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# Development of Portable Wireless Parking Sensor Device

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**ABSTRACT**

Parking is regarded as one of the most difficult aspects of driving a vehicle since it is a stressful and confusing situation, even for a competent driver. Therefore, there are many parking sensor devices designed to facilitate the user's search for a parking spot. The ultrasonic sensor was used for the construction of the parking sensor gadget because it is more resistant to environmental conditions than other sensors. This project's objective is to create a portable, wireless parking sensor device by utilizing ultrasonic sensor features in SolidWorks, Proteus, and Arduino. The prototype of the SolidWorks 3D portable wireless parking sensor gadget has to be rigorously tested at parking spaces for vehicles several times in order to depict the actual environment accurately. To facilitate a seamless vehicle detecting procedure, it was necessary that the prototype be strong and durable. After implementing 2 different types of ad-hoc networks, the outcomes showed that the nRF24L01 module normally offers two types of alternatives, either in mesh routed form or Point-to-Point link (PtP). However, the latter is most recommended to gain higher performance and more configurable.

## 1. Introduction

People frequently face trouble for locating empty parking spots, which is especially true in large indoor parking lots. In this situation, people have to spend a significant amount of time concentrating on navigating through the entirety of the parking area in order to manually look for any vacant space if the parking lot is nearly at its maximum capacity [1-2]. The issue that was being experienced by many individuals was addressed by the development of a parking sensor gadget with the assistance of current technologies.

In many ways, the development of this device is tricky and faces some drawbacks because of different factors. Some of the downsides are associated with the congestion of traffic during deployment and maintenance, construction-related issues on bad road surfaces and implementation procedures that fall short of the deployment of industry standards [3-5]. On the other hand, the reinstallation of these sensor forms is sometimes required when there is road surface maintenance and service repairs. This sensor system is also a part of non-intrusive technology [6].

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Even so, it is not necessary to install non-intrusive technology directly into or on top of the road surface when using sensors with solid mounting. The non-intrusive technology requires the sensor to be positioned either on top of or along the sides of the road or parking lot. This technology comprises a video image processor, a microwave scanner, active and passive infrared sensors, ultrasonic sensors, passive acoustic sensors, and included magnetic field sensors [7]. According to the claims made in past studies, it is expected that long-term experiments would demonstrate that non-intrusive technologies are more trustworthy than invasive technologies [8].

## 2. Related Work

### *2.1 Device Mechanism*

Several different kinds of parking sensor devices, including ones that identify vehicles in parking spaces, use camera sensors. In the implementation of the parking sensor device, there are many specifications and specific types of cameras were employed. In one of the studies by Blumer *et al.,* [3], vacant parking spots can be detected by using single perspective cameras using edge and road colour information. These records and information are also applied in recent vision-based parking lot structures to guide people to the region that still has empty parking spaces [4, 6]. Figure 1 below shows the example of empty slots for parking space, both from the camera and the display monitor.

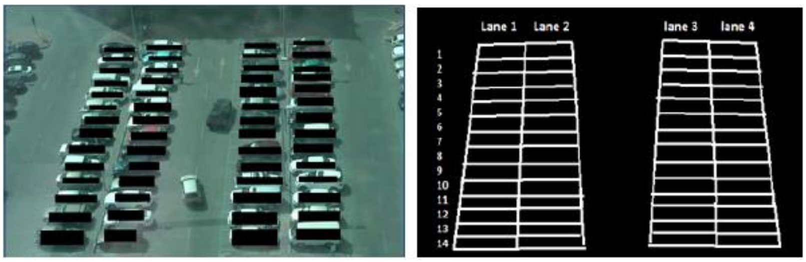



**Fig. 1.** Slots for parking space taken from the camera and displayed in monitor [9]

### *2.2 Identification and Working Method*

The simulation of the grid map serves as the foundation for the recognition, and ultrasonic detectors are incorporated into the process. After that, a digital grid map is utilized to establish a coordinate system and to take measurements of the target region that has to be measured [10]. The probable contours of the targets may be determined from the ultrasonic wave echo signal, and then those contours can be projected onto the grid map. Following that, the border of the item can be determined by locating and calculating the number of times that the outline overlaps itself with a threshold [11]. Furthermore, the grid's length in the order of centimeters can be determined by the actual application, which can range from $n \times n$ to any value. The grid is dynamic and able to change into different net densities as long as the same parameter, $n$ is matched with different spatial resolutions [10-11]. As a result, the grid is able to provide an accurate description of all of the spatial positions in the observation field. After the grid map has been finalized, the construction of the coordinate system may begin simultaneously. Both images in Figure 2 and Figure 3 below show the example of space grid map and the approximate location of the target when the signal is overlapping, respectively.

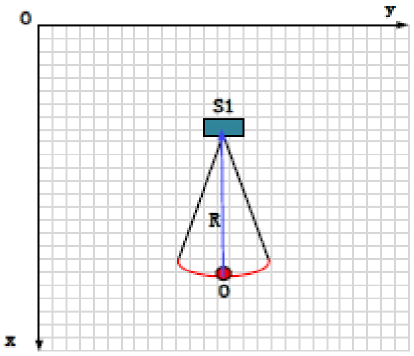



**Fig. 2.** The space grid map

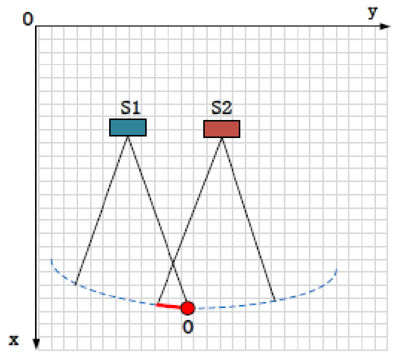



**Fig. 3.** The approximate location of the target

The flight time (TOF), also known as the acoustic wave time interval between the sensor and the object, is utilised by the ultrasonic sensor in order to determine the distance that exists between the sensor and the target accomplished based on the TOF [12].

By using Eq. (1), the value of R can be determined. In addition, Δt is denoted for TOF, and *c* represented the speed of sound. According to this formula, the potential locations of the target should be distributed around the surface of a sphere within the diameter of R [1, 13]. These sensors also may be put in any random order inside the system.

$$Distance = \frac{(\Delta t \ x \ speed \ of \ sound)}{2} \tag{1}$$

*2.3 Hardware Configuration with Arduino and Raspberry Pi*

Arduino is also has been utilized in a separate project that employs a different kind of sensor in order to identify vehicles [4-5]. This particular microcontroller could connect with more than two inputs at the same time without experiencing any interference. An Arduino microcontroller unit is known as the heart of the system. This component is interfaced with an infrared sensor, a power supply, a mobile application, and a GSM module so that the system can be controlled from a mobile device [14]. The Arduino Uno is also a microcontroller that is based on datasheets. It contains a quartz crystal operating at 16 MHz, a USB connection, an ICSP header, a reset button, and 14 digital input or output pins, of which 6 may be used as output signal large modulation (PWM). It also has 6 analogue inputs, a reset button, an ICSP header, and a reset button.

Another component that has been implemented as controller is Raspberry Pi. The Raspberry pi is a single-board computer controller that operates similarly to a computer. The Raspberry Pi is a tiny computer that can perform a broad variety of tasks such as browsing the internet, sending emails, composing letters using a word processor, streaming high-definition video, playing 3D players, and many other things [15]. In order for Raspberry pi to store data, a keyboard is required as its input, while a display unit is required as its output, and an SD card is required as its hard drive. Raspberry pi is equipped with an arm processor, which is responsible for doing all of the laborious tasks necessary to ensure that raspberry pi can function effectively. One of the studies by Shao *et al.,* [8] utilized Raspberry Pi as the interface between the sensor and the database system.

## 3. Methodology

### *3.1 Workflow Process and Prototype of the Device*

Figure 4 shows the essential steps and a bigger picture of the process in this study. The first step is to start with the project planning and list out all the objectives, problems and methods. After working on the literature review part to find all past studies and come up with a comprehensive summary of the study, the process is continued with understanding the basic concept and important elements. Then, it continued with designing and sketching a prototype of a portable wireless parking sensor gadget. This process is constructed in SolidWorks design software. The important idea behind this design is to design a parking sensor device that could be moved around easily whenever it needs to be installed or maintained. To be able to develop this project to its full potential, a thorough understanding of the ultrasonic sensor system and operation of the camera to conduct detection is crucial. After the process, the design prototype is completed, the system will be put through its paces in order to evaluate how well the parking sensor device functions. The accuracy of the device will be evaluated through a series of trials and experiments using the prototype that has been developed. Meanwhile, Figure 5 shows the proposed design for the portable wireless parking sensor device.

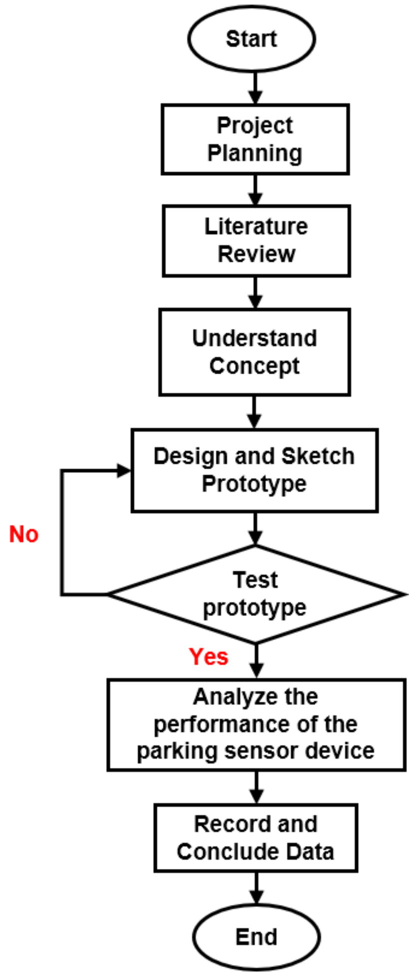



**Fig. 4.** Overall process of the study

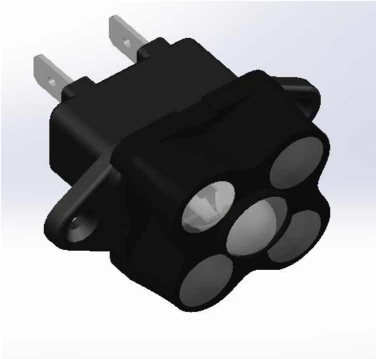


**Fig. 5.** Proposed design for portable wireless parking sensor device developed in SolidWorks.

### *3.2 Design of the Circuit in Simulation*

In this project, the controller of the parking sensor gadget is set on Arduino. In order for the Arduino to work, an AC-to-DC converter had to be developed. The AC-to-DC circuit has been simulated in circuit simulator, as laid out in Figure 6. This allowed the Arduino to work with the standard AC current. It also limiting the access current that may compromise the Arduino's ability to function once a certain amount of time has passed.

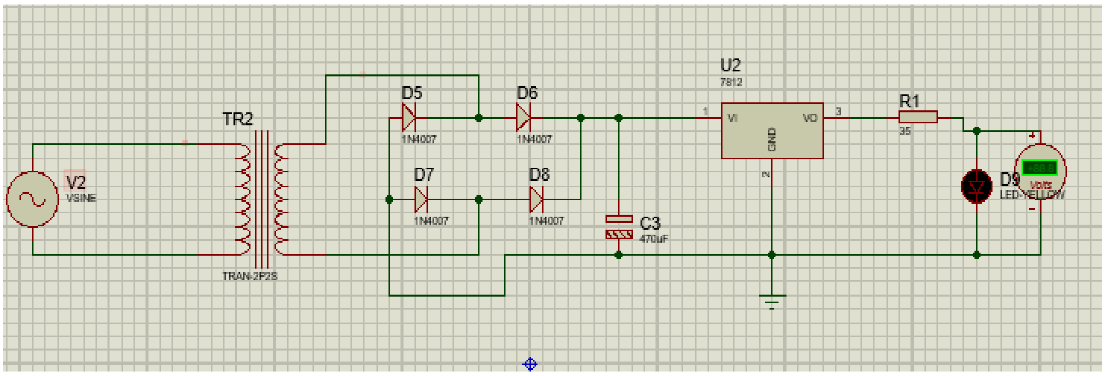
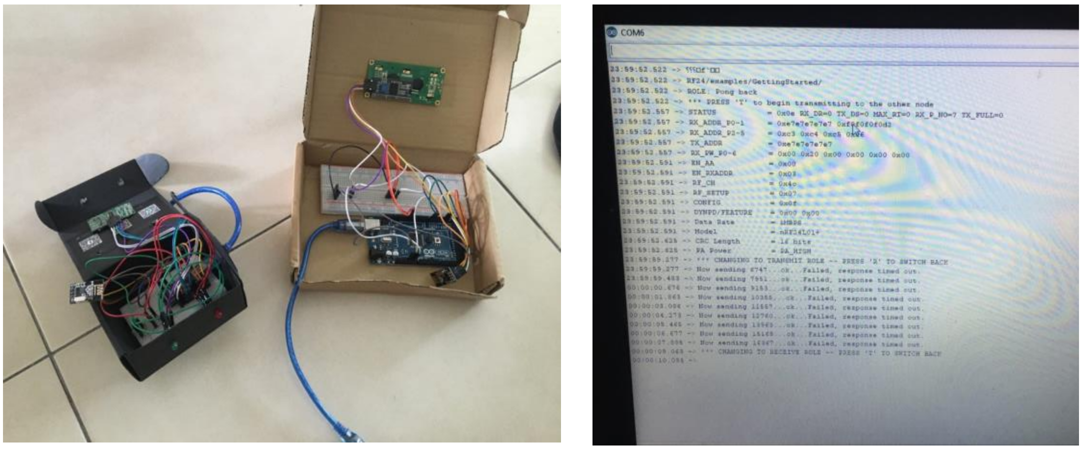



**Fig. 6.** Diagram of circuit schematics with AC-DC Converter

## 4. Results

The nRF24L01 is a transceiver, meaning that it may function as either a transmitter or a receiver, depending on the coding. The nRF24L01 in the sensor module is configured to act as a transmitter, while the database module serves as the location of the receiver. The sensor module is made up of an Arduino nano, an ultrasonic us-100, a breadboard, a red LED and a green LED cable, and an nRF24L01 for wireless communication. Referring to the Figure 7(a), it shows the portable hardware setup of the proposed device in a box. On the other hand, Figure 7(b) shows the nRF24L01 connection and output data recorded on the serial monitor of Arduino software.



(a) (b)

**Fig. 7.** (a) Setup of the portable hardware device; (b) Screenshot of active connection with nRF24L01

Even when the routing algorithms are implemented for a situation with only two nodes, the performance of nRF is quite low. Therefore, while creating a two-nodes network, the nRF normally gives two options. The options are distinguished as mesh routed or point-to-point (PtP). The demonstrated reading of the device is built into a chart in Figure 8. In most cases, the system would select the PtP version in order to get superior performance and connected to the portable hardware. On the other hand, when it comes to multi-hop nRF networks, the connection cannot be detected. Instead, the peak performance is observed as not having a significant change in a linear fashion with respect to the packet length. As a consequence of this, it is extremely challenging to identify any kind of connection between the different multi-hop instances which lead to the trouble to establish a fine communication with the portable hardware.

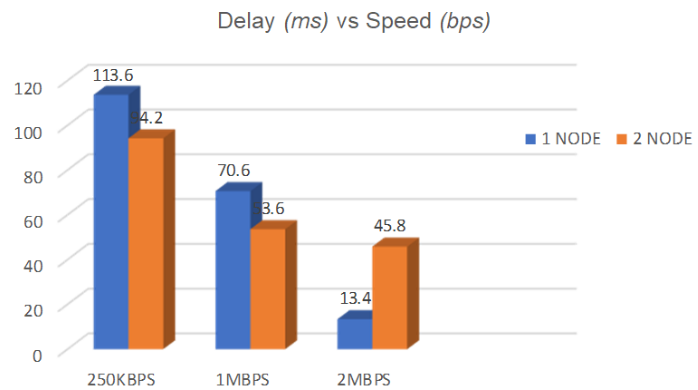



**Fig. 8.** Comparison of data collected by the device.

## 5. Conclusion

In conclusion, the focus of this study is to develop a system of the parking sensor. The purpose of this project is to design and develop a prototype of a portable wireless parking sensor device for the identification of vehicles in a parking space and to experimentally test the parking sensor device making use of wireless transmission modules. Additionally, the testing will focus on the identification of vehicles in a parking space. MATLAB has been used to evaluate the information that was collected via the use of wireless transmission. The effectiveness of the wireless transmission modules is determined by the result.

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## References

[1] Wang, Boyang, and Jafar Saniie. "Ultrasonic target echo detection using neural network." In *2017 IEEE International Conference on Electro Information Technology (EIT)*, pp. 286-290. IEEE, 2017. https://doi.org/10.1109/EIT.2017.8053371

[2] Mimbela, Luz Elena Y., and Lawrence A. Klein. "Summary of Vehicle Detection and Surveillance Technologies used in Intelligent Transportation Systems," *The Vehicle Detector Clearinghouse* (2007).

[3] Blumer, Katy, Hala R. Halaseh, Mian Umair Ahsan, Haiwei Dong, and Nikolaos Mavridis. "Cost-effective single-camera multi-car parking monitoring and vacancy detection towards real-world parking statistics and real-time reporting." In *Neural Information Processing: 19th International Conference*, ICONIP 2012, Doha, Qatar, November 12-15, 2012, Proceedings, Part V 19, pp. 506-515. Springer Berlin Heidelberg, 2012. https://doi.org/10.1007/978-3-642-34500-5_60

[4] Shih, Shen-En, and Wen-Hsiang Tsai. "A convenient vision-based system for automatic detection of parking spaces in indoor parking lots using wide-angle cameras." *IEEE Transactions on Vehicular Technology* 63, no. 6 (2014): 2521-2532. https://doi.org/10.1109/TVT.2013.2297331

[5] Daubaras, A., and M. Zilys. "Vehicle detection based on magneto-resistive magnetic field sensor." *Elektronika ir Elektrotechnika* 118, no. 2 (2012): 27-32. https://doi.org/10.5755/j01.eee.118.2.1169

[6] Abad, F., R. Bendahan, S. Wybo, S. Bougnoux, C. Vestri, and T. Kakinami. "Parking space detection." In *Proceedings of the 14th World Congress on Intelligent Transport Systems*. 2007.

[7] Beyer, P. "Non-intrusive detection, the way forward." In *Proceedings of the 34th Southern African Transport Conference*, pp. 879-888. 2015.

[8] Shao, Yunfeng, Pengzhen Chen, and Tongtong Cao. "A grid projection method based on ultrasonic sensor for parking space detection." In *IGARSS 2018-2018 IEEE International Geoscience and Remote Sensing Symposium*, pp. 3378-3381. IEEE, 2018. https://doi.org/10.1109/IGARSS.2018.8519022

[9] Stiawan, Roni, Adhi Kusumadjati, Nina Siti Aminah, Mitra Djamal, and Sparisoma Viridi. "An ultrasonic sensor system for vehicle detection application." In *Journal of Physics: Conference Series*, vol. 1204, no. 1, p. 012017. IOP Publishing, 2019. https://doi.org/10.1088/1742-6596/1204/1/012017

[10] Huang, Ching-Chun, and Sheng-Jyh Wang. "A hierarchical bayesian generation framework for vacant parking space detection." *IEEE Transactions on Circuits and Systems for Video Technology* 20, no. 12 (2010): 1770-1785. https://doi.org/10.1109/TCSVT.2010.2087510

[11] Prashanth, S. D., S. Sathyanathan, V. N. Makam, and N. Nagarathna. "Parking management systems and their technologies - A review." *International Journal of Research Science & Management* 4, no. 4 (2016): 243-249.

[12] Maggo, Surbhi, and Reema Aswani. "AUTOPARK: a sensor based, automated, secure and efficient parking guidance system." *IOSR Journal of Computer Engineering* 8, no. 3 (2013): 47-56. https://doi.org/10.9790/0661-0834756

[13] Hosur, Priya, Rajashekar Basavaraj Shettar, and Milind Potdar. "Environmental awareness around vehicle using ultrasonic sensors." In *2016 International Conference on Advances in Computing, Communications and Informatics (ICACCI)*, pp. 1154-1159. IEEE, 2016. https://doi.org/10.1109/ICACCI.2016.7732200

[14] Idris, Mohd Yamani Idna, E. M. Tamil, N. M. Noor, Zaidi Razak, and K. W. Fong. "Parking guidance system utilizing wireless sensor network and ultrasonic sensor." *Information Technology Journal* 8, no. 2 (2009): 138-146. https://doi.org/10.3923/itj.2009.138.146

[15] Sharma, Ankush, Shilpi Bansal, Shivam Mishra, Praveen Kumar, and Tanupriya Choudhury. "Automated Car Parking with empty slot detection using IoT." In *International Conference on Advances in Engineering Science Management & Technology (ICAESMT)-2019*, Uttaranchal University, Dehradun, India. 2019. https://doi.org/10.2139/ssrn.3403921