

Simulation of a PLC-based Car Parking System

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Abstract - Parking is an integral component of the transport system. It plays a crucial role in the management of traffic and congestion. On-street parking constitutes one major problem that makes traffic situation chaotic in Nigeria cities. Most roads in Nigeria cities are narrow and lack pedestrian lanes. As we all know, vehicles are used extensively for transportation. It is also important to have easy and effective system for maintaining the vehicles cleanliness as well which necessitate this simulation experiment. The simulation experiment involves the use of LADDER SIMULATOR which allows the Programmable Computer to simulate a Programmable Logic Controller such that Ladder Logic PLC programs can be developed in a simple 'Drag and Drop' manner. The system entails the use of several proximity sensors and components like Timers (On-Delay), Counters (Count-Up and Count-Down), LEDs to control the process of cars moving in to the car park with the proper arrangement of cars entering the car park and the exit of the cars. The sensors transfer the outputs to the PLC (programmable logic controller). This type of setup is an Advanced Parking System (APS) which acquire information any about available parking spaces, process the information and then present it to drivers by means of variable message signs using LADSIM simulation technique. The problem of car parking space is enormous which made this work relevant due to insufficient parking spaces and lack of skilled security men. There is a worldwide and global shift towards the automatic car parking system to calculate accurate space available for car and for revenue collection as parking fees. Opinion statistical analysis sample test with KMO and Bartlett's validity test conducted among fifty students revealed a strong positive significant (0.759) in support of the use of automated car parking system in Nigeria. The significant of this new scheme is that it provides an improvement and reliability in the present car parking system and this system can be implemented easily because it is very economical, dependable and cheap.

Keywords - Sensors, PLC (programmable logic controller), Car parking; LADSIM; Ladder Logic.

1 INTRODUCTION

Vehicle ownership is at high percentage in the world today, parking has become a contradictory and perplexing anomalous for many people (Asiyanbola & Akinpelu, 2012). The problems of parking are an everyday occurrence whether at churches/mosques, bus stations and shopping malls. Current parking design practices are unproductive and often ineffective at solving parking problems. In most cases minimum parking requirements tend to be undue because they are generally based on demand surveys performed in automobile-dependent locations, and so need more parking than required in areas with good travel options, available land use, or transportation and parking management programs. Yet this excess plan does not eliminate parking problems because spaces are often unavailable for significance uses or are hard to access of course the main problem is not inadequate supply, it is inefficient management (Linganagouda, 2016).

In fact, car parking systems have been around almost since the time cars were conceived. The fact is that any area where there is a significant amount of traffic, there must be car parking systems. The development of car parking systems starts as early as 20th century in answers to the need for storage space for vehicles (Grwal, 2012). There are numerous advantages of using a car park system for urban planners, business owners and vehicle drivers. In actual fact, it offers convenience for vehicle users and efficient usage of space for urban-based companies. car park systems that are automated save time, money, space and simplify also the often tedious task of parking. In most cases there are two types of car parking systems: the traditional ones and automated type. In the extensive term, automated car parking systems are likely to be more cost effective and easy when compared to traditional parking garages (Sarayu et al., 2013).

According to Dickinson & Johnson (2006), automatic multi- storey car park automated systems are less expensive per parking slot, since they tend to require less building volume per ground area than a conventional facility with the same capacity and volume. In the work of Hackworth & Hackworth (2006), it was stated that both automated car parking systems and automated parking garage systems reduce pollution as cars are not running or circling around while drivers look for parking spaces. Usually, getting a vacant space in a multilevel parking lot is very difficult if not impossible, especially on weekends or general public holidays (Khan, 2009). To get a spaces during weekends or public holidays can take more than 10 minutes even for about 66% of visitors. Worst still, stadiums or shopping malls are crowded at peak periods, and also difficulty in finding vacant slots at these places is a major problem for customers. Inadequate car park spaces no doubt lead to traffic congestion and driver's frustration. In a situation that a car is parked in such a way that it occupies two parking slots rather than one, this is called 'improper parking'. This improper parking may occur when a driver is not careful about another driver's rights (Kheiralla et al., 2007).

In order to solve these entire difficulties, we came to a conclusion of having an automated car parking structure that ensures the safety of the drivers as well as saves time, energy and parking spaces. Actually some of the benefits of automated intelligent car parking system are: it can accommodate maximum capacity number of cars in minimum spaces, modified parking solutions, lower maintenance and operation cost, provides safety for car and the driver, faster parking and retrieval and eco-friendliness (Yilmaz, & Çobantepe, 2010; Barrett, 2008).

2 METHOD AND MATERIALS

LADSIM stands for LADDER SIMULATOR, is a completely-functional Ladder Logic Editor and PLC Simulator that incorporates almost all the basic functions

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used in PLC Programming as well. It has Inputs, Outputs, Timers, Counters, Flags and Shift Registers which were also available, we can develop ladder programs quickly and easily. Each of the function is simply 'dragged' onto the ladder rung with name tags assigned via a regular pop-up window. Extra rungs may be added with the click of a button, together with branches to form more complex programs. This arrangement is closely similar to that of Birbir & Nogay (2008) and Bolton (2011).

LADSIM techniques integrate seven 'real' process simulations that will test our knowledge of Ladder Logic Programming. For each simulation we must develop the necessary ladder code to effect safe control of the scenario. The simulations provided within LADSIM are a Traffic Light, Annunciator, Car Park, Lift, Drinks Machine, Packing Line and Bottling Plant. In addition, LADSIM can be used as a stand-alone teaching aid with its library of internal simulations. It also has advantage of being capable of controlling external applications through one of our PC Internal Interface cards.

2.1 EXPERIMENTAL SETUP

This experiment involves simulation with LADSIM of a car park with 6 cars capacity. There are six cars space at the car parking ground and six LDRs were then placed on each car space to detect the presence of a car over it. Assuming six cars were parked at the parking then the LDR sends this information output to PLC. The presence of a car waiting to enter the car parking will be detected by a set of IR sensor placed at the main gate of the car parking arena. Immediately the IR sensor detects the presence of a car, then the output is automatically send signal to the PLC. The PLC works on the data provided to it by the LDR and the IR sensor process to ensure whether a car can be parked or not. In a situation where the data provided by the LDR shows the possibility of available space for car parking and at the same time IR sensor detects the presence of car waiting to get parked, the PLC will then direct the main parking gate to open and thereby allow the car to enter the parking arena.

On other hand if the data provided by the LDR shows the possibility of fully and completely occupied parking space, at that moment the PLC stops the main gate from opening and directs the car to next available parking ground. The Simulation image of the car parking system is as shown in Figure 1.

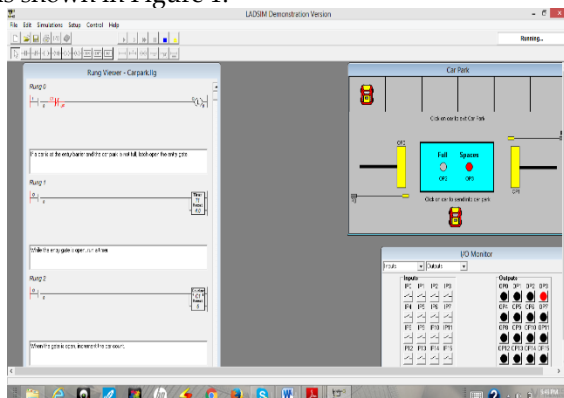


Fig. 1: Simulation of car parking system.

2.2 BLOCK DIAGRAM

The block diagram of the Simulation of a PLC-based Car parking system is shown in Figure 2. The diagram displays the input and output components connected to PLC. However, the input sections comprise of six numbers of LDR sensors, IR sensors and also a security camera while the output components comprise of entry gate and exit gate mechanism.

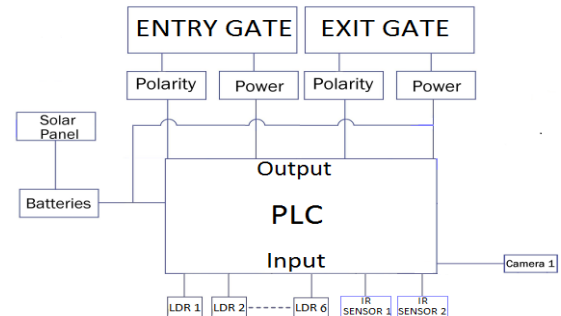


Fig. 2: Block diagram

3 RESULTS AND DISCUSSION

The operation of a PLC-based Car parking system is successfully done. The ladder program is established in the LADSIM software and checked for any bugs before downloading into PLC. In order to start the program select the LADSIM icon in Bytronic licensed software in the Start Menu and when a car breaks the beam, an accumulator (Acc) display for the timer increase in 0.1 second step and, after 3 seconds, the DN bit is then set. Then we have a timer which starts timing when the IP0 beam is broken and the T1/DN bit is set 3 seconds later.

A rung was added which will consequently unlatch OP0 when the T1/DN bit is set. Dragged a NOC to the left hand side which was identified as T1/DN from the dialog box then on the right hand side drag an Unlatch Output and identify it as OP3 as shown in Figure 3.3 of a completed ladder logic diagram. This T1/DN input is not highlighted and emphasised until 3 seconds after the first car goes through. Thereafter the T1/DN is then permanently set and thereafter no other car is allowed through. Then the Full and Spaces lights will come on when OP2 and OP3 are energised, respectively. Therefore, the Counter 1 (C1) in the 'count up' mode such that every time the entrance barrier beam is broken it triggers the counter, and preset to 6 to represent the total capacity of the car park, when the C1/UP bit is set, i.e. 6 is reached, the Full light (OP2) turns on. Conversely, this same bit (or flag) can equally be used to control OP3 in that, when it is not set, the space light is turned on. Finally, another additional rung with a NCC on the left identified as C1/UP, and OP3 (Spaces) on the right was added. Even when a car exits, the count is not changed. This can also be rectified by using the exit beam to trigger the same counter but this time in the 'count down' mode as it's been shown in Figure 3.



Fig. 3: Exit Beam

It was noticed that until the 7th cars allowed to enter into the car park, the last one cannot find a space so it exits

and the counter counts down to 5. This is obviously wrong as there are still 6 cars at the car park. To resolve these problem cars was prevented from entering the car park when it was full. Thus, a condition was added to the first rung that the full display was not on by modifying it as it is shown in Figure 4.



Fig. 4: Modified full displays rung

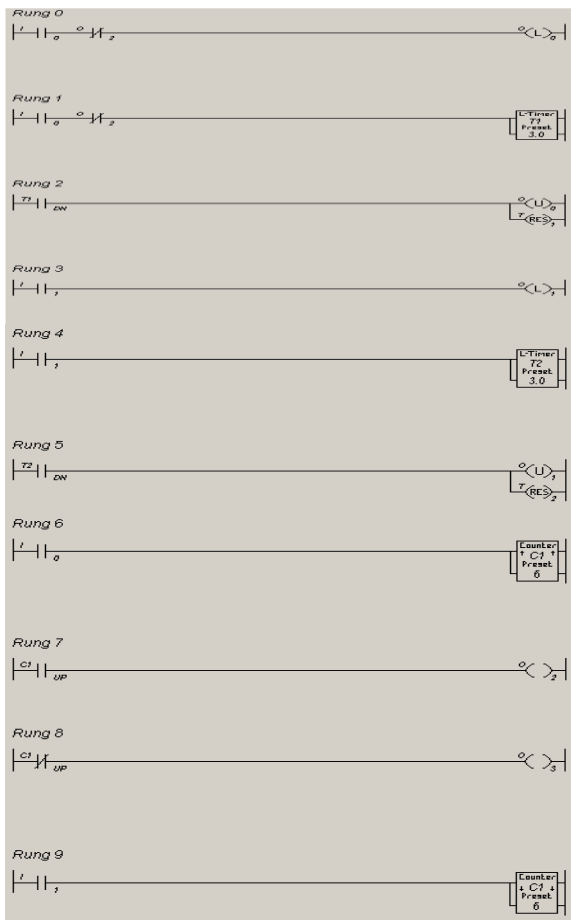


Fig. 5: Completed Ladder Logic Diagram Creation for Car Park

3.1 KMO AND BARTLETT'S TEST OF USERS PERCEPTION

Opinion sample test with KMO and Bartlett's validity test conducted among fifty students shown in Table 3.1 revealed a strong positive significant (0.759) in support of the use of automated car parking system in Nigeria. This shows that the use of automated car parking system is much better than the manual method.

Table 1. Validity sample Test of Simulation Results

Test		Risk Factors in Manual Parking	Automated Car Parking System Agreement
Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO)		0.824	0.759
Bartlett's Test of Sphericity	Approx. Chi-Square	2873.401	504.798
	df	630	45
	Sig.	.000	0.000

4 CONCLUSION

This system was successfully implemented using LADSIM PLC software simulation. The Simulation of a PLC-based Car parking system provides a unique 22nd century automated car park system with their ladder and rungs for clarity and proper understanding. This Simulation of a PLC-based Car parking system was designed in order to minimize human effort and to save car owners precious time waiting to get a parking spot. Validation exercise conducted with the opinion of fifty people also shows that people preferred automated car parking than manually operated one especially in Nigeria. The results show that there are many advantages of employing an automated car park system for urban developers, business owners and vehicle drivers. They offer convenience for vehicle users and efficient usage of space for urban-based companies. Automated car park systems save time, money, space and simplify the often tedious task of parking. This same data could also be incorporated in to an app which would enable users to access relevant information about the availability of parking space in different locations with this system installed in them.

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