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INTELLIGENT GUIDANCE PARKING SYSTEM USING MODIFIED DIJKSTRA'S ALGORITHM

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Abstract

Parking system is one of the main important facilities that should have in any infrastructure or building especially for the place of interest and place of people's attraction. The best parking system is the system that provides customers the ease of finding the available spaces, user friendly and less time consuming. This paper presents the intelligent parking system which apply Dijkstra's algorithm in finding the shortest path. The proposed intelligent parking guidance system is a system that assigns the nearest vacant bay to drivers with necessary direction printed on the ticket so that drivers are able to find the 'best' lot with the minimum amount of time. The system will automatically check for the nearest empty lot and reserve the lot for the user so that the next user will not get the same lot again. Software and hardware implementations have been carried out. Few electronic components such as PICs, IR sensors, push buttons, LEDs, LCDs, counters, comparators, and servo motors have been used to realize the system. Personal computer and DAQ cards are used to communicate and interface with the monitor to display the GUI which has been developed using Lab View. It will also present the real time simulation of the parking system and validate any information regarding the parking status.

Keywords: Shortest path, Real time, Dijkstra's algorithm, Graphic user interface.

1. Introduction

The conventional and current parking system in Malaysia requires drivers to receive parking tickets and find the parking lot by themselves. The difficulty in searching the available parking lot leads to time and fuel wasting and causes high frustration and stress level of drivers. The proposed intelligent parking system is a counter-based indoor car parking system which able to count, display, assign the nearest lot and print the location on the ticket. Upon arrival at the parking entrance, drivers will

Abbreviations	
ADC	Digital converter
DAQ	Data acquisition
GIS	Geographic information system
GPS	Global positioning system
GUI	Graphic user interface
IR	Infrared
LCD	Liquid-crystal display
LED	Light-emitting diode
NI	National instruments
PCB	Printed circuit board
PDA	Personal digital assistant
PIC	Microcontroller
PICs	Peripheral interface controllers

press the ticket button for a ticket, and they will receive a ticket with mini-map printed on it. The assigned vacant lot is locked for few minutes to allow drivers to park. Once it is done, LED indicator will turn to red. Dijkstra's algorithm is applied to calculate each of the lots distance to the specific mall entrance as the destination. All lots then are arranged in the priorities sequence based on the distance calculated by the algorithm.

1.1. Dijkstra'salgorithm

Shortest path search has been widely applied recently in many applications such as Geographic Information System (GIS), Global Positioning System (GPS), traffic information system, routing system, mapping such as Google Maps and many more [1-5]. One of the most used algorithms is Dijkstra. It was first introduced by Edsger Wybe Dijkstra in 1959. There are many ways to formulate the shortest path problem such as Breadth First Search, A*, Bellman-Ford-Moore, Floyd, Genetic and Dijkstra's Algorithm [2, 5]. Dijkstra's algorithm is applied to calculate each of the lots distance to the specific mall entrance. Dijkstra's algorithm is basically a graph search algorithm that solves the single source shortest path problem for a graph with nonnegative edge path cost thus, producing a shortest path tree [6, 7]. Shortest paths to all other vertices can be solved by using a single source shortest-path method given a source vertex s $\in$V and then computing the all-pairs shortest path problem which computing the distances between all pairs of vertices to computing the distance between vertices, we will want to provide some intermediate structure that makes it possible to reconstruct the shortest path [6, 7]. For a given source vertex (node) in the graph, the algorithm are able to find the path with lowest cost (i.e. the shortest path) between that vertex and every other vertex [8]. The Dijkstra's algorithm formulated the equation of $G = (V, E)$. This single source shortest path is applied to the parking management system to locate the nearest empty lot from the entrance gate to the entrance door of the shopping complex. The parking lot is considered as a weighted diagraph. Each parking lot is scanned and nodes generated to reach the

destination is collected. The shortest path between two points has the least number of nodes which act as the connection between points.

1.2. Proposed parking system and related works

The system is based on first come first serve basis. Each driver will be given an amount of time to park the car which depends on the lot's distance. The lot will be locked for a certain of time and will be available for the next driver if the time allocated has ended or if no car is parked as the sensor in that particular lot will always detect whether it is occupied or empty. In order to keep updating the parking status, this system will rescan after a certain period of time, thus the monitoring system will always synchronize in real time for the parking lot. This parking system will bring multiple benefits to the driver and car park management. The proposed car parking system has the specification below:

- The system that counts and displays the number of all vacant bays.
- The system that assign the nearest vacant lot to the mall entrance upon and prints a mini-map to show the location of assigned lot.
- The system that locks the assigned lot for a certain of time, depending on the distance and indicate all vacant and occupied bays.
- The system that has a GUI for system monitoring and real time control.
- The system that able to self-recalculate vacant bays after the locked-in period has ended.

Few related works on smart parking system used GPS-based or search algorithm which runs on a PDA (or smart phones) and allows drivers to find a parking space that suits their needs inside a parking lot [9, 12-13]. Most of related works used wireless sensor network to allocated and monitor the vacant lots [10-15]. Comparison, advantage and limitations of various parking systems with the proposed system are shown in Table 1.

2. Methodology

The project methodology includes the system design by identifying requirement and the specification of the system, software design and simulation, hardware implementation and testing and GUI development and real time simulation.

2.1. System design

This intelligent parking guidance system basically consists of few main parts which are sensors interfacing to circuits and data acquisition, few main circuits and microcontroller processing and development of system monitoring (GUI) which connected to data acquisition card and a computer with pre-installed Lab View software. Microcontroller (PIC) will determine the nearest lot based on the programs downloaded into it which based on the algorithm. The GUI for system monitoring is developed for the security or maintenance purposes. The designed GUI are the real time simulation which will display the actual status of parking lot in the GUI simultaneously. The National Instruments (NI) Lab View software is

installed into a computer to display the GUI. The overall system based on the input by Infrared (IR) sensors. Detailed each of block function is described in Fig. 1.

Table 1. Comparison between the Parking Systems.

Types of Parking System	Advantage	Limitations
Server Connected-Based and GPS –Based [9, 12-13]	Users are able to get the information faster and in effective way.	Users must have Android system.
Real Time Display Based [14]	Provide the up-to-date information by the sensor attached at the each lot, without signal from loop detector.	Only provides the total number of available lot.
Wireless Sensor Network-Based [10,15]	Wireless connection for the system.	Cost is higher due to wireless sensor usage.
Embedded Internet Access-Based [11]	Users are able to access the current parking condition on the internet, thus making the user have the better planning.	Unable to provide the best parking lot for user.
Proposed Intelligent Parking Guidance System	This system has the smooth running of traffic in parking areas and user friendly. Moreover, it easy to follow without the need for sophisticated equipment.	Human factor.

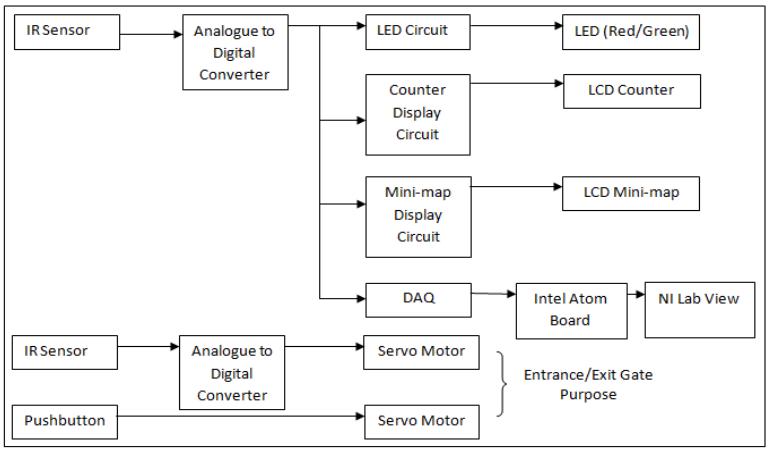

Fig. 1. Specified Block Diagram of the Proposed System.

Based on Fig. 1, there are 2 main circuits, which are indicator or display circuit and the gate circuit. Both of this circuit used IR sensor as the input device except for the entrance gate circuit which uses pushbutton as the input device. Output from IR sensors which in the form of analogue signal will be processed by Analogue to Digital Converter (ADC). As signals from IR sensors pass through the ADC, digital signals will be generated and will be the input of LED, counter, mini-map and DAQ circuits. PIC 16F877A is used to process all the circuits

based on programming codes installed in it. Output of each circuits are then displayed by LED and LCDs. Signals from sensors are also connected to the input ports of DAQ card which then connected to a computer by USB connection to display the GUI developed and real time simulation. Servo motor is used in the gate circuit and they are controlled by sending them a pulse of variable width [16].

2.2. Development of GUI

GUI interfacing and portal development includes the synchronisation between the circuit simulation and the Lab View, in order to ensure the GUI from Lab View are able to be used with the circuit. In this proposed system, PC is used as the GUI platform and NI USB-6009 DAQ is used as a medium for translating hardware signals into software for further processing. The outputs from the hardware are hardwired into the NI USB-6009 DAQ and the signal is read in Lab View. The PC will then displays the developed GUI. The program downloaded with defined input and output ports of the NI USB-6009 DAQ then communicates with all the hardware. Infrared sensors on top of each parking lots and parking ticket button are connected as the input port while barrier gate and ticket printer are connected as the output port. Programs is written to analyse the signal received from input, runs the calculations, and decides the activation of outputs. This system is developed mainly as the monitoring system and safety system to view the status of each parking lot in real time situation of what's happening in the parking zone through the designed GUI. This may benefit both user and parking management company. Figure 2 illustrates the communication between parking system and the GUI system.

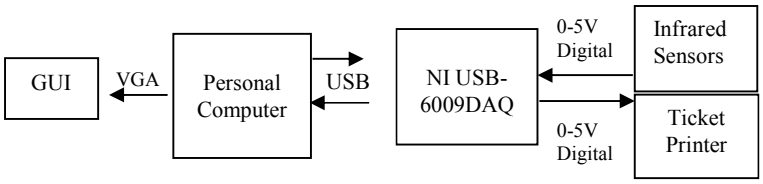

Fig. 2. Configuration of System Communication Protocol.

2.3. Hardware implementation and software simulation

Electronic hardware construction includes the hardware implementation, testing of sensor circuit, counter and gate circuit, LED circuit and the GUI in order to ensure both of the systems are compatible. All circuits are simulated in Proteus software before implemented. Prototype of model parking lot or building is also designed in the 3D model using Solid Works before implemented using hardware. For software simulation, C language is applied to program the PIC. The whole design circuit was tested on the breadboard and printed circuit board (PCB). Seven main circuits fabricated are IR sensor, green/red LED, push button, analogue to digital converter (ADC), counter, and gate circuit. For IR sensor circuit, both of transmitter and receiver must be placed upright and beside each other. IR sensor will generate an analogue signal and then converted to digital form. Comparator LM324 is used to convert it into the digital signal. In

pushbutton circuit, the button will activate a signal and send it to the microcontroller either HIGH or LOW signal. Servo motor is used as the gate for entrance and exit purposes. Two inputs from pushbutton is used for entrance purpose, while two IR Sensors act as the inputs at the exit. Servos are controlled by sending them a pulse of variable width [16].

3. Result and Discussion

3.1. Parking system model

The concept of Dijkstra algorithm applied and modified to a simple parking lot modelled as shown in Fig. 3. There are 16 parking lots with two gates for entrance and two gates for exit based on the prototype. The specification also based on normal facilities that provided in the shopping complex nowadays. Each user enters through different gates will be assigned to a different zone. The distance is calculated from entrance 1 (for gate A) or 2 (from gate B) from the assigned lots.

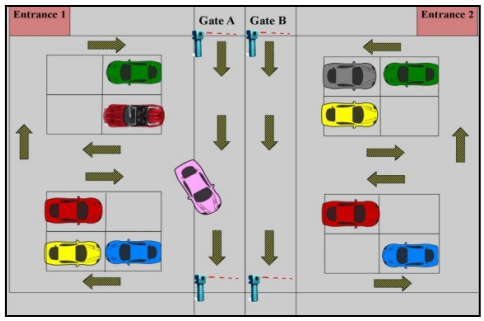

Fig. 3. Floor Plan of the Parking Zones and Lots.

3.2. Nodes and routes generated from Dijkstra's algorithm

As this system applies Dijkstra's algorithm, where the initial node, destination node and several nodes that user will pass through are identified. In this system, the initial node will be the parking lots and destination node is the mall entrance. Next, all the identified nodes will be labelled as unvisited nodes. The distance from the initial node to the second node nearby will be calculated and the shortest distance node will be selected. The selected node is now the initial node and calculations will be performed onto the nearby nodes to look for the nearest distance. The steps will proceed until the destination node has been reached and all the nodes have been visited. All the steps above are then repeated to get the second shortest distance from parking lot to the mall and goes on until all the parking lots in the system have been calculated [17]. This is to check which nearest parking lot is available for users to park their car in the parking zone. All the distance calculation values for each parking lot will be stored in an array so that this massive calculation steps need not to be repeated for every user's entrance. If the first shortest distance parking lot is occupied, the program will loop to check on the second shortest distance lot, and so on, until an unoccupied lot is detected. Once the available lot is detected, the loop will end and instructs

the printing machine to print out the available parking lot number with its route map on the parking ticket. At the same time, it will send signal to the control system to indicate that the assigned parking lot is occupied. The barrier gate will open to allow the user to enter the parking zone. As soon as the user parked his/her car at the allocated parking lot, the sensor will detect the presence of car and turn off the indicator.

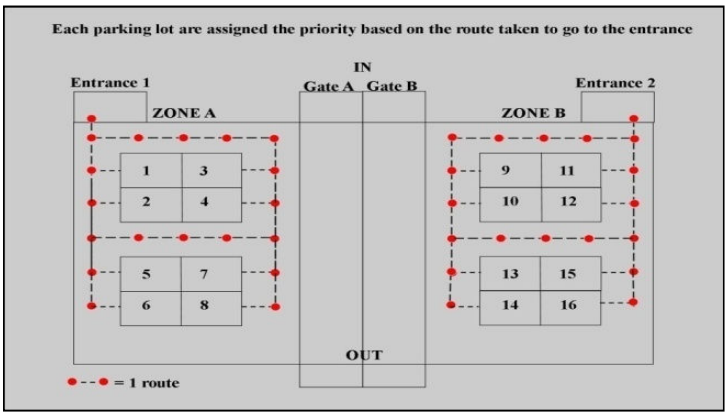

Fig. 4. Calculated Routes and Nodes Each Assigned Parking Lot.

All of lot distances to their corresponding entrance are generated after scanning the Dijkstra's algorithm are as shown in Fig. 4. The nodes calculated are then written in C language for the system to automatically assign the lot based on its priority processed by microcontroller. The Dijkstra's algorithm is modified based on walking distance instead of vehicle's distance. The modified nodes are then used to arrange the priority of parking lots are as shown in Table 2 for parking zone A and B respectively.

Table 2. Distance vs. Priority for Lot 1 To 8 and for Lot 9 to 16.

Lot Number	Distance to the main entrance, A(route)	Priority (for A)	Lot Number	Distance to the main entrance, A(route)	Priority (for A)
1	3	1	**11**	3	1
2	4	2	**12**	4	2
3	7	3	**9**	7	3
4	8	4	**10**	8	4
5	6	5	**15**	6	5
6	7	6	**16**	7	6
7	10	7	**13**	10	7
8	11	8	**14**	11	8

Generally, users who enter through gate A will be assigned to the parking lot number 1, 2, 3, 4, 5, 6, 7 or 8 (referring to Fig. 4). However, if all lots have been

occupied, the empty lot from the nearest zone will be allocated based on the distance from the zone to the nearest entrance (9, 10, 11, 12, 13, 14, 15 or 16). The case also implemented for those who come in from gate B and it is full.

3.3. Result and discussion: circuit simulation

Simulation is carried out to verify the built C programming is able to perform as desired. In the simulation, variable resistors are used as IR sensors since sensors varying resistance value whenever they detect any object. When resistance value exceed 50% of variable resistance rating, it is considered occupied while less than 50% of variable resistance rating is considered empty. In Fig. 5, lot A, B, C and D show the example of occupied parking lots while lot E, F, G and H show empty parking lots. Thus, the indicator at parking lot A, B, C and D appear in red while parking lot E, F, G and H appear in green.

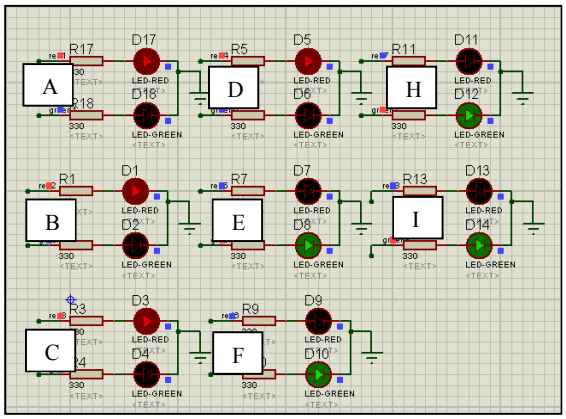

Fig. 5. LED Simulation after Received Signal from Sensor.

In simulation, an assumption is made as such parking lot A, B, C and D are located at the first level of building while parking lot E, F, G and H are located at the second level. For LCD display, information of the number of available parking lot and assigned parking lot is shown. The result of the LCD display shown in Fig. 6. For mini-map purpose, the "X" marked represent the parking lot location as shown in Fig. 7.

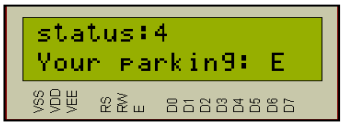

Fig. 6. Parking Status Display.

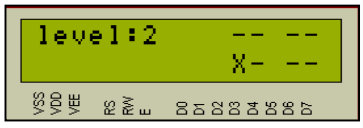

Fig. 7. Mini-Map Display.

Figure 8 illustrates the design of GUI that is used to display information of the parking system to the parking administrator. From the GUI, administrators can view the graph of vacancies, probability of having zero unit of car in queue,

server utilization and estimated number of vehicles in queue. All these parameters are calculated in real-time and displayed in the form of plots. The indicators at the right side of the GUI are to indicate the status of each parking lot, where light green indicates available and dark green for unavailable lot, which is in the same condition as the indicator installed on the parking lot. Administrator may navigate to another level by clicking on the tab on top. The program may be stopped immediately by clicking on the *Stop Monitoring* button, or *Reset Statistics* to clear out all the previous values and start all over again. For modelling purpose, the number of parking lots has been reduced from 32 to 16 lots per level, in order to minimize the size of the model structure.

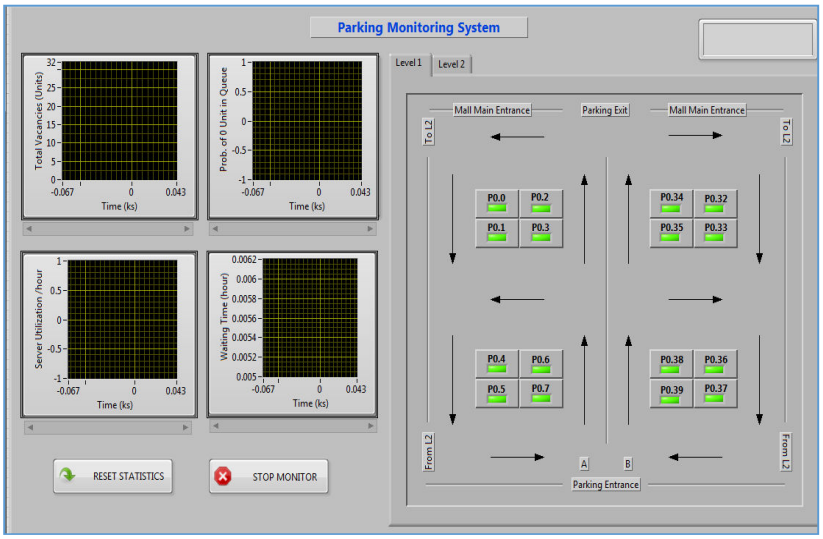

Fig. 8. GUI for Real-Time Monitoring.

4. Conclusion

Intelligent Parking Guidance System using modified Dijkstra's algorithm has been successfully developed. The system has provided more convenience parking system to the user. Users are able to park their vehicle at the nearest lot to the mall entrance without searching around for it. The existence of red and green LED functions as an additional guidance for drivers to locate the empty lot. This system has been proved to display the right number of vacant bays, determine the nearest parking lot number, assign the nearest lot, print a mini-map to guide drivers and also equipped with GUI system and real time simulation. The system is very efficient if all users park at the assigned lot to ensure the system is fully utilised. Penalties may be suggested for those who disobey the system.

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