RESEARCH ARTICLE

REVISED The accuracy of Infrared sensor detection in a smart toilet [version 2; peer review: 1 approved, 2 approved with reservations, 1 not approved]

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Latest published: 14 Mar 2022, **10**:949
https://doi.org/10.12688/f1000research.73086.2

Abstract

Background: Infrared (IR) sensors are useful tools for detecting distance and proximity. However, these sensors are not good at detecting edges of an area, therefore when used in a smart toilet it has difficulty in detecting the orientation and position of the user's body. The aim of this study was to design an IR sensor for a smart toilet with a more accurate and consistent detection.
Methods: A total of 12(six men and six women) participants with different body types were involved in this study. IR sensor detection was tested in the sitting and squatting toilets.
For the best accuracy, the IR sensor's angle was measured.
Red, blue, and red-blue plastic covers were used, as
these colors improve precision.
The microcontroller was set up to calculate the participant's distance an
Results: Toilet positioning varied greatly depending on whether one i
s sitting or squatting. For sitting
toilet, the red cover was close to the accurate distance at a
172˚ angle. IR detected a man but not a woman's body.
The blue cover provided the same best angle of 172˚ with a
higher sensor distance. When the red and blue cover combination was a
angle. The actual distance for squatting toilets was 158cm. The
optimal angle for both red and blue covers was 176˚,
however the sensor distance was greater for the blue cover. Finally,
the red and blue cover combination gave a more accurate distance of
up to 163cm from the actual reading, when detecting both genders at
a normal angle of 76˚.
Conclusion: The combination of red and blue cover gave the
most accurate detection for the squatting and sitting toilets. The best
angle for sitting was 172˚, and for squatting was 176˚.

Keywords

Infrared sensor, Raspberry Pi, Internet of Things (IoT)

Open Peer Review

Approval Status ✓ ✗ ? ?

	1	2	3	4
version 2 (revision) 14 Mar 2022	✓ view	✗ view	? view	? view
version 1 21 Sep 2021	? view			

1. **Mira Kania Sabariah**, Telkom University, Bandung, Indonesia
2. **Isaac Machorro-Cano**, Universidad del Papaloapan, Loma Bonita, Mexico
3. **Cosmas Ifeanyi Nwakanma**, Kumoh National Institute of Technology, Gumi-si, South Korea
4. **Jin Zhou**, Duke University, Durham, USA

Any reports and responses or comments on the article can be found at the end of the article.

This article is included in the Research Synergy Foundation gateway.

Corresponding author: R Kanesaraj Ramasamy (kanes87@gmail.com)

Author roles: Lokman A: Formal Analysis, Investigation, Methodology, Validation, Writing – Original Draft Preparation; **Rajendran K**: Investigation, Writing – Original Draft Preparation; **Ramasamy RK**: Funding Acquisition, Methodology, Resources, Supervision, Writing – Review & Editing

Competing interests: No competing interests were disclosed.

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First published: 21 Sep 2021, **10**:949 https://doi.org/10.12688/f1000research.73086.1

REVISED **Amendments from Version 1**

We have explained the steps and type of material in the method section. We have also included the limitation in the conclusion.

Any further responses from the reviewers can be found at the end of the article

Introduction

Technological advancement across the world allows for almost everything to be connected to each other. The Internet of Things (IoT) defines objects that are instilled with sensors and other technologies that can share data with other devices and systems over the internet[1].

Smart Toilet is one of the examples of the IoT system. Smart Toilet implementation consists of infrared (IR) sensor which can accurately measure the distance from the height of the toilet. The IR sensor is connected to Raspberry Pi as a micro-controller, also called a tiny computer that has a router for internet connection.

The SHARP GP2Y0A710K0F is an IR distance sensor with an extra-long range of 100–500 cm, which is incredibly simple to use. As such, this IR sensor is a preferred option for this study compared to ultrasonic sensors.

The IR sensor measures a distance with the use of the triangulation principle, in which the measurement of the distance is dependent on the angle of the reflected beam. The sensor consists of an IR light-emitting diode (LED) and a Position Sensing Device (PSD) or light detector. The IR emitted from the LED emitter, hits an object which is then mirrored off at a certain angle. This reflected beam will reach the PSD, creating an "optical spot". As the object's direction/position changes (Figure 1), the angle of the reflected beam and the direction of the position on the PSD changes as well.

The sensor has a signal processing circuit that is built-in. This circuit processes the position of the "optical spot" on the PSD to determine the location and the distance of the reflective object. It outputs an analogue signal depending on the distance between the sensor and the object. The output voltage of the SHARP GP2Y0A710K0F ranges from 2.5 - 1.4 V when an object is placed within 100–500 cm distance, respectively[2]. The input, ground, and analog signals are all connected to three pins on this sensor. To connect to the Raspberry Pi, the MCP 3008 chip is utilized as an analogue to digital converter. The positioning graph for each computation is shown in Figure 2. Each adjustment has a 5ms delay.

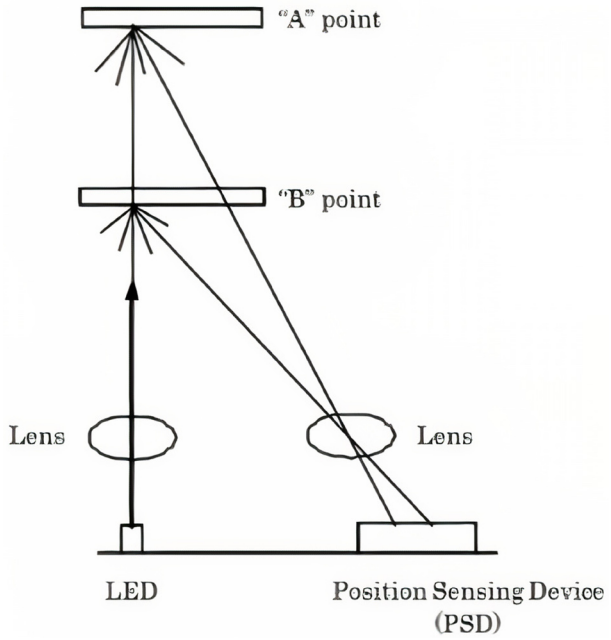

Figure 1. Infrared sensor architecture system[2].

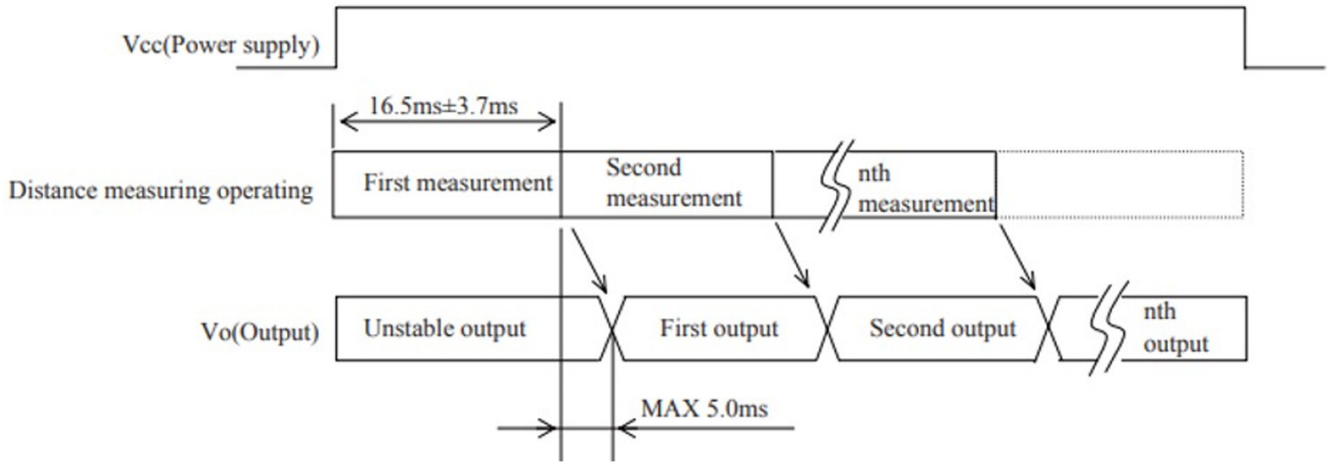

Figure 2. The positioning diagram for measures of distance[3].

For the IR sensor, detecting the position and the orientation of the user's body in the toilet is a great challenge, as the sensor responds more accurately to a flat surface compared to a curved one (the position of the participant's body during sitting or squatting). Additionally, this sensor measures the distance based on the type of toilets used (seated or squatting) (Figure 3). In this paper, an IR detection system is used to locate people using these two types of toilets. The goal was to ensure sensitivity of the sensor readings for precise distance measurements, and accurate detection of different body shapes and sizes.

There are many that have used sensors and proven its efficacy[3]. For example, the complex framework of traffic management[4], operates the traffic control system by using IoT, IR sensors, and image processing to make the road system operate efficiently. Car movement and traffic is detected by the IR-sensors. Information on direction of the traffic is then sent to the drivers' mobile device. The driver uses his/her mobile device to monitor the traffic density and the position of the closest traffic signal. The IR sensor is placed on the roadside pole near the traffic light, where the transmitter and receiver face the road. Disadvantage of this sensor is that it works poorly under the sun as the receiver is sent both the IR waves from the transmitter and the sun causing inaccuracy. Therefore, the IR sensor needs to be installed in a closed box, safe from sunlight and rain.

Singh, A, *et al.*[5] suggested a solution based on IoT for reliable and safe collection of waste. The route of waste collection vehicles is dependent on the waste status of the smart bin. In order to optimize the framework upon use, the program uses Cloud Analytics and Deep Learning. This aids with managing the variations in the processing of waste. The rim of the bin has four Infrared Obstacle Line Sensors (the black boxes are the sensors, and the yellow lines are the obstacle routes they cover) mounted on the upper rim of a dustbin. It is possible to mount the sensor system on both lid-based bins and without lid-based bins. A Raspberry Pi 2 board is mounted on the IR sensors. A Wi-Fi Card / Global System for Mobile communication (GSM) module linking it to the internet is mounted on the surface. The board notifies the machine when the dustbin is full. The device is a web application built on Python (Django Framework), which manages all updates from the bins and their exact coordinate positions on a map. The system then plans the strategy and proposes an optimal path.

Another example is the blind people's assistive IR sensor based smart stick[6], which was suggested as a solution for these individuals to detect obstacles on their path. The smart stick uses horizontal and inclined IR sensors, as they are lightweight, inexpensive, have a specific range and have low power consumption compared to ultrasonic sensors. The horizontal IR sensor is located below the hand stick at a height of 90 cm to check the area in front of the blind individual, while the inclined IR sensor is located at a height of 75 cm. The smart stick works by transmitting a pulse of IR signal which travels into the environment. In the absence of an obstacle this signal is not emulated, and as a result no signal, except a dull noise signal, might be sent to the receiver. In the event of finding an obstacle, the signal is transmitted back to the receiver[6].

This paper aims to examine how to improve IR sensor for more accurate human detection, and to also assess which cover color will result in more precise measurements.

Methods

In this study, six men and six women (n=12) participated. We only utilised 12 people because this is a qualitative study to see what angle is optimal for toilets so the sensor can detect them.

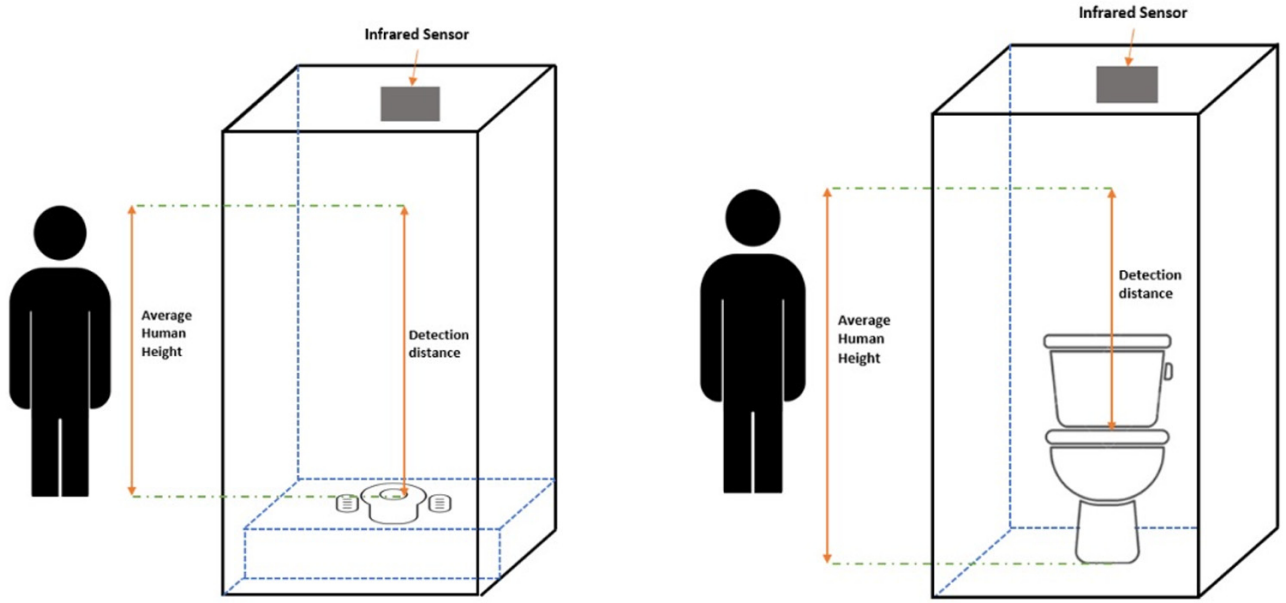

Figure 3. Toilet cubicle for squatting toilet and sitting toilet.

We used students of varied sizes. Both men and women were included as different body sizes and types affected the reflection of the IR signal. Defecation posture needs to be in the right body position, which is 35° - 45°. The distance of the IR detection for the squatting toilet is greater than the sitting toilet (toilet bowl) (Figure 3). The average height of male and female participants was taken, to determine the ratio of the body size to the specific area of IR detection. The detection distance ranged from 50 cm to 200 cm.

The SHARP GP2Y0A710K0F IR sensor was placed in an enclosure box to protect the sensor from water damage and other IR radiation, to avoid interference. The enclosure box was then attached to where the cubical celling meets the wall, in both squatting and sitting toilets (Figure 5). The angle of the IR sensor was measured to obtain the most optimal and accurate distance. The angle of the sensor depended on the plastic covers used; red, blue, and a combination of both covers. Blue and red covers were used as these colours are suitable for infrared sensor detection[7], thus these specific colours can provide a more accurate result. The plastic covers were placed directly outside the enclosure box, parallel to the IR sensor emitter and detector, so that the ray can be transmitted from the enclosure box and pass through the plastic cover without an obstacle in between.

The Raspberry Pi microcontroller was programmed to calculate distance[8] and presence of the human body inside the cubicle (See underlying data)[9]. IR sensor used analogue voltage input from the Raspberry Pi. MCP3008 chip was used to convert digital output to analogue input for the IR sensor (Figure 4). This chip has eight output channels, and it connects to the Raspberry Pi by using a Serial Peripheral Interface (SPI) serial connection[9]. SPI is a protocol for synchronous serial data, that interacts very easily with one or more computers.

In general, the sensors were first mounted at a set angle according to Table 1. After that, users must enter one by one. This is done for each colour in turn to get the percentage of correctness. PVC was used as the material. The purpose of utilising this material is to conceal the IR sensor from consumers so that they are not alarmed. Because the IR sensor resembles a camera, we covered it with this material to alleviate user concerns. As IR rays are similar to lights, different colours have varied effects on the IR sensor.

Raspberry Pi programming function

Raspberry Pi 4 Model B that runs Python as the main language, was used. This model contains a small computer operating on a 4 GB Random Access Memory (RAM) Raspbian operating system, and a built-in WIFI. Overall code is shown in below.

Figure 4. Block diagram of the overall system.

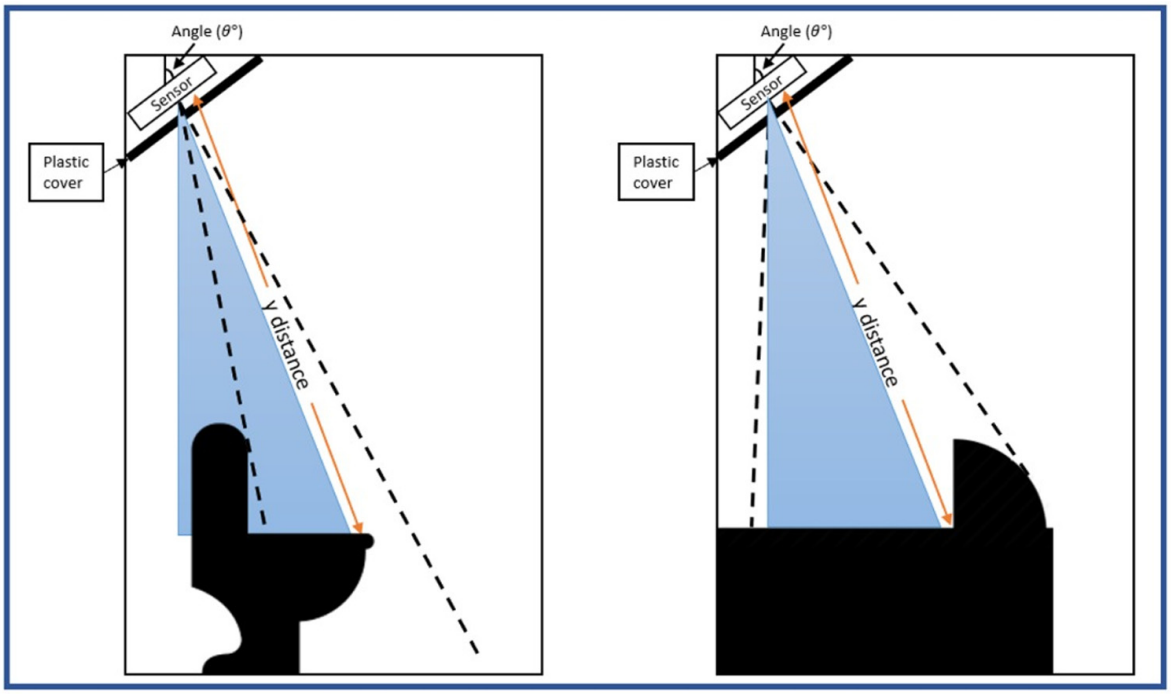

Figure 5. Position of the sensor and plastic cover inside the cubicle.

Table 1. IR detection for sitting toilet.

Angle (θ°)	Plastic cover	Sensor dist. (cm)	Actual dist. (cm)	Man	Woman	% Error
168	Red Cover	273	141	0	0	93.62
170		248	141	1	0	75.89
172		172	141	1	1	21.99
174		252	141	0	0	78.72
168	Blue Cover	224	141	0	0	58.87
170		214	141	1	0	51.77
172		184	141	1	1	30.50
174		236	141	0	0	67.38
168	Red and Blue Cover	271	141	0	0	92.20
170		263	141	1	0	86.52
172		150	141	1	1	6.38
174		239	141	0	0	69.50

```
FUNCTION distance ():
   Define analog pin, total distance and avg
factor var.
   While average factor <= 75:
       Read analog pin value in voltage unit.
       Distance = 28250 / (voltage – 229.5)
       Total distance = total distance +
Distance
   Distance = total distance / average factor
   RETURN distance
```

Results

The result for sitting toilet is shown in Table 1, and result for squatting toilet in Table 2. For sitting toilet, angle stared at 168° to 174° while squatting toilet starts at 174° to 180°. Data 0 and 1 for man and woman indicated the detection of human body. Data 0 represented no detection while data 1 represented detection.

For sitting toilet, red cover received a value close to the actual distance at angle 172°. At angle 170°, IR was able to detect a man, and not a women's body. This is because at this angle a man's body which is usually larger in size, is easier to detect than a women's body. Other angles gave a very high sensor distance, which is not suitable for human body detection. Similarly, the blue cover resulted in the same best angle, which was 172°, however the sensor distance was higher than the red cover. The red and blue cover combination, on the other hand, provided a more accurate distance reading of 150cm, as opposed to the actual reading of 141cm. Additionally, at the 172° angle both man and woman's bodies were detected by the sensor.

For the squatting toilet, actual distance (158cm) was higher than the sitting toilet. The best angle for the red cover was 176°. At 178° angle, IR could detect a man and not a woman's body. Other angles gave a very high sensor distance, which is not suitable for human body detection. The blue cover gave the same best angle which was 176°, but the sensor distance was higher than the red cover. Finally, the red and blue cover combination gave more accurate distance of up to 163cm from the actual reading. The 176° angle could also detect both man and woman's bodies.

Discussion

This project was carried out at a temperature of 30° C, which can affect the temperature of the sensor and as a result increase the sensor detection error. The formulation of percentage error is shown in the equation below.

$$\%\,\boldsymbol{Error} = \frac{|\,sensor\ distance - actual\ distance\,|}{actual\ distance} \times \mathbf{100} \quad [10]$$

For sitting toilet, the lowest percentage error was 6.38%, which was obtained with the combination of red and blue plastic cover at 172° (Table 1). This angle was the best suited for the human body for this type of toilet. The red cover gave the lowest percentage error (22%), which was good but not consistent. The distance for the red cover was challenging to calculate due to the fluctuations in the value. For the blue cover, percentage error was higher (30.5%) than the red cover. The blue cover deflects more IR light.

For squatting toilet, the lowest percentage error was 3.16%, which was obtained with the combination of red and blue plastic cover at 176° (Table 2). This angle is the best suited for the

Table 2. IR detection for squatting toilet.

Angle (θ°)	Plastic cover	Sensor dist. (cm)	Actual dist. (cm)	Man	Woman	% Error
174	Red Cover	249	158	0	0	57.59
176		189	158	1	1	19.62
178		216	158	1	0	36.71
180		228	158	0	0	44.30
174	Blue Cover	252	158	0	0	59.49
176		175	158	1	1	10.76
178		230	158	1	0	45.57
180		246	158	0	0	55.70
174	Red and Blue Cover	276	158	0	0	74.68
176		163	158	1	1	3.16
178		243	158	1	0	53.80
180		259	158	0	0	63.92

human body for this type of toilet. The red cover gave the lowest percentage error (19.6%). Similar to the sitting toilet, measuring the distance was difficult due to the fluctuating value of the red cover. For the blue cover, percentage error was 10.76%, which was lower than the red cover.

In a similar study we used ultrasonic sound to detect the user's presence in a smart toilet[3]. This form of detection proved challenging as the sound wave was absorbed by the participant's clothes, as a result the accurate distance could not be detected by the ultrasonic sound[3]. Therefore, compared to our previous study, IR sensor is a more reliable detection system for smart toilets as it can precisely detect human presence in the toilet.

Conclusions

This study utilizes an IR sensor with various angles and several different types of plastic covers to detect the user's presence and distance from the smart toilet. Red cover and blue cover provide fluctuating distances for the sensor, which also impacts accuracy. The combination of blue and red plastic hides the sensor better, preventing the user from seeing it clearly while increasing accuracy. To get more reliable and precise results, the sensor voltage can be increased. This study has shown that IR sensor can detect human body with different postures more accurately while providing precise distance with the combination of the blue and red covers. This study can be further improved with implementation with various different materials which is more in industrial standard.

Ethics approval

The Research Ethics Committee (REC) of Multimedia University has granted ethical approval for this research with the approval number EA0592021. This study did not obtain participant personal details, therefore taking informed consent was not required.

Data availability

Underlying data

Figshare: An overview of infrared sensor's capability in Internet of Things implementation

DOI: https://doi.org/10.6084/m9.figshare.16571331[9]

This project contains the following underlying data:

Data file. This file contains all the data that was generated from our analysis.

Author contribution

AL has contributed to our previous study as well as the model proposal in this study. KR supervised selection of sensor types and performed the experiment. RK validated the suggested model and obtained ethical approvals from the Multimedia University's Research Ethics Committee (REC).

References

1. Jasim NA, ALRikabi HTS: **Design and Implementation of Smart City Applications Based on the Internet of Things.** *Int J Interact Mob Technol.* 2021; **15**(13): 4–15.
Publisher Full Text
2. de Bakker B: **How to use a SHARP GP2Y0A710K0F IR Distance Sensor with Arduino**. 2019.
Reference Source
3. Lokman A, Ramasamy RK: **Smart toilet: Threats and challenges identifying human presence using iot sensor**. 2019; 56–60.
Publisher Full Text
4. Rani LPJ, Kumar MK, Naresh KS, *et al.*: **Dynamic traffic management system using infrared (IR) and Internet of Things (IoT).** *2017 Third International Conference on Science Technology Engineering & Management (ICONSTEM).* 2017; 353–357.
Publisher Full Text
5. Singh A, Aggarwal P, Arora R: **IoT based waste collection system using infrared sensors.** *2016 5th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO).* 2016; 505–509.
Publisher Full Text
6. Nada AA, Fakhr MA, Seddik AF: **Assistive infrared sensor based smart stick for blind people.** *2015 Science and Information Conference (SAI).* 2015; 1149–1154.
Publisher Full Text
7. Atkins MD, Boer MF: **Flow Visualization.** *Appl Thermo-Fluidic Meas Tech An Introd.* 2016; 15–59.
Publisher Full Text
8. **Raspberry Pi Analog to Digital Converters.** *Adafruit Learning System.* 2016.
Reference Source
9. Ramasamy RK: **Data in human presence and distance in the smart toilet.** *figshare.* Dataset. 2021.
10. Stephanie: **Percent Error / Percent Difference: Definition, Examples.** Statistic How To. 2016.
Reference Source

Open Peer Review

Current Peer Review Status: ✔ ✘ ? ?

Version 2

Reviewer Report 11 May 2024

https://doi.org/10.5256/f1000research.122235.r178495

?

Jin Zhou
Duke University, Durham, North Carolina, USA

This paper provides an experimental study about the use of an IR sensor for human detection in a smart toilet. While the overall presentation is clear, certain aspects need clarification or improvement.

1. The motivation of detecting a user's proximity to the smart toilet is not very clear. Can the authors elaborate on the practical applications of this functionality, such as touch-free flushing?

2. The Introduction section includes two paragraphs detailing examples of IR sensor applications in different fields, which do not seem directly relevant to the paper's main topic. Condensing it might improve the overall flow.

3. In the 'Raspberry Pi Programming Function' section, numbers used in the pseudocode need some explanations, are they linked to the specifics of the IR sensor used?

4. In the ‘Results’ section, sensor distance seems to be always lager than actual distance. If possible, could we tune the parameters in the pseudocode to improve the performance?

5. How many trials were conducted for each angle-color combination. If each combination was tested only once, could the authors comment on the reproducibility and reliability of the results?

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Are all the source data underlying the results available to ensure full reproducibility?
No source data required

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: sensor array optimization; medical image analysis; machine learning

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 11 May 2024

https://doi.org/10.5256/f1000research.122235.r178516

?

Cosmas Ifeanyi Nwakanma
Kumoh National Institute of Technology, Gumi-si, Gyeongsangbuk-do, South Korea

A. The only missing link is the dearth of Citations and references. the reviewer will appreciate it if critical claims are supported with citations. Examples of such claims are:
1. "The SHARP GP2Y0A710K0F is an IR distance sensor with an extra-long range of 100–500 cm, which is incredibly simple to use. As such, this IR sensor is a preferred option for this study compared to ultrasonic sensors".
2. "To connect to the Raspberry Pi, the MCP 3008 chip is utilized as an analogue to digital converter".

The critical question here is "What will happen if MCP 3008 is not used and how can readers know about this chip? Citations and explanations will help.

B. There seems to be too much "free advertisement" of products. For instance the mentions of "MCP 3008", and "SHARP GP2Y0A710K0F". A general name of the product would have been better as readers might be given the impression that these results are not possible with other company products.

Check this reference if relevant

Nwakanma, C.I et al, (2021[1])

References

1. Nwakanma C, Islam F, Maharani M, Lee J, et al.: Detection and Classification of Human Activity for Emergency Response in Smart Factory Shop Floor. *Applied Sciences*. 2021; **11** (8). Publisher Full Text

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Internet of Things and Machine Learning for Smart Spaces.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 11 May 2024

https://doi.org/10.5256/f1000research.122235.r178506

Isaac Machorro-Cano
Universidad del Papaloapan, Loma Bonita, Oaxaca, Mexico

The proposal presented an IR sensor with various angles and several different types of plastic covers to detect the user's presence and distance from the smart toilet. The proposal presents an

actual and interesting topic; however, the following aspects were identified:

1. In the introduction, it is suggested to give a broader context of the problems of the use of the IR sensor, especially to indicate the advantages of a correct functioning in terms of people's health. In this context, it is suggested to mention worldwide statistical data of this problem or opportunity for innovation using the IoT. Indicate the advantages of using IoT in this context and its importance for innovation. Indicate and clearly highlight the scientific contribution of the proposal.

2. It is noted that only three papers related to the proposal are indicated, but it is suggested to increase the search for related papers of the last 7 years to identify those papers that are most related to the proposal, especially in the context of research and it is necessary to perform a comparative analysis and indicate the main differences of the proposal with respect to the related papers identified to determine and clarify the novelty of the work presented.

3. Why is it important to detect the human toilet position?, why use the IR sensor and not another sensor?, what other sensors could be used?, what happens if the person does not have a good defecation posture?.

4. It is observed that a section of obtained results is presented, however, a table of all the obtained results is not indicated in which it is possible to perceive the cases of correct detection of the IR sensor. Also, if the sensor detects a bad posture of the human being, is it indicated to the user?, is it verified that he/she is in the correct posture?, and when entering the toilet is the correct posture visually indicated to the user?

5. In the discussion, the authors are expected to discuss at length the findings and challenges identified, as well as their impressions and comments based on the results obtained. Reaffirm and discuss the scientific contribution.

6. In the conclusions, the main conclusion of the scientific contribution is not indicated, and the future work to be done is not indicated.

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Not applicable

Are all the source data underlying the results available to ensure full reproducibility?
Partly

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: IoT

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Reviewer Report 28 March 2022

https://doi.org/10.5256/f1000research.122235.r127394

Mira Kania Sabariah
School of Computing, Telkom University, Bandung, Indonesia

I have received all the revisions, so I declare this article has been approved

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Are all the source data underlying the results available to ensure full reproducibility?
Partly

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Software Engineering

I confirm that I have read this submission and believe that I have an appropriate level of

expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 04 March 2022

https://doi.org/10.5256/f1000research.76710.r124303

?

Mira Kania Sabariah
School of Computing, Telkom University, Bandung, Indonesia

- The research idea is good.
- There needs to be justification for the number of participants which only involved 12 participants. According to statistics, in determining the number of samples, it is necessary to pay attention to the number of populations or to follow a minimum limit of 30.
- The research steps have not been presented in the paper.
- The scenarios and instruments/tools of the experiments carried out were not well explained in the paper.
- The reason for choosing the colour and combination of plastic covers should be explained.
- The factors that become the limitations of the research carried out must be conveyed to the conclusion.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
No

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?

No source data required

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Software Engineering

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.