing, and maintaining the automatic height-adjustable stretcher and compared the cost of the new stretcher with existing manual stretchers for cost-effectiveness. Overall, the potential cost savings associated with improved ergonomics and reduced risk of injury for medical personnel have proved that this will create a revolution in the medical industry.
6. Additional Features: We have incorporated a range of sensing technologies to improve the stretcher's performance. For instance, object detection sensors could stop crashes during transport, or weight sensors could automatically change the height for the best possible patient comfort. The Stretcher is completely made of cutting-edge materials making it both strong and lightweight.

10.BENEFITS

1. **Improved Patient Safety:** AHAS reduces the risk of falls and injuries associated with manual lifting and transferring.
2. **Enhanced Patient Comfort:** Automatic height adjustments ensure smooth alignment with beds, wheelchairs, and other equipment, minimizing strain and discomfort.
3. **Reduced Workload for Healthcare Workers:** AHAS decreases the physical exertion required for transfers, mitigating musculoskeletal disorders among healthcare personnel.
4. **Increased Efficiency:** The automation of height adjustment streamlines transfer processes, saving time and resources.
5. **Improved Ergonomics:** AHAS promotes proper posture and biomechanics for workers, further reducing injury risks.

11.CONCLUSION

The development of an automatic height-adjustable stretcher for hospital applications represents a significant advancement in patient care and healthcare infrastructure. This innovative solution addresses several critical needs within healthcare facilities, offering numerous benefits to both patients and medical staff.

Firstly, the automatic height-adjustable stretcher enhances patient comfort and safety by providing a customizable platform that can be adjusted to suit individual needs. This feature is particularly beneficial for patients with mobility issues or those requiring specialized care, as it ensures optimal positioning during transport and treatment. Moreover, the integration of automation technology streamlines the process of adjusting the stretcher's height, reducing the physical strain on healthcare workers and improving overall efficiency. By automating this task, medical staff can focus more on patient care and less on manual handling, ultimately enhancing workflow and productivity within the hospital setting. Additionally, the automatic height-adjustable stretcher contributes to a more ergonomic and user-friendly environment for medical professionals. Its intuitive controls and ergonomic design facilitate ease of use, allowing staff to operate the stretcher safely and efficiently, even in high-pressure situations.

Furthermore, the development of such a stretcher underscores the commitment of healthcare organizations to embracing innovation and technology to improve patient outcomes and enhance the quality of care. By investing in cutting-edge solutions like automatic height-adjustable stretchers, hospitals demonstrate their dedication to providing the highest standards of patient care and safety. In conclusion, the development of an automatic height-adjustable stretcher for hospital applications represents a significant step forward in modernizing healthcare infrastructure and improving patient care delivery. With its ability to enhance patient comfort, streamline workflow, and promote ergonomic practices, this innovative solution has the potential to revolutionize the way patient transportation and treatment are conducted within healthcare facilities.

12.ACKNOWLEDGMENT

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