ISSN 2712-0562
Original Research

Sustainable Engineering and Innovation
Vol. 3, No. 1, June 2021, pp.44-48
https://doi.org/10.37868/sei.v3i1.id 123

Designing and analyzing park sensor system for efficient and sustainable car park area management

Ahmet Faruk Karakebelioğlu[1*], Özkan Eren[2], Hasan Köten[3], Hüseyin Alp[1]
[1] R&D and Inovation Department, Isbak A.Ş. Istanbul, Turkey
[2] Faculty of Technology, Marmara University, Istanbul, Turkey
[3] Faculty of Engineering, Istanbul Medeniyet University, Istanbul, Turkey

*Corresponding author: ahmetfaruk_afk@hotmail.com

Abstract
Many problems have been seen in cities because of increasing vehicle density, especially in parking lots, where people, looking for empty parking areas waste time. Due to density in parking lots, CO_2 emission and energy consumption increase. This research addresses these problems by applying Magnetic Car Park Sensor, the system that helps people to find empty parking lots. Magnetic Car Park Sensor detects cars in car parks, sends information to center server and shows it in the system interface. As people find empty car park areas fast, energy consumption and CO_2 emission are decreased significantly.

Keywords: CO_2 emission declining, Vehicle detecting, Sensor system, Smart city technologies

1. Introduction

Many studies implemented car detection for the car park area. Some of them were done by cameras [1] which can detect cars in any area and special sensor studies [2]. In our study, we designed a car park sensor to detect cars in car parks. Firstly, we looked for academic studies in order to analyze the systems designed before, with emphasis on the software for a system's performance [3]. In some studies classification of cars is done with software [4, however the accuracy of detection is not stable [5]. The components like MCU (microcontroller unit), magnetic sensor, and communication module were searched at the beginning of the research. The schematic design of the project was started after the components were chosen in accordance with the read datasheets. After this, the PCB (Printed Circuit Board) design started in PCB designing program. The system's software was sent to MCU in PCB, and the functionality was tested in electronic laboratory and real life conditions. The conclusions were drawn after the evaluation of the energy consumption and CO_2 emission.

2. Schematic design

Before the schematic design started, the required components were selected. The system's schematic design had three schematic pages; sensor, CPU (Central Processing Unit) and communication pages. It was designed with a PCB design program with one battery supply energy to the system of 3,6Volt. The magnetic sensor page with three-axis sensor was another schematic page. The module took the sensor's information and sent it to the CPU and the connection between module and CPU to communicate these IC (Integrated Circuit)'s was made. The third schematic page was a communication page with the NB-IoT (Narrow Band Internet of Things) module. The selected NB-IoT antenna was added to this page.

2.1. The PCB design

The main components were put to PCB for best positioning, with CPU and communication module on PCB's top layer. In order to detect car, the magnetic sensor was also placed on PCB's top layer. In order to get the best performance from sensors, all barriers in front of them were removed. The PCB also had NB-IoT communication which required antenna and RF routing. The selected one was RF (Radio Frequency) for designing tool on internet [6]. Related studies were investigated during this design [7-13]. The PCB's parameters were inserted into RF design tool to use the Coplanar wave guide with ground in RF route. Results of simulation were as following:

- Characteristic Impedance: 52,63ohm
- RF signal loss: 0,0488dB
- Delay: 0,1440ns

2.2. Working tests of device

Firstly, working tests were done with object which included metal, where the PCB was detecting metal object and it was sending detecting information to center. Then, these tests were done with a car on car parks. The PCB was set with its box to a car park and observation whether PCB was detecting car on park confirmed that the PCB is working properly.

The software was working with this algorithm; as the cars came to the car parks, the device was detecting them and presented information on software. Magnetic sensor had three axes: x, y, z. If three axis's values are higher than 200, the software showed "araç var" (there is a vehicle), and if three axis's values fall below 100, the software showed "araç çik ti" (there is no vehicle). This made it clear whether the car park is empty or not.

2.3. Analysis of environment conditions and device's box design

The Magnetic Park Sensor system was set in ground, whereas the top of the device was at ground level. Therefore, the system faced many bad conditions, such as variation in highest and lowest weather temperatures, water contact, objects that can have a contact with the sensor device, pressure which can occur when cars are passing on sensor device, etc. All of these were estimated as high risks for magnetic park sensor device. All of these were considered when the device's box was designed.

In order to comply with the temperatures that reflect different climate conditions in Turkey, from east Turkey which can be cold in winter or south Turkey which can be very hot in summer, the preferred material for device's box was polyamide, as it is a very stable, a bit hard and rigid.

The box had five feet to stay stable in place. It had 12 slots 55mm high, placed inside edges of box that were used to hold it in its place. Another important parameter to meet was waterproofing of the box. The research included o-type ring gasket between box and box's cover. The box's screws were tightened sufficiently, so it did not take water inside. The box passed IP68 test and got IP68 certificate.

3. Results and discussion

3.1. Detection of system's benefits – decreasing CO_2 emissions of cars

The calculation of the CO_2 emission was made with and without the system installed in the car park. The test was made in the Florya social facilities car park, where the car park's density is changing according to days of week and hours of day. In order to find empty car park area in Florya social facilities car park, the driver must be driving for approximately 200mm.
The calculation estimated that the car park was used by people once a day.

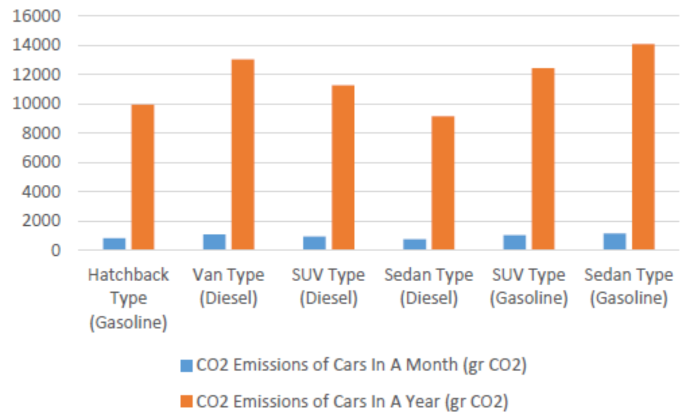

Figure 1. The CO_2 emissions of cars without the system installed in the car park

Fig. 1 shows CO_2 emissions of cars before the system is installed in the car park. The further research was investigating the reduction of CO_2 by installing the system in the car park. It was detected that if the system is installed in Florya social facilities car park, people will find empty car park area by driving approximately 40m. Fig. 2 shows the values of CO_2 after the installment.

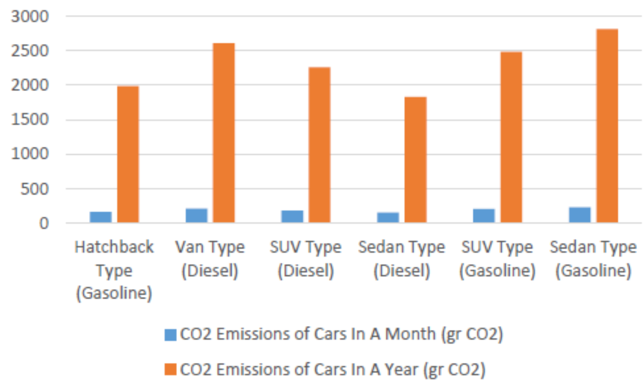

Figure 2. The CO_2 emissions of cars after the system is installed in the car park

3.2. Detection of system's benefits – decreasing fuel consumptions of cars

The second benefit of this system is decreasing the fuel consumption of cars. Due to the decrease in the search for an empty car park area, fuel consumption decreased significantly. Thus, the research investigated the saving of the fuel in Florya social facilities car park for 6 selected car types. The fuel costs in Istanbul for the date of 16.04.2019 were taken from one seller's web site and were as following: Gasoline cost: 6,99TL(Turkish Liras)/lt, Diesel cost: 6,36TL/lt.

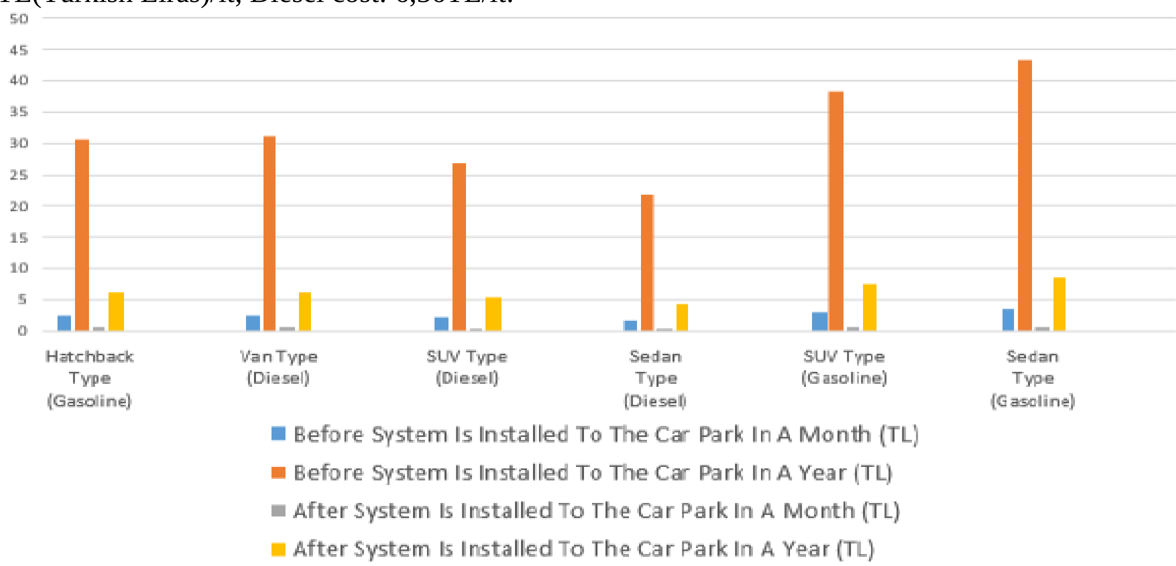

Figure 3. Decrease in fuel consumption after the system was installed in the car park

4. Conclusion

This research designed a device that can detect vehicles in the car park, in order to decrease empty car park area searching time. After the device was designed, the empty car park area searching time was decreased; the study obtained the benefits from the system reflected in decrease of CO_2 emissions, decrease in fuel consumption, time saving and indirectly decreasing people's stress. If the system is installed in all car parks in the city, energy savings and CO_2 emissions reduction can reach the maximum level that can significantly impact the protection our environment.

5. References

[1] M. Karakaya and F.C. Akıncı, Şehirlerin digital dönüşümü: görüntü işleme yöntemlerinin boş park yerlerinin tespitinde kullanılması, 34th National Informatics Congress Proceedings Book, Ankara: Atılım University, 69-73, 2017.

[2] A. Akbaş, İ. Kösesoy, İ. Delibaşoğlu, GMR sensörler ile gerçek zamanlı trafik verilerinin elde edilmesi için bir gömülü sistem tasarımı, National Public Transport Symposium and Exhibition, İstanbul: Istanbul Metropolitan Municipality, (1-2 December 2011), 2011, pp. 53-57.

[3] S. Gürbüz, Dikgen eşleştirme algoritmasıyla ferromanyetik hedef konumlama ve tanıma, 20th Signal Processing and Communications Applications Conference (SIU), Ankara: IEEE, 2012.

[4] S. Thirumal and M. Ushakiranmai, "Design portable sensors system for vehicle countingclassification and speed measurement in traffic junctions," International Journal of Professional Engineering Studies, vol.5, no. 5, pp. 174-179, 2015.

[5] F. Yalçınlı, Algılama ve özellik çıkartma tabanlı manyetik araç sensörü tasarımı, Selçuk University, Graduate School Of Natural Sciences, 2013.

[6] Coplanar Waveguide Analysis/Synthesis Calculator, Available: http://wcalc.sourceforge.net/cgi- bin/coplanar.cgi. [Accessed: Sept, 2020]

[7] Opet Petrolcülük A.Ş., (2019). Fuel Prices for Istanbul, Available: https://www.opet.com.tr/istanbul- akaryakit-fiyatlari. [Accessed: Sept, 2020]

[8] L. Stenneth, O. Wolfson, Bo Xu, and P.S. Yu, PhonePark: Street parking using mobile phones. In Mobile Data Management (MDM), 2012, IEEE 13th International Conference, pp. 278–279, July 2012.

[9] J. Rico, J. Sancho, B. Cendon, and M. Camus, Parking easier by using context information of a smart city: Enabling fast search and management of parking resources. In Advanced Information Networking and Applications Workshops (WAINA), 2013 27th International Conference, pp. 1380–1385, March 2013.

[10] J. Yick, B. Mukherjee, and D. Ghosal, "Wireless sensor network survey," Computer Networks: Computer Networks: The International Journal of Computer and Telecommunications Networking, vol. 52, no. 12, pp. 2292 – 2330, 2008.

[11]P. Rawat, K. Singh, H. Chaouchi, and J. Boning, "Wireless sensor networks: a survey on recent developments and potential synergies," The Journal of Supercomputing, vol. 68, no. 1, pp. 1–48, 2014.

[12]Y. Rahayu and F.N. Mustapa, "A secure parking reservation system using gsm technology;" International Journal of Computer and Communication Engineering, vol. 2, pp. 518–520, 2013.

[13] M. Jian, K.S. Yang, and C. Lee, "Modular RFID parking management system based on existed gate system integration", WSEAS Transactions on Systems, vol. 7, no. 6, pp. 706–716, 2008.