Smart Parking System with IoT

Manoj K. N.[1,*], R. Adhithya S.[1], A. H. Calvin[2], Heaven R. A.[2], K. S. Suriya[2]

[1]Department of Electrical and Electronics Engineering College, India
[2]Department of Mechanical Engineering Panimalar Engineering College, India

Emails: manojkumarneee@gmail.com; rameshadhithya99@gmail.com; abraham.calvin99@gmail.com; heavenireny@gmail.com; k.s.suriya0902@gmail.com

Abstract

Based on the findings of leading analytics organizations, an average person living in a metropolitan city wastes around 17 hours each year by driving around trying to find a parking spot. In this paper, we will be attempting to solve this problem by using a microcontroller module and IR sensors that work in tandem with an IoT (Internet of Things) system. The prototype consists of a NodeMCU ESP8266 wifi module with a built-in microcontroller and 5 IR sensors. The microcontroller module receives the data gathered by the 5 IR sensors, two of which are placed at the entrance and exit gates while the other three are placed at the respective parking spots to detect whether that spot is occupied or not. The microcontroller module then uploads the received data to the IoT system which then uses the data to guide the driver to a free parking spot. When implementing this concept, we find that the driver experiences a much less tedious and much more time-efficient process when parking his/her vehicle.

Keywords: ESP-8266 NodeMCU; Internet of Things (IoT); Message Queueing Telemetry Transport (MQTT); Infrared Sensors (IR Sensors)

1. Introduction

Since the dawn of civilization, mankind has been constantly trying to automate every possible task there is. From taking our clothes to the washer, doing our housework, cooking our food, and pretty much anything else, we have been trying to replace human interaction with machines and computers. Now with human innovation at its peak, it gave rise to astounding modern technologies like Artificial Intelligence, Cloud Computing, and Internet of Things(IoT). We have all been in a situation where parking our vehicle in a metropolitan city has caused a lot of hassle and annoyance. Thus fixing this problem that is faced by most individuals living in a city is of significant priority when it comes to improving the day-to-day commuting experience. The use of IoT or cloud computing can significantly simplify an engineer's job when attempting to automate parking. IoT (Internet of Things) is an advanced automation and analytics system which exploits networking, sensing, big data, and artificial intelligence technology to deliver complete systems for a product or service. IoT systems allow users to achieve deeper automation, analysis, and integration within a system.

Based on an analytics report from INRIX in their global traffic scorecard [1] an average driver spends about 17 hours a year on finding a parking spot and costs the local and national economies about $ 4.2 Billion and $72 Billion respectively. This issue has a wide impact beyond macro economical levels and has environmental effects by adding more carbon into the already polluted metropolitan atmosphere.

This dilemma further deteriorates a driver's mental health by inducing parking anxiety. [2] Parking anxiety decreases a person's efficiency in using his time and as a result, makes him/her less productive. This also reduces the usability and usefulness of a private mode of transport, as the benefits of using a private mode of transport are outweighed by its disadvantages. This might drive people away from the use of private modes of transportation. . Data from the Ministry of Transportation indicates that the number of vehicles registered from 2011 to 2020 has increased exponentially from the previous decade [3]. So it is important to address this problem and increase efficiencies involved in the urban design of parking vehicles [4].

Doi : https://doi.org/10.54216/JCHCI.030201
Received: January 24, 2022 Accepted: May 27, 2022

"Smart parking System with IoT" will give us a solution to all of the problems discussed above. It provides us with a method to bring automation to vehicular parking. The basic idea is to provide real-time data regarding the availability and location of parking spots to the driver over the internet.

2.Literature Review

Several innovations have been made to solve problems associated with vehicles and traffic specifically to improve the perception of parking vehicles D.Azshwanth et al 2019., [5] generalizes the use of different modules of sensors to resolve the conventional obstruction of a person's in parking his/her vehicle. Different sensors modules and microcontroller units co-ordinate together to provide a platform for much easier vehicle parking. Now, this is the conventional concept for all kinds of intelligent parking prototypes. However, advances have been made in the modernization of sensors and the use of new technologies has proven to be efficient to help solve a city's major problems like parking, lighting, and emergency systems on

the city's grid [6].

Figure 1: Block Diagram

In the past five years alone developments in Cloud Computing has grown to a highly significant level so the use of cloud computing gives a technical advantage over every other conventional system in our day to day life, M. Sakthimohan et al 2021., points out the use of Adafruit Cloud Service in monitoring, controlling, managing a parking space advocates the need for a much more cost-effective approach to the parking structure [7] and Juwita, PutriSandika, et al (2020).,The author explains the secure communication of data between various sensors and ensures the protected transmission of data throughout the cloud server and the implemented system with the use of the MQTT protocol[8].

Concerns have been raised by authors [5], [9] over the use of proximity sensors nevertheless the recent developments in CMOS-based sensors [10] have been improved significantly to overcome the issues regarding the accuracy and the operation and performance evaluations between sensors have studied by various authors including S Adarsh et al.,[11] and Perković, T et al., [12].

The extensive use of Artificial Intelligence (AI) and Machine Learning in the parking [13], [14] has been studied and instigated but due to the high development and deployment costs, these procedures are often limited to developed countries and giant metropolises and seldom implemented in the rural parts or tier 2 cities around the world. So a need for a much more economical and simpler solution is required to service all the levels of the world and not just for well-to-do places. This paper speculates the low-cost implementation of the smart parking system with IoT.

Doi : https://doi.org/10.54216/JCHCI.030201
Received: January 24, 2022 Accepted: May 27, 2022

3.General overview

The parking system has an ESP-8266 NodeMCU microcontroller unit to facilitate the communications between the IR sensors and the servo motor/gate. It is also the computational processing component in the system and manipulates the signals from the sensors and coordinates the activities of the system in conjunction with the Internet or in this case Adafruit.io Cloud services.

The communication protocol implemented in this system is MQTT. It is a lightweight publish/subscribe messaging protocol designed for low-bandwidth networks. The Object Detection signal from the IR sensors is transmitted to the microcontroller unit, which then prompts the gate/servo motor to function and updates these values on the cloud server. The system functions contrariwise for a vehicle entering or leaving a parking space by utilizing the signals from the sensors.

However, in the case of any discrepancies in the working of sensors a manual control function is provided in the prototype which will act as a contingency mechanism and avoid any potential disruptions to the operation of the parking space. The block diagram attached below displays the various components of the system connected to the central ESP-8266 NodeMCU module.

3.1 Existing system

- Much more complex and has many single-point failures present in the arrangement.
- The components used in the conventional systems are expensive compared to the proposed system.
- Some of the methods in use are not economically feasible for rural deployment and require constant maintenance.
- In some prototypes entire system would have to be taken offline in case of any service maintenance.

3.2 Proposed system

- Can be deployed quickly with limited infrastructural constraints
- Capable of achieving greater economies of scale in a rather shorter period.
- Doesn't require frequent maintenance and can be serviced without taking down the whole system offline.
- The system is cloud migrated so transmitted data is reliable and secure due to the external cloud provider and reduces much of the necessities in managing the cloud servers.

4. **working**

The VCC pins of the sensors are connected to the VCC port of the NodeMCU and the respective ground pins are connected to a common ground. A servo motor is interfaced with the NodeMCUgiving power supply and ground connections to it. After that, the IR sensor's output pins are connected to D0, D2, D3, D6, and D7 digital ports of the NodeMCU.

The Servo motor's Pulse width modulating pin is interfaced at the digital pin D5 of the ESP-8266 and the Infrared Sensors at the entry and exit places are interfaced with Pin D0 and D2 respectively. The Sensors used for slot detection are interfaced with the Microcontroller at the Pins D3, D6, D7 of NodeMCU. The code is written for the simulation and debugged for any errors.

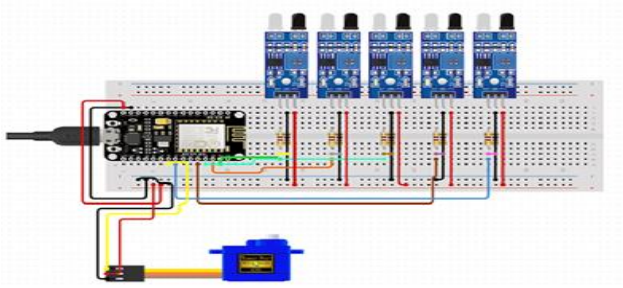

Figure 2: Circuit Diagram

Thecircuit diagram shows the connections needed for the prototype and displays the interfacing of the microcontroller unit with the proximity sensors and the servo motor.

Subsequently, the NodeMCU is given a power supply. The Sensors interfaced with the MCU's VCC and GND are activated and it tries to detect any objects within their effective range. If a car is detected at the entry gate IR sensor,

Doi : https://doi.org/10.54216/JCHCI.030201
Received: January 24, 2022 Accepted: May 27, 2022

it sends a signal to MCU about that object, and MCU acknowledges the signal and instructs the servo motor to rotate at a pre-coded angle. The car can be parked in any of the available slots.

The servo comes back to its start position/closed position after a brief interval of time. This data is concurrently published to the adafruitio feed using the MQTT protocol coded to the NodeMCU via the internet and the Status of the Slots in the parking structure was updated to the serial monitor as notations *Available/Occupied* for each of the slots present in the parking structure. Similarly, if a car is detected at the exit gate IR sensor the MCU opens the servo/gate to facilitate the passage through the gate. If all the slots are occupied the servo motor stops functioning and the status indicator turns into red color indicating non-availability of parking spaces and turns green when a slot is available for parking.

4.1 Hardware requirements

- ESP-8266 NodeMCU
- Infrared Proximity Sensors
- 9G Micro Servo

4.2 Software Requirements

- Arduino IDE
- Adafruit IO

4.1.1 ESP-8266 NODEMCU

The NodeMCU is a microcontroller unit with an inbuilt wifi module. It has 4 power pins and 17 GPIO pins with I2C and UART support of 17 pins 4 pins can be used to PWM. Control Pins are used to control the NodeMCU/ESP8266. These pins include Chip Enable pin (EN), Reset pin (RST), and WAKE pin. NodeMCU/ESP8266 also features SPI in slave and master modes which supports the 4 timing modes of format transfer and divided clock pulse at 80MHz. The NodeMCU is available in various package styles. Common to all the designs is the base ESP8266 core. Designs based on the architecture have maintained the standard 30-pin layout. Some designs use the more common narrow (0.9″) footprint, while others use a wide (1.1″) footprint.

This Microcontroller unit acts as the central processing unit for the system and also the communication enabler between the sensor components and the internet. It is also the wifi module of the system and connects the system with the cloud service.

4.1.2 Infrared Proximity Sensors

Infrared Sensor is the most used sensor in wireless technology where remote controlling functions and detection of surrounding objects/obstacles are involved. It is a simple electronic device that emits and detects IR radiation to find out certain objects/obstacles in its range.

Infrared sensors are used in this prototype due to their cost-effective applications. They use infrared radiation of wavelength between 0.75 to 1000µm which falls between visible and microwave regions of the electromagnetic spectrum. Infrared Sensors have a detection angle of 35 ° which is sufficient enough to detect objects within their range. They operate on a 5V DC supply.

4.1.3 9G micro servo motor

Are power supply and ground and the other one is a signal wire that communicates using signals from the mcu. the signal that comes from the mcu is a pwmsignal, it manipulates the servo hand to rotate with advanced precision. thepwm signal is determined in the mcu and transmitted via the control pin of the mcu.

Doi : https://doi.org/10.54216/JCHCI.030201
Received: January 24, 2022 Accepted: May 27, 2022

Figure 3: 9G Micro Servo Motor

4.2.1 ADAFRUITIO

Adafruit IO is a cloud-based service built on Ruby and NodeJS that makes data useful by allowing simple data connections with little programming required. This service contains an extensive collection of client libraries that include REST and MQTT APIs.

Adafruit IO can handle and visualize multiple feeds of data. In this concept, it helps to display data from all the 5 IR Sensors and the servo motor's current position data. Feeds are the core of Adafruit IO. They hold both the data the system uploaded and meta-data about the sensors pushed to Adafruit IO. The dashboard is a feature integrated into Adafruit IO which allows users to map charts, graph, gauge, log, and visualize their data. Users can view their system's data in the dashboard via the internet.

4.2.2 ARDUINO IDE

Arduino IDE is an open-source software tool that provides an environment to program devices to develop several innovative designs. It is built on the JAVA platform and supports all the operating systems Windows, Mac OS, and Linux.

The Arduino IDE contains a substantial number of libraries to provision different projects and is abundantly used by many people. The syntax for the Arduino IDE is similar to C++, the code is written and debugged in the sketch window and uploaded to the device via a computer. Arduino IDE is suitable for this prototype because it is coded consistently and supports a wide range of AVR boards and also supports ESP-8266.

5. Prototype Output

The Prototype displays the contemporary data on the PC/Laptop screen in the adafruit.io webpage. The *LiveFeed section* of the webpage illustrates the current status of the designed parking space with the date, time, and numerical values of the vehicles/objects. The *Status Indicator* embedded at the bottom portion of the dashboard indicates the availability of the parking space on an updated order. The dashboard is set up in a way that it can be customized according to the needs and demands as the concept continues to function.

The inserted figure below shows the values on how many vehicles were entered and present in the parking space in the *Live Feed* and sequentially keeps the value of the Status Indicator updated. *Green* on the status indicator implies that parking space is available at the parking structure and *Red* indicates that all the available spaces at the parking structure were Occupied.

Doi : https://doi.org/10.54216/JCHCI.030201
Received: January 24, 2022 Accepted: May 27, 2022

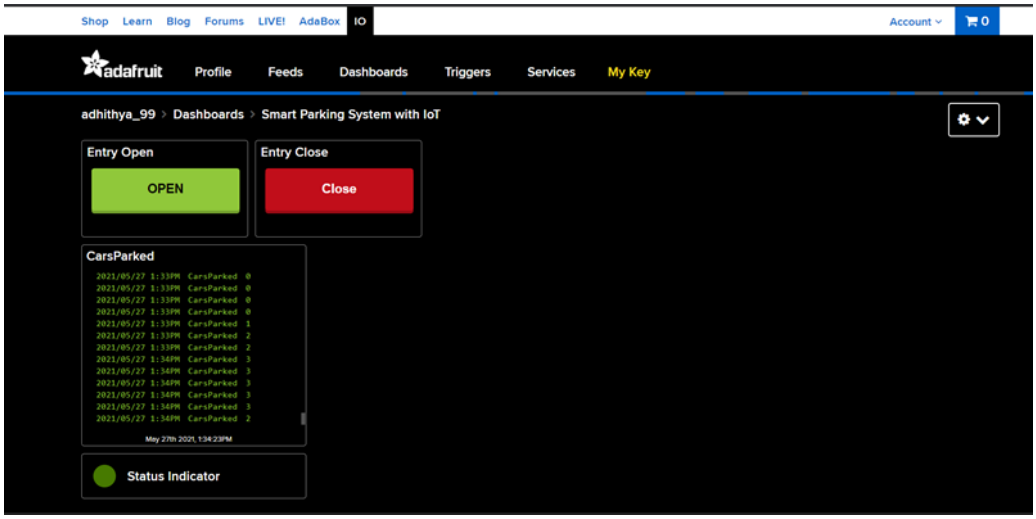

Figure 4:Mode 1: Parking space available; Status: Green

The Servo motor will function only when the Status indicator is in *Green* as shown in Figure 4. The below figure illustrates the resting phase of the servo motor as the Status Indicator is in *Red*.

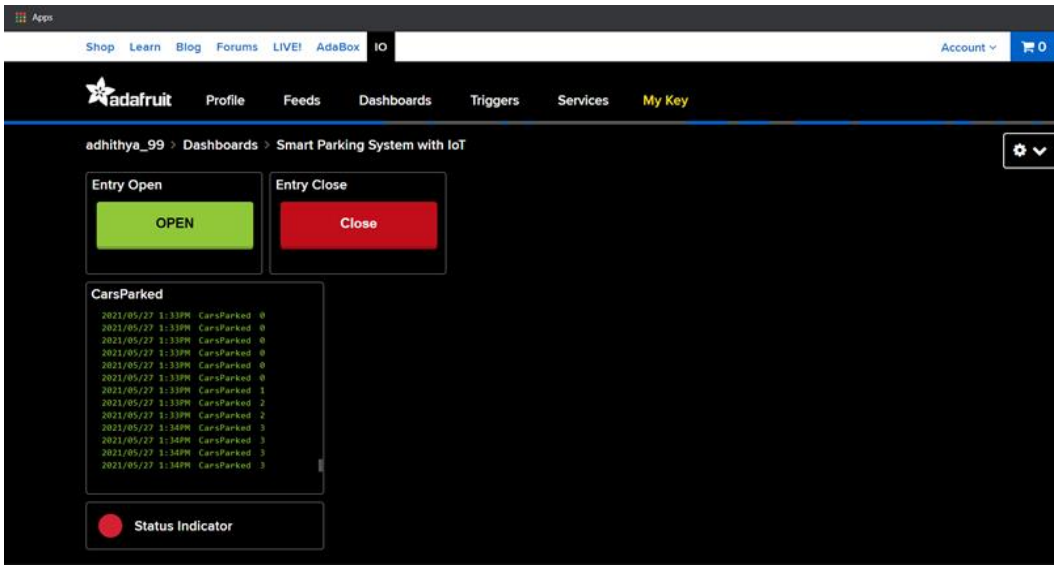

Figure 5:Mode 2: Parking spaces occupied; Status: Red

The Servo motor will not function in the above-mentioned situation in Figure 5 as the Status indicator turned *Red* infers that the parking spaces inside the parking structure are occupied and vehicles are prohibited to enter the parking structure. Concurrently the values of the respective slots will be updated to the current values as *Occupied*. Figure 6 displays the working model of the proposed system with all the connections.

Doi : https://doi.org/10.54216/JCHCI.030201
Received: January 24, 2022 Accepted: May 27, 2022

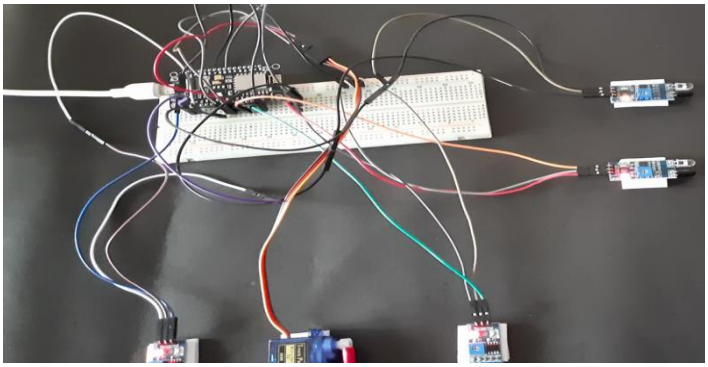

Figure 6: The Prototype model

6. Conclusion

This paper has demonstrated the working and purpose of a smart parking system based on internet/cloud computing. The hardware and software aspects of the system have been explained in detail. The improvements made compared to previous iterations of our prototype that justify the existence of our prototype have been explained. The direct and indirect advantages of implementing our system in various parking areas have also been discussed.

References

[1] Reed, Trevor. "Inrix global traffic scorecard." (2019).

[2] Bajçinovci, Bujar, and MejremeBajçinovci. "Anxiety and Urban Stress for Parking Spots." Journal of Science, Humanities and Arts 6 (2019).

[3] "State-wise Total Registered Motor Vehicles In India: Academic" Available:https://data.gov.in/catalog/state-wise-total-registered-motor-vehicles-india.

[4] Shen, T., Hong, Y., Thompson, M.M., Liu, J., Huo, X., and Wu, L., 2020. How does parking availability interplay with land use and affect traffic congestion in urban areas? The case study of Xi'an, China. Sustainable Cities and Society, 57, p.102126.

[5] Azshwanth, D., Koshy, M.T. and Balachander, M.T., 2019, November. "Automated car parking system". In Journal of Physics: Conference Series (Vol. 1362, No. 1, p. 012059). IOP Publishing.

[6] Ramírez-Moreno, M.A., Keshtkar, S., Padilla-Reyes, D.A., Ramos-López, E., García-Martínez, M., Hernández-Luna, M.C., Mogro, A.E., Mahlknecht, J., Huertas, J.I., Peimbert-García, R.E. and Ramírez-Mendoza, R.A., 2021. "Sensors for sustainable smart cities: A review". Applied Sciences, 11(17), p.8198.

[7] Sakthimohan, M., Pasupulti, M.K., Gopa, V., Gosi, N., and Elizabeth, R.G., 2021, May. "IOT Established Agile Parking System". In 2021 3rd International Conference on Signal Processing and Communication (ICPSC) (pp. 637-641). IEEE.

[8] Juwita, P.S., Fadhil, R., Damayanti, T.N. and Ramadan, D.N., 2020. Smart parking management system using SSGA MQTT and real-time database. Telkomnika, 18(3), pp.1243-1251.

[9] Özcan, Mustafa, FuadAliew, and HalukGörgün. "Accurate and precise distance estimation for noisy IR sensor readings contaminated by outliers." Measurement 156 (2020): 107633.

[10] Gramuglia, Francesco. *High-Performance CMOS SPAD-Based Sensors for Time-of-Flight PET Applications*. No. THESIS. EPFL, 2022.

[11] S Adarsh et al "Performance comparison of Infrared and Ultrasonic sensorsfor obstacles of different materials in vehicle/ robot navigation applications" 2016 IOP Conf. Ser.: Mater. Sci. Eng. 149 012141.

[12] Perković, T., Šolić, P., Zargariasl, H., Čoko, D. and Rodrigues, J.J., 2020. Smart parking sensors: state of the art and performance evaluation. Journal of Cleaner Production, 262, p.121181.

[13] Jung, In Hwan, Jae Moon Lee, and Kitae Hwang. "Smart Parking Management System Using AI." *Webology* 19, no. 1 (2022).

[14] Manjula, G., G. GovindaRajulu, R. Anand, and J. T. Thirukrishna. "Implementation of Smart Parking Application Using IoT and Machine Learning Algorithms." In *Computer Networks and Inventive Communication Technologies*, pp. 247-257. Springer, Singapore, 2022.

Doi : https://doi.org/10.54216/JCHCI.030201
Received: January 24, 2022 Accepted: May 27, 2022

[15] Ramisetty, S.V., Venkatesh, T. and Sujatha, R., 2022. Electric Vehicle Smart Parking System Using IoT and Telecommunication. In *Proceedings of the 2nd International Conference on Recent Trends in Machine Learning, IoT, Smart Cities, and Applications* (pp. 569-581). Springer, Singapore.

[16] Charles, J., Dhage, A., Bodele, G., Bargat, T. and Gawai, J., 2022. RFID Based Smart Parking System Using Firebase. *International Journal of Research in Engineering, Science and Management*, *5*(2), pp.31-33.

[17] Floris, A., Porcu, S., Atzori, L. and Girau, R., 2022. A Social IoT-based platform for the deployment of a smart parking solution. *Computer Networks*, p.108756.

[18] Saleem, SaleemIbraheem, S. Zeebaree, DiyarQaderZeebaree, and Adnan MohsinAbdulazeez. "Building smart cities applications based on IoT technologies: A review." Technology Reports of Kansai University 62, no. 3 (2020): 1083-1092.

[19] D. Ashok, A. Tiwari, and V. Jirge (2020), "Smart Parking System using IoTTechnology,"International Conference on Emerging Trends in Information Technology and Engineering (ic-ETITE), 2020, pp. 1-7.

[20] Agarwal, Yash, PunitRatnani, Umang Shah, and Puru Jain. "IoT based Smart Parking System." In 2021 5th International Conference on Intelligent Computing and Control Systems (ICICCS), pp. 464-470. IEEE, 2021.

[21] Y. -Y. Chu and K. -H. Liu (2020), "IoT in Vehicle Presence Detection of Smart Parking System,"IEEE Eurasia Conference on IoT, Communication, and Engineering (ECICE), 2020, pp. 56-5.

[22] H. Ávalos, E. Gómez, D. Guzmán, D. Ordóñez-Camacho, J. Román, and O. Taipe, "Where to park? Architecture and implementation of an empty parking lot, automatic recognition system", Enfoque UTE, vol. 10, no. 1, pp. pp- 54 , Mar. 2019.

[23] Vakula, D., and Yeshwanth Krishna Kolli. "Low cost smart parking system for smart cities." 2017 International Conference on Intelligent Sustainable Systems (ICISS). IEEE, 2017

[24] Patro, Sibo Prasad, Padmaja Patel, Murali Krishna Senapaty, NeelamadhabPadhy, and Rahul DeoSah. "IoT based smart parking system: a proposed algorithm and model." In 2020 International Conference on Computer Science, Engineering and Applications (ICCSEA), pp. 1-6. IEEE, 2020.

[25] V.D.Ambeth Kumar, G.Saranya , D.Elangovan, V.RahulChiranjeevi, V.D.Ashok Kumar, "IOT Based Smart Museum Using Wearable Device", Lecture Notes in Networks and Systems, Vol.55, pp: 33-42, 2018(Springer) https://doi.org/10.1007/978-981-13-2324-9_5.

[26] V.D.Ambeth Kumar, , "Precautionary measures for accidents due to mobile phone using IOT", Clinical eHealth, Volume 1, Issue 1, March 2018, Pages 30-35. https://doi.org/10.1016/j.ceh.2018.12.001

[27] V.D.Ambeth Kumar, G.Saranya ,D.Elangovan, V.RahulChiranjeevi, V.D.Ashok Kumar, IOT Based Smart Museum Using Wearable Device", International Conference on Innovative Computing and Communication ICICC-2018, 5-6th May 2018(Springer).

Doi : https://doi.org/10.54216/JCHCI.030201
Received: January 24, 2022 Accepted: May 27, 2022