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System for Monitoring the Distance During the Spread of Corona Variants in India

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Abstract

Global outbreak COVID-19 virus spreads, societies are asked to reduce close interactions between individuals. It is known as social dissociation and is an effective and reliable way to prevent the spreading of the virus. This research paper develops an ultrasonic sensor-enabled device to maintain social distances in public places such as the market, shopping malls and government offices, etc. A DC motor-based vibration mechanism enhanced the function of this portable technology device. Total four ultrasonic sensors are integrated with a separate vibrator in all four directions, such as right, left, front, and back real-time monitoring. Ultrasonic sensors monitor the social distance (in cm) and, by measuring the distance between the persons, the modes of vibration are categorized as; (i) normal, (ii) high and (iii) very high/critical as alarming to the user for preventing direct human contact. This proposed system enabled data storage capability (micro SD card) for post-trial decision-making analysis of distance measurement samples during social interactions. The obtained results show the importance to maintain social distance in such a global pandemic situation.

Keywords: *COVID-19, social distancing, global pandemic, ultrasonic sensor, distance measurement.*

1. Introduction

In current scenario, the COVID-19 corona virus pandemic is high risk public health issue and the major threat. At global level, medical experts are trying to control the spread of the virus through exploring the various commendable steps such as monitoring and caring for patients, monitoring contacts, restricting transport, quarantine, large-scale public gathering such as sports and schools [1]. It can create debilitating social, economic and political problems that leave deep blemish in every country it influence. According to the World Health Organization (WHO) advisory, the merely huge protection hazards are social separation, self-isolation, and quarantine to separate the COVID-19 pandemic socially / globally. Social distancing organization is an well-organized result to control the spread of virus. Human being is necessary to follow the social distancing guidelines in community, whether in one of the risk categories [2].

1.1 A. Social distancing

Because COVID-19 spreads from individual to individual, it is critical to limit contact between people. Staying at home a lot and avoiding public places where close contact is likely are examples of social distancing. The administration issues house residence orders, cancels religious activities, prohibits groups of more than ten people from gathering, and closes shops, restaurants, and bars. Because of this pandemic, many schools adopt an online culture for teaching and learning processes, grocery shopping and promoting economic transactions. In addition, the Centres for Disease Control (CDC) recommend wearing a covered cloth and at least 6 feet from the others [2] [3].

1.2 B. Self-Isolation and quarantine

Just before symptoms start, COVID-19 spreads from one person to another. If you start feeling very ill, tired or sick in your family, you have to stay at home and "self-isolation" is practised. This ensures there is little interaction with anyone, and if severe symptoms such as fever, cough, or shortness of breath arise, the doctor is called. If the COVID-19 test is acceptable, your medical team will inform you and take the next steps. If someone in your family is suspected of being affected by COVID-19, quarantine is usually needed, and further medical attention may be needed [3].

Self-isolation and quarantine mean you have no public contact. However, quarantine is the term used for people with a positive impact and exposure to the COVID-19 virus. You are recommended to stay away from others for 14 days or more to ensure that they will not transmit the virus during this duration of pre-illness or incubation.

1.3 Novelty of work

This research paper shows an alternative, efficient and cheap way of maintaining social distancing. The salient point of the study is given as,

•The proposed system is simple to build, low maintenance, economical as well. Users will find all the components used in the system locally.

•The system helped to warn us of the direction from which the user is in danger of coming into contact with other people by simply vibrating the motor of that side.

•The proposed device also encourages post-analysis of the data recorded by the sensors, contributing to a more focused approach during the COVID-19 pandemic.

2. Literature review

The ultrasonic sensor-based devices for use inappropriate applications are reported in this literature review section. All of the systems are tested and evaluated for accuracy, robustness, ease of use, performance, usability, and functionality, and the strengths and limitations of each implementation are defined. Based on existing literature, research topics are listed and explored for further study. The appropriate number of research papers [4-20] are considered for literature review to cover the extensive analysis.

For distance measurement, a hardware device is designed. The performance analysis of the system developed is validated by comparison of the actual distance. In addition, the temperature effect on the performance of the device is analyzed [4]. The test results performed on an ultrasonic proximity-tracking instrument (composed of the Polaroid 600 high range and the Sonar Ranging Module SN28827) are shown in [5]. Distance between 0.4 and 11 m was taken into account in the experiments. In [6], work on distance measurements is provided in an inter-modal container with ultrasonic sensors. Self-developed ultrasonic sensor platforms are placed with sensor nodes for this purpose, and a difference in time algorithm is enforced. After that, the machine is checked and adjusted to minimize the distance error.

In [7], a new approach for developing the highly directive ultrasonic range sensor transducer is adopted to detect obstacles in mobile robot applications. This research aimed at designing an optimum transducer to efficiently produce the two simultaneous longitudinal modes. For active public safety purpose, the authors developed ultrasonic sensors based hardware system. The proposed system is completely automated and tested on the prototype vehicle under real-life conditions and satisfactory performance [8]. In [9], an ultrasonic and capacitive sensors based hardware system is presented. Experimental work demonstrates the benefits of this strategy and enables identifying an approaching object up to 2 m without any gaps. The device is mounted on a car bumper to show its usability in automotive applications. The distance measurement device is developed using an ultrasonic sensor. The device is designed for compact, low power and high accuracy. It can be used for water level monitoring, robot obstruction prevention, parking sensor and other areas [10]. Ultrasonic and parallax ping sensors are used for performance assessment in distant measurement applications with accuracy. Finally, some experimental tests are performed with the developed system to demonstrate the efficiency [11]. In [12], the implementation of neural control systems with ultrasound sensors in mobile robots prevents obstacles in real-time. A developed Arduino model is used to test neural control and design and test low-cost ultrasonic sensing devices in different fluid media and target objects at distances up to 5 m. LabVIEW based simulated results are closely agreed with the underwater sensing application experimental results before actual implementation [13]. In [14], a Bebop Parrot drone sensor array was deployed to detect objects within a rank to minimize background noise in the measurements collected. The findings show that distance sensors enhance data measurements to make the drone more accurate in data acquisition. In [15], a list of environmental parameters developed significantly affects ultrasonic sensor-based device accuracy. The results showed that the derived simplified sound equation results in a maximum error of 0.33 for the temperature range from 0- 50◦C.

In [16], Based on the combination of Passive Infrared Sensors and Ultrasonic distance finder, this sensing system is used in combination with wireless sensor networks to identify, classify, and estimate vehicle speed in real-time. In [17], developed a system based on an ultrasonic sensor that determines the number, form and speed of vehicles passing through a given period. The device proposed consists of two ultrasonic sensors and a microcontroller with a data logging shield and a graphical user interface (GUI) to view the results. In [18], Ultrasonic sensors implement a practical, cheap curb detection and location system. Compared with other high-cost sensors, field tests under four standard curb scenarios have demonstrated the efficiency of the proposed treatment algorithms to take account of the relatively low performance of ultrasonic sensors. When an obstacle is detected in the field of operation, the machine performs the intended operation accurately. The change of the driver less vehicles increases confidence and results in loss of control. The objective of fewer drivers is to reduce malfunctions by focussing on the main driver: driving error, deviation, and sleepiness [19]. Three ultrasonic sensors are attached to the autonomous mobile robot in [20]. The efficiency of the new ultrasonic positioning method was demonstrated by experimental results. When compared to the conventional ultrasonic positioning method, the proposed method's positioning accuracy is significantly improved by using the default ultrasonic velocity [21-27].

The above literature review is helpful to give extensive exposure/motivation for developing the proposed system for maintaining the social distance during the world COVID-19 pandemic effectively. Features of the developed system are very efficient and having satisfactory performance as per the author's best knowledge.

3. Modelling of the proposed system

For the operation during social distance measurements, the designed setup comprises primarily of four components. The first section of the distance measurement input unit, consisting of 4 Ultrasonic sensors, is placed at the particular positions of the user body, such as RIGHT, LEFT, FRONT, and BACK. In the second section, control of the system operation is executed by Arduino Mega-ATmega2560 microcontroller. DC motor included as a controller with the supporting component to maintaining DC motor speed at a variable distance measured by the particular ultrasonic sensor unit in section three. In the fourth section, the display unit and the micro SD card assembly collect distance (mm) from human contact. This information is gathered to assess distance measurement samples obtained during social encounters in order to make post-trial decisions. The suggested system's circuit design for preserving social distance and hardware layout is shown in Figures 1-2 as follows:

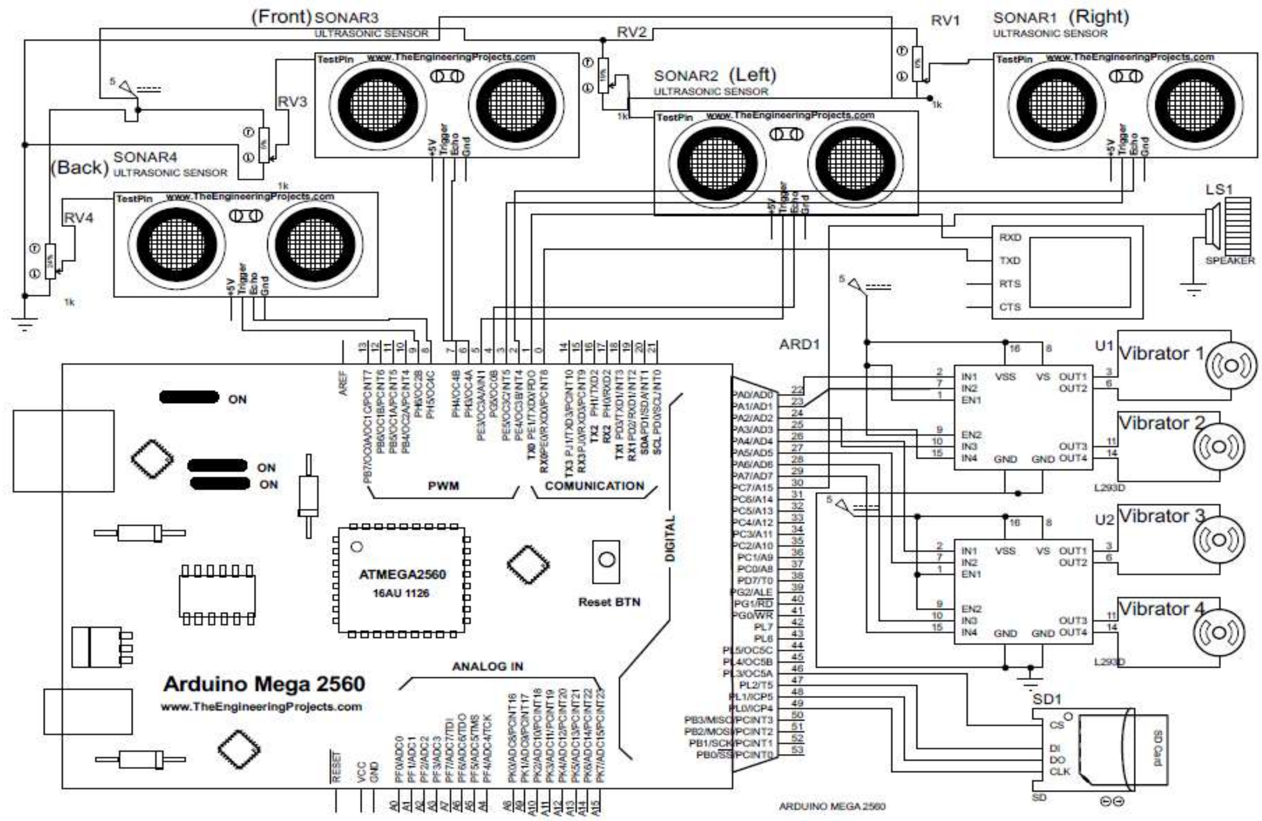


Figure 1. Proteus circuit diagram of the proposed system for maintaining social distance

Figure 1 displays the Proteus simulation of the prototype model under external stimulants. As seen, pin numbers from '2-9' Arduino-mega (2560) are used to attach to ultrasonic sensors (2-13 are PWM pins of Arduino mega). The PINs' 0' and '1' of the Arduino mega are used to connect the virtual terminal to display the simulation result. Pin numbers from '22-29' are used to set up two circuits for the motor driver, connected to two separate circuits for each motor. PIN '30' is attached to the buzzing alarm system. PINs' 46-49' are linked to the micro SD card module to store data for future observation and decision-making. Total four numbers of ultrasonic sensors are combined with four separate rheostats so that the response of the different distances can be obtained by adjusting the values. These distances are sent to the Arduino-mega for comparison. If any Arduino mega sensor reaches a critical distance, the equivalent motor is set to vibrate to warn the anxiety user. Also, the vibration frequency is inversely proportional to the distance measured by the sensor, i.e. as the person beside or behind or in front of us gets faster to us and feels a more powerful vibration from that direction. After being processed by Arduino-mega, the sensor's data are written to a micro SD card for storage and post-analysis.

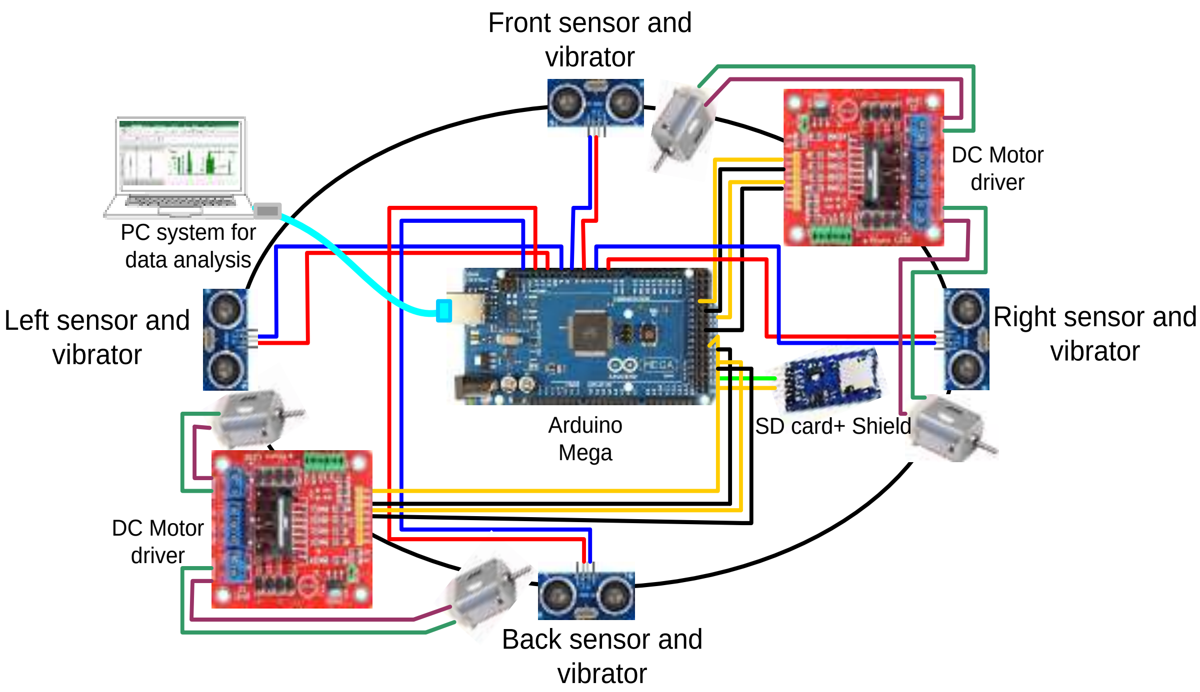


Figure 2. Design of proposed social distancing device

3.1 Supportive components: Specifications and use

The needs for and use of all the components comprised in the system are set out in Table 1.

Table 1. The specifications and items for the developed setup

Section	Components	Specifications	Role/function
1.Distance measurement function module	Ultrasonic sensor	Model: HC-SR04 Dimension (mm): 25x20x15 Minimum range: 2 cm Maximum range: 4m DC operating voltage: 5V No. of US modules: 4	In this project, an ultrasonic sensor is utilised to estimate the distance between the surrounding environment and the reference point. There are 4 sensors close (Left, Right, Front, Back) to the user.
2.System operation control unit	Arduino Mega	Microcontroller: ATmega2550 Number of units: 01 Required supply voltage: +5V Digital I/O pins: 54 Flash memory: 256KB Temperature Range:-40°C to 85°C Clock Speed: 16MHz EEPROM: 4KB SRAM: 8KB	This component is the device's principal microcontroller, and its job is to watch over the data collected by the sensor and process it for further output.
3.Mechanical	DC motor controller	Speed and Direction control is possible Vs: 4.5-36V Motor Current: 600mA Vss: 4.5-7V Transition time: 300ns	Allows you to control the direction and speed of the motor.
		Op. voltage: 4.5- 9V	To determine the direction, a DC motor

vibrator unit	DC motor	Current (no load): 70mA Speed (no load): 9000 rpm	produces vibrations.
	Alarm (Buzzer) system	Voltage (rated): 6V (DC) Op. voltage: 4-8V DC Current (rated): <30mA	Connect to a DC power source. A buzzing switch is frequently used as part of a timed on or off circuit.
4.Display and data storage unit	Liquid crystal display (Terminal display)	Size: 16x2 Supply voltage: +5V Data pins: 8- bit	16x2 LCD is used to display the measured voltage and current values at the time of experimentation.
	Micro SD card with shield	Working Voltage: 5V/3.3V Size:20x28mm Interface: SPI Compatible: Micro SD	The measured electrical parameters are saved via the integration of a Micro SD card with a shield.
	Personal Computer system	Windows PC system with Arduino open-source.	It is necessary for code writing and uploading to the Arduino Nano setup.
5.Power assistance	12 v to 5v Buck converter	Input voltage: DC 9V - 36V.	It is used to exchange 12v dc supply to 5v dc deliver appropriate for all the electronic components in this project.

3.2 Cost analysis

Furthermore, the budget of the proposed program is divided into its diverse components. Table 2 shows the total budget of the components mandatory for design and online availability (access all the components: ROBU.IN, April 25, 2020) in the Indian context.

Table 2. Availability and price of supportive components use in the proposed system

Name of component	Commercial Availability	Unit price (INR)
Ultrasonic sensor	Yes	365
Arduino Mega	Yes	825
DC motor controller	Yes	119
DC motor assembly	Yes	158
Alarm (Buzzer) system	Yes	60
Liquid crystal display (Terminal display)	Yes	225
Micro SD card with shield	Yes	403
DC power supply	Yes	229

** Miscellaneous cost is not considered for some components.*

4. Results and Discussion

4.1 Pre-testing analysis of system error

To increase accuracy, consistency, and social acceptance, a pre-test assessment of the created system (during the prototype stage) is required. a variety of methods of error analysis are accessible in the literature [8] [11] [15] [16] [18]. Based on the static and dynamic positions of the device and the obstacles to recording the measurement data, three test cases are considered as,

4.1.1 A. Device and obstacles are kept in a static position

In this test case, the device's position being developed and the obstacle are considered to be set. A whole of 100 numbers of ultrasonic echoes are recorded in a range of 100 cm distance measurements of the obstacles located (from all sides) during the test. The data collected in terms of distance (mm) is stored in a micro SD card, which can be used to display an efficient operation in terms of the accuracy of the device using Figure 3 as,

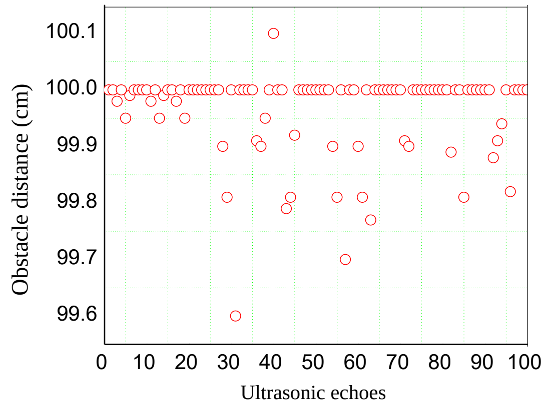


Figure 3. Distance measurement recorded of obstacles with the US sensor at a static position

Whereas both were at rest, the distance from the sensor to the obstacle was measured 100 times at numerous distances between 30 cm and 180 cm. For statistical analysis, the captured data is plotted. And the results are shown in Figure 4.

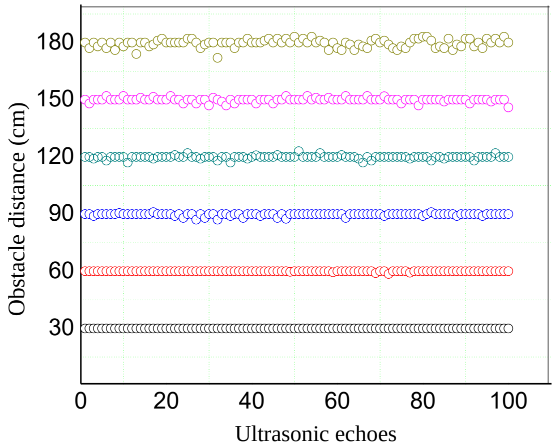


Figure 4. Measured distances from the sensor obstacle

Because of the rising turbulence impact, the dispersion of readings rises with distance. The standard deviation and total relative error were calculated using the median of the 100 observations as the correct distance for each distance. The obtained results are summarised in Table 3 as,

Table 3. Measurement results of distances between the sensor and obstacle

Actual distance (cm)	Standard deviation	Median	Standard Error (%)
30	0.02	29.996	1
60	0.21	59.96	2
90	0.70	89.76	7
120	0.88	119.87	9

150	1.07	149.89	11
180	2.09	179.60	21

Above Table 3 shows that both the standard deviation and the overall relative error increase with the distance as it increases the turbulence variations in the sound speed. Nevertheless, the standard error for a distance of 180 cm was 21%—approximately twice as much as 11% of a distance of 150 cm.

4.1.2 B. Device and/or obstacles are kept in a dynamic position

The position of the device and/or obstacle being developed shall be treated in a dynamic position. Only 30 ultrasonic echoes are triggered and recorded at a distance of between 30 and 145 cm (from all sides) of the detected obstacles. Figure 5 shows the measurements taken throughout the second test case to show an efficient operation and accuracy of the system.

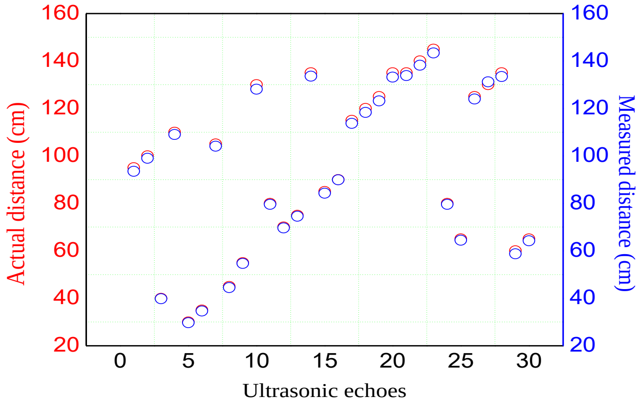


Figure 5. Distance measurement recorded of obstacles with the US sensor at dynamic position

4.2 Field test results

The Indian Prime Minister, Narendra Modi, declared the total lockdown of 21 days for the entire population of 1.3 billion people at the Indian Time Zone at 8:00 PM on March 24 2020. He advocates Indians to stay at home to slow the virus spread [21, 22, 23]. More than 90% of the Indian population works in the informal sector, and more than 100 million rural people are working as regular employees, casual workers, contract workers, and service providers in various cities [24, 25, 26, 27, 28]. Meeting their daily needs depends on daily employment, and the implementation of such drastic action without concrete support only reinforces social inequalities – instilling fear and uncertainty. Back to back lockdown extension 2.0 and 3.0 until May 17 2020.

The gradual propagation of the COVID -19 virus in India achieved the aim of this narrowing in the Indian context [29]. After 50 days of lockdown, the entire nation has been divided into three areas: green, red, and orange, with the relaxation of economic stabilization implemented accordingly. However, it is a worldwide urge to keep the social distance from this pandemic virus [30, 31, 32]. The device developed can be a milestone in this direction of social distance [33-37].

Field results forever test the performance validation and well-organized operation of any developed hardware system [38-42]. The existing hardware setup is used for field-testing in conditions of social distance measurement. Two distinct paths are chosen in this context to illustrate the remote sampling device's efficient operation [43-45]. The user is informed by the available distance measured during human contact in society during real-time functioning of the gadget. In addition, the stored sample data is useful for further analysis. User can track his/her past travel/contact records to find out how much he/she is following the instructions to maintain a social distance.

The location of the test show is selected on two dissimilar routes as per high and low mass gathering in Prem Nagar, Dehradun, and Uttarakhand, India. The start and ends of both the routes are set during the device testing, as shown during google image in Figure 6. Route-1 passes through the main market area, where there is a high chance of people gathering. The second route was chosen through the residential society, where the minimum number of people gathered during the current global curfew.

Figure 6. Walking routes for the field test in Prem Nagar, Dehradun, India (Distance: 0.45 to 0.50 Km)

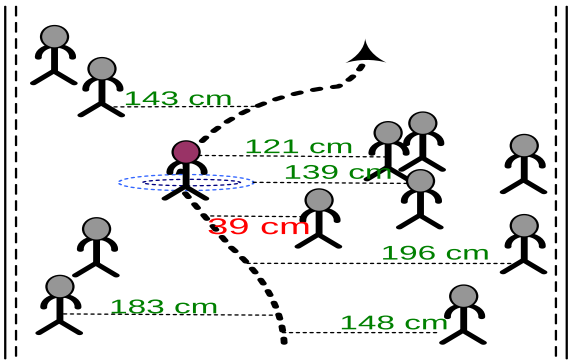
Various social interaction/distance testing situations are registered in the device's memory during the user's walking experience of each route. Some of the test scenarios at certain places are characterised as violating the social gap in route-1, which is part of the primary market region, for example, in critical observations or mass gathering.

4.2.1 A. Test scenario-1

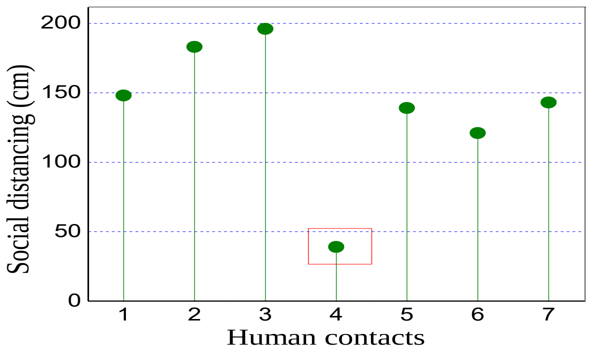
During the walking history of Route-1, a human mass gathering place is identified, and the user has tried to move away from obedience to social distance in Figure 7(a). Under this test scenario-1, all the measured distances are proof in the device. The outcomes are plotted for further analysis to identify how many people were in close contact with the user during his walking history at a
particular location. Only one reading is found to have very close interaction, as seen in 39 cm, as shown in Figure 7(b).

4.2.2 B. Test scenario-2

Based on the data collected, the second mass gathering point was identified and plotted as shown in Figure 8 for observations in the logic of social distancing. The graphical vision of every reported experience indicates that the user has sought to adhere to the social distancing law. Still, his reported data symbolize a critical condition for the possibility of covid-19 virus infectivity. The social distance does not follow all the communications details.

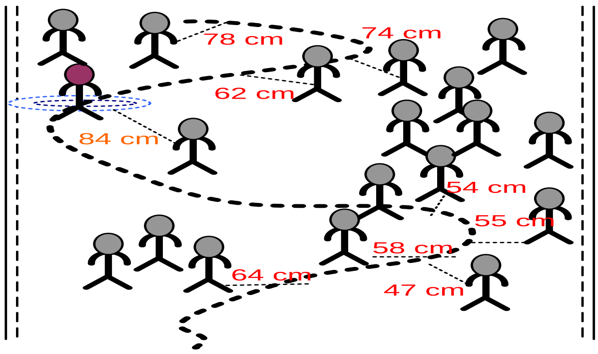


(a)



(b)

Figure 7(a). Walking history at route-1 (b) graphical representation of distance during test scenario-1



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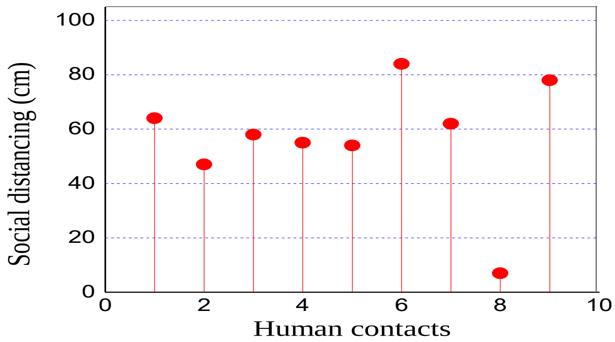
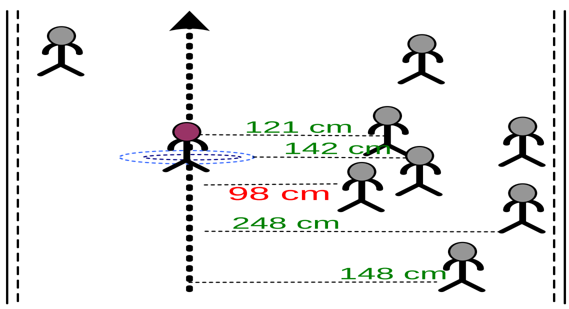


(b)

Figure 8 (a). Walking history at route-1 (b) graphical representation of distance during test scenario-2

4.2.3 C. Test scenario-3

The user has attempted to follow dutiful social distance in this scenario-3, which depicts a very low people mass-gathering place. Shown in Figure 9(a). All measured distances are reported in the system during this process. The recorded data is plotted for further study to determine how many people were in close contact with the user during his walking experience at a specific spot. Earliest, the recorded interaction is found to maintain a satisfactory distance to properly follow the social distance. Simply one reading of 98 cm showing the normal distance shown in Figure 9(b) is found.



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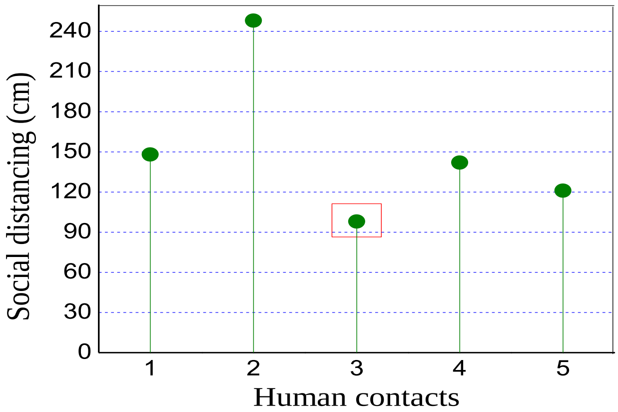

(b)

Figure 9 (a). Walking history at route-2 (b) graphical representation of distance during test scenario-3

During field testing, the compiled record is saved on a micro SD card attached to the device. Passing via routes-1 and 2, many events/distances are recorded to characterize the social distance history. Through study Figure 10, a large number of readings have less than 80 cm of human obstruction distance from the user while passing through Route-1. It suggests that social distances are effectively avoided. According to the administrative requirements for social distancing, very few readings take place at a safe distance. Figure 11 demonstrates the history of route 2. That passes through the residential area. The nature of the readings shown in complete agreement to follow the social distance to a safe and healthy life in the current global COVID-19 pandemic.

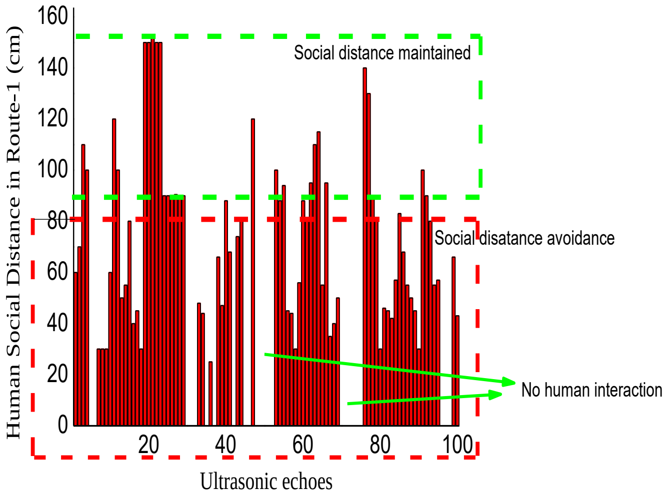

Figure 10. Recorded human social distance data from walking Route-1

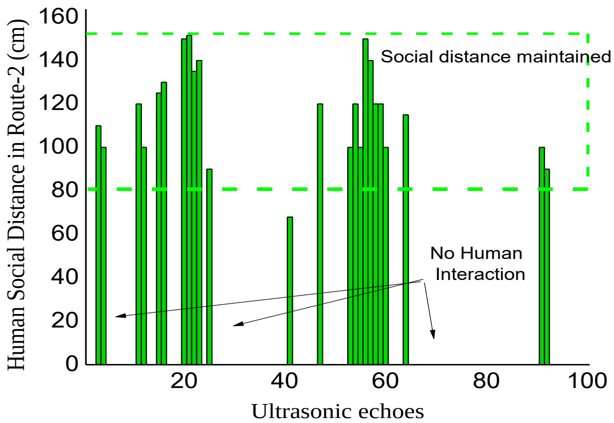

Figure 11. Recorded human social distance data from walking Route-2

5. Conclusion

Ultrasonic sensors are commonly used as low-cost sensors in the automotive industry and construct a distance measuring obstruction device. An ultrasonic sensor that is cheaper and less demanding than any other sensor currently used. The system can also notice any type of obstacle, prevent footpath clash or reduce injuries. Pre-test analysis is carried out by a system for measuring error evaluation with static and/or dynamic obstruction and established system conditions. Current analyses obtained show a top error value of 21% with a high distance of 180 cm. still, the performance of the established model has been demonstrated in three field test scenarios and reflects results to alert users of social distances. In addition, the data recorded during the history of the selected routes show the user's behaviour, whether or not they comply with the social distance administrative rule. Since the algorithms proposed are easy, rapid and well-organized sufficient for real-time processing, our approach provides a practical means of identifying the presence of human/obstacles to maintain social distances.

Appendix A.

The software built for the new system must be simple to modify in order to meet the various criteria. The code is entered in Arduino IDE (open source software) and Figure A-1. As can be seen, the measurement loop, which is the algorithm in charge of data measurement, is relatively short, compact, and straightforward. The calibrated steps of the ultrasonic sensor-measured data are included in the code.

Fig A-1. Screenshot of Embedded 'C' programming for system

Conflicts of Interest: No conflict of interest exists for all authors.

References

[1] United nation development Programme: A report is available on https://www.undp.org/content/undp/en/home/coronavirus.html, access date: May 8, 2020.

[2] Healthy children.org: A report is available on https://www.healthychildren.org/English/health-issues/conditions/chest-lungs/Pages/Social-Distancing-Why-Keeping-Your-Distance-Helps-Keep-Others-Safe.aspx, access date: May 8, 2020.

[3] Centres of Disease Control and Prevention: A report is available https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/social-distancing.html, access date: May 8, 2020.

[4] Y. S. Huang, M. S. Young, (2009). An accurate ultrasonic distance measurement system with self-temperature compensation. Instrumentation Science and Technology 37(1): 124-133.

[5] J. Majchrzak, M. Michalski, G. Wiczynski, (2009). Distance estimation with a long range ultrasonic sensor system. IEEE Sensor Journal 9(7): 767- 773.

[6] O. Bischoff, X. Wanga, N. Heidmanna, R. Laura, S. Paula, (2010), implementing an ultrasonic distance measuring system with Kalman filtering in wireless sensor networks for transport logistics. Procedia Engineering 5: 196-199.

[7] Anjali Sharma,Dr. Garima Sinha(Aug 2021). "An Efficient Approach on Data Security with Cloud Computing Environment: A Comprehensive Research". **e-ISSN** 1309-4653

https://turcomat.org/index.php/turkbilmat/article/view/10464/7880

[8] Alonso, V. Milanes, C. T. Ferrero, J. Godoy, J. P. Oria, T. D. Pedro, (2011). Ultrasonic sensors in urban traffic driving aid systems. Sensors 11: 661-673.

[9] T. Schlegl, T. Bretterklieber, M. Neumayer, H. Zangl, (2011). Combined capacitive and ultrasonic distance measurement for automotive applications. IEEE Sensors Journal 11(11): 2636-2642.

[10] S. Wang, Q. Liu, S. Chen, Y. Xue1, (2013). Design and application of distance measure ultrasonic sensor. Advances in Mechanical and Electronic Engineering 178: 109–114.

[11] G. Gaşparesc, A. Gontean, (2014). Performance evaluation of ultrasonic sensors accuracy in distance measurement. IEEE Conference on Electronics and Telecommunications, Timisoara, pp. 1-4.

[12] A. M. Santiago, J. L. C. Anzueto, J. A. V. Feijoo, H. R. H. León, R. M. Grajales, (2014) Neural control system in obstacle avoidance in mobile robots using ultrasonic sensors. Journal of Applied Research and Technology 12: 104-110.

[13] D. Z. Wan, C. S. Chin, (2014) Simulation and prototype testing of a low-cost ultrasonic distance measurement device in underwater. Journal of Marine Science and Technology 20:142–154.

[14] J. S. G. Guerrero, A. F. C. Gonzalez, J. I. H. Vega, L. A. N. Tovar, (2015). Instrumentation of an array of ultrasonic sensors and data processing for the unmanned aerial vehicle (UAV) for teaching the application of the Kalman Filter. Procedia Computer Science 75: 375 – 380.

[15] K. G. Panda, D. Agrawal, A. Nshimiyimana, A. Hossain, (2016). Effects of the environment on accuracy of ultrasonic sensor operates in the millimetre range. Perspectives in Science 8: 574-576.

[16] E. Odat, J. S. Shamma, C. Claudel, (2018). Vehicle classification and speed estimation using combined passive infrared/ultrasonic sensors. IEEE Transactions on Intelligent Transportation Systems 19: 1593–1606.

[17] R. Stiawan, A. Kusumadjati, N. S. Aminah, M. Djamal, S. Viridi, (2019). An ultrasonic sensor system for vehicle detection application. Journal of Physics: Conference Series. 1204: 12-17.

[18] J. H. Rhee, J. Seo, (2019). Low-cost curb detection and localization system using multiple ultrasonic sensors. Sensors 19: 1-22.

[19] D. V. Sai, C. K. Babu, K. S. Akhil, N. Vurukonda, A. K. Patel, (2019). A novel approach for ultrasonic sensor obstacle detection using the internet of things. International Journal of Innovative Technology and Exploring Engineering 8(6): 1454-1459.

[20] M. Shen, Y. Wang, Y. Jiang, H. Ji, B. Wang, Z. Huang, (2020). A new positioning method based on multiple ultrasonic sensors for an autonomous mobile robot. Sensors 20: 1-15.

[21] Gettleman, Jeffrey; Schultz, Kai (March 24 2020). Modi Orders 3-Week Total Lockdown for All 1.3 Billion Indians. The New York Times. ISSN 0362-4331, access date: May 10, 2020

[22] PM Modi announces extension of lockdown till May 3". Live mint. April 14 2020, access date: May 10, 2020.

[23] Lockdown extended till May 17: Read MHA guideline. News World 24. May 1 2020. Retrieved May 1 2020, access date: May 10, 2020.

[24] Thacker, Teena (May 1 2020). Centre issues state-wise division of Covid-19 red, orange and green zones. The Economic Times, access date: May 10, 2020.

[25] D. Datta, S. Mishra, S. S. Rajest, (2020). Quantification of tolerance limits of an engineering system using uncertainty modelling for sustainable energy" International Journal of Intelligent Networks. 1: 1-8, https://doi.org/10.1016/j.ijin.2020.05.006

[26] L. W. Santoso, B. Singh, S. S. Rajest, R. Regin, K. H. Kadhim (2021). A Genetic Programming Approach to Binary Classification Problem. EAI Endorsed Transactions on Energy 8(31): 1-8. DOI: 10.4108/eai.13-7-2018.165523

[27] K.K.D. Ramesh, G. Kiran Kumar, K. Swapna, Debabrata Datta, and S. S. Rajest (2021). A Review of Medical Image Segmentation Algorithms. EAI Endorsed Transactions on Pervasive Health and Technology. 10.4108/eai.12-4-2021.169184.

[28] M. Cheng, Y. Zhang, Y. Su, J. M. Alvarez, H. Kong, (2018). Curb detection for road and sidewalk detection" IEEE Transaction Vehicular Technology 67: 10330–10342.

[29] S. Li, C. Feng, X. Liang, H. Qin, H. Li, L. Shi (2018). A guided vehicle under fire conditions based on a modified ultrasonic obstacle avoidance technology. Sensors 18: 43-66.

[30] M. Bernas, B. Placzek, W. Korski, P. Loska, J. Smyla, P. Szymala (2018). A survey and comparison of low-cost sensing technologies for road traffic monitoring. Sensors 18: 32-43.

[31] A. Jain, A. K. AlokGahlot, and S. K. S. RakeshDwivedi, "Design and FPGA Performance Analysis of 2D and 3D Router in Mesh NoC," Int. J. Control Theory Appl. IJCTA ISSN, pp. 0974–5572, 2017.

[32] M. B. D. Paula, C. R. Jung (2015). Automatic detection and classification of road lane markings using on board vehicular cameras. IEEE Transaction Intelligent Transportation System 16: 3160–3169.

[33] G. Cui, J. Wang, J. Li (2014). Robust multilane detection and tracking in urban scenarios based on LIDAR and mono-vision. IEEE Transaction Image Process 8: 269–279.

[34] A. Jain, A. Kumar, and S. Sharma, "Comparative Design and Analysis of Mesh, Torus and Ring NoC," Procedia Comput. Sci., vol. 48, pp. 330–337, 2015.

[35] A. Jain, R. Dwivedi, A. Kumar, and S. Sharma, "Scalable design and synthesis of 3D mesh network on chip," in Proceeding of International Conference on Intelligent Communication, Control and Devices, 2017, pp. 661–666.

[36] A. Jain, A. K. Gahlot, R. Dwivedi, A. Kumar, and S. K. Sharma, "Fat Tree NoC Design and Synthesis," in Intelligent Communication, Control and Devices, Springer, 2018, pp. 1749–1756.

[37] A.K. Gupta, Y.K Chauhan, and T Maity and R Nanda, "Study of Solar PV Panel Under Partial Vacuum Conditions: A Step Towards Performance Improvement," IETE Journal of Research, pp.1-8, 2020.

[38] A.K. Gupta, Y.K Chauhan, and T Maity, "A new gamma scaling maximum power point tracking method for solar photovoltaic panel Feeding energy storage system," IETE Journal of Research, vol.67, no.1, pp.1-21, 2018.

[39] S. K. Sharma, A. Jain, K. Gupta, D. Prasad, and V. Singh, "An internal schematic view and simulation of major diagonal mesh network-on-chip," J. Comput. Theor. Nanosci., vol. 16, no. 10, pp. 4412–4417, 2019.

[40] D. Ghai, H. K. Gianey, A. Jain, and R. S. Uppal, "Quantum and dual-tree complex wavelet transform-based image watermarking," Int. J. Mod. Phys. B, vol. 34, no. 04, p. 2050009, 2020.

[41] A. Jain and A. Kumar, "Desmogging of still smoggy images using a novel channel prior," J. Ambient Intell. Humaniz. Comput., vol. 12, no. 1, pp. 1161–1177, 2021.

[42] S. Kumar et al., "A Comparative Analysis of Machine Learning Algorithms for Detection of Organic and Nonorganic Cotton Diseases," Math. Probl. Eng., vol. 2021, 2021.

[43] N. R. Misra, S. Kumar, and A. Jain, "A Review on E-waste: Fostering the Need for Green Electronics," in 2021 International Conference on Computing, Communication, and Intelligent Systems (ICCCIS), 2021, pp. 1032–1036.

[44] A. Jain, R. Dwivedi, A. Kumar, and S. Sharma, "Network on chip router for 2D mesh design," Int. J. Comput. Sci. Inf. Secur., vol. 14, no. 9, p. 1092, 2016.

[45] J. Kubiczek and B. Hadasik, "Challenges in Reporting the COVID-19 Spread and its Presentation to the Society," J. Data and Information Quality, vol. 13, no. 4, pp. 1–7, Dec. 2021, doi: 10.1145/3470851.