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Smart Automated Civilian Detection System for Multistorey Buildings

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Abstract:

In the modern age multistorey buildings are in trend especially in the developed countries or in metro cities etc. Exiguousness of residential land and construction cost saving is the another reason of multistorey buildings. These buildings have advance security features which is based on automated devices like fire alert system, CCTV cameras, elevators etc. large number of persons live and working in these flats/offices. It is very difficult to know the exact number of persons in a particular building. It has been observed that many times citizens are found dead in their flats and about this even Neighbors are totally unaware about the same. The available solution of this problem is CCTV cameras but sometime cameras may consider as interferer in the privacy and it cannot be implement in some specific locations. Secondly camera can record the videos and capture the images but not able to count the number of citizen in a building at a particular time. Manual entry registers are also not the solution of this problem as it is very difficult to maintain and trace the record. In case of any natural calamity happened like earthquake as happened in Turkey, terrorist attack then no data is available how many people are exists in the building at a particular time and what is their last location in the building. The proposed system provides the solution of this existing problem. System will work in the fully automated mode and can provide the information 24x7 with the exact location and time stamp. It can be implemented in jails, hostels, rehabilitation, army areas, Hospitals, COVID centers etc. System will maintain the records of the citizens movements with in the rooms and floors. When there is no movement detected for a long time, alert will be generated by the system with the help of alert unit. Proposed system is a fully automatic system which is based on sensors. System is distributed into three units sensing, counting and display unit. Sensing unit detect the human presence inside a flat / floor. Secondunit is counting unit which will count the exact number of persons exists and the third unit will work as display which will show the exact number of persons inside a room along with their last location. Thus system can work as a lift saving security system.

Keywords: Ultrasonic, IPR, Sensor, LED Display.

1. Introduction:

Find out the exact number of persons in a multistorey building and keeping their record offline is much difficult. In a modern multistorey building, many extended models of home automation are available such as Bluetooth connectivity and Ethernet connection as well [1]. An automated home can be controlled using Mobiledevices which is connected with the IOT devices [2]. These devices can be used for security purpose and send an alert to the owner when someone trespass the home [3]. These sensors help the persons with their intelligence and a great benefit to the disabled persons or patients [4]. These all the inventions don't provide the exact number of persons inside a multistorey building. Hence, there is a need of a system which can tell the exact number of persons inside a multistorey building. This paper presents a system which automatic detects and keep record of the number of the person inside a multistorey building. In case of fire, it is difficult to find out how many persons are inside a large multistorey building. This system will be helpful to save all the person inside a multistorey building. This system fully works on the basis of sensors. All the sensors are integrated with each other through Arduino Mega 2560. This system is divided in three units are Sensing, Counting and Other unit. Every unit have a different role like PIR sensor is used to detect the human presence. Counting unit will count the exact number of the persons. Other unit contains LED Display which shows theexact number of the person inside a building.

- **Ultrasonic Sensor**

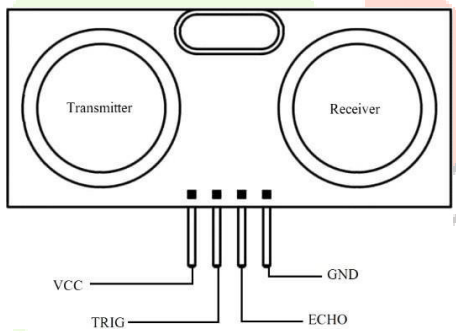


Image 1: Ultrasonic Sensor HC-SR04

Ultrasonic Sensor is used to measure the distance between Ultrasonic Sensor and the person. In this system, two Ultrasonic Sensors are used. Ultrasonic Sensor is placed on the wall on the outside area of the door. As soon as the humanbody enters, this system will increase the counting by one. Ultrasonic Sensor is placed on the wall on the inside area of the door. As soon as the humanbody comes out, this system will decrease the counting by one.

- **PIR Sensor**

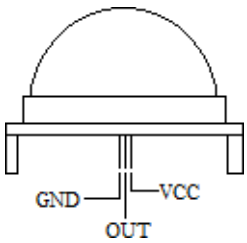


Image 2: PIR Sensor

PIR sensor is used to detect the IR (infrared radiation). If there IR (infrared radiation) change detected due to existence of human body, then, PIR sensor will give response. In this system, a PIR sensor (102) is used. PIR Sensor is attached on the wall in such a way that it will detect the human body while coming in and going out.

- **LED Display**

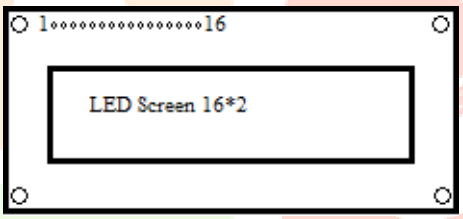


Image 3: LED Display

LED Display is used to show the number of the person inside a building. In this system, LED Display will increase and decrease the counting by one when a person comes in or going out the building respectively.

2. Proposed Model

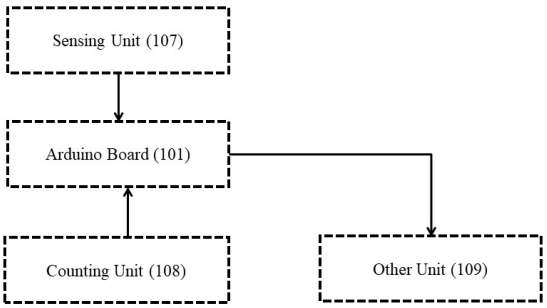


Figure 1: Citizens counting system inside a building

The Figure 1 states that Sensing Unit is connected with Arduino Board which give the information of human presence. Counting Unit will count the number inside a building and increase / decrease number of person while comes in and going out fromthe building respectively. The Other unit will show the number of persons that the counting has detected.

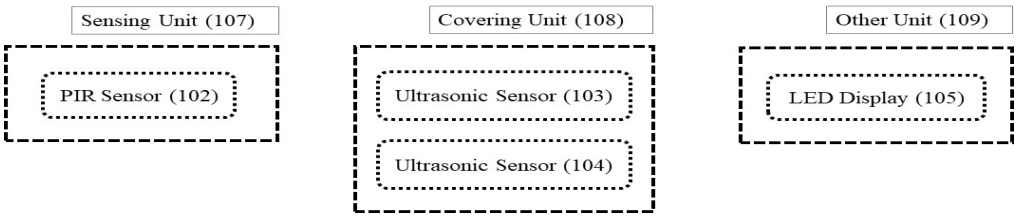


Figure 2: Architecture of Proposed system

Figure 2 states that Sensing unit contains PIR Sensor. PIR Sensor is used to detect the human presence. In Covering unit, two Ultrasonic Sensors are used. Ultrasonic Sensor will measure the distance between Ultrasonic Sensor and human. Ultrasonic Sensor (103) is used to increase the number of person by one when person comes in the building. Ultrasonic Sensor (104) is used to decrease the number of persons by one when person goes out from the building. LED Display is used as other unit which shows the number of the persons inside the building.

3. Hardware Components of the system:

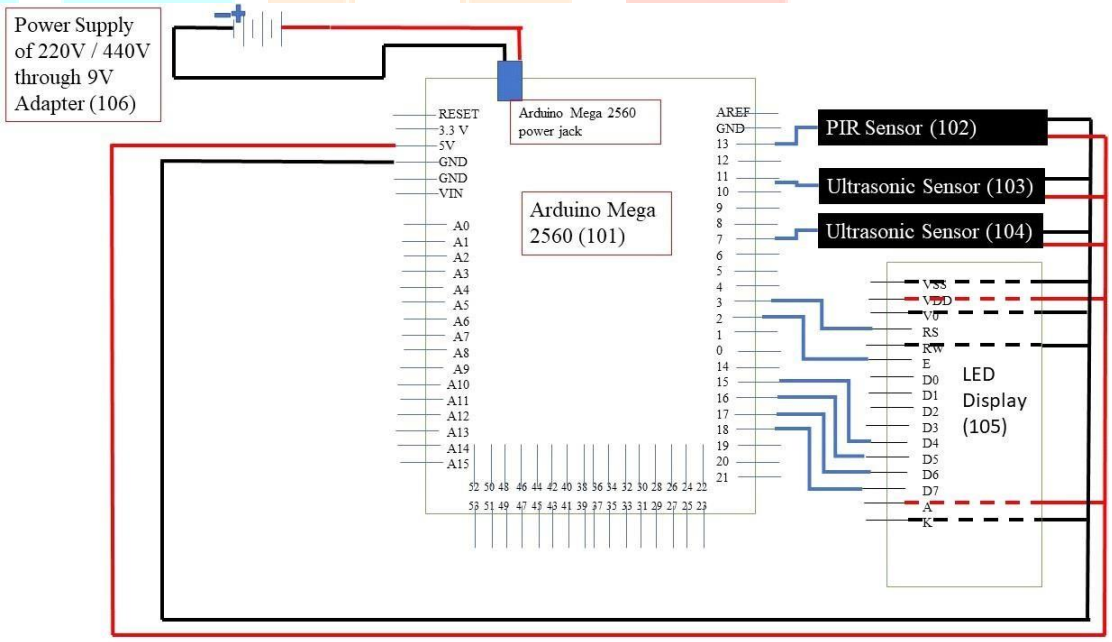


Figure 3: Circuit Diagram

The Figure 3 shows the connection of all the components with Arduino Mega 2560. Ultrasonic Sensor, PIR Sensor, LED Display are directly connected with Arduino Mega 2560 and doesn't require power supply from other source except Arduino Mega 2560. Arduino Mega 2560 will receive power supply of 220V / 440V through 9V Adapter.

4. Workflow of the system:

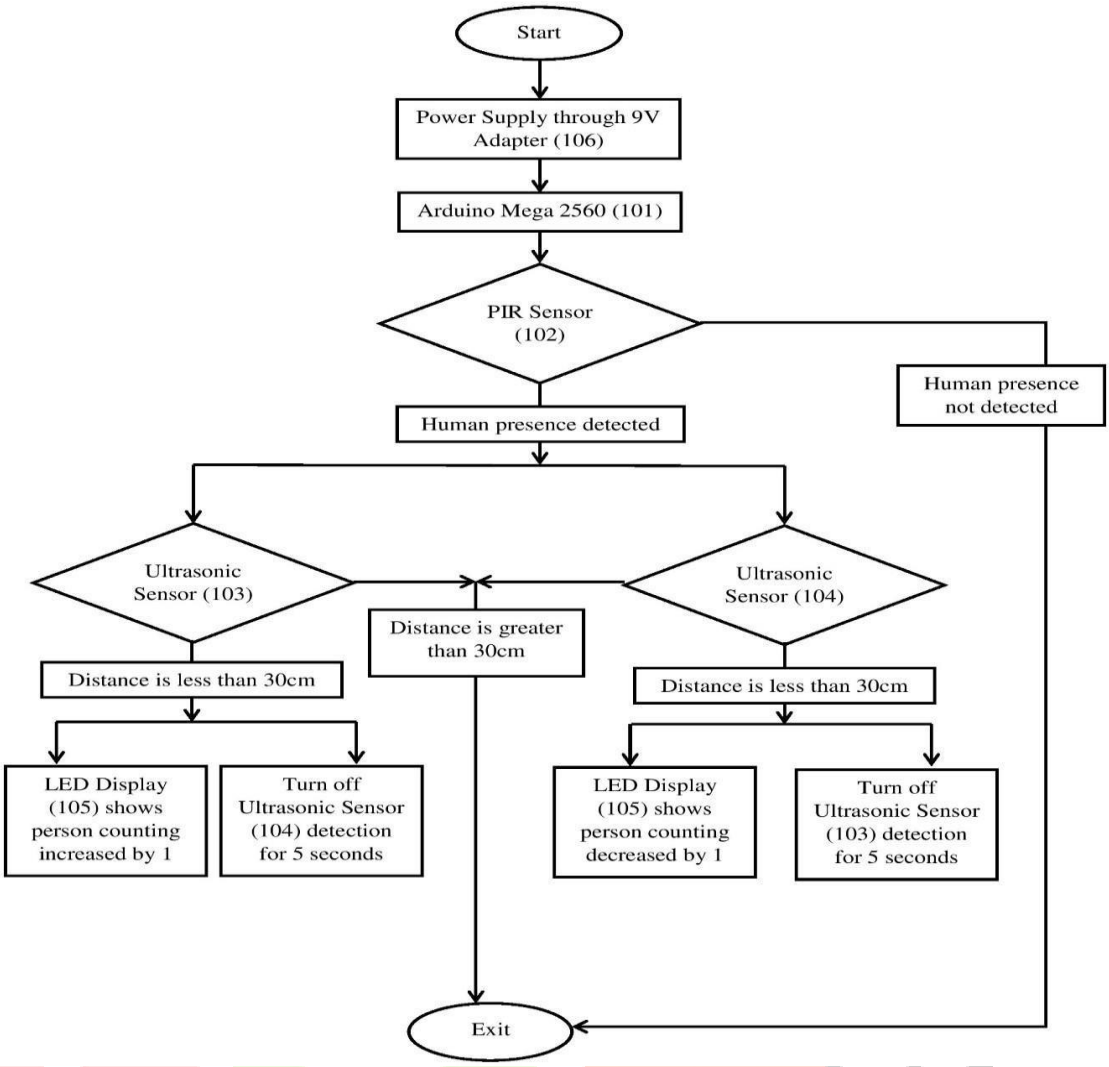


Figure 4: Workflow of the system

Figure 4 shows the flow of the system. All the units are connected through Arduino Mega 2560. Arduino Mega is connected with power supply of 220V / 440V through 9V Adapter. PIR Sensor will continuously detects the human presence. As the human presence is detected through PIR Sensor, then, system will check the distance between the Ultrasonic Sensor and the human body. If the distance between Ultrasonic Sensor (103) and human body is less than 30 cm, then, the system will increase the number of persons by one and turn off the Ultrasonic Sensor (104) for 5 seconds. If the distance between Ultrasonic Sensor (104) and human body is less than 30 cm, then, the system will decrease the number of persons by one and turn off the Ultrasonic Sensor (103) for 5 seconds. The number of the person is displayed by LED Display screen.

5. Implementation:

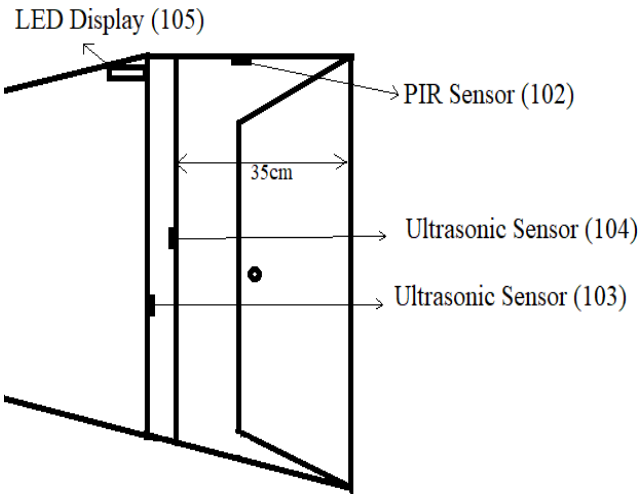


Figure 5: Citizen counting system

Figure 5 is the diagram of the building gate with the positions of the sensors. In this diagram, PIR Sensor is set on the top of doorframe as shown. Ultrasonic Sensor (103)is used on the outer side of the doorframe which confirms the person comes in the building. Ultrasonic sensor (104) is used on the inner side of the doorframe which confirms the person goes out of the building. LED Display is set on the wall outside the building to show the exact number of persons inside building. It is assumed that the width of the door-frame is 35 cm. The distance may vary of doorframe. Hence,the distance between the Ultrasonic Sensor and human body may also vary dependingon the width of the door-frame.

6. Probability of actions with respect to the sensor value:

This table is created considering the width of the door-frame is 35 cm.

S.no	**PIR Sensor (102)**	**Ultrasonic Sensor (103)**	**Ultrasonic Senor (104)**	**LED Display(105)**
	Human presencedetected	Measured distance less than 30cm	--	Person number increase by one
	Human presenceis not detected	Measured distance less than 30 cm	--	No change
	Human presenceis detected	Measured distance greaterthan 30 cm	--	No change
	Human presenceis not detected	Measured distance greaterthan 30 cm	--	No change
	Human presencedetected	--	Measured distance less than 30 cm	Person number decrease by one
	Human presenceis not detected	--	Measured distance less than30 cm	No change
	Human presencedetected	--	Measured distance greater than 30 cm	No change

	Human presencenot detected	--	Measured distance greater than 30 cm	No change

Table 1: Action Table

Table 1 describes that when the system will increase the number of person and when the system will decrease the number of persons.

Case 1: If PIR sensor detects the human presence and the measured distance through Ultrasonic Sensor (103) is less than 30 cm, then, the system will increase the number persons by one and turn off the Ultrasonic Senor (104) for 5 seconds.

Case 2: If PIR sensor does not detect the human presence and the measured distance through Ultrasonic Senor (103) is less than 30 cm, then, there is no change in total number of persons.

Case 3: If PIR sensor detects the human presence and the measured distance through Ultrasonic Sensor (103) is greater than 30 cm, then, there is no change in total number of persons.

Case 4: If PIR sensor does not detect the human presence and the measured distance through Ultrasonic Senor (103) is greater than 30 cm, then, there is no change in total number of persons.

Case 5: If PIR sensor detects the human presence and the measured distance through Ultrasonic Sensor (104) is less than 30 cm, then, the system will decrease the number persons by one and turn off the Ultrasonic Senor (103) for 5 seconds.

Case 6: If PIR sensor does not detect the human presence and the measured distance through Ultrasonic Senor (104) is less than 30 cm, then, there is no change in total number of persons.

Case 7: If PIR sensor detects the human presence and the measured distance through Ultrasonic Sensor (104) is greater than 30 cm, then, there is no change in totalnumber of persons.

Case 8: If PIR sensor does not detect the human presence and the measured distance through Ultrasonic Senor (104) is greater than 30 cm, then, there is no change in total number of persons.

7. Experimental Results and Analysis:

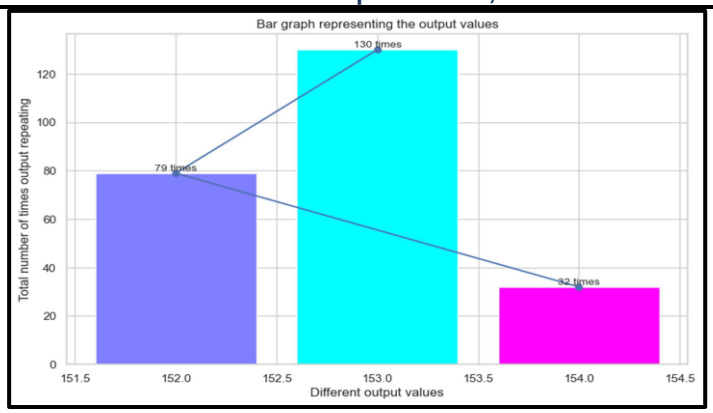


Figure 6: Frequency of sensor's responses

Insights of bar graph :

- We have observed that the outcomes are 152,153 and 154
- The maximum number of outcome is 153 which is repeating 130 times
- The minimum number of outcome is 154 which is repeating 32 times

The outcomes repeating with their frequecy of repeatation:

Outcome	Frequency of repeatation
152	79
153	130
154	32
Total 241 entries	

Table 1: Action Table

KDE Plot of frequency of outcomes :

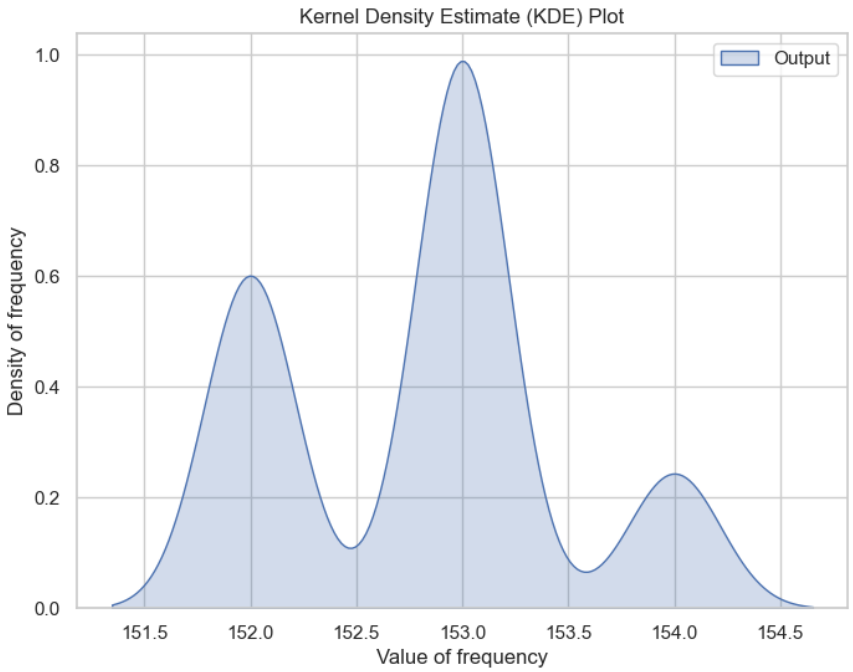


Figure 7: Kernel Density Estimate of sensor's responses

Insights of KDE Plot:

- The maximum distribution of outcome is around 153.
- The minimum distribution of outcome is around 154.
- The distribution of outcome is of following order: 153 > 152 > 154

Pie plot of frequency of outcomes:

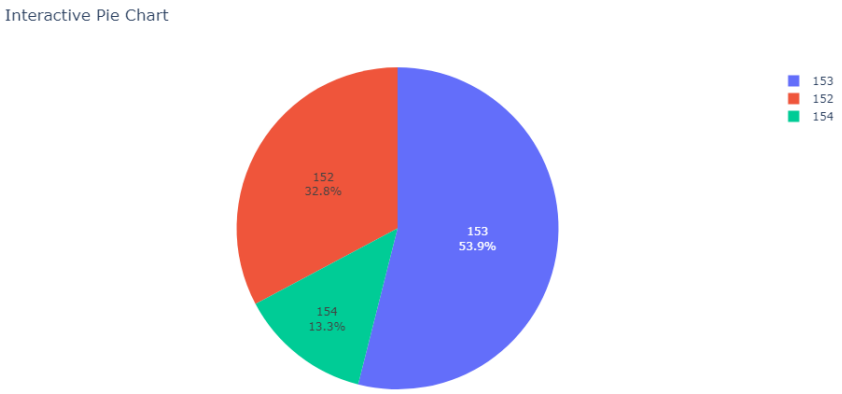


Figure 8: Percent share of Sensor's Responses

Insights of the pie plot:

- The maximum frequency of outcome is covered by 153 which is 53.9% of total.
- The minimum frequency of outcome is covered by 154 which is 13.3% of total.

Outcome	Percent share
152	32.8%
153	53.9%
154	13.3%
Total 241 entries	

Box Plot of frequency of outcomes:

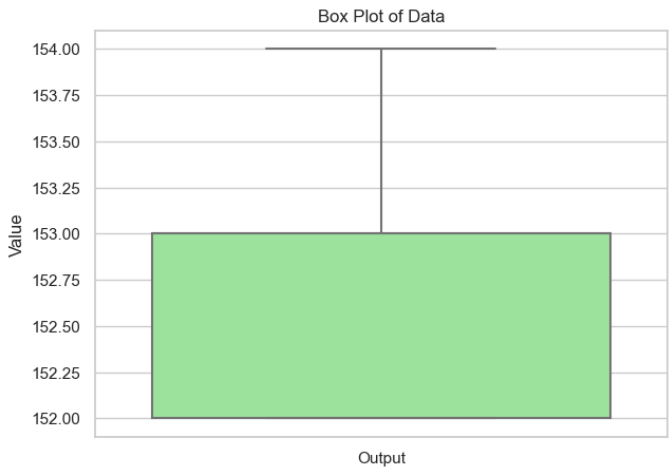
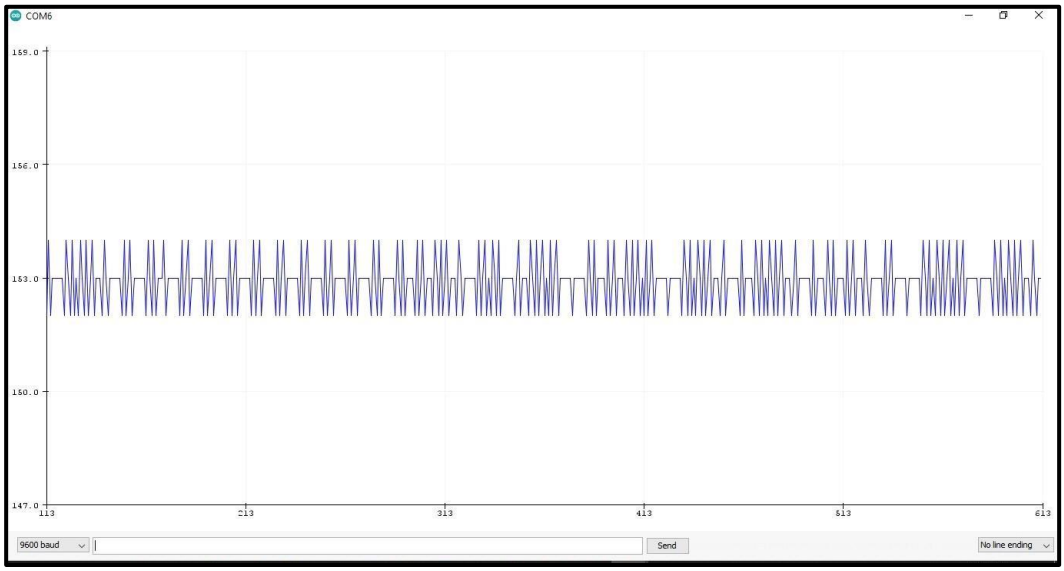


Figure 8: Box Plot of Sensor's Data

Insights of box plot :

- Maximum value of outcome is 154.
- Minimum value of outcome is 152.
- 3rd quartile is 153
- 1st quartile is 152
- Median of the outcomes is 153.

8. Response Time:



Total 241 continuous time units have been recorded with the system response time. The average response time of complete system is 152.8049793 milliseconds. i.e., 0.152804979 second.

9. Advantages and Impact of the research:

- **i.** Number of Civilian can be counted easily in a particular room / floor and particular multi story building.
- **ii.** System can be implanted in jails and rehabitation centers.
- **iii.** It can be applied in special wards of hospital like COVID / Tuberculosis (TB) etc.
- **iv.** It is helpful to maintain the privacy as compare to the cameras.
- v. Implemented in the university / colleges hostels.
- vi. It can be used in the terrorist / suspected areas by the army.
- vii. Fully automated system can work without any user input.
- viii. System can be integrated with cameras.
- **ix.** Detailed numbers provide / display by the system.
- **x.** Low cost system it is easy to upgrade / maintain.

10. Conclusion:

A Sensor Based System to Compute the Number of Citizens inside the MultiStorey Building is very effective. It has features like automatic count the person and keep its record. There is no need to make an offline entry. In case of any emergency like fire causes in the building, then, this system will tell the exact number of the person inside the building. When a person comes in the building, then, the system will increase the total number of persons by one. When a person goes out of the building, then, the system will decrease the total number of the persons by one. Average response time of the system is less than one-fifth of a second shows that the sensors are responding in real time.

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