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Design and Implementation Accurate Three Distance Sensors Device Using Neural Network

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Keywords:
Dataset; Distance; IR Sensor; Neural Network; Ultrasonic Sensor.

Highlights:

- *Dataset prepared from three sensors using MATLAB.*
- *Implementation of accurate distance device using on-line fast proposed NN structure.*
- *This device has two HC-SR04 ultrasonic and one SHARP GP2Y0A21YK0F IR sensors.*
- *This device was implemented for use in robotic and radar applications to detect object with accurate distance.*
- *MATLAB 2018b was interfaced with Arduino.*
- *Validate's performance was 0.0036122 with 100% fitting.*

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Abstract: This paper suggested and created a proposed device for sensing an accurate distance from 5 to 400 cm with three sensors using the proposed on-line Feedforward Backpropagation Neural Network (FFBPN). Firstly, preparing a dataset (distances) with two distances utilizing Arduino and measured distance calculated from three sensors (2 ultrasonic and 1 IR). Secondly, target distances are calculated from the ground manually using a distance tape tool. Thirdly, interfacing Arduino and MATLAB using USB easily saved datasets from Arduino directly to MATLAB, then training, and testing data. The proposed device divides reading distances into three distances, getting from three sensors to get accurate distances. The first reading was 5-10 cm from down ultrasonic sensor 3. The second reading was 10-80 cm from middle IR sensor 2. The third reading was 80-400 cm from up ultrasonic sensor 1. The dataset was created and improved using the suggested FFBPN to create a very accurate distance gadget with three sensors. A suggested FFBPN consisted of 3 layers: The first input measured distance layer (from 3 sensors), the second hidden layer with ten neurons, and the third output layer distance. The numerical results showed that the proposed distance device was significantly accurate due to regression result R=1 using the proposed Neural Network (NN), which meanings that the device had 100% fitting. It had the best validation performance in 464 epochs, i.e., is 0.0036122. Furthermore, the proposed on-line FFBPN was fast because the training time equals three seconds. This distance device was implemented for use in robotic and radar applications to detect objects accurately because this device successfully detects near and far objects.

تصميم وتنفيذ جهاز دقيق بثلاثة حساسات مسافة باستخدام الشبكة العصبية

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الخلاصة

اقترح هذا البحث وتم إنشاء جهاز جديد لتحسس مسافة دقيقة من ٥ إلى ٤٠٠ سم مع ٣ أجهزة استشعار باستخدام الشبكة العصبية ذات الانتشار العكسي Feedforward Backpropagation (FFBPN) المقترحة اونلاين. أولاً، إعداد مجموعة بيانات (المسافات) بمسافتين باستخدام الاردوينو وقياس المسافة المحسوبة من ٣ أجهزة استشعار (٢ بالموجات فوق الصوتية و١ IR). ثانياً، يتم حساب مسافات الهدف من الأرض يدوياً باستخدام أداة شريط المسافة. ثالثًا، ربط Arduino وMATLAB باستخدام مجموعات البيانات المحفوظة بسهولة عبر USB من Arduino مباشرة إلى MATLAB ثم التدريب واختبار البيانات. يقوم الجهاز الجديد بتقسيم مسافات القراءة إلى ٣ مسافات ابتداء من ٣ حساسات للحصول على مسافات دقيقة. تراوحت القراءة الأولى من ٥ إلى ١٠ سم من مستشعر الموجات فوق الصوتية ٣. تراوحت القراءة الثانية من ١٠ إلى ٨٠ سم من مستشعر الأشعة تحت الحمراء الأوسط ٢. تراوحت القراءة الثالثة من ٨٠ إلى ٤٠٠ سم من مستشعر الموجات فوق الصوتية ١. تم إنشاء مجموعة البيانات وتحسينها باستخدام اقترح FFBPN إنشاء جهاز مسافة دقيق للغاية ب ٣ أجهزة استشعار. يتكون FFBPN المقترح من ٣ طبقات: طبقة المسافة المقاسة للمدخل الأول (من ٣ أجهزة استشعار)، والطبقة المخفية الثانية التي تحتوي على ١٠ خلايا عصبية، ومسافة طبقة الإخراج الثالثة. أظهرت النتائج العددية أن جهاز المسافة الجديد دقيق للغاية بسبب نتيجة الانحدار R = 1 باستخدام الشبكة العصبية (NN) المقترح مما يعني أن الجهاز مناسب بنسبة ١٠٠٪. يتمتع بأفضل أداء للتحقق في ٤٦٤ حقبة وهو ٠,٠٠٣٦١٢٢. علاوة على ذلك، فإن FFBPN الاونلاين المقترح سريع لأن وقت التدريب يساوي ٣ ثوانٍ. وساهم هذا الجهاز في استخدام تطبيقات الانسان الالي والرادار لكشف الأجسام بمسافة دقيقة وذلك بسبب هذا الجهاز يتحسس الاجسام القريبة والبعيدة بنجاح.

الكلمات الدالة: البيانات، المسافة، متحسس IR، الشبكة العصبية، جهاز الاستشعار بالموجات فوق الصوتية.

1.INTRODUCTION

Sensor technologies have made daily life better for people. The design of the response is based on the data collected by sensors, which are tools used to detect changes in the source or surroundings. Light, temperature, motion, pressure, and other sources are just a few that might be employed. Innovative sensor technologies are used in various applications in daily life, industry [1], and healthcare and medical field applications [2]. One of the most distant sensors is called an ultrasonic sensor type HC-SR04 sensor. It is an inexpensive sensor that can deliver distances from 2 cm to 400 cm. It is an economical and simple-to-use distance measurement sensor. Two ultrasonic transducers structure the sensor. The first is a transmitter that emits ultrasonic sound pulses, while the second is a receiver that searches for reflected waves. It has four pins: VCC pin, Trig pin for Trigger waves, Echo pin for receive waves, and finally, GND pin for Ground [3-6]. In numerous applications: including obstacle avoidance, obstacle detection, indoor location, tracking systems, industrial robot applications: mobile robot applications, healthcare, automotive, and unmanned aerial vehicle applications: infrared (IR) sensors are contactless sensors that measure distance [7,8]. One of the most popular types of IR sensor is SHARP GP2Y0A21YK0F which, ranging from 10 to 80 cm. It depends on emitting a beam of infrared light that reflects off of it [9-12]. In addition to providing open-source software and hardware for projects, Arduino also provides community-based services for producing of intelligent digital products [13-15]. The Arduino microcontroller has many types, such as UNO, the most common Arduino board. It is powered by the Atmega328 processor and is compatible with most improvement board shields. The Arduino Mega is powered by the ATmega 2560 processor and has more I/O pins and larger memory space than the UNO [16]. Anguraj et al. [17] maintained keeping individuals at a social distance from one another. PIR, Ultrasonic, and Arduino UNO sensors are employed in the suggested work. The ultrasonic sensor monitors the space between persons when the Infrared PIR sensor notices motion. The gadget alerts a person if they are inside the vital six-foot zone. This buzzer signals the presence of infected people if the distance is less than six feet. Goh et al. [18] designed an IR thermometer and HC-SR04 ultrasonic sensors construct a digital IR thermometer with distance correction based on Arduino. The authors also discovered ways to program compensation mechanisms for the final built digital IR thermometer to offer more precise readings and measurements, along with some analysis of these parameters. Cenkeramaddi et al. [19] surveyed state-of-the-art sensors for autonomous systems. In-depth research was done on the main performance metrics and functional principles of the sensors utilized in autonomous systems. A summary of practical factors including performance metrics, sensor output data format, sensor interfaces, size, power consumption, suitable hardware platforms, data analysis, and signal processing complexity was provided. Such knowledge is a useful manual for creating intelligent sensing systems for autonomous systems. Artificial Intelligence (AI) approaches such as the ANFIS method are used to solve nonlinear problems [20]. Neural Network (NN) is also used to solve nonlinear problems with these sensors and in many applications [21].

Arafat et al. [22] demonstrated creating and using a revolutionary mobile robot. As the robot's brain, an Arduino Uno is employed. Inputs from the surroundings are collected using an ultrasonic sensor and a sharp IR distance-measuring sensor. To recognize and avoid obstacles like potholes, the robot trains a neural network based on a feedforward backpropagation algorithm. According to the researcher's experiment, the technology they built was suitable for detecting, dodging, and navigating obstacles and potholes. This work aims to design and implement a proposed device with three sensors to measure the accurate distance from 5 to 400cm using the proposed Neural forward and backward (FFBPN) Network. This paper begins with achieving and preparing accurate distances (dataset) from three sensors from Arduino code. The distances have been divided into three due to three sensor readings from 5 to 400 cm. A down ultrasonic sensor3 measured distance from 5 to 10 cm. A middle IR sensor 2 measured distances from 10 to 80 cm. A top ultrasonic sensor 1 measured distance from 80 to 400 cm. The FFBPN model proposed to enhance the distance measurements and the distance result tested after NN using MATLAB to get accurate distances for small, middle, and large distances. Furthermore, the interfacing between MATLAB and Arduino was implemented to easily save, prepare, and train the dataset using the proposed NN through MATLAB, proposing one device that could be used in robotic and radar applications to detect the objects accurately. This paper is highlighted as follows: Section 2 presents the methodology, Section 3 presents the results and discussions, and the last section summarizes the conclusions.

2.METHODOLOGY

This research methodology proposed and implemented an accurate distance device based on the proposed on-line Feedforward Backpropagation Neural Network method using three distance sensors. These three sensors were: one ultrasonic sensor senses distance from 5 to 10 cm (sense near distance of object), the second sensor, IR, senses distance from 10 to 80 cm (sense middle distance of object), and the third ultrasonic sensor senses distance from 80 to 400 cm (sense far distance of object). This methodology used to accurately detect near and far objects ranging between 5 and 400 cm. This section contains implementing and interfacing between the Arduino board and MATLAB program, as mentioned in Section 2.3.2. The proposed block diagram was proposed, as mentioned in Fig. 3. The proposed flowchart is mentioned in Section 2.4 and Fig. 13. The main principles of operation work of two sensors, i.e., (ultrasonic and IR) are presented as follows:

2.1.The Working Principle of HC-SR04 Ultrasonic Sensor

Ultrasonic sensor type HC-SR04 was used to measure the distance between 2 cm to 400 cm. It contains a transmitter to generate an ultrasonic wave named trigger (Trig) and a receiver called Echo [23], as shown in Fig.1.

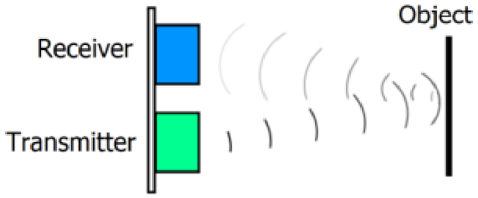

Fig. 1 Ultrasonic Signal Motivation from Trigger Echo [23].

Sound travels about 340 m/s in the air. The Ultrasonic Sensor uses this data and the delay between sending and receiving the sound pulse to determine an object's distance. The distance is divided by 2 because the sound wave travels forward and backward. The sound speed becomes 0.034 cm/s, and the sensor distance in cm becomes [23].

$$\text{Distance of ultrasonic sensor (cm)} = \frac{\text{Time x } 0.034}{2} \quad (1)$$

Where Time is the time calculated between an ultrasonic sensor and an object [24-26].

2.2.The Working Principle of SHARP GP2Y0A21YK0F IR Sensor

Infrared (IR) distance sensors generate an analog signal that varies in response to the object's distance from the sensor. SHARP GP2Y0A21YK0F is available in lengths of 10 to 80 cm. Infrared distance sensors calculate an object's distance by emitting a beam of infrared light reflected off of it. The distance is determined utilizing the light beam's triangulation. An IR LED and a light detector, or PSD (Position Sensing Device), structure the sensor. An "optical spot" will be developed on the PSD when the light beam is reflected by an object and reaches the light detector, as shown in Fig.2 [11].

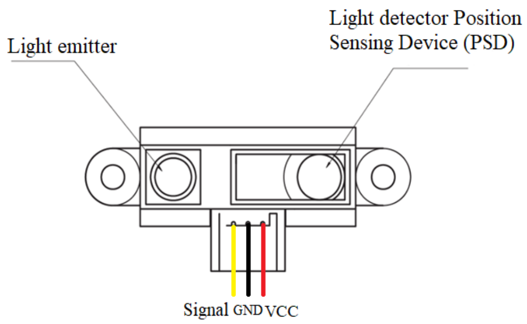

Fig. 2 IR Distance Sensor [11].

The final formula of converting analog to digit signal distance of Sharp IR sensor between object and sensor is [9,12,27].

$$\text{Distance of Sharp IR sensor (cm)} = 27.86 \times (V)^{-1.15} \quad (2)$$

Where, the V is the output voltage measured in Volt.

2.3.The Proposed Block Diagram of Accurate Three Distance Sensors Device Distance

The proposed block diagram begins with the hardware connection of the device and then reads the measured distance from three sensors and target distances from the ground. After that, these distances are saved and programmed in MATLAB to train them using the proposed neural network method, and the MSE is computed. The distances have been tested in MATLAB to check the proposed NN and get accurate distance results, as shown in Fig.3. These steps of the proposed work are explained below:

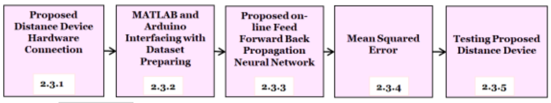

Fig. 3 The Proposed Block Diagram.

2.3.1.Proposed Distance Device Hardware Connection

The hardware of this work consisted of the following parts:

1- The first part had two HC-SR04 ultrasonic distance sensors. The first sensor was placed above proposed device, and the second was placed below device to measure the distances. Each sensor had four pins connected to the Arduino Mega microcontroller. These pins were VCC, GND, Trig, and Echo. VCC (power) and GND (ground) sensors connected to 5 volts and GND in the Arduino, respectively, with breadboard. Trig and Echo pins of sensor 1 were linked to pins 7 and 6 in Arduino. Trig and Echo pins of ultrasonic sensor 3 linked to pins 5 and 4 in Arduino Mega 2560 controller.

2- The second part was the SHARP GP2Y0A21YK0F IR sensor, which had three pins: VCC, GND, and signal a linked to Arduino Mega. The sensor's analog signal was linked to A0 of Arduino Mega. The five-volt power was supplied to the Arduino Mega using a USB cable from a laptop computer, as shown in Fig.4 and Fig.5. Fig.6 shows a white object of 80x40 cm² to read the short and long distances from sensors. The object was covered with a white layer because an IR sensor senses this color 90% compared to other colors, as described in [9,11,12,27].

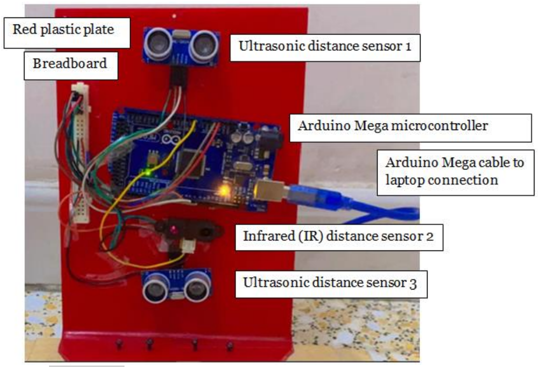

Fig. 4 The Proposed Experimental Work.

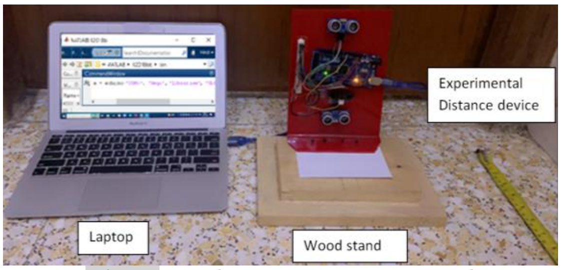

Fig. 5 Implementation Proposed Experimental Work with the Laptop.

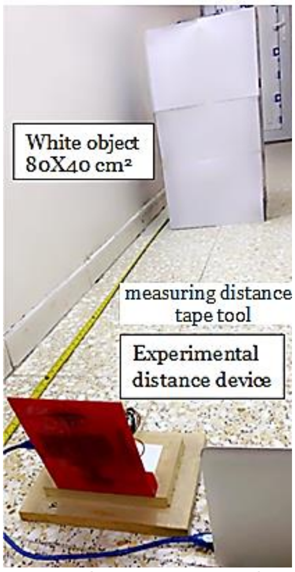

Fig. 6 Proposed Experimental Work with Laptop and Object.

2.3.2.MATLAB and Arduino Interfacing with Dataset Preparing

The interfacing between MATLAB with Arduino Mega implementing and connecting an Arduino Mega board to the MATLAB program is done as follows:

1) Instal MATLAB R2018b on a laptop.
2) Start the MATLAB program and click the "Add-Ons" drop-down menu. After that, instal the Arduino package on MATLAB program, as seen in Fig.7. In the drop-down menu, click "Get Hardware Support Packages."

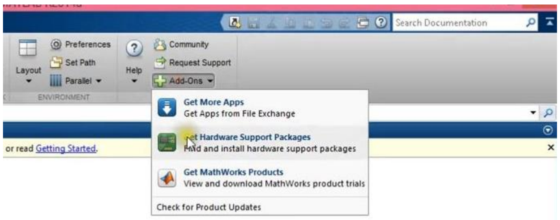

Fig. 7 Installing Arduino Package on MATLAB.

3) Select "Install from Internet," then click "Next", as shown in Fig.8.

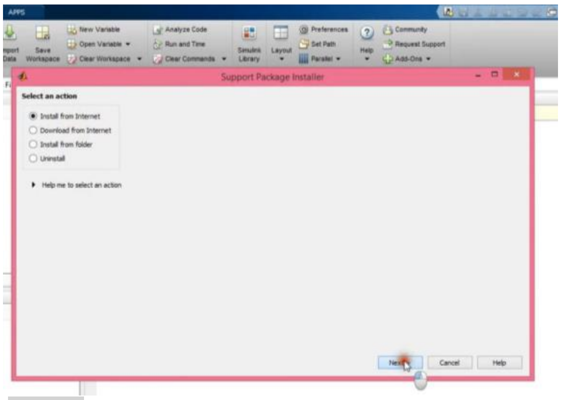

Fig. 8 Completing Install Arduino Package on MATLAB.

4) In the next window, Select "Arduino UNO/Nano/Mega," then check all the packages displayed and click "Next" to continue installation, as shown in Fig.9.

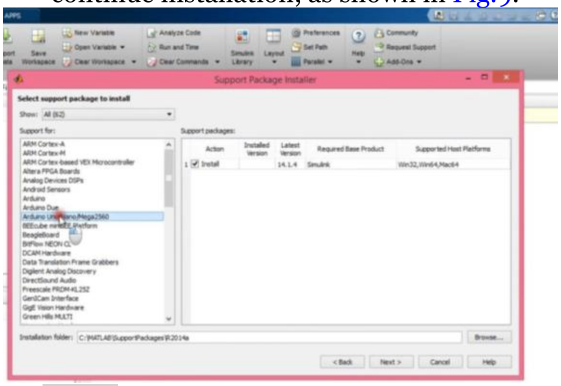

Fig. 9 Completing Install Arduino Mega Package on MATLAB.

5) Communicate between MATLAB and Arduino Mega board hardware of this work through a USB cable, as shown in Fig.10.

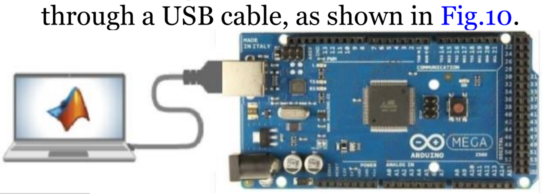

Fig. 10 Interfacing MATLAB on a laptop with Arduino Mega using USB.

6) Test connection between Arduino board and MATLAB on the laptop by typing the following commands in the MATLAB command window:

```
>> a = arduino()
```

7) Then, selecting of laptop's port connected to the Arduino board's USB cable. After that, import the libraries of two Ultrasonic sensors and an IR sensor.

```
>> a = arduino('COM5', 'Mega', 'Libraries', 'Ultrasonic1', 'Ultrasonic2', 'IR')
```

8) The connection between MATLAB and Arduino was successful.
9) After completing writing the MATLAB code, including Eqs. (1) to (3). The dataset was computed from two parts: the first part named measured distances, which are inputs (X1) to the proposed Feed Forward Back Propagation Neural Network (FFBPN), as described in the next section. At the same time, the second part of the dataset, named target distances output prepared and calculated from the ground manually using a yellow measuring distance tape tool, as shown in Fig.6. Then, all datasets were saved in MATLAB.
10) The proposed Feed Forward Back Propagation Neural Network was written in MATLAB code and compared the target output (from ground) with the desired output (from (FFBPN)) using MSE as described in the next section. The measured distances (dataset) are classified into:
    - Down ultrasonic sensor 3 senses distance from 5 to 10 cm.
    - Middle IR sensor 2 senses distance from 10 to 80 cm.
    - Up ultrasonic sensor 1 senses distance from 80 to 400 cm.

Each number of measured and target distances has 431 samples.

2.3.3. Proposed On-line Feed Forward Back Propagation Neural Network

In this work, the Feed Forward Back Propagation Neural Network (FFBPN) [28,29] method is proposed to train the dataset evaluated. FFBPN technique is a good performance method because it training the dataset in two ways: one way is the feed-forward step calculation of input weights, and the other way is the backpropagation step calculation for updating the weights and evaluating error. Fig. 11 presents the FFBPN layers which contain three neural layers. The first input layer had one input (dataset): x1 is the measured distance (from three sensors), and b is the bias. The second hidden neural layer had one hidden neural layer with ten neurons. The last layer is the output (y), the desired distance after the neural network.

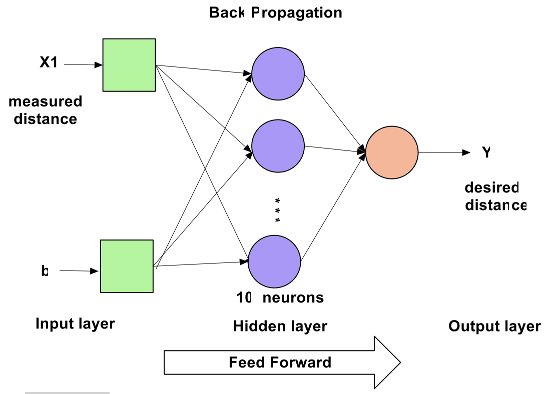

Fig. 11 Two Layers of the Proposed Feed-Forward Back Propagation Neural Network Architecture.

This network works as feed forward and back propagation so that the dataset using the FFBPN method was trained forward and backward. Due to the easily differentiable nature of hyperbolic and linear functions, hidden layer neurons chose a matching activation function known as the sigmoid Eq.(3) [28,29]. The mathematical model begins with the following:

$$f(x) = \frac{1}{1+\exp(-x)} \qquad \textbf{(3)}$$

where, x is the measured input distance, and f(x) is sigmoid. During the forward propagation, the two formulas must evaluate one for the hidden layer and the other for the output layer, Eq. (4) and Eq. (5) [28,29]:

$$u_j = f\left(\sum_{i=1}^{n} v_{ij}x_i + b_j\right) \qquad \textbf{(4)}$$

$$y_i = f\left(\sum_{j=1}^{m} w_j u_j + k\right) \qquad \textbf{(5)}$$

The variables of Eqs. (4) and (5) are named as u_j is the output of the hidden layer, n is the number of input layers and equals 431 samples, and w_j is the weight value neuron variable. In this work, v_{ij} is the input layer weight, x_i is the input value, b_j is the bias value of the hidden layer, y_i is the desired distance output layer, n: number of hidden layers, and k is the bias value of the output layer.

2.3.4.Mean Squared Error

The FFBPN performance method is calculated using Mean Squared Error (MSE), Eq. (6) [30].

$$MSE = \frac{1}{n}\sum_{i}^{n}(y_i - y_{ti})^2 \qquad \textbf{(6)}$$

where n is the number of inputs=431 samples, y_i is the desired distance value after the neural network, and y_{ti} is the target distance output calculated from the ground using the measuring distance tape tool, as mentioned in Section 2.3.2. In the backpropagation method, each input design from the train case was represented by the input neural layer. After that, it was propagated forward to the output layer, to obtain the error signal, and the result value was compared between the desired and the target output. The weights in the middle layers were then adjusted while the error signal was propagated back to the input layer to reduce the output errors.

2.3.5.Testing Proposed Distance Device

The proposed FFBPN testing in MATLAB program was used to check the proposed distance device's accurate operation. In the MATLAB command window for the case study, the trained network named "network1" was tested using "tested_output" variable command. It equaled the best output distance for example, this variable = 150.0036 cm, where the input variable = 150. The "sim" is a function of MATLAB used to simulate a dynamic system, as shown in Fig. 12.

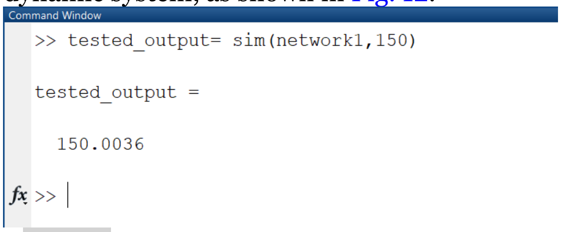

Fig. 12 MATLAB Tested Distances after the Proposed Neural Network.

2.4.The Proposed Practical Flowchart of Accurate Three Distance Sensors Device Distance

In this work, the hardware implementation and the training of the neural network flowchart are shown in Fig.13. The proposed flowchart begins with initializing and connecting all hardware described in Section 2.3. Then, an Arduino Mega board interfaced with the MATLAB program, as described in Section 2.3.2. From MATLAB code, read measured distances between each sensor and object of three sensors (first dataset named measured distance). From ground, manually read target distances between each sensor and object using a measuring distance tape tool and save it on the laptop (the second dataset is called target distance). These datasets were collected and prepared to propose a Feedforward Backpropagation Neural Network. In addition, the proposed Feedforward Backpropagation Neural Network was implemented to get the best-desired distances and compared with target distances calculated using the measuring distance tape tool manually by computing MSE between them. If the MSE < 0.03, then the algorithm was stopped.

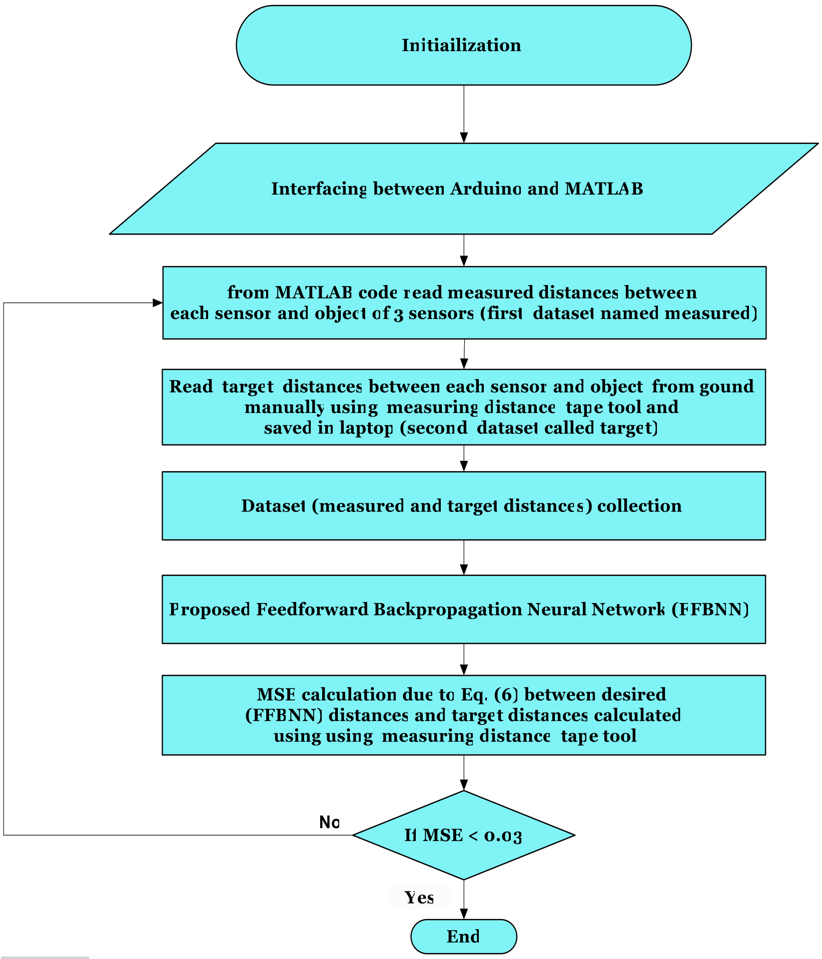

Fig. 13 The Practical Proposed Accurate Three Distance Sensors Device Flowchart Implementation.

3.RESULTS AND DISCUSSIONS

Figure 14 shows the case study of the proposed experimental device where three sensors (up ultrasonic, middle IR sensor, and down ultrasonic) computed measured and target distances for 90 cm between objects.

Fig. 14 The 90 cm Distance Example of Experimental Implementation.

In this paper, MATLAB® 2018b was used for training the dataset of the FFBPN algorithm. A version of the backpropagation algorithm called Levenberg Marquardt and named LM algorithm [29] was also used to train the data. The proposed neural network used hyperbolic specifications: tangent activation function (tansig), training function (TRAINLM), and adaptation learning function (LEARNGDM) used for the hidden layer and the output layer. These functions are presented in detail in [30] [31]. The number of epochs =464. The dataset had 431 samples alienated arbitrarily into three parts: 344 (80%) samples to train and 87 samples (20%) for validation and testing. The training time was completed in 3 seconds. Fig.15 shows the suggested FFBPN neural network structure with one measured distance x1 from a prepared dataset of sensors. In addition, the hidden layer included ten neurons with one desired output distance layer.

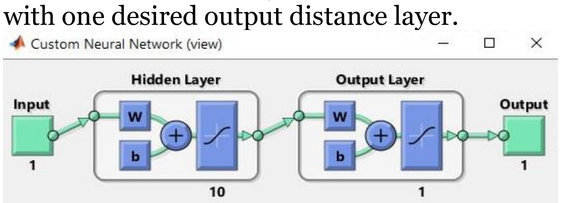

Fig. 15 The Suggested FFBPN Structure.

After programming and running MATLAB code for this work, the distance outputs were displaced on the "MATLAB command window." The measured distances example between three sensors and object is shown in Fig. 16. Where, Distance 1, Distance 2, and Distance 3 are the measured distances from ultrasonic 1 (up), IR (middle), and ultrasonic 2 (down) sensors, respectively.

```
Distance 1: 47.38 cm
,Distance 2: 7.00 cm,  Distance 3: 50.57 cm
Distance 1: 46.91 cm
,Distance 2: 7.00 cm,  Distance 3: 50.26 cm
Distance 1: 44.57 cm
,Distance 2: 7.00 cm,  Distance 3: 50.72 cm
Distance 1: 12.02 cm
,Distance 2: 119.00 cm,  Distance 3: 34.48 cm
Distance 1: 101.53 cm
,Distance 2: 7.00 cm,  Distance 3: 148.34 cm
Distance 1: 131.33 cm
,Distance 2: 8.00 cm,  Distance 3: 147.79 cm
Distance 1: 134.47 cm
,Distance 2: 8.00 cm,  Distance 3: 147.17 cm
Distance 1: 64.72 cm
,Distance 2: 7.00 cm,  Distance 3: 9.24 cm
```

Fig. 16 MATLAB Example of Implementation System.

Figure 17 shows the performance plot of the proposed neural network. The y-axis is MSE (mean squared error), and the x-axis is 464 epochs. The green color of the validation has less MSE than the train's blue color, and the test's red color. So, the performance's feedforward backpropagation network provided dependent readings during and after train cases. The best performance of the validate case reached 0.0036122 in 464 epochs. The MSE results were good, and the validation performance was good at 464 epochs.

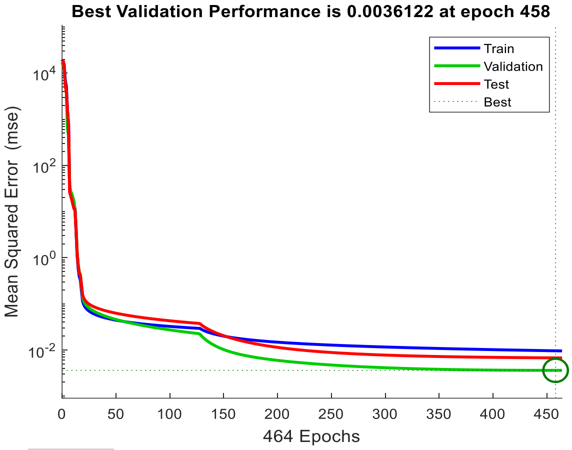

Fig. 17 Feedforward Backpropagation Neural Network Training Performance with epochs.

Figure 18 shows the training procedure, including the test and the validation, train, and all cases of data, indicating a very good curve fitting with the coefficient regression R values =1. It means that the all data of proposed and desired work data fit equal target outputs with very small errors, as mentioned in Fig. 17 above.

The training in a neural network is too useful to get best-desired distances, as mentioned in Fig. 18. The validation performance equals 0.0036122, i.e., the MSE is near zero with 100% fitting.

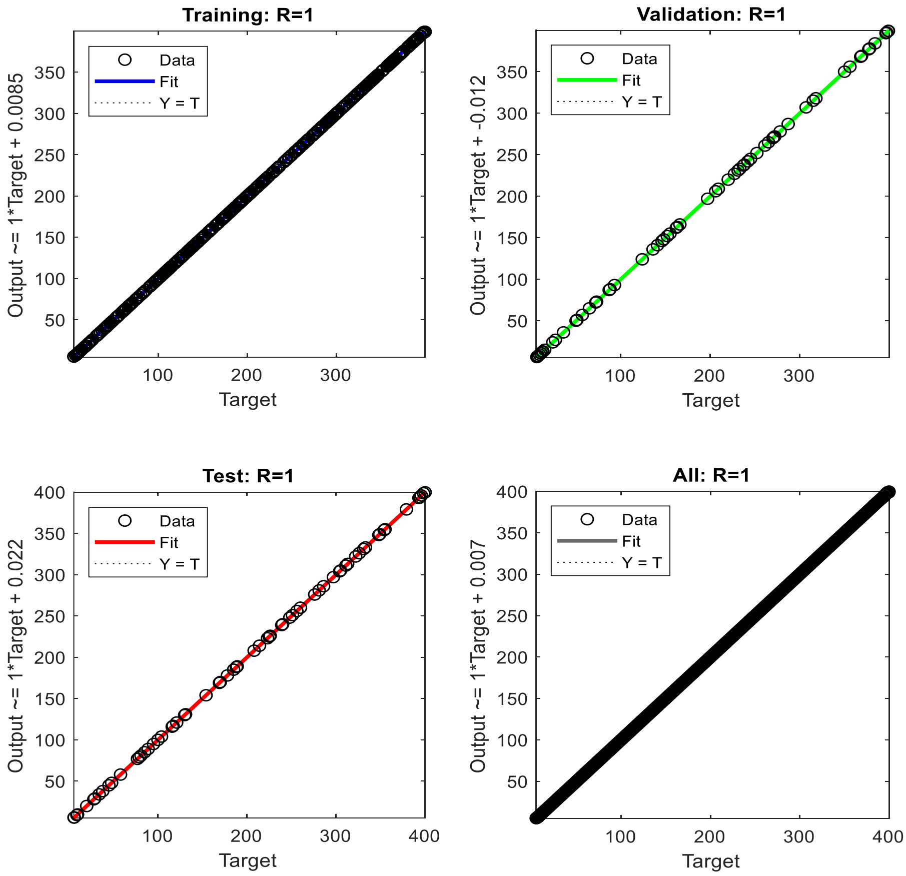

Fig. 18 Proposed Feedforward Backpropagation Neural Network Training Regression.

4.CONCLUSION

In this study, an intelligent measurement device was developed based on the FFBPN algorithm to evaluate the distance from 5 to 400 cm. The dataset of distances was acquired from three physical sensors, and fed to the MATLAB environment via a special microcontroller (Arduino). Three ranges of distances were considered, and a specified sensor was assigned to measure each range. The intelligent algorithm was trained to cope with all measures in the range. The measurement due to the intelligent algorithm was tested manually. It was shown that the measurement of distances resulting from the intelligent algorithm had high accuracy. Moreover, different and repeated tests showed that the intelligent device is reliable and efficient, especially when using different sensors for different ranges. Therefore, the intelligent algorithm is a promising device for robotic applications where multiple sensors are used for measurements.

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NOMENCLATURE

FFBPN	Feedforward Backpropagation Neural Network
VCC	Vancouver Community College
GND	Ground
LED	Light Emitting Diode
PSD	Position Sensing Device
NN	Neural Network
MSE	Mean Squared Error
ANFIS	Adaptive Neuro-Fuzzy Inference System
v_{ij}	Input Layer Weight
x_i	Input
u_j	Output of Hidden Layer
w_j	Weight Value Neuron Variable
b_j	Bias Value of the Hidden Layer
n	Number of Inputs
y_i	Desired Distance Output
K	Bias Value of Output Layer
y_{ti}	Target Distance Output

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