MODELLING OF SMART CAR PARKING SYSTEM USING PLC

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ABSTRACT

The improved lifestyle of people accompanied with an increase in the number of private vehicles has posed a problem of unavailability of appropriate parking places. This problem is a root cause of many other problems such as traffic jams and road accidents. The designing of a smart, secure and efficient parking system to tackle the problems caused by the limited parking spaces such as undesirable road fights and traffic jams are presented in the paper. In the paper, Programmable Logic Controller (PLC) and Supervisory Control and Data Acquisition (SCADA) based system has been proposed to automate the process. The simulation studies of the designed system are also shown in the paper. The smart car parking system provides complete guidance for parking the vehicles in a particular sequence along with a proper arrangement for the security of the vehicles. The implementation of the designed system in real time can reduce parking related issues.

Keywords: PLC, SCADA, Smart Parking System, TIA Portal, Sensor.

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1. INTRODUCTION

The population of India is growing at an alarming rate and the lifestyle of people is getting better day by day with the availability of cars being the prime attribute of the improved lifestyle. The private transport has increased to such an extent that the country itself cannot afford as per the geographical conditions of the country. The average number of car registrations per year recorded for a period of 28 years from 1991 to 2018 is approximately 112638 cars [1]. The year 2016-17 witnessed a production of approximately 20 million vehicles – including cars and two-wheelers resulting in India’s total registered non-commercial vehicle population to around 220 million which is a number pretty much comparable to the number of households in India. One of the major reasons of increase in the
number of vehicles is the scrapping of vehicles by Indians once they get 15-20 years old at max. All this has resulted in the failure of the infrastructure ability of India to handle such a high volume of vehicles.

Road traffic accidents constitute to approximately 16.6% of all the deaths in India yearly, making it the 6th leading cause of deaths in India [2]. This further leads to socio-economic losses, the disability burden caused by the accidents, and hospitalization. In order to save the country from suffering under the attack of traffic congestion and vehicular pollution there is need to reverse the trend of usage of private transportation vehicles or improve the infrastructure to a level that can easily organize and handle such higher volumes of cars. One solution to this huge problem is the availability of smart parking systems in the basic public buildings like hospitals, hotels, shopping malls etc. The smart car parking system ensures a safe, secure and reliable parking facility for the people by providing parking assistance automatically to the drivers at the time of parking the vehicle.

The priority is set for the parking of the cars in the available spaces. The security can be achieved by generating a unique security code for each parking space that is provided to the driver while entering the parking facility and that he/she has to enter before taking the car out of the parking space. This automation process can be easily achieved using a PLC and SCADA (Supervisory Control and Data Acquisition) based system. The SCADA system can be used for the control and monitoring of the parking slots from a remote location also.

PLCs are better suited over microcontrollers for automation of the large scale processes. PLCs provide scalability in the number of inputs and outputs. PLCs are modular which guarantees the ease of modification of the set system for further requirements. PLCs can handle extreme levels of temperature and pressure. PLCs have better protection methods as compared to the microcontrollers as they support immediate shutdown of the system under emergency conditions.

Some of different ways in which smart parking services can be provided are discussed in several different research papers. According to one of the research papers [3], the automatic systems can deal with the problems that arise because of the absence of an efficient and reliable parking system. These systems promote the usage of new and advance techniques like expert systems which include wireless sensor based, fuzzy logic based, GPS based, vehicular communication based systems.

Another method of automatic parking of vehicles considers automation as a combination of self-moving machines that coordinate and work together without the requirement of any attention to develop a place where vehicles can be left for parking [4]. These systems also help in the monitoring of vacant spaces through SCADA system.

Some research papers provide an insight into automation through microcontrollers. The designing and implementation of prototypes based on sensors and microcontrollers for automation, on small scale basis has been tried which proves that it is a robust system [5]. The developed system can be used practically at multi-level parking lots also. It is an ideal practice to use such a system in underground parking areas in Metros, commercial buildings etc. A multilevel driver assistance system in order to create a better and efficient parking process can be achieved through the iCAN (intelligent car navigation systems) project framework [6].

This paper presents the designing of smart car parking system for four cars. The programming for the system has been done on the PLC S7-300 through the use of Totally Integrated Portal (TIA portal) [7]. The SCADA system is used to control and monitor the performance of the designed system. The experiment results of lane and row parking are also shown in the paper.
2. METHODOLOGY
The parking spaces have been designed at an angle of 45° with the horizontal [8]. This tilt increases the efficiency of the space usage in the parking area. Each parking space has been provided with a motion sensor. The motion sensor remains OFF only for 10 seconds after the customer clicks the ‘Park’ button and the sensor may remain OFF for 5 minutes if the system is implemented in real time.

2.1. Entry of car
Whenever a car enters the parking facility, a certain amount of fee has to be paid for the parking space. The tariff rates for the parking can be decided as per the suitability of the user. Once the car enters the area as per the flow chart shown in Fig.1, the parking assistance will be ON. The following flow chart describes the various stages of parking a car in the smart parking area.

![Flow chart for entry of car](image)

Figure 1 Flow chart for entry of car

2.2. Parking assistance
Once the car gets into the parking zone, it will be guided to the available parking space through arrow shaped the LEDs. The green colour LED glows as per the ‘Priority method’ set to avoid any conflict in the parking order.

2.3. Security
A unique passcode for different parking slots would be generated. This passcode would be necessary for unparking the car. The motion sensor turns ON once the car is parked. It turns OFF for approximately 10 seconds after the correct passcode has been filled for unparking the car.

2.4. Unparking of car
The procedure of unparking the car has been described in the flow chart as shown in in Fig. 2. The customer has to click on ‘Unpark’ button which leads to opening of a ‘Passcode screen’ on the panel. The customer has to fill in the correct passcode for unparking the car. If the customer fills the wrong passcode, another chance would be given failing which, security breach alarm would blow.
2.5. Interfacing between PLC and SCADA system
The following steps need to be followed for addition of required components and establishing communication interface between PLC and SCADA:

- In the TIA portal, start new project.
- Open the project in ‘Project View’.
- From the ‘ADD NEW DEVICE’ option, add Controller and choose PLC S7-300.
- Choose a specific model of PLC from the menu. Choose PLC 317-2PN/DP.
- From the ADD NEW DEVICE option, add SIMATIC HMI screen and choose WinCC RT professional which is basically the SCADA system.
- Add IE General port in WinCC device.
- Make connection between PLC and WinCC device.
- Set the PG/PC interface to PLCSIM TCP/IP for enabling simulation of the program.
- The IP addresses of the PLC and WinCC professional must be different. However, the IP addresses of the WinCC professional and the computer must be same.
- After the successful connection establishment of SCADA system and PLC, simulation can be run and the design can be easily monitored and controlled.

3. SOFTWARE IMPLEMENTATION OF THE DESIGNED SYSTEM
Simulation of the main gate when the first car is allowed to enter the smart parking area is shown in Fig. 3. This screen would be visible to the person monitoring and controlling the smart parking system. The facility for communicating the instructions to the new customers has been provided.
Figure 3 Entry allowed after payment through smart meters

It has been shown that the car count increases from 0 to 1 and the green light glows showing the availability of the empty parking spaces. When the car count would be 4, the red light would glow showing the unavailability of the empty parking space inside the area. The Fig. 4 shows that the slot 1 has been blocked by the parked car. The arrows shaped LEDs guide the car to the next available location which has further indication of green or red color based on the ‘Available’ or ‘Blocked’ slot respectively. The ‘Protection’ button represents a motion sensor in the Fig. 4. The motion sensor remains OFF for a certain fixed amount of time after the parking of the car. If any external agent tries to enter the motion sensor area, the alarm along with the hooter blows.

The system has been designed such that the motion sensor turns OFF automatically only after the ‘Unpark’ button is pressed and correct password is entered in the ‘Passcode screen’ as can be seen in Fig. 5. The parking of the car is carried out as per a ‘priority method’ which allows a specific slot to be filled before the filling of the other slot. This ‘priority method’ has been set through the use of binary digits.

Figure 4 Parking slot 1 blocked and parking assistance for slot 2 ON

The procedure for unparking a parked car is presented in Fig. 5. On clicking ‘Unpark’, a ‘Passcode Screen’ opens on the ‘Panel’, the customer is required to fill in the correct password for the particular parking slot in order to unpark the car and stop the motion sensor temporarily. If the customer fills in the wrong password the set system allows the customer to fill the password again. A total of 2 chances would be given to fill in the right password within 20 seconds. However, this time can be set to minutes in real time implementation of the proposed system.
The first alarm blows when the customer fills the wrong password twice as depicted in Fig. 6. The second alarm blows if the motion sensor senses any movement in the parking slot with car already parked. The motion sensor gets disabled only and only if correct password is filled after clicking ‘Unpark’.

4. CONCLUSION
The modelling of a smart car parking system using PLC and SCADA has been done in the paper. The designed system is a smart one as it provides security, parking guidance based on a set priority, efficient usage of the parking area and protection of the parked cars. It can be concluded that security has been given prime importance in the smart system as each car once parked can be unparked only through a unique passcode. The parked cars are completely protected from any foreign disturbance through automated motion sensors. It can also be concluded that setting up the parking slots at an angle of 45° results in efficient usage of the parking area. The rotary structures may also be used but the use of the motors that can bear high load increases the construction cost as well as the maintenance cost. The hardware implementation of the designed system in real time can reduce parking related issues and provides high end security to the customers.

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REFERENCES


