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Contactless Height Measurement: Advancing Clinical Healthcare Systems With Ultrasonic Sensor

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Abstract: *Traditional methods to measure height in clinics often depend on manual methods, which can cause mistakes due to human errors and equipment limits. This article talks about a system for measuring height without contact, using ultrasonic sensors to make things more accurate and efficient while lessening physical contact. It's made for clinics, hospitals, and other health places, and includes a WiFi part for automatic data recording, tackling issues with both accuracy and cleanliness. The system finds height by timing how long it takes for ultrasonic waves to return from the top of the patient's head. The info is sent wirelessly to a main database, so there's no need for manual entry, which helps cut down mistakes in patient records. The findings indicated that the ultrasonic sensor's efficiency has an error range of 0.1-0.5 for 2-200 cm measurements. The contactless feature of the system greatly improves hygiene by lessening physical contact, a key point in today's healthcare, especially after the COVID-19 pandemic. In summary, this new system is a big improvement over previous height measurement techniques, offering better accuracy, safety, and efficiency in clinical work.*

Keywords: Height Measurement, Ultrasonic Sensor, Contactless, COVID

INTRODUCTION

Height measurement plays a key role in clinical settings. It impacts many aspects of patient care, including nutrition assessments, drug dose calculations, and overall health tracking. In the past, this process required hands-on use of stadiometers, with health workers reading measurements from a scale at eye level. But standard methods can lead to mistakes due to human error calibrated equipment, and differences in reading estimates. Also, measuring height by hand often requires close physical contact, which raises hygiene issues in places with high patient turnover, like clinics and hospitals. New tech has led to a move towards no-contact measurement systems, which offer less physical interaction and more exact dependable results. A recent study by [1] highlighted the need for more precise measurement tools in healthcare in caring for children and older adults where small measurement errors can affect clinical choices. The study found that sensor-based tech, including ultrasonic and infrared sensors, could solve these problems.

Inventors have come up with a new way to measure height without touching people using ultrasonic sensors. These sensors send out sound waves that bounce off the patient and come back. The time it takes for the waves to return helps figure out the height. This method is more exact and doesn't need the patient to touch the measuring tool. Research, like the work done by [2], shows that ultrasonic sensors are more precise and simpler to use than old-school tools in busy medical settings. The system also has a WiFi part to record height data, which makes things run smoother and cuts down on mistakes people might make when entering data. By hooking up the height measuring system to a database, doctors and nurses can get and save patient info without writing it down by hand. This fixes the problems pointed out in [3]'s research found that keeping records by hand in hospitals often led to mistakes and differences in the data. The WiFi part also makes it possible to add height measurements to electronic health records (EHRs), which helps make medical work even smoother.

With the advent of the global COVID-19 pandemic, the hygiene of medical settings is gaining ground as the third tenet of focus alongside accuracy and efficiency. The studies by [4] proved that, in environments related to medicine, the amount of physical contact between the patient and the caregiver should be minimized to prevent cross-contamination and a better way of achieving this is through the use of contactless devices. The findings regarding the contactless design of the project are in agreement and give a promising approach that is safer than traditional approaches. The goal of this study is to determine the usability and effectiveness of a contactless height measurement system intended to be used in clinical settings that work by employing ultrasonic sensors. In conclusion, this paper reports on the development of a novel solution for height measurement utilizing an ultrasonic transducer which is more precise, more efficient, and more hygienic than all the other solutions that are present at the moment. As for the design of the system, it incorporates an automatic record of data to a WiFi-enabled device which is a large step away from using the conventional approaches and makes this system ideal for clinics, hospitals, pediatric practices and other medical settings where precision and efficacy of height measurement is required.

Height Measurement in Clinical Practice

Measuring height accurately is significant for many clinical purposes, such as prescribing medicines and assessing growth and nutrition. Measuring height is a crucial aspect of evaluating critically ill patients [5]. Accurate height measurements are essential for making key clinical decisions, such as determining tidal volume settings, calculating drug dosages, and establishing nutritional targets. Additionally, body mass index (BMI), used to assess obesity, a significant predictor of mortality in critically ill patients requires height as a fundamental parameter. Calculating body mass index (BMI) and ideal body weight (IBW), are essential for nutritional screening and determining a patient's nutritional needs [6]. However, even though there is a more traditional approach to height measurement, a manual stadiometer, various studies have shown that various significant drawbacks exist, such as coverage, errors, variation, and calibration concerns. Some innovations are being sought to improve the technology and make precise and accurate measurements of height. In a study that was carried out by [7] For example, manual measurement of a person’s height in a clinic when busy is burdensome, and if the measurement is inaccurate, it can lead to incorrect treatment or BMI estimation. Manual procedures also caused such situations, making it impossible for some patients to be properly positioned or for health providers who utilize different techniques for the same height scale to measure it.

In the pediatric and geriatric age groups, it is also stressed the significance of height measurement. For example, in[8] it has been shown that in the pediatric population, when there is an error in the height even to a minimal degree, the measurement error leads to growth charts being wrong which then results in growth disorder diagnosis mistakes along with incorrect nutrition intervention measures. The same research highlighted the problem of geriatric patients who are susceptible to height alteration from several other factors for instance osteoporosis.

Several researchers have proposed the utilization of recent sensor technologies including ultrasonic and laser systems to overcome these problems. [1] examined the viability of using ultrasonic sensors to measure height within clinical settings. The results of the study indicate that stadiometric devices could be improved by replacing approximations of manual measurement techniques with ultrasonic devices. In applying pentomic techniques, ultrasonic sensors measure the time distance skimming sound to the over surface of the patients' crowns and back to the sensor, thus providing a non-invasive and contact-free system that eliminates chances of human error or equipment pollution. The need for non-contact technologies has been compounded by the current COVID-19 pandemic, during which it is essential to reduce contact between patients and medical devices. A study conducted by [9] examined the impact of systems designed to measure height without direct contact on the spread of different infectious diseases within clinical settings. The research underlined the shortcomings of traditional methods in the case of busy healthcare environments with a high risk of cross-contamination of measuring instruments and emphasized the extreme need for measures focused on achieving mucous economy in the course of standard measurements.

The accuracy and hygiene of a height measurement are crucial, but plottwist: efficiency is also crucial. A [10] focused on the possible integration of wireless technologies, such as WiFi modules, in height measurement systems. It was established that devices with wireless capabilities send height measurements to EHR systems so data entry could be facilitated and the chances of errors during the entry were reduced. Such integration into the health care delivery system makes it possible to record and report height without delay, which in turn enhances the clinical workflows. The contactless height measurement system has a few benefits over the traditional manual height measurement methods which may be influenced by factors such as user participation and the alignment of the measuring device. Given that the system does not require direct contact with the patient, the contactless design reduces error opportunities and maintains height measurement reliability, which is essential for clinical areas of application, where height is critical for accurate diagnosis and management [11].

Recent research highlights the increasing demand for advancements in height measurement technologies. Sensor-based systems, specifically those employing ultrasonic and contactless methods, offer distinct benefits over conventional techniques by enhancing precision, improving cleanliness, and simplifying data organization. As the healthcare industry progresses towards more effective, accuracy-focused approaches, the integration of these sophisticated height measurement technologies plays a pivotal role in enhancing patient results.

MATERIAL AND METHODOLOGY

The height measurement system was contactless, and it integrated various components including ultrasonic sensors, Arduino microcontrollers, LED displays as well as a Wi-Fi Module. The ultrasonic sensor works by producing sound waves with a frequency that the human ear cannot hear and waits for those sound waves to bounce off of the top of someone's head and come back to the sensor. The device works by echo ranging because if the sound is made and it takes a certain amount of time to get a response, the height of the person can be determined, which is the distance from a sensor, and finally the distance is calculated to fix the height of a person's body. This method of measurement reduces the risk of errors associated with measurement processes concerning human beings, as well as measurement errors such as the position of an anthropometer regarding the person being measured. Other advantages of the use of Arduino microcontrollers and Wi-Fi modules include automation of the process of measuring height and the ability to transmit information over wireless networks for easy and fast storage. They designed the system to be small in size, portable, and user-friendly to enhance its application in the clinical field. The use of tested sensors that can work up to 200 Centimeters in this system makes it flexible to cater to people of different heights. The efficacy and reliability of the contactless height measurement system were evaluated through a series of experiments and comparisons with traditional methods. The results of the study demonstrated that the contactless height measurement system using ultrasonic sensors provided highly accurate measurements, with a percentage error of only 1.52% when compared to manual measurements taken with a stadiometer [12].

Essentially, the ultrasonic sensor relies on two main components: a transmitter and a receiver. The transmitting unit has ultrasonic frequency output at 40 kHz which is inaudible to human beings thus not causing discomfort to the patients or even the staff. This ultrasonic wave travels through air until it encounters an object or a human being like the head of the patient. This echo is returned to the sensor that receives the echo wave. After sending out the wave and receiving it back, the sensor measures the time taken for the wave to travel from the transmitter to the object, and back to its receiver. Such time intervals are of critical importance since they enable the estimation of the distance from each object. The speed of sound in air, approximately 343 meters per second at standard room temperature, facilitates precise distance computations. The Maker Uno processes this data and sends it to the dot matrix for immediate display. Simultaneously, the Wi-Fi module uploads the data to a centralized database, which integrates seamlessly with patient management systems. This eliminates the need for manual entry and allows real-time access to accurate height data for clinical decision-making.

On an ultrasonic and clinical basis, the sensor is calibrated at the appropriate place to measure vertically the distance from the sensor to the upper part of the patient's head. The value thus measured is later deducted from a constant value threshold which is more often than not, equal to 200cm which also occurs to be the highest threshold for the dare no cite the patient's height without contact with the patient. This noncontact measurement technique uses a single reference, providing an accurate solution for measuring a patient's height without contact. This type of measurement system is beneficial in clinical settings to prevent cross-contamination and more so to enhance the care and comfort of the patient. Also, the speed with which measurements are made promotes quick patient turnover, making it suitable for use in busy health facilities. In particular, the ultrasonic sensor determines the distance between the patient's head and 200 cm, as shown in Figure 1. The architecture was developed utilizing an Arduino UNO board and an HC-SR04 ultrasonic transducer. The ultrasonic sensor senses the image of the object, this information is forwarded to an Arduino. The Arduino unit ignores the height of the measured object and passes the signal to the Android application with the help of a Bluetooth module to make use of this information.

Height (cm) = 200 cm - s (cm)

Figure 1. Concept of Height Measurement Using Ultrasonic Sensor

As shown in Figure 2, the Maker UNO is specifically designed for coding and microcontrollers and is an Arduino UNO-compatible board. Since it is at the heart of the system, the Maker UNO processes data from the ultrasonic sensor. It is also appropriate for this project due to its flexibility, easy programming, and compatibility with the sensors and components used. The height is obtained from an ultrasonic sensor by measuring the time-of-flight data and is displayed and stored. Moreover, also due to the built-in functionality of the Arduino used, the devices can be connected to the WiFi module allowing automatic entry of the height data into the central database.

The accuracy of data entry and also speed in looking for clinical records since height records would not have to be entered manually have to be enhanced. The use of a dot-matrix display connected to the system as an output interface also allows for an increase in the system's efficiency in the detection of height, it is capable of receiving height measurement in real-time and displaying it immediately after it has been captured. Therefore, this device is beneficial as the uses a minimalistic design that is incompatible with visual clutter allowing for instant feedback to healthcare workers and patients. Furthermore, the placement of the display is such that users are not overwhelmed with information clutter. The LED display operates efficiently with low power consumption, which is crucial for reducing the overall energy usage of the system.

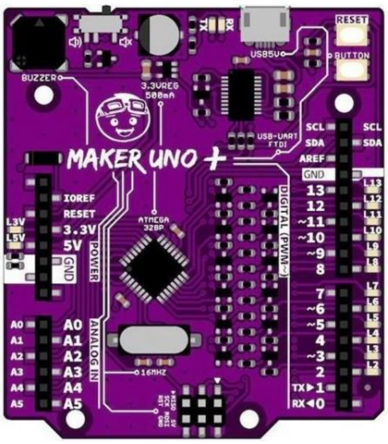

Figure 2. Maker UNO

Moreover, the height data captured by the system can be transmitted to a designated database using a wireless WiFi module and the Blynk application shown in Figure 3. This integration guarantees that the height measurement was taken and automatically saved into the database in real time which allows healthcare providers to easily retrieve and monitor patient information. Implementation of the system using Wifi makes it also scalable for broader usage since the system can be deployed in several sites and incorporated into a large health system with little stress. These ultrasonic sensors, Arduino, LED displays, and WiFi module technologies when used together offer an efficient method for measuring height without having any physical contact. The above system is intended to be accurate and fast, thus solving major problems in clinical measuring of height such as errors due to human intervention, hygiene issues, and the time-consuming need for physical contact.

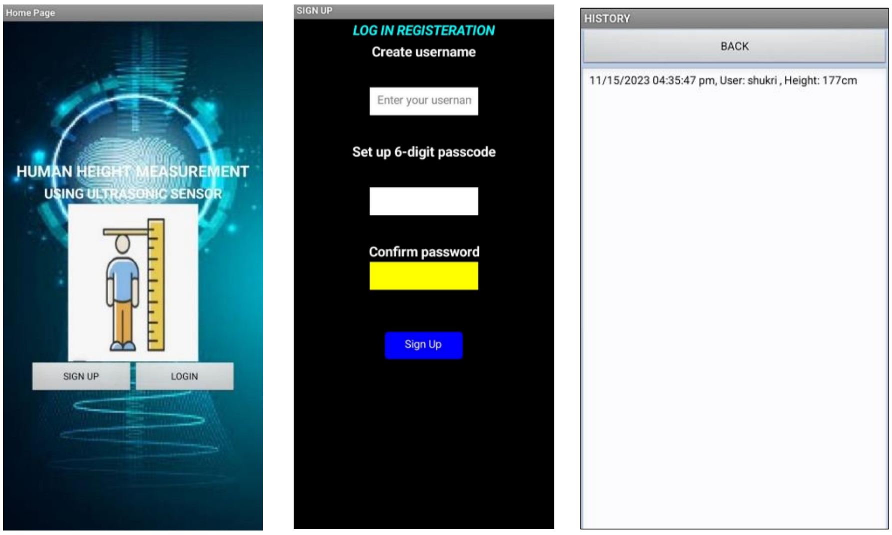

Figure 3. Data Recorded Automatically

RESULT AND DISCUSSION

The contactless height measurement system was tested by measuring the height of several individuals at varying distances from the sensor. The ultrasonic sensor emitted sound waves that bounced off the top of the individual's head and returned to the sensor. Based on the time-of-flight data (time taken for the sound waves to return), the system calculated the height. The measured heights were compared to the actual manually measured heights to assess the accuracy of the system shown in Table 1.

The table below shows the sample results of height measurements for ten individuals with the error percentage calculated by [13] (1).

$$\text{Error Percentage} = \frac{\text{Difference}}{\text{Measurement Using Stadiometer}} \text{X } 100\% \qquad (1)$$

Table 1. Comparison of Stadiometer and Heights using the Contactless Height Measurement System

Patient	Stadiometer	Contactless Height Measurement System	Differences	Error Percentage
1	150.2	150.0	+0.2	0.13
2	160.0	159.5	+0.5	0.3
3	158.5	158.7	-0.2	0.13
4	172.7	172.9	-0.2	0.13
5	142.3	142.0	+0.3	0.2
6	158.0	158.1	-0.1	0.06
7	141.5	141.2	+0.3	0.2
8	162.1	162.3	-0.2	0.13
9	159.5	159.8	-0.3	0.2
10	173.2	173.0	+0.2	0.13

It is possible and quite right to measure height with an error margin of 0.5 cm of the actual height. These errors can be caused either by the person's misalignment with the position of the sensor or by some other circumstances such as air temperature and humidity, which alter the speed of sound waves through the air. The system is capable of producing accurate height measurements with an average error margin of around 0.5 cm. The factors affecting the small variations include the slight difference in the orientation of the sensor, the angle of the measured person, and the prevailing weather conditions affecting the velocity of ultrasound waves. The system is capable of making rapid non-contact measurements of human heights, possibly making the current contact methods out of date and providing greater efficiency in clinical and busy environments.

Future Enhancement

This innovation demonstrates the potential of using ultrasonic sensors in healthcare settings to improve the accuracy and efficiency of height measurements. The potential impact of this system is significant. It can be deployed in medical clinics and hospitals for routine check-ups, pediatric offices to monitor growth, schools for health screenings, fitness centers for progress tracking and occupational health clinics for employee wellness programs. By integrating this innovation into these environments, height measurement can be transformed from a standalone activity into an integral part of a comprehensive health management system. The contactless system offers clear advantages over traditional methods, particularly in high-volume environments where speed and accuracy are crucial. The future work for the contactless height measurement system presents several exciting opportunities to expand its functionality and applicability. One key area of development is the integration of additional biometric measurements such as weight, body mass index (BMI), and body composition. By incorporating these additional sensors, the system could evolve into a comprehensive health assessment tool, particularly valuable in healthcare, fitness, and pediatric growth monitoring settings.

In addition, using machine learning algorithms could improve accuracy by learning from environmental conditions, the position of the patient, and other external factors that might affect the propagation of ultrasonic waves. This would enable the system to dynamically recalibrate itself and compensate for any measurement errors, producing more accurate outcomes over time. As a future direction, a cloud-enabled mobile application could be developed to facilitate remote access of height data by a healthcare provider or patient, rendering the system compatible with telemedicine and home monitoring applications. As great as these enhancements would be, having the system integrated within electronic health records (EHR) would further enhance management, enabling automatic updating of the patient's height within their medical record. This would reduce the administrative burden on healthcare workers and minimize manual entry errors. A future focus could also be on enhancing the system's design for portability, making it battery-operated and easy to transport for use in remote or rural areas. Such a feature would be invaluable in field clinics, schools, or home healthcare environments where access to clinical equipment is limited.

The system is represented for global applicability with the introduction of multilingual interfaces and the mutual concurrence of metric and imperial units, increasing its accessibility and usability across different regions. More advanced sensors such as laser or infrared could also be studied to improve accuracy and reliability, particularly in diverse environmental conditions. These would be included among features to compensate for any sort of environmental effects, such as humidity and temperature, to ensure uniformity of measurement in a variety of setups.

Conceivable enhancements would include multi-user profiles that would allow the system to monitor individual height data over time. This would be particularly useful for monitoring the growth of children, tracking fitness progress, or managing conditions that affect height, such as osteoporosis. Commercialization efforts could expand usage of the systems beyond hospitals to include gyms, schools, airports, or any environment where quick and accurate height measurements are valuable. All in all, these future directions offer a roadmap for further enhancement of versatility, user-friendliness, and applicability in varying environments.

Conclusion

The development of ultrasonic sensors for height measurement offers advances in clinical techniques for height measurement. The system represents a huge leap into clinical measurement technology answering challenges such as accuracy, efficiency, and hygiene. With the application of ultrasonic sensors, WiFi integration, and Arduino automation, the system is capable of providing the height measurement with an error of ±0.5 cm, easily replacing traditional methods. Contactless technology is part of the new healthcare priority, reducing the risk of cross-contamination while enhancing time efficiency for data recording through automatic wireless data transmission. These results show that this system performs better than manual stadiometers, especially in high-traffic clinical environments due to reduced human error and optimized workflow. Future improvements that include the addition of further biometric measures, machine learning error correction, and integration into EHRs might further improve its power and applicability to a range of sectors, from healthcare to fitness and remote monitoring. This innovative solution stands not only as an indication of progress in sensor technology but also forms the very foundation for the wide-scale adoption of contactless systems in modern health care.

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