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Autonomous Robot with Artificial Intelligence for Taking Health Constants

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Abstract

Health facilities are generally short-staffed and overworked. This has a significant impact on the reliability of the acquisition of health constants required at the start of diagnosis. Manual acquisition and transmission of these constants and other data leads to delays in the execution of successive care-related tasks. What's more, the quality of service is sometimes compromised by a lack of communication between patients and staff. In pediatrics, this is compounded by the difficulty of diagnosis in the face of children's silence, intimidated by the hospital environment. Technological assistance would relieve healthcare staff of the need to perform certain repetitive tasks. The solution proposed in this document studies a robot, based on electrical, electronic, computer and artificial intelligence resources, with human-machine interaction for taking vitals and health data in health facilities. This system enables height, mass and temperature to be taken autonomously and without contact. The algorithm we've developed uses artificial intelligence to check the conditions for correct measurements, both bareheaded and barefoot. This solution also alerts you to epidemic trends such as obesity. This health data is made available in the healthcare facility on terminals such as tablets, smartphones and computers used by nursing staff. This work will help healthcare staff to take automatic health vitals without contact, and to acquire and circulate data via a computer network.

Keywords

Health Constants, Instrumentation, Mechatronics, Arduino, Cloud, AI

1. Introduction

Over the coming decades, Africa's population is set to grow considerably, reaching 2.489 million by 2050 [1]. This will increase the demand for healthcare services.

In Senegal, the population coverage rate for health services is below the standards set by the health map. For health centers, the ratio is 149,455 inhabitants, whereas the standard is set at 88,000 inhabitants. While for hospitals, the ratio is 402,777 inhabitants, *i.e.* above the average standard of 300,000 inhabitants. However, the situation at health posts is less worrying, with a ratio of 9667 inhabitants per health post, close to the norm of 10,000 inhabitants for urban health posts [2]-[7]. This explains the work overload of practicing health staff, particularly orderlies. Whose qualifications need to be improved, will have an impact on the reliability of the collection of vitals and health data required at the start of diagnosis. Manual collection and transmission of these data, including health constants, leads to delays in subsequent care tasks.

To deal with these situations, the use of innovative solutions such as mechatronics, information and communication technologies will help to achieve Universal Health Coverage. The development of digital health represents an extraordinary opportunity for Senegal. It will make healthcare provision more efficient and reduce costs [8]. As an example, Canada has achieved a return on investment of $16 billion over a 9-year period. Researchers have proposed a number of solutions to improve the monitoring of vital parameters and patient management: using innovative technologies such as contactless measurement of cardiac activity [9], the collection of vital parameters from the moment of emergency admission [10], the use of connected health devices [11] and the application of artificial intelligence to predict hospital length of stay [12].

We are proposing a technological solution to improve the quality of healthcare services by integrating artificial intelligence into a mechatronic device. This solution, a robot, will enable nursing staff to autonomously acquire patient vitals and other health data, with verification of correct measurement conditions. In addition, the robot will interact with patients, including children, to obtain additional relevant data. The aim is to enhance the quality of healthcare delivery by using the advantages of artificial intelligence and automation in healthcare facilities.

2. Materials and Methods

The robot is made up of a number of interconnected components as shown in **Figure 1**. Its main component is a central computer responsible for managing the processing of data received via an electronic acquisition card, which is associated with sensors and actuators. It is also equipped with a screen for interacting with users and displaying acquired data.

2.1. Main Computer

The computer plays an essential role in the system's operation, processing information and controlling the robot. As the robot is equipped with sensors and

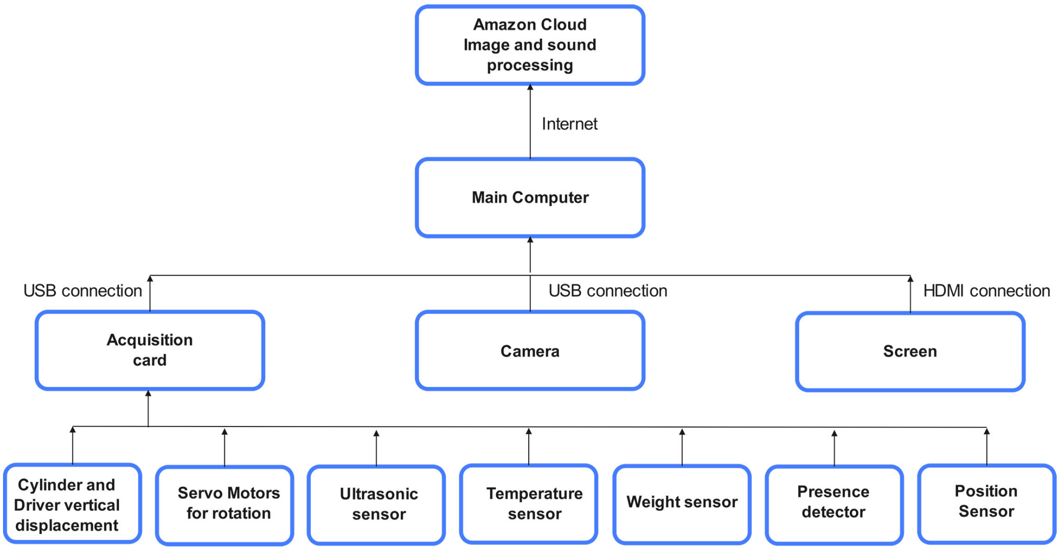


Figure 1. Architecture of the health monitoring system.

actuators. It collects information on its external environment, which the computer can then analyze and decide which tasks to perform according to the algorithm designed. Pre-processed data is sent to the cloud for processing with artificial intelligence to offer finer, more precise data analysis, thanks to machine learning. The computer also controls actuators such as motors and cylinders to enable the robot to perform tasks precisely and synchronously.

Communication with users is also ensured through user interfaces such as the screen and speech controls.

2.2. The Acquisition Board

The acquisition board used in this project is an Arduino board featuring complementary components that facilitate programming and connection with other circuits. It can be programmed to perform a variety of tasks, such as controlling a robot. It is used here to acquire sensor data (presence. temperature. weight. size) and control electronic components such as motors and visual and audible signals. Figure 2 illustrates the connection of the inputs and outputs of the electronic card.

2.3. Display Screen

A graphical user interface developed in Python is displayed on the screen, enabling the user in front of the machine to view his constants after the robot has acquired his data.

2.4. The Camera

The camera is used to take photos of the person's head and feet, so that the robot can retrieve this data and check whether the person is wearing a hat or shoes, providing a more accurate measurement.

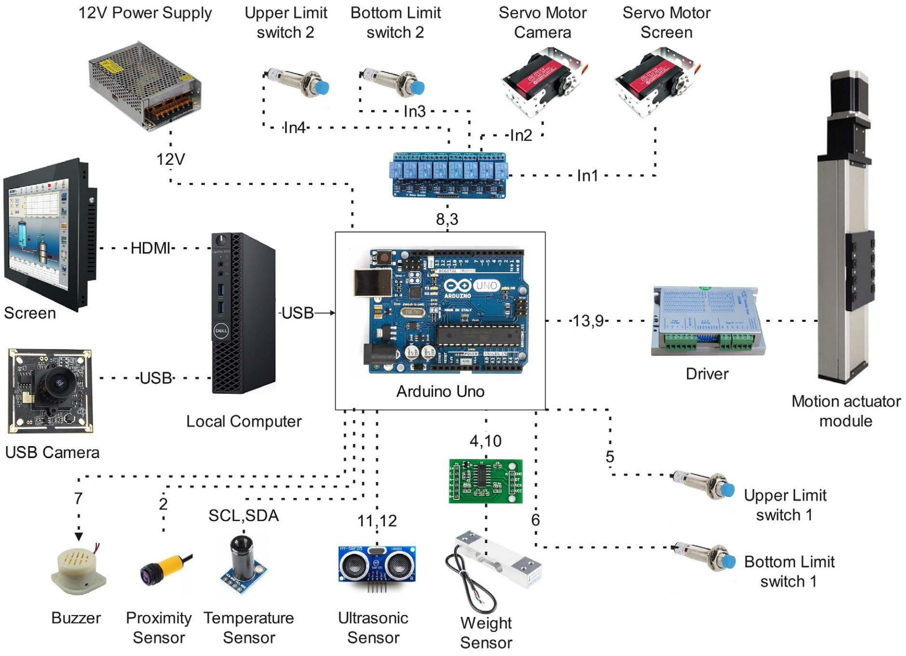


Figure 2. Overall view of the robot with PCB addressing.

2.5. Sensors and Actuators

2.5.1. The Ultrasonic Sensor

Often used to measure distances between various types of objects. The ultrasonic sensor is used in this project to measure the height of the person in front of the robot.

2.5.2. Servomotors

Two servo motors are used. The first is to rotate the screen from the rest position to the display position. The second is used to rotate the camera to check whether a hat or shoe is being worn.

2.5.3. The Temperature Sensor

This sensor enables non-contact temperature measurement.

2.5.4. Position Sensors

Position sensors are used to detect the cylinder's end-of-stroke position, in order to prevent jamming or damage to the equipment. Two of these sensors are connected to the Arduino board for automatic end-of-stroke detection, while the other two are connected directly to the cylinder's power supply for the emergency end-of-stroke stop function.

2.5.5. Presence Detector

This detects the user standing in front of the machine, triggering the measurement process.

2.5.6. The Mass Sensor

Frequently used in weighing applications, it is capable of accurately measuring the mass of any person standing on the load cell. In fact, this device is capable of detecting the pressure exerted by the object placed on it and converting it into a numerical value representing the mass.

3. Results and Discussion

3.1. The Health Vitals System

The robot was set up using Python programming to manage data, the graphical user interface, the acquisition of sensor values, and the control of actuators and signaling. The flowcharts below illustrate the sequence of instructions to be followed to control the robot.

The preceding flowcharts describe the operation of the robot, starting with the configuration of the graphical interface and the inputs and outputs of the Arduino board. When a person appears in front of the robot, he or she is detected by a presence sensor, and the robot then acquires a measurement of his or her height using an ultrasonic sensor. After acquiring the height, the robot rotates the screen from horizontal to vertical.

If it detects a hat twice, the robot returns to its initial position. Reading the message "Goodbye". The height measurement cannot be performed in the presence of a hat";

If not, it displays the measured height value on the screen, and a voice message asks the user to come closer for a better temperature reading.

The robot then retrieves the temperature and asks the user to step back to display the temperature on the screen. The camera rotates to take a picture of the feet to check for shoes and. as with the hat check, if shoes are present a voice message asks the user to remove his or her shoes. After two attempts, the robot reads the error message and returns to its initial position. If not, it recovers the weight, displays it on the screen together with the body mass index, and reads an audible message to give advice in relation to the index found. **Figure 3** & **Figure 4** illustrate the robot and the display screen respectively.

The robot consists of a computer (**Figure 5**), an Arduino board (**Figure 6**) and a display screen (**Figure 7**).

Figure 8 & **Figure 9** show the robot in front view, rear view and side views.

3.2. Comparative Study of Temperature Measurement Results Obtained with the Robot and a Thermo Flash

Table 1 presents the temperatures collected by the thermoflash and those taken by the robot according to the number of people. The results obtained made it possible to produce a graph in **Figure 10**.

Comparing the temperatures measured by the thermoflash and those taken by the robot. We note that the temperature measured by the thermoflash remains stable at 36.6˚C, while the temperature measured by the robot varies between 34.8˚C and 36.7˚C.

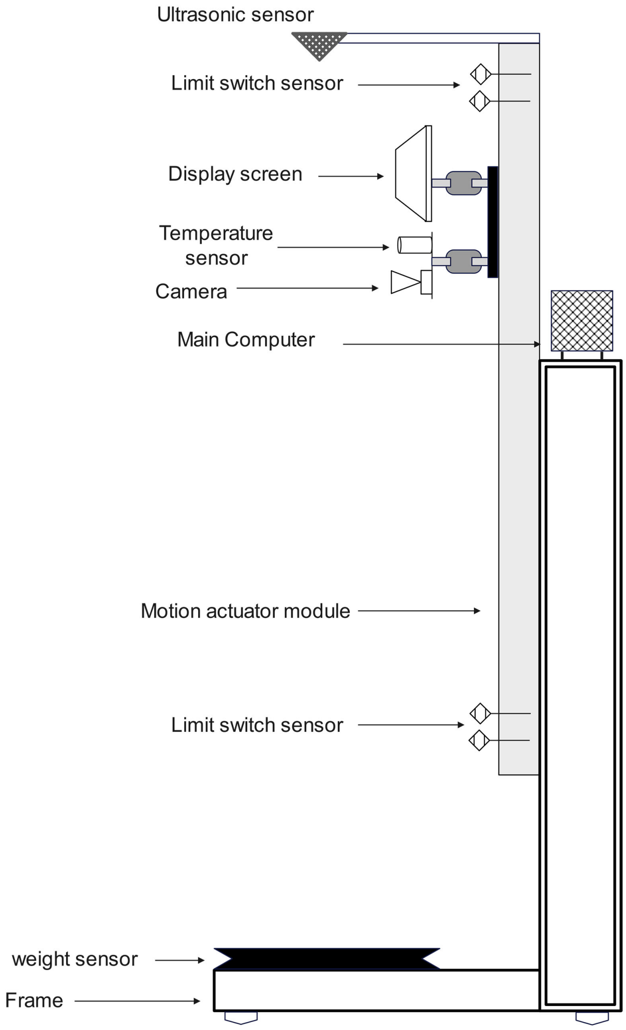
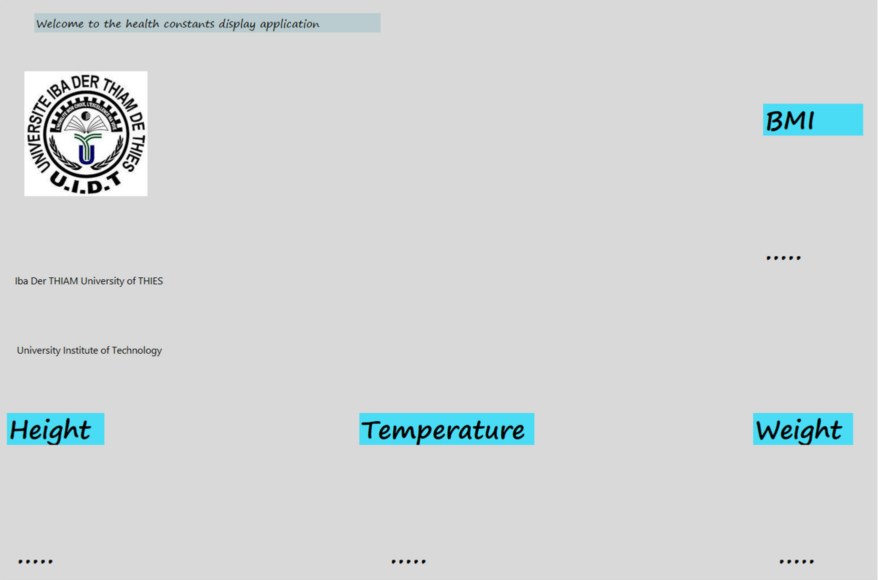


Figure 3. Illustration of the health constants recording system.



Welcome to the health constants display application

Iba Der THIAM University of THIES

University Institute of Technology

BMI .....

Height .....

Temperature .....

Weight .....

Figure 4. Example of screen display.

Table 1. Temperature measurement.

Person number	Temperature measured with thermo flash (˚C)	Temperature measured with robot (˚C)
1	36.6	36.6
2	36.6	36.6
3	36.6	35.8
4	36.6	36.7
5	36.6	36
6	36.7	36.2
7	36.7	36.7
8	36.7	36.7
9	36.7	35.1
10	36.7	35.5
11	36.7	34.8
12	36.7	36.2
13	36.7	36.4
14	36.4	36.4
15	36.2	36.7
16	36.7	36.7
17	36.5	36.5
18	36.4	36.3
19	36.4	36.4
20	36.4	36.5

Figure 5. Computer presentation.

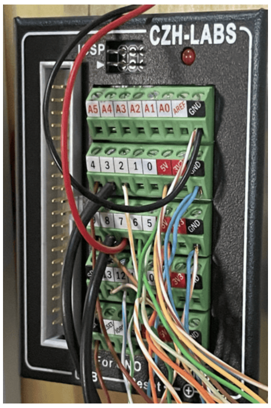


Figure 6. Introducing the Arduino board.

Figure 7. Display presentation.

Figure 8. Front view of robot.

Figure 9. Side view 1 of robot.

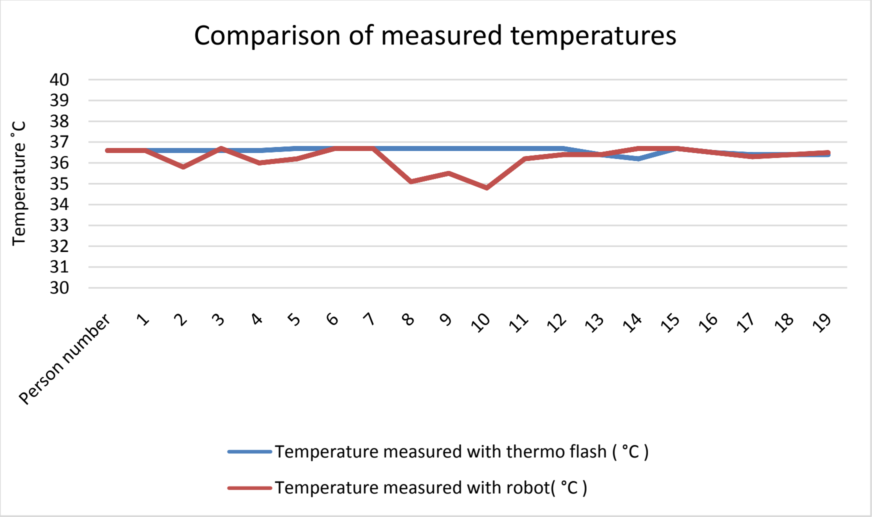


Figure 10. Temperature according to number of people.

This may be due to a number of factors, such as the measurement location, the person's posture, environmental conditions and so on. On average, the robot measures a temperature that is 0.36˚C lower than that measured by the thermoflash. The difference between the two measurements is 0.43˚C, giving a percentage of 1.18%. This percentage is relatively low, suggesting that the robot is relatively accurate compared with the thermoflash. This means that the robot's measurements are generally very close to those of the thermoflash. In summary, although the above measurements suggest that the robot could be used in place of the thermoflash in a hospital setting. A thorough evaluation of its accuracy and reliability under hospital-like conditions is needed for possible improvements to the instrumentation developed.

3.3. Comparative Study of Mass Measurement Results Obtained with the Robot and a Balance

Table 2 provides the scale mass measurements as well as the robot mass measurements taken by the robot. Figure 11 gives the graphical representation of the results obtained.

Comparing the mass measurements of the scale and the robot, we can see that for most people the mass measured by the robot is very close to that measured by the scale. However, there are some differences, particularly for person number 16. On average, the robot measures mass with 99% accuracy compared to the scale.

Table 2. Mass measurement.

Person number	Weight measured by the scale (kg)	Mass measured by the robot (kg)
1	70.8	70.6
2	96.5	96.1
3	70	69.9
4	63	62.7
5	73.5	73.1
6	76.2	75.9
7	52.1	51.8
8	61.8	61.7
9	59.6	59.4
10	48.5	48.9
11	73	72.5
12	60.3	60
13	74.7	74.8
14	75.1	74.69
15	48.9	48.85
16	57.1	56.56
17	54	53.5
18	85	85
19	62.3	61.97
20	57.8	57.95

3.4. Comparative Study between Size Measurement Results Obtained with the Robot and Conventional Methods

Table 3 presents the height of the people made by the robot and the measurements obtained using a tape measure. The results obtained are shown in **Figure 12** illustrated.

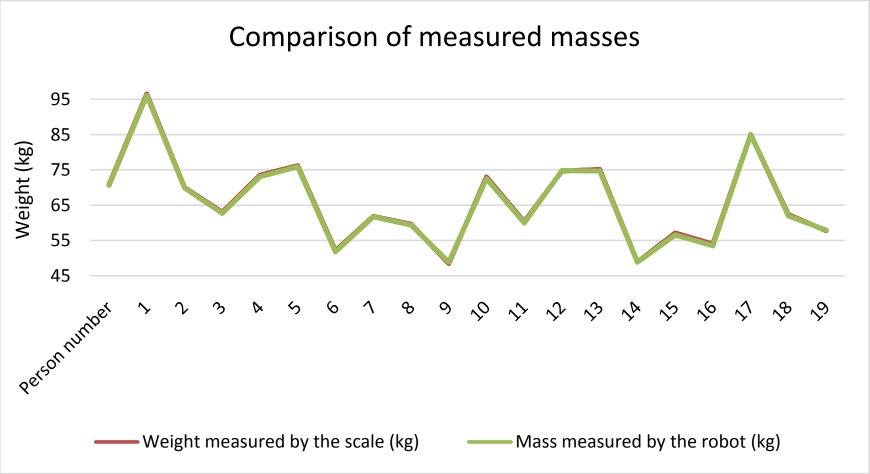


Figure 11. Mass as a function of the number of people.

Table 3. Size measurement.

Person number	Size measured with a decameter (cm)	Size measured by the robot (cm)
1	180	180
2	180	180.1
3	180.5	180.8
4	173.6	174.2
5	186.6	186.2
6	197.3	196.1
7	169.7	170.2
8	175	175.3
9	174	175.5
10	158.8	158.7
11	167	167.6
12	182.7	182.2
13	184	184.2
14	168.5	169
15	161.5	160.5
16	172.1	172.3
17	164.3	164.5
18	188.7	188.4
19	193	192.6
20	171.4	171.6

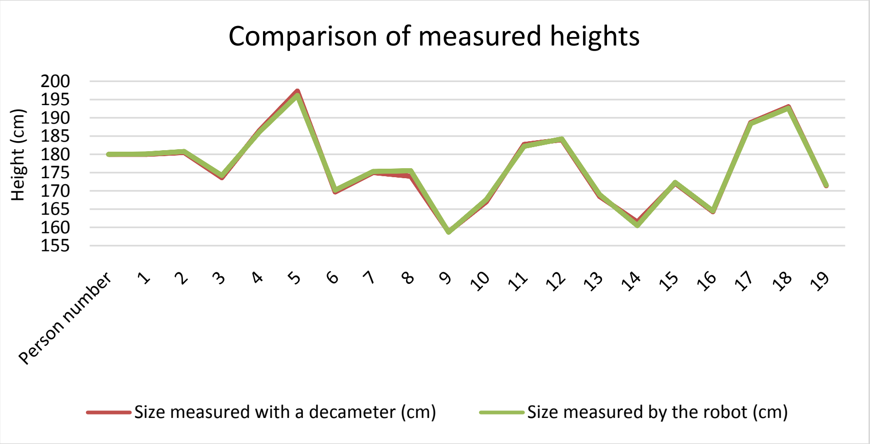


Figure 12. Size according to number of people.

If we compare the height measurements taken by the robot with those taken by a decameter. We can see that most of the measurements are relatively close. However, some of the robot's measurements are slightly higher or lower than those of the decameter.

Overall, we can say that the measurements taken by the robot are relatively accurate compared with those taken by a decameter. Measurements taken by the robot are on average within 0.5% of those taken by the decameter. This accuracy is generally considered quite well for most practical applications.

4. Conclusion

The workload of healthcare staff and the reliability of the collection of health constants required at the start of diagnosis represent a major challenge for healthcare facilities in Senegal. The use of innovative technological solutions, such as artificial intelligence integrated with electronic systems, can help improve quality in healthcare facilities. The proposed solution enables autonomous, contactless acquisition of health constants, verification of correct measurement conditions, and fast, efficient data transmission via a local network. The introduction of this technological solution in Senegalese healthcare facilities could be beneficial for enhancing the quality of healthcare and improving the efficiency of healthcare provision, although it will be necessary to improve the accuracy of measurements and also ensure the security of personal data taken by the robot.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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