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RESEARCH ARTICLE

Weighing the Weight of Bedridden Patient by using Strain Gauge (Weighing Scale) - Prototype

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ABSTRACT

In today's healthcare landscape, weighing beds plays a pivotal role in patient care and management. These specialized beds provide critical data on a patient's weight, which is integral for monitoring health, tailoring treatment plans, and ensuring accurate medication dosages in bed rest patients, etc. They are particularly crucial in critical care settings, where precise weight measurements are essential for fluid balance and medication adjustments. Weighing beds also has a significant impact on preventive healthcare, enabling timely interventions and lifestyle recommendations based on weight-related health risks. In post-operative care, they assist in assessing factors like fluid retention, and guiding post-surgical interventions. Furthermore, in pediatric healthcare, weighing beds are indispensable for monitoring growth and development. Integration with electronic health records streamlines data management, enhancing efficiency for healthcare providers. Overall, weighing beds are indispensable tool in modern healthcare, contributing to comprehensive patient care and well-being. As the medication requirement of the bedridden patient depends on weight, overdose or underdose of the drug is expected to complicate the problems further. Till now, in the market, there were available detecting devices, but the main problem with them is those devices lift the patient totally or lift the bed totally; For this workforce is more required and also time-consuming and cost-effective. For bedridden patients, it is difficult to measure body weight due to lifting and equipment, as well as the need for a workforce. Some beds have inbuilt measuring sensors, but they are cost-effective for bed purchase. For this, there is a possible way to measure the patient's weight by using a strain gauge sensor.

Keywords: Strain, Strain gauge, Resistance, HX711 module, Arduino.

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INTRODUCTION

In the realm of healthcare, accurate monitoring of a patient's weight is of paramount importance. For bedridden or bed rest[1] and for infants[2] individuals, obtaining precise weight measurements poses a unique challenge due to their limited mobility[3] and a lot of physiological consequences considered under bed rest.[4] We have seen the bed scales for measuring the patient weight by lifting them and placing them on the belt.[5] Traditional weighing scales prove impractical in such cases, necessitating specialized equipment designed to cater to the specific needs of bed-bound patients. That's why strain gauges have become a pivotal tool in modern healthcare.

Strain gauges, initially developed for engineering applications, have found a critical role in the medical field, particularly in accurately measuring forces and weights. These sensitive devices can convert mechanical deformation into electrical signals, enabling precise weight determination even for patients confined to their beds.

This article explores the indispensable role of strain gauges in revolutionizing the way we weigh bedridden patients. We will examine the fundamental ideas behind strain gauge technology,[6] how it fits into contemporary medical scales, and how it helps patients and healthcare providers alike. Additionally, we will examine the various considerations and best practices for ensuring accurate and reliable weight measurements, enhancing the quality of care provided to bedridden individuals. Through this comprehensive exploration, we aim to shed light on the pivotal role of strain gauges in elevating the standard of care for immobile patients, ultimately contributing to their overall well-being and recovery.

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MATERIALS AND METHOD

An electrical resistance sensor that changes in response to strain is called a strain gauge in Figure 1 starin guage is shown in a pictorial way. Strain is the displacement or distortion of a material brought on by an applied stress. The force applied to a material divided by its cross-sectional area is known as stress.[7]

Strain gauges play a crucial role in evaluating material strain under various conditions, whether arising from static or dynamic loads originating internally or externally, including mechanical, thermal, and pressure influences.[8] Four-wire strain gauges are particularly adept at capturing low-frequency dynamic strains due to their high sensitivity.[9] However, when measuring higher-frequency pressures, amplification of the bridge output becomes necessary.[10] Interestingly, both a semiconductor strain gauge sensor and a high-speed digital voltmeter can effectively utilize the same circuit.[11] In practice, these strain gauge sensors are affixed to scales, integrated with the HX711 module and Arduino board, and placed on a level surface.[12-14] This setup facilitates precise and reliable measurements of strain, offering valuable insights into material behavior under various load conditions.

Procedure

- In the meticulous process of measuring deformation and stress in materials and structures, it is imperative to start by carefully selecting the appropriate number of strain gauges. This decision is pivotal in ensuring the accuracy and reliability of the gathered data. Furthermore, it is crucial to strategically place these gauges at key points, including corners and various locations on the surfaces.[15] This meticulous placement is guided by capturing a comprehensive view of the strain distribution. By doing so, we can gain valuable insights into how the material responds to different conditions and loads. This approach allows for a thorough analysis of its behavior, ultimately contributing to a deeper understanding of its mechanical properties and structural integrity.
- Attach them to any flexible surfaces like scale, strips, etc., as shown in Figure 2
- Now, it is imperative to establish a connection between one terminal of each strain gauge. This strategic linking ensures that any alteration in resistance resulting from applied stress is uniformly distributed and subsequently measured without any deviations.[16] This step is pivotal in achieving accurate and consistent readings across all strain gauges, thereby enabling a comprehensive assessment of the material's response to external forces. By maintaining this uniform electrical connection, we can effectively capture and analyze the collective impact of stress on the material, providing invaluable insights into its mechanical behavior and connecting other terminals remaining in strain gauges to the HX711 module.[17] as shown in Figure 3.
- Next, proceed to establish a connection between the HX711 module and the Arduino board following the schematic diagram illustrated in Figure 4. This crucial step ensures the seamless communication and interaction between the two components. By adhering to the prescribed wiring configuration, we enable the Arduino board to effectively interface with the HX711 module, facilitating the accurate acquisition and processing of data from the connected strain gauges.[18] This connection is fundamental to the successful integration of the sensing system, laying the foundation for precise measurements and subsequent analysis.

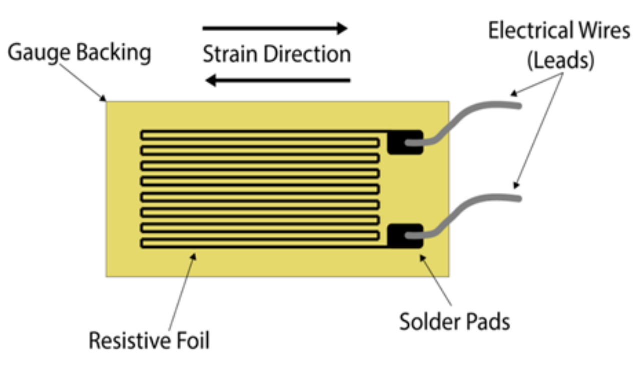


Figure 1: Strain Guage

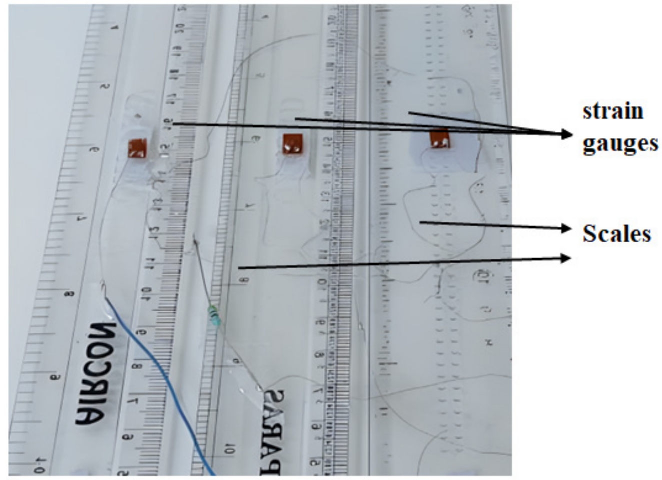


Figure 2: Fabricated of each strain gauge on each scale by using glue

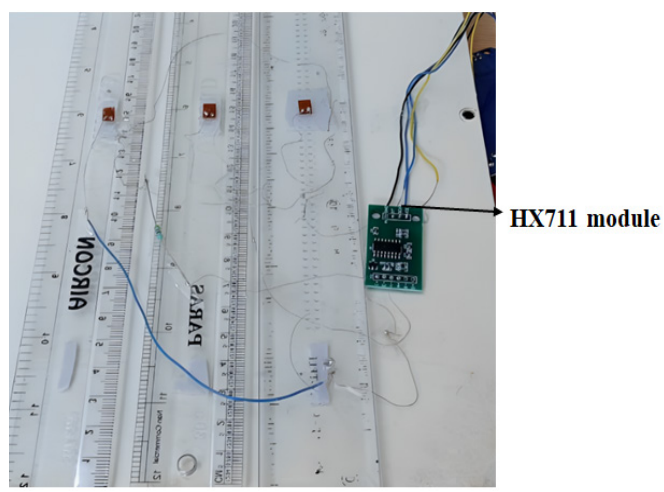


Figure 3: Interconnection of strain gauges and also with HX711 module

- Following the establishment of hardware connections, the next crucial step involves coding the Arduino microcontroller to execute the designated commands.[19] This code is instrumental in processing the data acquired from the strain gauges and establishing a correlation with variations in weight.[20] The objective is to ensure that changes in resistance, indicative of strain, are accurately and proportionally mapped to the applied weight. Figure 5 provides a visual representation of this coding process, offering a clear blueprint for implementing the necessary algorithms. This meticulous programming enables the system to convert electrical signals into meaningful weight measurements, a pivotal aspect in the functionality of the entire setup.[21]
- At this juncture, it is imperative to calibrate the system for accurate and reliable measurements. This involves inputting the calibration value, which is indicated as the 'calibration factor,' as depicted in Figure 6. This step allows for fine-tuning the system's response to variations in weight, ensuring that the measurements obtained are precise and consistent. The choice of y/n in response to the calibration prompt guides the system toward the appropriate adjustment.[22] A carefully determined calibration factor is instrumental in aligning the system's output with real-world weight values, enhancing its overall accuracy and reliability in practical applications.
- Now, check all the connections shown in Figure 7.
- At this stage, the fabricated surface is prepared to emulate the weighing balance model.[23] By tilting it appropriately, we create the conditions for the addition of weights, inducing deformation and subsequently causing changes in the strain gauge sensors. This orchestrated process, depicted

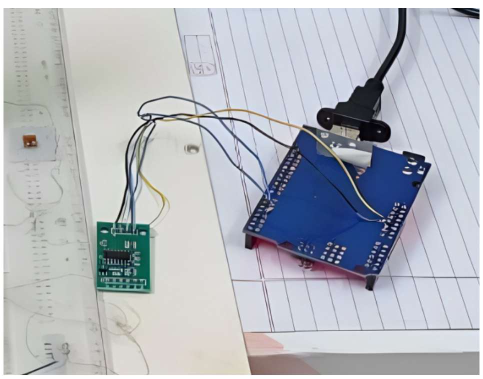


Figure 4: connecting of HX711 module to Arduino

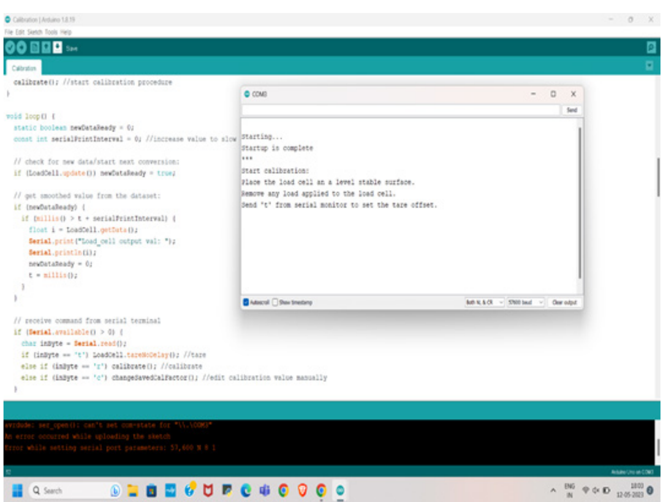


Figure 5: coding the code for detection of weight variation and giving the tare value

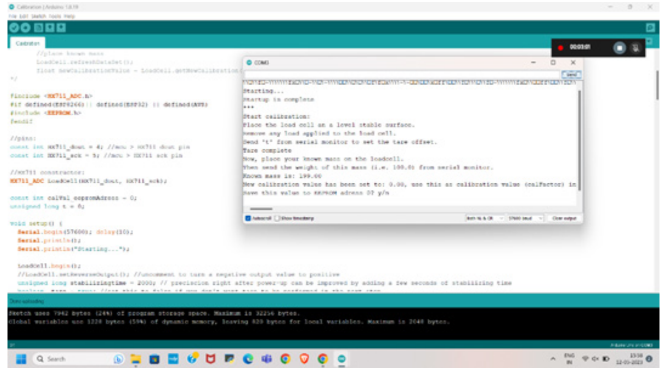


Figure 6: Setting the calibration factor

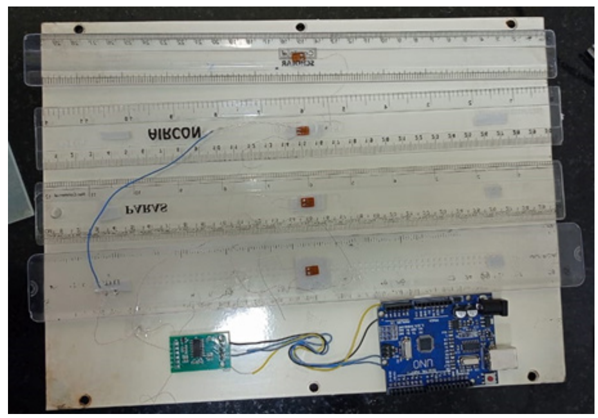


Figure 7: Overall setup of the fabricated strain gauges and Arduino connections

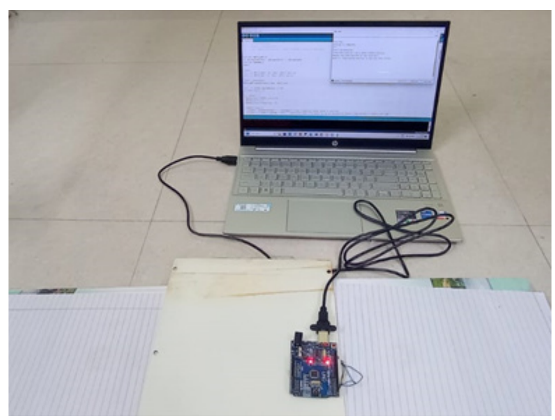


Figure 8: The tilted surface and the overall setup is ready for weighing

in Figure 8, sets the stage for obtaining meaningful results. By strategically placing various samples on both sides, we can vary the loads as desired, a procedure illustrated in Figures 9-12. Through this method, we can precisely measure the resulting values. This meticulous approach allows us to quantify the relationship between applied weights, resulting deformations, and the corresponding strain changes recorded by the sensors, providing valuable insights into the material's mechanical behavior.

RESULTS

The different samples of weights are added and removed; each sample is measured on both sides of the surface, and plotted in the Graph 1 to check the linear regression.
The measured values are entered in Table 1.

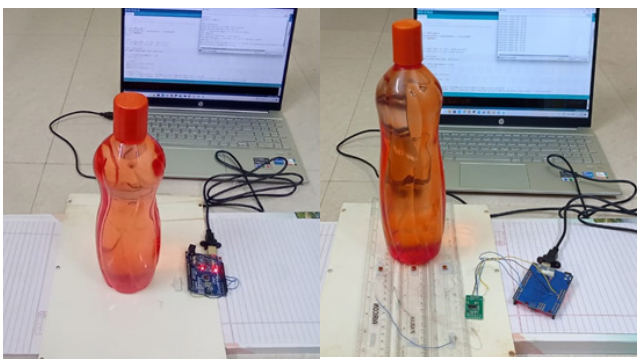


Figure 9: Measuring the weights on either side of plate surface

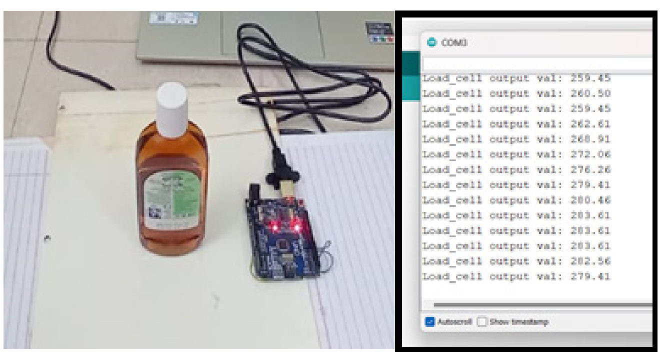


Figure 10: Weighing scale with 250 mL weight

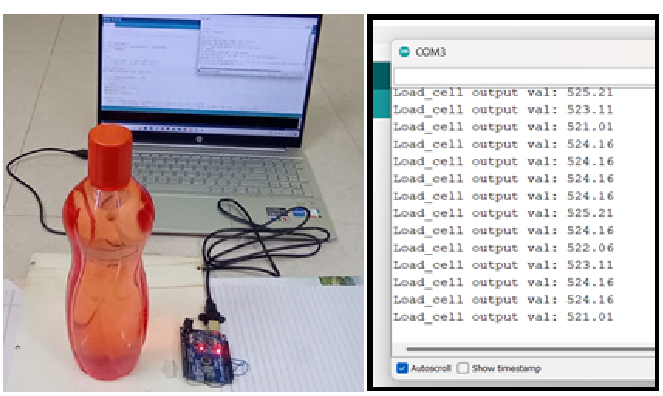


Figure 11: Weighing scale with 500ml weigh

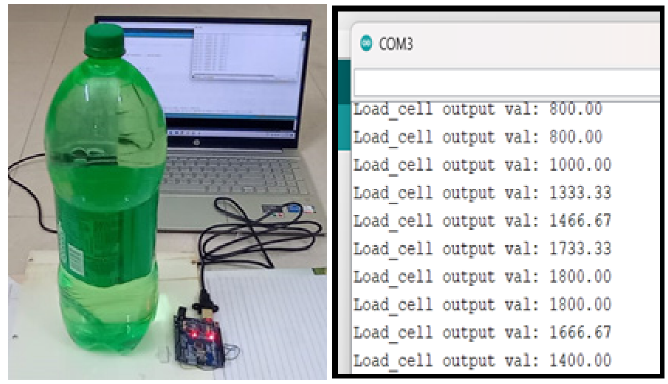
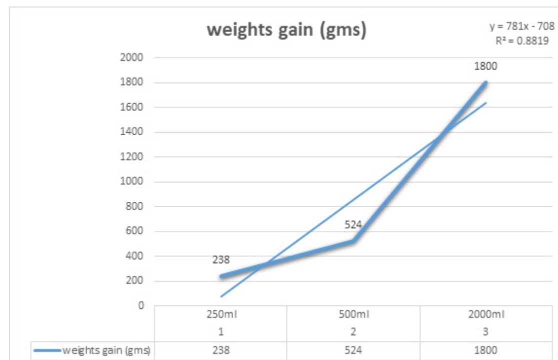


Figure 12: Weighing scale with 2 liters weighed and removed



Graph 1: We plotted the average values of different weights in graphs, Linear Regression found an R^2 of 88%.

Table 1: Trail values of a test with different weights

Sl.no	*Weight given (mL)*	*Weight gain in trail -1*	*Weight gain in trail -2*
1	250	238	220
2	500	524	538
3	2000	1800	1744

In this study, a comprehensive analysis was conducted to examine the relationship between the weight given and the resulting weight gain. To achieve this, the average values from multiple trials were calculated, providing a more representative measure of the observed changes. These averages were then used to construct a linear regression model, a powerful statistical tool for establishing quantitative relationships between variables. The coefficient of determination (R^2) was employed as a measure of how well the data conforms to the linear regression model. This step is pivotal in understanding the degree of correlation and predictive capability between the two variables under investigation. The ensuing regression analysis offers valuable insights into the dynamics of weight gain as a function of the weight provided, shedding light on potential patterns.

DISCUSSION

- Introduction of Innovative Method: We've developed a novel method using strain gauges to accurately measure the weight of bedridden patients.

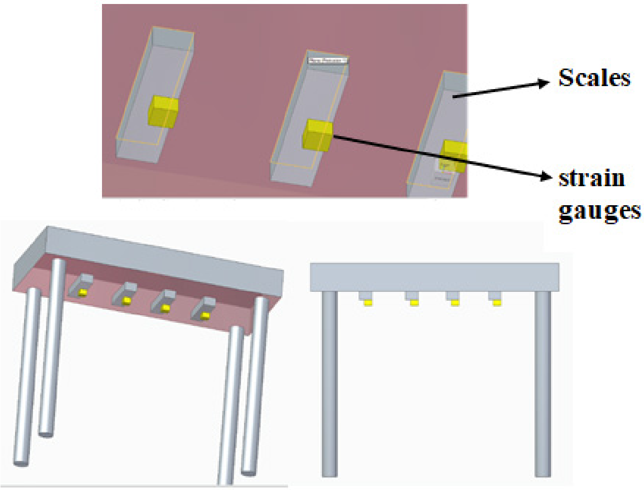


Figure 13: Weighing scales under bed

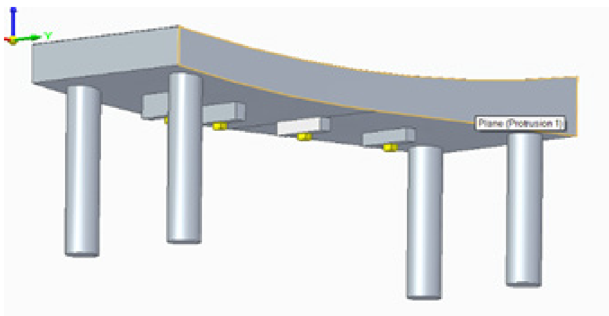


Figure 14: Weighing scales under bed getting strain while subjected to weight

- Specialized Scale Design: A custom-designed scale is created to seamlessly fit underneath a patient's bed, ensuring convenience and precision in weight measurement.
- Calibration Process: Before implementation, the scale undergoes a calibration process. It is first placed on a standard; unoccupied bed and a 'tare' operation is performed. Additionally, a known weight is applied to fine-tune its accuracy.
- Readiness for Patient Use: Once calibrated, the scale is ready for practical use beneath a bed already occupied by a patient, streamlining the weighing process.
- Real-time Strain Readings: As the scale, integrated with strain gauges, is gently positioned beneath the bed, it begins to capture real-time strain readings. These readings vary based on the unique weight of each patient.
- Enhanced Quality of Care: This innovative approach not only simplifies the process of obtaining accurate weight measurements for bedridden individuals but also holds great promise for elevating the overall quality of care provided in healthcare settings.

CONCLUSION

In summary, our strain gauge-based weighing bed prototype, crafted as a scale surface model, demonstrates commendable proximity to accurate results while maintaining cost-effectiveness. The ingenious design facilitates effortless placement under any bed, ensuring a seamless and secure attachment as shown in Figures 13 and 14 drawn in CAD design. The prototype's strategic construction upholds accuracy and enhances practicality by enabling easy shifting between beds. Its inherent portability adds a layer of versatility, making it a standout solution for precise and efficient weight measurement across various applications. In essence, our prototype represents a significant leap toward providing an accessible, adaptable, and accurate weighing system in diverse settings.

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