DESIGN AND PROTOTYPE DEVELOPMENT OF A WIRELESS SENSOR NETWORK (WSN) – BASED CAR PARK MONITORING SYSTEM

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ABSTRACT. *With the rapidly increasing number of automobiles, car traffic congestion in parking areas is growing at an alarming rate in every urban city. This study gives the drivers or users a choice of where the most available parking cell to park their vehicles. The study developed a prototype that monitors the real-time scenarios in every parking area. Vehicle detection technology using WSN was implemented. Sensor nodes using HMC1021Z Magneto Resistive Sensor and US-100 Ultrasonic Sonar Sensor, a sink node and a gateway/server constitute a wireless network monitoring that acts as a way-finder to recognize the vacant spots in the area. Each sensor node used a UHF-Ex data transceiver that receives and transmits information, and a microcontroller Gizduino+ Mini Atmega 324P and Gizduino Atmega 328P as a processing unit. A display unit installed at the entrance of the parking area provides real-time parking information which used Raspberry Pi and an Infrared (IR)-based touch screen reservation section using color OLED (Organic Light Emitting Diode) shield.*

Keywords: Wireless sensor network, car park monitoring system, Internet of Things (IOT)

1. INTRODUCTION

Drivers cannot park as easily as they would like. Searching for a parking space in busy areas is often a frustrating task for many drivers. Time and fuel are wasted in searching for a vacant spot and increase the traffic in the area due to the slow-moving vehicles circling. Finding a parking spot during peak hours causes inconvenience to drivers and has negative consequences for the environment. In busy areas, parking availability must be somehow monitored to provide the necessary information to the motorists [1-7].

The aforementioned problem strives for a parking infrastructure accessible to the general public. This study described the car management monitoring system using wireless sensor networks. This study was subjected to consider the following concerns: (1) can a sensor node be developed to display the collected data to the real-time monitoring status of a parking area? and (2) can WSN-based car parking monitoring system be developed and could it provide a touch screen space reservation section?

This study had the following specific objectives: (1) to develop sensor nodes that provide real-time monitoring scenarios on the availability of parking spaces using Raspberry Pi; and (2) to develop a prototype WSN-based car parking monitoring system that provides an IR-based touch screen reservation section.

2. FRAMEWORK OF THE STUDY

Figure 1 shows the general framework of this prototype development project for a WSN-based car parking monitoring system. Ground sensors were deployed to monitor the presence or absence of the car in a particular position. Access points gather information from the ground sensors and pass on information to the cloud and finally to a web-based application to display the necessary information.

3. REVIEW OF RELATED LITERATURE

The study [8] shows that the pre-existing security surveillance (CCTVs) will be used as a sensing node to identify vacant parking spaces. The captured image will be processed through the ARM7 Microcontroller and the processed data will update the occupancy status of available parking space vacancies in the database. However, video sensors are too expensive.

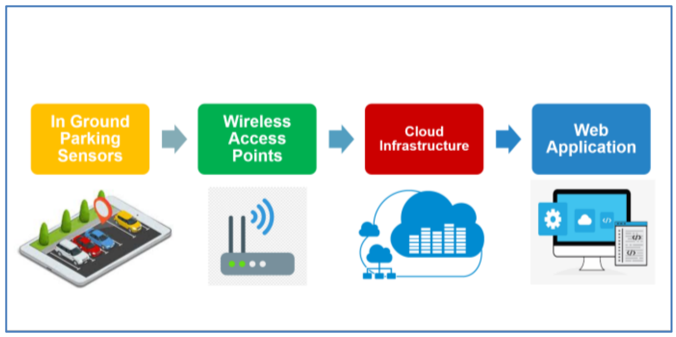

Figure 1. General Framework of the WSN-based System

The Street Parking System (SPS) consists of a base station, routers, sensor nodes, and a remote server. Sensor nodes are deployed alongside the roadside and each node is mounted on the center floor of a parking space [8]. When a node detected a car entering or leaving, it transmits a message to the router and will be transmitted to the LED board and remote server [9].

The design of the parking simulator platform [4] used wireless sensor motes which are complaints of its RF module. The FIS is coded in each wireless sensor mote. The adaptive rule base module from the sink node was programmed in Java. In simulating parking events, the active RFID was put on top of the car model. Every time a car parked on a parking lot, the wireless sensor under that slot detected the car and sent a message to the active RFID on top of the car model to initialize the location technique.

The integration of artificial intelligence (AI) in various applications has found relevance in many engineering applications, including renewable energy systems [11-12], healthcare [13-14], car park monitoring systems [15-18].

WSN-based Car Park Monitoring System

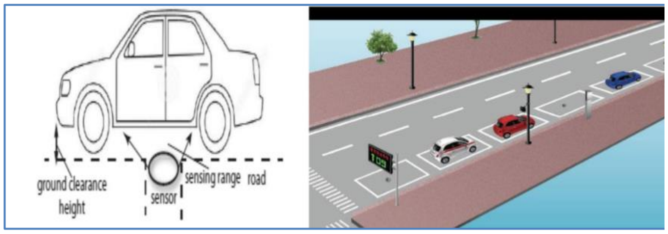

Figure 2. A WSN-based car park monitoring system [19].

Kumar, et.al, recently proposed their version of the Intelligent Vehicle Parking System (IVPS) that provides the following elements: a base station, switches, sensor hubs, and a remote server. Sensor hubs are set near to the roadside and each sensor hub is mounted within, focus floor of a parking space. Each sensor hub distinguishes intermittently the world's attractive field. Right, when a sensor hub distinguishes a vehicle entering or leaving, at that point it transmits a message to the switch. The switch propels the got message to a base station which is set some distance from the sensor hubs. In the base station, information from different sensor hubs will be blended and by examining an ultimate conclusion is made for the stopping direction data and afterward, the information will be transmitted to LED board to show the choice made and the same is kept up in the remote server [19].

Similar studies had been carried by other authors with the extensive use of wireless sensor networks [20-25].

This confirms that this research study is aligned with the development and advancements of a smart parking monitoring system.

4. METHODOLOGY

The WSN-based system typically adopts a 3-layer framework for deployment as shown in Figure 3. In this study, the first layer was the mote layer or the sensor layer. The motes (or nodes) were programmed to perform some tasks, for example, environment monitoring. The second layer was the server layer or the sink node which provided data logging and database services for the sensory data to be transferred to the base station or gateway and stored on the server. Finally, the software at the client layer or end-user provided visualizing, monitoring, and analyzing tools to display and interpret sensory data.

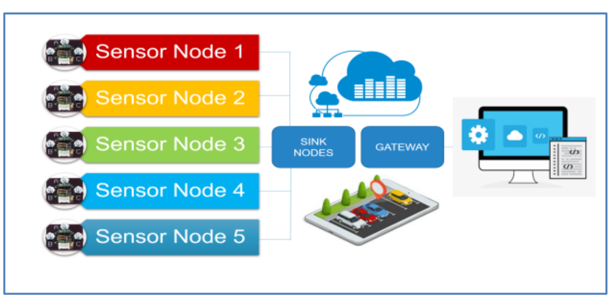

Figure 3. Design Framework

A. The architecture of the system

There were two sections in this study: the monitoring section and control the section that contained sensing and processing elements and display devices. First were the sensor nodes, and the second was the LCD.

B. Monitoring Section

The monitoring section contained the sensor network, the controller to process, and the display device. The WSN in the parking lot contained three kinds of sensor nodes: the monitoring nodes, the sink nodes and the gateway. In addition, the LCD was installed at the entrance of the parking lot.

C. Control section

The control section was at the entrance of the parking area, it was used for reserving the parking space. At the entrance of the parking area, there was an IR-based touch-screen reservation section for reserving the vacant spot so that the driver could reserve a specified vacant spot that was displayed on the monitor. As it was, if ever there were two or more cars that arrived at almost the same time, there was already a clue to all the cars that followed that even if the first car has not arrived yet in the spot, the next car would know that the spot was reserved and that the user had to choose another spot according to the data in the monitoring board.

5. RESULTS AND DISCUSSIONS

Hardware Assembly and Software Development

Figure 4 shows the assembled components including the web-based monitoring system. Shown in this image are the electronic components used and assembled to fully form the motes and sink nodes. The data are passed on or collected at the gateway and using the database. These collected data were processed and displayed in the web-based device to determine the availability or unavailability of the parking area.

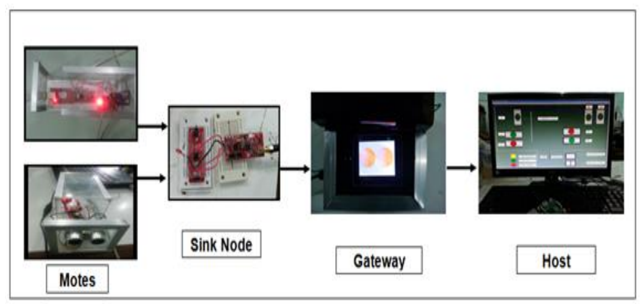

Figure 4. Actual System's hardware and program developed

A. Main Hardware and Software Components

The other microcontroller that was used in this study was the Gizduino+ Mini 324P and Gizduino Atmega 328P. The transceiver that the authors used was a UHF-EX data transceiver. The authors used the Raspberry Pi B+ version to display the end-user interface and used a color OLED Shield for the touch screen.

The authors used Arduino and python as the programming language of the whole system. This language was a tool for coding the desired task in every section of this study.

IR-based Touch Screen - This layer defined the operations of the end-user reservation section. This was embedded into the entrance of the parking area for the selection of parking spaces.

The Color OLED shield was placed on top while the SD card shield was stacked in the middle place. All were placed above the Gizduino ATMega 328P Microcontroller.

The main component of the sensor node was composed of the microcontroller, transceiver, external memory, power source and a sensor. This layer defined a platform where a sensor device was embedded into a parking space to detect the presence or absence of a car. The sensors that the authors used in the study were the magnetic car sensor and ultrasonic sensor.

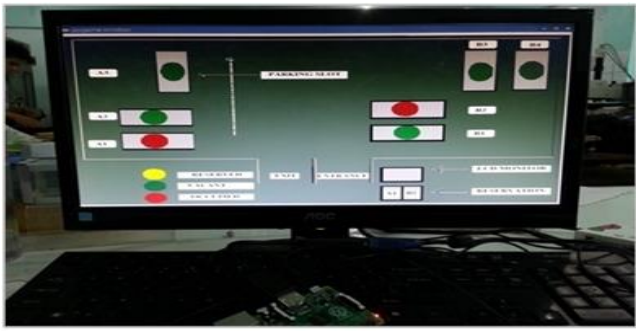

Figure 5. Sample Layout Display

Whenever the sensor detected the presence of a metal or any object within a specific area, it would transmit a pulse signal to the sink node. This would interpret the received data and transmit it to the gateway which in turn would send a command to the monitoring board and display it to the end-user interface.

B. Testing and Evaluation

The main concern of this study was to make a reliable transmission of information according to the specific received data.

This is the field test conducted for the car detection test. The encircled part where the LED was ON in the sensor node indicated that the sensor had detected the car.

Table 1. Reservation Test

Series of touch	*Previous Display*	*Processing Time*	*Response*	*Current Display*
1st touch	Green	2 seconds	Reserved	Yellow
2nd touch	Green	2 seconds	Reserved	Yellow

C. Car Parking Model Simulation

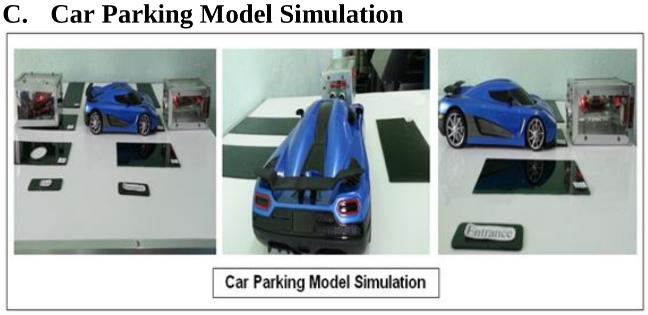

Figure 6. Parking Model Simulation

D. Field Testing

Figure 7. Field Testing with the sensor node deployed

Field testing was carried out to determine if the components are working or not. Shown in Figure 7 images show the sensor deployed on the ground with the vehicle.

6. CONCLUSION AND RECOMMENDATIONS

A prototype WSN-based car parking monitoring system has been developed. Based on the different series of tests, the developed sensor nodes, the sink node and the gateway had reliable and efficient communications. However, through RF transmission, the data didn't transmit as far as 700 meters line of sight (unobstructed) that the authors would have wanted.

The authors recommend the use of a magnetic sensor that has high distance sensing capabilities and the purchase of a transceiver that can transmit much longer-range data. Moreover, the use of the solar panel in every sensor node can be an additional feature to decrease the power consumption of the sensor nodes, and therefore the battery life can be extended. The authors also recommend the development of higher tensile strength and waterproof casing for the sensor node to protect it from any damage.

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REFERENCES

[1] Lambros Lambrinos, Eftychios Protopapadakis Elena Polycarpou, "*Smart Parking Solutions for Urban Areas*".

[2] Ionita, A., Pomp, A., Cochez, M., Meisen, T., & Decker, S.. Where to park? predicting free parking spots in unmonitored city areas. *In Proceedings of the 8th International Conference on Web Intelligence, Mining and Semantics* (pp. 1-12). (2018, June)

[3] Polycarpou, E., Lambrinos, L., & Protopapadakis, E. Smart parking solutions for urban areas. *In 2013 IEEE 14th International Symposium on" A World of Wireless, Mobile and Multimedia Networks"(WoWMoM)* (pp. 1-6). IEEE. (2013, June).

[4] Dellosa, Jeffrey T., and Eleonor C. Palconit. "Artificial Intelligence (AI) in Renewable Energy Systems: A Condensed Review of its Applications and Techniques." In *2021 IEEE International Conference on Environment and Electrical Engineering and 2021 IEEE Industrial and Commercial Power Systems Europe (EEEIC/I&CPS*

Europe), pp. 1-6. IEEE, 2021.

[5] Shah, A. A., Mustafa, G., Ali, Z., & Anees, T. Video Stitching with Localized 360o Model for Intelligent Car Parking Monitoring and Assistance System. IJCSNS, **19**(5), 43. 2019.

[6] Dellosa, J. T., & Palconit, E. C. Artificial Intelligence (AI) in Renewable Energy Systems: A Condensed Review of its Applications and Techniques. 2021.

[7] Swatha, M., & Pooja, K. Smart car parking with monitoring system. *In 2018 IEEE International Conference on System, Computation, Automation and Networking (ICSCA)* (pp. 1-5). IEEE. 2018.

[8] Mr. P.Vijay Kumar et.al, "A Prototype Parking System Using Wireless Sensor Networks," *International Journal of Computer Communication and Information System (IJCCIS),* **vol. Vol2. No1.** ISSN: 0976–1349, July-December 2010.

[9] Zusheng Zhang et al., "A Street Parking System Using Wireless Sensor Networks,*" International Journal of Distributed Sensor Networks*, 2013.

[10] Bobby D. Gerardo, and Jaewan Lee Romeo Mark A. Mateo. Location Technique based on Pattern Recognition of Radio Signal Strength for Parking Management (2012).

[11] Dellosa, Jeffrey T., and Eleonor C. Palconit. "Artificial Intelligence (AI) in Renewable Energy Systems: A Condensed Review of its Applications and Techniques." In *2021 IEEE International Conference on Environment and Electrical Engineering and 2021 IEEE Industrial and Commercial Power Systems Europe (EEEIC/I&CPS Europe)*, pp. 1-6. IEEE, 2021.

[12] Dellosa, J. T., & Palconit, E. C. Artificial Intelligence (AI) in Renewable Energy Systems: A Condensed Review of its Applications and Techniques. 2021.

[13] Yu, K. H., Beam, A. L., & Kohane, I. S. Artificial intelligence in healthcare. *Nature biomedical engineering*, **2**(10), 719-731, 2018.

[14] Li, R. C., Asch, S. M., & Shah, N. H. Developing a delivery science for artificial intelligence in healthcare. *NPJ digital medicine*, **3**(1), 1-3 (2020).

[15] Camero, A., Toutouh, J., Stolfi, D. H., & Alba, E. Evolutionary deep learning for car park occupancy prediction in smart cities. *In International Conference on Learning and Intelligent Optimization* (pp. 386-401). Springer, Cham (2018).

[16] Alsafery, W., Alturki, B., Reiff-Marganiec, S., & Jambi, K. Smart car parking system solution for the internet of things in smart cities. *In 2018 1st International Conference on Computer Applications & Information Security (ICCAIS)* (pp. 1-5). IEEE (2018).

[17] Nikitas, A., Michalakopoulou, K., Njoya, E. T., & Karampatzakis, D. Artificial intelligence, transport and the smart city: Definitions and dimensions of a new mobility era. *Sustainability*, **12**(7), 2789 (2020).

[18] Sharma, R., & Singh, U. Fuzzy based energy efficient clustering for designing WSN-based smart parking systems. *International Journal of Information Technology*, 1-7 (2021).

[19] Kumar, S. A., Nair, R. R., Kannan, E., Suresh, A., & Anand, S. R. Intelligent Vehicle Parking System (IVPS) Using Wireless Sensor Networks. *Wireless Personal Communications*, 1-16 (2021).

[20] Jeffrey, J., Patil, R. G., Narahari, S. K. K., Didagi, Y., Bapat, J., & Das, D. Smart parking system using wireless sensor networks. *In The Sixth International Conference on Sensor Technologies and Applications* (pp. 306-311) 2012.

[21] Zhang, Zusheng, et al. "A street parking system using wireless sensor networks." *International Journal of Distributed Sensor Networks* **9**.6 (2013).

[22] Yang, J., Portilla, J., & Riesgo, T. Smart parking service based on wireless sensor networks. *In IECON 2012-38th Annual Conference on IEEE Industrial Electronics Society* (pp. 6029-6034), IEEE, (2012).

[23] Tacconi, D., Miorandi, D., Carreras, I., Chiti, F., & Fantacci, R. Using wireless sensor networks to support intelligent transportation systems. *Ad Hoc Networks*, **8**(5), 462-473 (2010).

[24] Patil, M., & Bhonge, V. N. Wireless sensor network and RFID for smart parking system. *International Journal of Emerging Technology and Advanced Engineering*, **3**(4), 188-192, (2013).

[25] Kandris, D., Nakas, C., Vomvas, D., & Koulouras, G. Applications of wireless sensor networks: an up-to-date survey. *Applied System Innovation*, **3**(1), 14, (2020).