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New methodology to detect the effects of emotions on different biometrics in real time

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ABSTRACT

Recently, some problems have appeared among medical workers during the diagnosis of some diseases due to human errors or the lack of sufficient information for the diagnosis. In medical diagnosis, doctors always resort to separating human emotions and their impact on vital parameters. In this paper, a methodology is presented to measure vital parameters more accurately while studying the effect of different human emotions on vital signs. Two designs were implemented based on the microcontroller and National Instruments (NI) myRIO. Measurements of four different vital parameters are measured and recorded in real time. At the same time, the effects of different emotions on those vital parameters are recorded and stored for use in analysis and early diagnosis. The results proved that the proposed methodology can contribute to the prediction and diagnosis of the initial symptoms of some diseases such as the seventh nerve and Parkinson's disease. The two proposed designs are compared with the reference device (beurer) results. The design using NI myRIO achieved more accurate results and a response time of 1.4 seconds for real-time measurements compared to its counterpart based on microcontrollers, which qualifies it to work in intensive care units.

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1. INTRODUCTION

As information technology and medical discoveries advanced, it became vital to combine the two in order to improve the quality of medical services supplied to patients. So, Brucal *et al.* [1] developed a portable electrocardiogram (ECG) device based on National Instruments (NI) myRIO 1900. The NI LabView program was used to develop a graphical interface to facilitate reading and analysis of the results of the proposed device. The results proved that the proposed system achieved an accuracy rate of 90.68% compared to other devices available in the local market. The researchers also confirmed that the system can be used in remote places that are difficult for doctors to reach due to its portable design. Eesee [2] conducted a galvanic skin response (GSR) study to monitor the agitation and tension of a group of volunteers and analyze the GSR signal while performing a walking exercise on the treadmill. The results and statistical analyzes showed that using pictures only as an emotional stimulus did not give the desired results [2]. Karanchery and Palaniswamy [3] have worked to provide a solution using machine learning technology to help healthcare providers deal with individuals with autism spectrum disorders. A machine learning model is designed that uses emotional data captured for individuals to identify and display emotions. The accuracy of the model reached (99.8%) with a total of 125 training images. Azgomi *et al.* [4] create a simulation environment to study the state of kinetic stress in a closed motion method using GSR. An easy filter was used for diagnosis and analysis. The results confirmed that the proposed structure is an initial step for diagnosing cognitive disorders related to the state of the brain. Satti *et al.* [5] used GSR to collect data for a group of volunteers to study and analyze stress patterns based on a learning model. The results proved that the accuracy of the analysis reached (63.39%) compared to similar models. The proposed model also achieved an increase in the rate of class recall to determine stress, which reached (27.08%). Hanoon and Aal-Nouman presented an internet of things (IoT) application connected to a low-cost health monitoring device. The proposed device for health monitoring depends on the Arduino to measure the heart rate and the level of oxygen saturation in the blood [6].

Some patient health monitors relied on Arduino UNO, Arduino NANO, Raspberry pi, and PIC16f877 as a processor for these systems. Advanced technologies were used to transfer data from patients to doctors in hospitals and patient's relatives. Where Xbee used a short message service (SMS) to send data to doctors. The data was processed in real-time using LabVIEW. Some researchers also tried to use and repurpose these systems to measure vital parameters in other similar research [7]–[13]. Previous research relied on designing systems using Arduino and some sensors to measure vital parameters. Data is transmitted over the IoT and machine learning and fuzzy logic techniques are used to analyze different data. Most of these systems help to notify physicians as quickly as possible of a patient's medical condition and past medical history. Various technologies are used to transmit information such as Wi-Fi and GSM. The researchers did not address the impact of positive and negative emotions on these measurements [14]–[25].

Lubis *et al.* [26] presented a model that relies entirely on industrial intelligence to assess the implementation of laws and study caliphs and the principles based on the assessment of crimes. The study proved that the model is effective as a first model in the same matter, and the researchers recommend an evolution. Ibrahim *et al.* [27] Create a graphical interface to characterize the respiratory conditions of the respiratory system. LabView program was used to create the graphic interface with the addition of a software algorithm that receives data from a set of sensors. The proposed model has proven effective in measuring lung parameters with high accuracy and is connected to 81.1%. Hutagalung *et al.* [28] provided a cumulative analysis of the performance of family planning trainers and analysis of the factors supporting improving their work performance. Use in the analysis of more than one ready statistical model dependent on the machine learning algorithms. The results of the analysis using ready-made algorithms were almost satisfactory and showed effectiveness in assessing cumulative performance. Despite the efforts of the aforementioned researchers, they did not address the development and design of low-cost devices that work in the actual time to monitor the health condition or performance analysis. None of the researchers presented how to remove the chosen receiving signals and did not provide an automatic learning model that enables prediction or diagnosis.

This paper describes two designs implemented using microcontrollers and myRIO from National Instruments Corporation. By these two designs, four parameters (temperature-heartbeat-blood pressure-body resistance) are measured in real-time. Relying on the heart rate sensor, blood pressure sensor, temperature sensor, as well as GSR sensor, the results are recorded and saved to analyze people's feelings. A database is established for more than four hundred people who are tested, ranging in age from 3 to 72. The people are exposed to a set of short videos and some music representing different emotional states (anger, sadness, happiness, fear, neutrality). At the same time, the change in their vital readings is recorded. This paper contributes to diagnosing the initial symptoms of some diseases such as (Seventh nerve-Parkinson's) by analyzing people's feelings and their impact on vital readings. The indicated contributions are presented in several sections where electronic circuits designed for the proposed devices using microcontrollers and myRIO are explained in section 2. The results and decision-making are presented in section 3. Conclusions and future work are described in section 4.

2. METHOD

2.1. Research significance

The main contribution of this paper is to design an integrated mobile system for actual time. This paper addresses previous problems, as it provides a lower financial cost system, efficiency, and high measurement accuracy. The research methodology presented contributes to providing a sufficient study on the effect of human feelings on vital parameters while providing a learning model capable of diagnosis and classification based on these data.

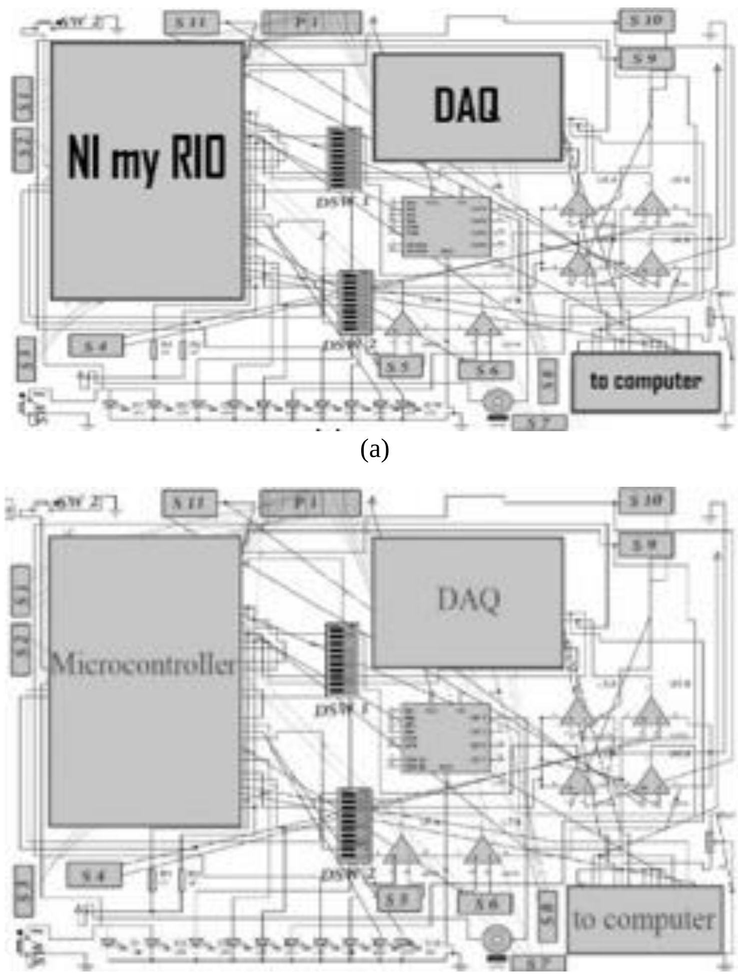
2.2. Functional scheme

Two designs are built based on a microcontroller (ATMEGA 16) and NI myRIO using different sensors to measure vital parameters of patients. Figure 1 illustrates the components used in these designs: i) pulse sensor to measure heart rate, ii) a galvanic skin response sensor that detects changes in body posture via the skin, iii) a thermometer to measure body temperature, and iv) blood pressure sensor BMP085 to measure blood pressure (systolic-diastolic). After measuring the vital signs of the patients, the measured data is sent to the computer for analysis using the MATLAB program. To provoke certain emotions, test participants are given brief videos and photographs. Anger, sorrow, happiness, fear, and neutrality are among the five emotions represented by the five videos. Each of the videos utilized in this study reflects a distinct emotional state. It also shows five groups of pictures to everyone, each representing a distinct feeling. Each group of photos has 50 photographs depicting a certain feeling. Vital data (temperature, heart rate, blood pressure, and body resistance) are monitored at the same time as the photos and videos are shown. The MATLAB application saves and analyses the data for use in forecasting and early detection.

2.3. System circuits

Figure 2 shows a circuit of the proposed system. The circuit diagram is designed with the aid of easy. This algorithm is important to handle the drawing of big circuits like in our case. Let's go to describe the details of each one of the designs in Figures 2(a) and 2(b). The first design using NI myRIO connected to the aforementioned sensors to measure heart rate, blood pressure, body temperature, and skin resistance as shown in Figure 2(a).

Figure 1. The design structure's block diagram



(a)

(b)

Figure 2. A circuit of the proposed system (a) design one using NI myRIO and (b) design two using microcontroller

NI myRIO is a tool that allows the use of real-time (RT) and field-programmable gate array (FPGA) capabilities. The main reason for choosing this board is that two of its most important features are the two analog outputs connected to the ground, which allow communication with countless sensors and devices and programmable control of the systems. A data acquisition board (DAQ) is linked to convert analogue waveforms to digital values and to eliminate noise from measurements. An array of light-emitting diodes (LEDs) is used in the circuit to indicate the reading on the liquid-crystal display (LCD) screen. Green lights indicate normal, yellow indicates medium, and red indicates dangerous. At the same time, the readings appear on the LCD screen, then the readings are sent to the computer for analysis. All sensors are connected to amplifiers to amplify the measured signals. The pulse sensor (S1) is a medical sensor used for non-invasive heart rate monitoring. The pulse sensor responds to relative changes in light intensity by reflecting light from the sensor’s built-in green LED during each pulse. The galvanic skin response (GSR) sensor (S2) is used to determine how much change there is in electrical resistance values. The sweat glands are controlled by the human body’s nervous system, so when a person experiences strong emotional moments, the electrical resistance of the skin changes. The temperature sensor (S3) is used to measure the temperature of the human body. Blood pressure sensor BMP085 (S4) to measure (diastolic-systolic blood pressure). Measurements are sent in real-time to a computer to analyze the results and use them in early diagnosis and forecasting programs.

Figure 2(b) shows the second design using the ATmega328P microcontroller. This microcontroller is selected based on its availability in the local market and its ease of programming. Sensors used to measure patients’ vital parameters are connected to an amplifier to further amplify the received signal. The amplifier output of each sensor is connected to the analog-to-digital converter (ADC1) output control unit on the microcontroller. Sensors on the circuit are indicated by (S1-S2-S3-S4). Where S1 is an indicator of the heart rate sensor. S2 stands for the galvanic skin response sensor. The human body temperature sensor can be found under the symbol S3. The pressure sensor for measuring blood pressure is denoted by S4. The circuit is designed so that more than one sensor can be connected to it in the future. A set of LED lights are used to indicate the reading of the sensors. The lighting is green if the measurements are in the normal position. The mean average of the measurements is indicated by yellow illumination. The circuit gives a red-light warning when the measurements are at a critical level. All measurements are shown on an LCD screen connected directly to the microcontroller.

3. RESULTS AND DISCUSSION

In our research, participants are expected to watch brief movies and images to provoke specific emotions. Patients’ reactions are captured while they watch live films (5 videos), each representing one of the five main emotions (anger, sadness, happiness, fear, and neutrality). Each video is limited to 4 minutes in length, and all vital signs of the persons being evaluated are measured before, during, and after the exam. Each person being evaluated is shown five sets of images, each representing a different emotion. Each group of photos has 50 visuals depicting a certain feeling. Vital parameters (temperature, heart rate, blood pressure, and body resistance) are monitored at the same time. The MATLAB program keeps track of the results and analyses them for use in prediction and early detection systems.

3.1. Effect of emotions on blood pressure measurements

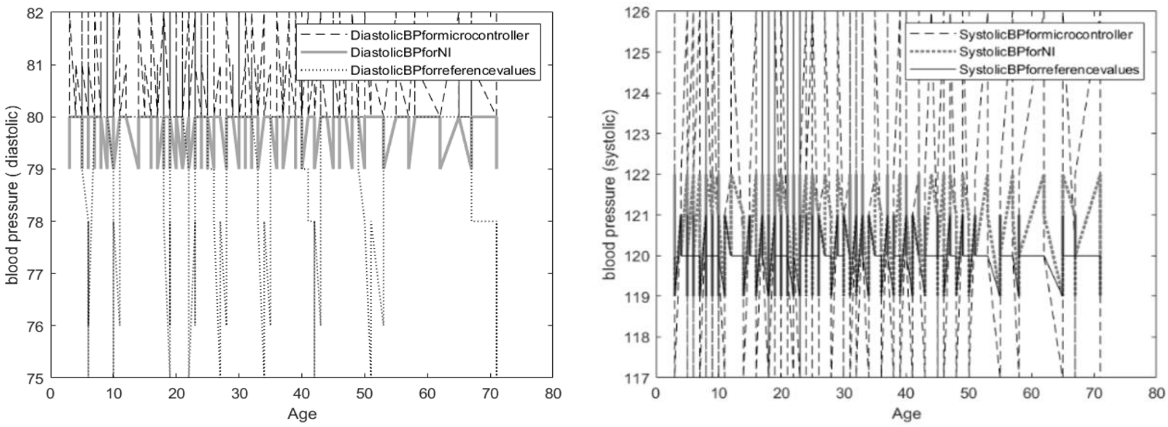
Table 1 presents the systolic and diastolic blood pressure data acquired using the three devices. The Table 1 shows the average results of blood pressure measurements for five moods. The resulting findings are compared to certified reference devices utilizing the created devices.

Table 1. Average blood pressure readings

	Systolic BP			Diastolic BP			Time(sec)			Emotion
AGE	NI	Micro-controller	Reference value	NI	Micro-controller	Reference values	NI	Micro-controller	Reference values	type
20	122	126	120	80	80	80	20	21	20	Neutral
60	121	121	121	80	80	80	20	25	20	(calm)
20	130	133	131	85	82	85	21	23	22	Angry
60	153	153	153	99	105	100	23	26	20	
20	113	113	113	75	75	75	23	26	20	Sad
60	99	98	98	70	70	70	20	25	23	
20	120	126	120	81	81	81	20	26	21	happy
60	120	120	120	80	81	80	19	23	21	
20	113	115	115	59	62	60	20	24	20	Fear
60	146	139	144	94	90	94	19	24	21	

Table 1 denotes a calm state, in which blood pressure measurements taken with the NI myRIO are close to those taken with the reference device. In the anger stage, the NI myRIO-based design delivers outcomes that are as near to the reference device. In the sad condition, the outcomes of the microcontroller-based design are comparable to those of the reference device. NI myRIO gives values that are remarkably close to the reference device readings in both the joyful and terror phases. Figure 3 shows the relationship between blood pressure measurements versus age using the proposed devices. The results of the reference device are shown by a dotted line, while the Dash-style font displays the design results based on the microcontroller, and the solid font style is used to separate the design results based on myRIO.

Figure 3(a) indicates that the myRIO design's normal-state diastolic blood pressure values are comparable to those of the reference device. Figure 3(b) illustrates that the systolic blood pressure measurements varied in rising and fall, despite the fact that the myRIO device generated essentially identical findings to the reference device.



(a) (b)

Figure 3. The relationship between BP and age using three devices (a) indicates that normal-state diastolic blood pressure and (b) indicates that normal-state systolic blood pressure

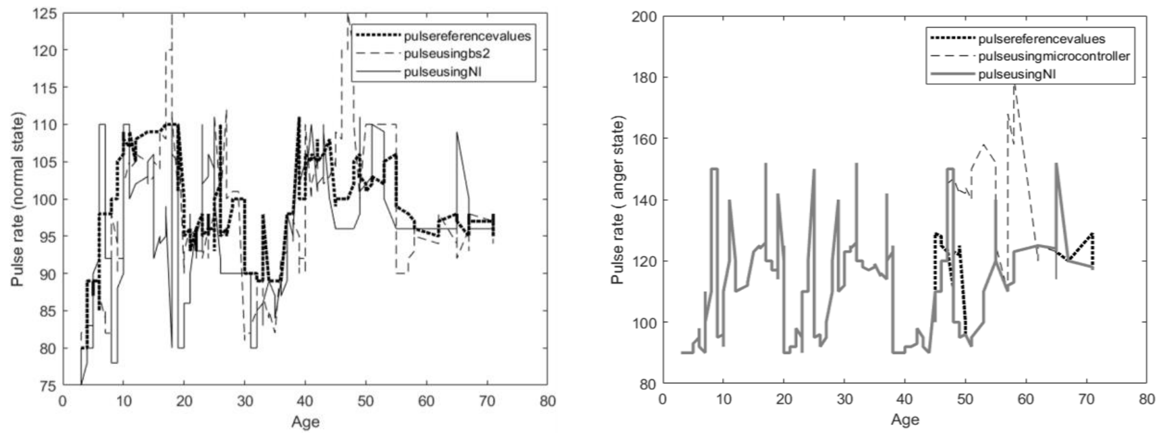
3.2. Effect of emotions on heart rate measurements

Table 2 presents the pulse rate data obtained from three devices. The data in the Table 2 are the averages of pulse rate measurements for five human emotions. It is noticed in Table 2 that the time taken to measure using myRIO is closer to the time taken to measure using reference devices. It is also noted that the device designed using the microcontroller gives a relatively long time to measure compared to the time taken to measure using the reference device. Table 2 also indicates the difference in heart rate readings across the three devices utilized for the measurement; nonetheless, the values obtained with the myRIO device are the most similar to the data obtained with the reference device.

Figure 4 depicts the graphical association between pulse rate and age in the normal and angry states of the three devices. The dot-style line represents the results obtained with the reference device, the dash style illustrates the results obtained with the microcontroller, and the solid-style results are obtained with the myRIO device. Figures 4(a) and 4(b) depict the shift in heart rate during normal and angry states, respectively.

Table 2. Estimates of average desired heart rate

Age	Heart Rate			Time (Sec)			Emotion type
	NI	Microcontroller	Reference Value	NI	Microcontroller	Reference Value	
20	80	75	80	20	21	20	Neutral (calm)
60	80	90	79	19	25	21	
20	95	96	95	19	20	20	Angry
60	101	95	99	20	26	20	
20	70	74	70	21	28	22	Sad
60	64	61	64	20	18	20	
20	83	80	80	19	19	20	happy
60	85	79	79	20	21	20	
20	95	92	95	20	21	20	Fear
60	105	100	100	20	21	20	



(a) (b)

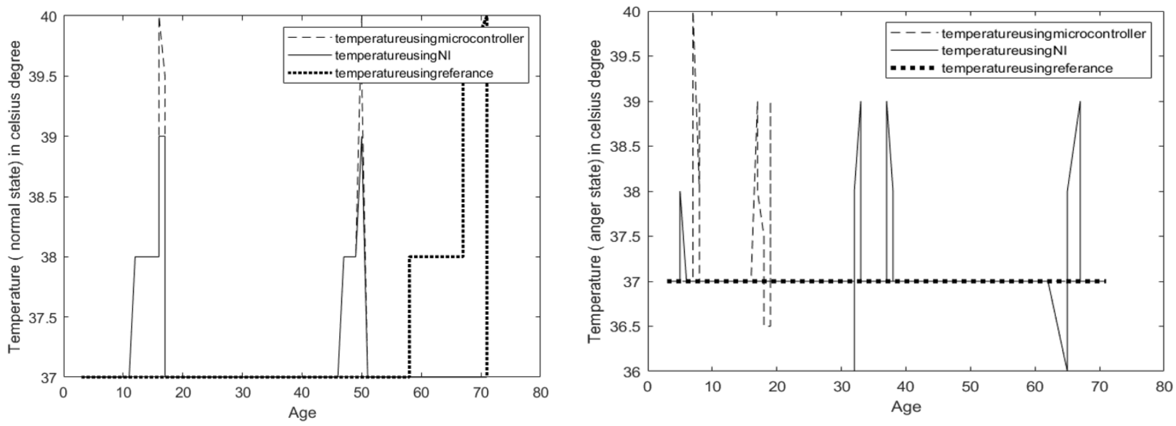
Figure 4. The relationship between pulse rate and age using three devices (a) heart rate during normal state and (b) heart rate during angry state

3.3. Effect of emotions on temperature measurements

Table 3 illustrates that there is a modest variation in temperature data as people's emotional states vary. The temperature change utilizing the three suggested devices is shown in this table. When the three devices were utilized, Figure 5 depicts the association between body temperature and age. The results of using the reference device are presented in the dotted line, while the results of using the microcontroller are shown in the dashed line, and the results of using the myRIO device are shown in the solid line. Figures 5(a) and 5(b) depict the temperature change in the normal and angry states, respectively.

Table 3. Body temperature on average readings

Age	Temperature measurements (degrees Celsius)			Time (Sec)			Emotion type
	NI	Microcontroller	Reference Value	NI	Microcontroller	Reference Value	
20	36.6	36.9	36.5	60	60	60	Neutral (calm)
60	37.1	36.6	37	60	60	60	
20	37	37	37.5	60	60	60	Angry
60	37	37.1	37	60	60	60	
20	36.4	36.1	36.5	60	60	60	Sad
60	36.6	36.6	36.6	60	60	60	
20	37.1	37.2	37	60	60	60	happy
60	37.3	37	37.2	60	60	60	
20	36.3	36.5	36.3	60	60	60	Fear
60	36	36.3	36.1	60	60	60	



(a) (b)

Figure 5. Relationship between body temperature and age using three devices (a) temperature in normal state and (b) temperature in angry state

3.4. Effect of emotions on GSR measurements

Because the GSR signal has a low frequency (2 Hz), we employed a low-pass filter to eliminate any noise. An Op-amp is a buffered signal that is used to convert high impedance to low impedance. The voltage across the resistance of the body is:

$$\mathrm{Va} = 50\mathrm{M}\Omega/(50\mathrm{M}\Omega + \mathrm{R6})\ \ \mathrm{Vi} \tag{1}$$

which the output voltage is:

$$\mathrm{Vo} = \mathrm{R4}/\mathrm{R3}\ (\mathrm{Vref} - \mathrm{Va}) + \mathrm{Vref} \tag{2}$$

The (1) depicts the connection between the voltage flowing through the resistance of the human body (*Va*) and the input voltage (*Vi*). The connection between the output voltage (*Vo*) and the reference voltage (*Vref*) is depicted in (2). Table 4 demonstrates how the resistance value (R6) and voltage values (*Va*) and (*Vo*) alter depending on the person's emotional state. Table 4 shows that the value of R6 grows as the value of *Va* drops. As indicated in Table 5, the statistical analysis approach is utilized to determine the correctness of the various findings obtained from the reference device and devices suggested in this work.

The proposed machine learning model depends on data for training, learning, and improving accuracy over time. A set of vital data available internet medical web [29] is used as an input to train the model. When using the form to decide the actual time, the model compares the new inputs with the inputs stored during training, and the decision is extracted with the highest accuracy possible. And to get the best performance of the proposed form and the highest accuracy of the diagnosis, a set of algorithms was tried and know what is best. Figure 6 shows the method of designing the proposed learning program.

Table 4. Emotional changes in Va and Vo

Age	R	Vo	Va	Emotion
20	1.00E+05	0.291	4.993	neutral
60	3.80E+05	0.812	3.992	
20	6.10E+05	0.664	3.942	angry
60	1.30E+06	0.881	3.767	
20	2.60E+06	0.983	3.197	sad
60	5.80E+06	1.667	2.743	
20	2.00E+07	2.141	2.083	happy
60	3.80E+07	2.551	1.677	
20	6.60E+05	0.464	3.642	fear
60	1.00E+06	0.581	3.467	

Table 5. Statistical analysis of average measured data

Parameters	Heart rate			Blood pressure (diastole)			Blood pressure (systolic)			Temperature		
	Ref device	NI	Micro	Ref device	NI	Micro	Ref device	NI	Micro	Ref device	NI	Micro
Min	75.1	75.3	76	81.5	80	82	75.5	76	76.6	77.3	77	78
Max	97.5	98	98.5	94	95	96	98.1	98	99	99	99	98.5
Mean	86	85.3	85.9	87	86.9	86.9	86	87	86.5	87	87.5	86.2
Median	86	85.9	86.5	87.5	88	89.6	87	86.5	85.2	88	88.7	88

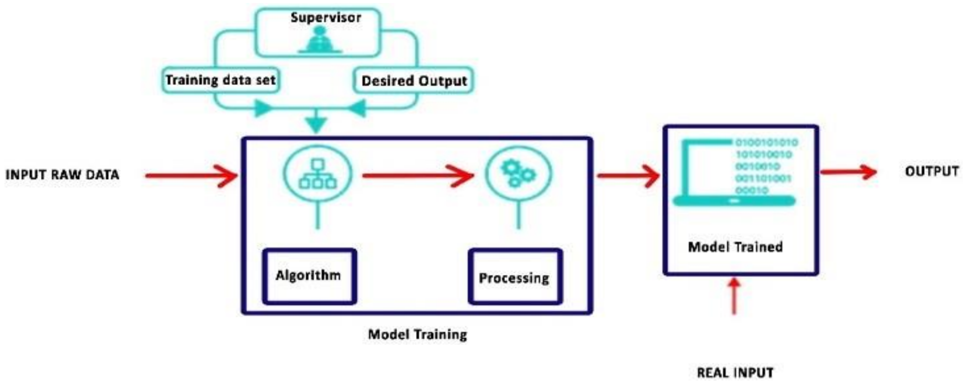


Figure 6. block diagram of proposed machine learning training steps

The machine learning model is designed to diagnose all possible medical conditions that may arise depending on the type of data that is entered. The proposed form was also tested using several algorithms. The model passes two stages when created, the first stage is the use of a well-known diagnostic data set and predictions. The second stage is using real data, and the outputs are a diagnosis or expectation of these data produced by the proposed form automatically. Table 6 shows the algorithms used with the accuracy and efficiency of each of them. Five algorithms were tested to build the proposed system (naive Bayes (NB), k-nearest neighbors (KNN), supportive vectors (SVM), random forest (RF), and simple logistical decade (SL)).

Table 6. Performance of five algorithms

Criterion	NB	SVM	RF	SL	KNN
Accuracy	91.54%	94.62%	92.88%	92.72%	89.89%
Sensitivity	88.50	95.10	95.00	94.22	86.32
F-score	87.30	96.22	94.20	95.01	87.75

4. CONCLUSION

It is clear from the results of the tests; Some important conclusions, as the proposed design using NI provides a lower error rate than the microcontroller design. The statistical analysis of the results also showed that the results of the proposed device using NI are close to reference readings, although there are 1.4 seconds delay in showing the results. The design based on myRIO can be considered a reliable device by recording readings in actual time and is very suitable for use in intensive care and can be used as a first aid tool in accidents or distant places. The proposed machine learning model gives accuracy and effectiveness to use the diagnosis of some diseases such as COVID-19 and some heart diseases and muscle neuropathy.

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