ENERGY EFFICIENT AUTOMATED CAR PARKING SYSTEM

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Abstract— **Due to a rapid increase in the number of vehicles, the need for parking spaces is on rise. It is important to park the cars in close proximity to avoid traffic congestion and use a parking area efficiently. Current car parking management systems utilize human personnel to find available parking areas or use a video based system that collects the information in the form of images and tracks available parking slots. This paper describes an alternative energy efficient system which allots a unique parking 'slot' for every incoming car. The parking area has a number of 'slots' to park which are prioritized in such a way that the available slot nearest to the entry is allotted to every incoming car. The driver has to park in that particular slot allotted without searching for a vacant space thus reducing the time for parking and making an efficient use of available space. The System additionally makes efficient use of energy by switching the lights in the parking area ON only when a car is in motion. The application is developed on LPC1343 ARM processor and tested on a miniature prototype. The results suggest that it is a robust system and can be implemented in real time with an option to increase the number of parking slots as required.**

INTRODUCTION

With increasing number of automobiles in the recent days and lack of free parking space, especially in metros, the need for developing an automated car parking system which makes efficient use of space and avoids traffic congestion arises. It creates a challenging design problem to park the cars in close proximity and to operate and maintain such systems. Earlier there were parking areas which required human personnel to track the available parking slots making it time consuming. In this paper, we describe a semi-automated parking system which allots a unique parking slot to every car thus obviating the driver to search for a vacant slot and also requires less manpower. Moreover, it is a robust system that accommodates any number of cars entering or leaving the area at the same time instead of stalling the driver at the entrance.

The system is made highly energy efficient by switching ON the lights in the parking area only when a car is on the move which makes it distinctive from most parking systems. A study on the existing systems reveals that there are automated systems based on sensor networks or video based systems that track the presence of cars and availability of free spaces in parking areas. They lack the advantage of allotting a unique slot to every car thus creating confusion when many cars arrive simultaneously.

BACKGROUND

The concept of the automated parking system was mainly driven by two factors: a need for parking spaces and a scarcity of available land. With the emerging problem of parking cars, the ordinary parking system which does not provide any information about vacant parking areas would not be able to handle the problem effectively. These systems would get the drivers to search the parking areas on their own and thus create a problem where there would be too many cars in the car park area.

The systems that are in existence consist of two types:

Semi Automated Systems: The available free parking slots are known to the driver without searching for them but the driver has to park in the slot by himself.

Fully automated systems: These are more sophisticated. In such systems the car is parked by itself into an allotted slot through robotic systems. These can save a lot of space and time but would be very costly in practice.

The model discussed in this paper is an efficient version of the traditional semi-automated system. There are several semi automated systems currently in practice.

Vision Based Systems

Vision based systems continuously monitor all the parking slots through cameras fixed at multiple points thus detecting available free slots. These cameras continuously capture images which are processed and observed for changes in the features thus detecting the presence of a car. The processing includes *feature extraction* and *object identification*. The images contain a number of pixels which are captured consecutively. By observing the contrast values between adjacent groups of pixels rather than actual pixel values it is possible to determine common features within an image. Based on the pixel data it is possible to detect the presence of a car.

However, a vision sensor has the following disadvantages; a video based sensor is too expensive and can generate a very large amount of data which could be very difficult to process.

The drawbacks with this system are.

1. It only locates all the vacant slots available but cannot allot a slot to an incoming car.
2. It cannot be used in outdoor parking lots owing to atmospheric factors.

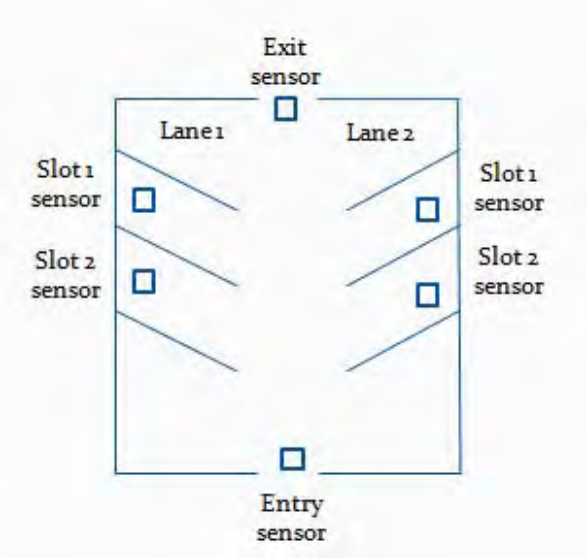
Sensor Based Systems

A common type of pavement embedded sensors are inductive loop detectors (ILDs), which are wired loops installed at the entrance/exit to count the number of vehicles entering and leaving or at each parking slot to find vacant spaces. It requires expensive and disruptive maintenance work. Another type of embedded systems uses magnetic field sensors that measure changes in the magnetic flux to detect parking vehicles. These kind of sensors need to be employed at each parking slot which requires sensors attached with a processing unit and a transceiver. Radar sensors perform well in rugged weather conditions, but sometimes need to be equipped with additional sensors to detect parked vehicles. Therefore, it is ideal to install strain based sensors in outdoor parking systems. The sensors are usually connected through relays or programmed in PLCs. This requires a complex hardware and expansion in such systems is highly expensive.

Considering the factors discussed above, a microcontroller based system is modeled which considers several design challenges and the common problems faced in parking garages

DESIGN AND IMPLEMENTATION

The car parking system allots unique parking slots to the cars and the system utilizes sensors for detecting the presence of cars. The prototype consists of two lanes and two slots in each of them. The slot nearest to the entrance has a higher priority and is allotted first to an incoming car thus saving the time for parking. Figure 1 shows the layout of the parking model containing 4 slots. Each slot is equipped with an indicator lamp which is switched '*on*' if it is allocated thus indicating the driver to park in that particular slot.



Layout of the prototype.

Sensors for detection

The sensors used enable detection of empty parking slots which are to be allotted. Infrared proximity sensors are used in the prototype. These IR source in the sensor continuously emits infrared rays which upon collision with an object (say, a car) are reflected on to a detector placed adjacent to the source. Six IR sensors are used for the prototype; one each at the entrance, exit and at every slot. The output range for the sensors is processed to 3-5Volts and the detection range is about 80mm.The output of the IR sensors is given to a processor, which does the allotment of slots.

LPC 1343 Cortex M-3 Processor

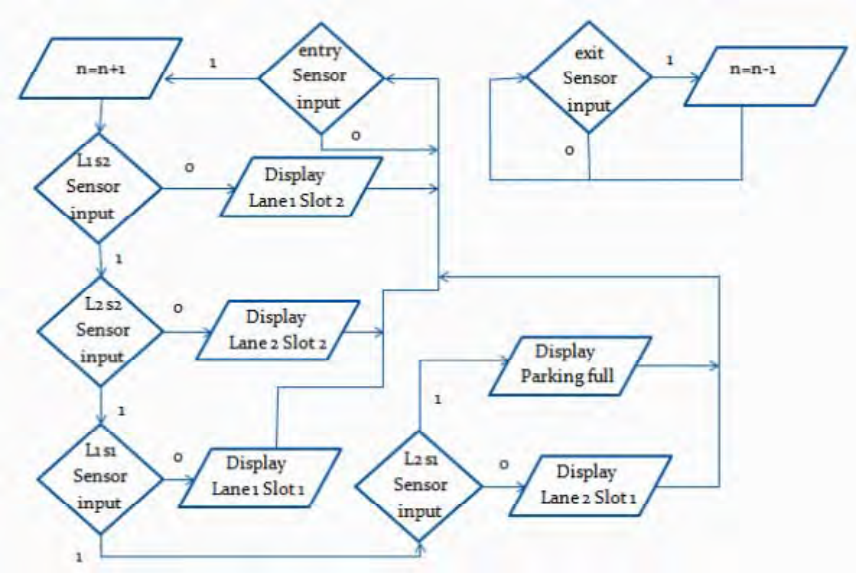
The system implements "ARM Cortex M-3 LPC1343" processor for control and automation of the slot-allotment and for switching the surrounding lights in the parking garage ON or OFF. It takes 3-5V input from the sensors and gives 3-5V output to drive the surrounding lights and the indicator lamps. This operates by plugging the LPC board to an external AC supply of 240V.

Programming using LPC 1343

The code is developed using the C compiler of 'LPCxpresso', the software used to build and debug programs on the LPC series microcontrollers. The LPC1343 has 42 General purpose input/output pins which can be configured as either input or output as required. Some of these pins are declared as inputs (which are connected to the IR sensor's output) and some of them as outputs. The voltage from the output pins can be used to drive output devices like bulbs or LEDs after amplification. The developed code performs the function of allotting the slots and switching the lights ON in the parking area upon detecting the movement of cars.

The design includes the following functions.

1. Finds the nearest vacant slot available.
2. Allocate the vacant slots as available to any number of cars.
3. Switches the lights ON and OFF according to the position of the car.
4. Switch 'ON' an indicator lamp in the slot that is allocated.



The Flow Chart explains the allotment of free slots by checking the output of each sensor and allotting them according to the priority.

The number of cars present is tracked and the free slots are prioritized and allotted to incoming cars.

Energy Efficiency

The position of the car is tracked using the IR sensors. The lights surrounding the parking area are switched on only when a car is in motion i.e. until an incoming car reaches its assigned slot or until a departing car moves past the exit. These lights are switched ON after the car crosses the entry sensor until it reached the allotted slot. Similarly, when a car comes out of its slot for exit, the lights are switched ON until it reaches the exit. The Processor determines the position of the car based on the inputs from the IR sensors and determines when to switch the lights ON or OFF. ARM Cortex M-3 is highly efficient and delivers much better performance than the PLC or Relay based system which utilizes higher power.

RESULTS AND ANALYSIS

In traditional PLC programming, the cars can only enter on by one. In this system, any number of cars can simultaneously enter or exit at the same time. Moreover the LPC1343 has the advantage of serial communication which enables several processors to be connected. This enables expansion of the system to many more lanes and slots. Several possible cases of cars entering and leaving were considered for developing the algorithm and are described below.

1. Several Cars exiting simultaneously

Many cars might leave the slots towards the exit at the same time. The surrounding lights are also kept ON until the last car leaves. The program takes care of allotting the unoccupied slots to the cars arriving later. The cars can leave in any order from any lane and any slot.

2. Car entering the parking lot while another car is leaving

A Free slot is allocated to a car (A) entering the parking lot even if another car (B) simultaneously leaves its slot and is on its way to the exit. The cars entering and leaving are kept track and the surrounding lights remain '*on*' until no movement is observed i.e. until the car B has exited and the car A has reached its slot.

3. Car leaving the parking lot while another car is entering

Say a slot is allotted to an incoming car and it passes the entrance. Another car might exit from its slot at the same time. The surrounding lights remain on until the first car occupies its slot and the second crosses the exit sensor.

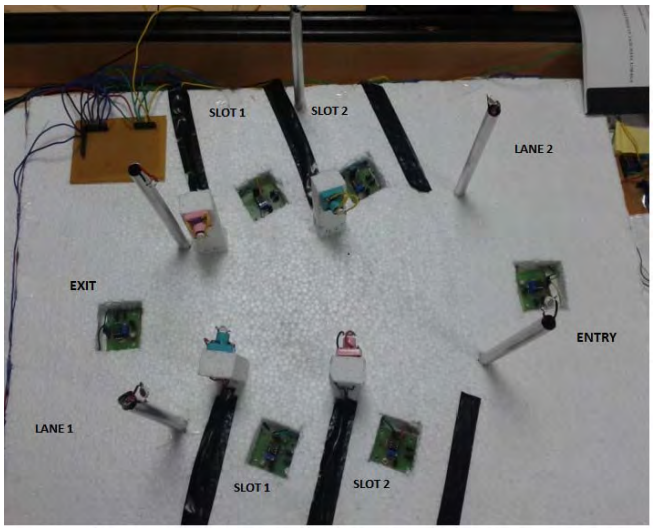
4. Many cars entering one after other

In real time, the cars don't come and leave in an orderly fashion. Several cars might enter or exit at a time. Free slots are allotted to all the cars entering to ensure uninterrupted movement of cars and reduce waiting time. An allotted slot is displayed only until the car is at the entrance. When the car leaves the entrance the indicator lamp at the particular slot is switched on. If another car arrives, another free slot is allotted and displayed even though the previous car hasn't yet reached its allotted slot. Similarly, the vacant slots can be allotted to any number of cars sequentially until the parking area becomes fully occupied.

5. Parking in wrong slot

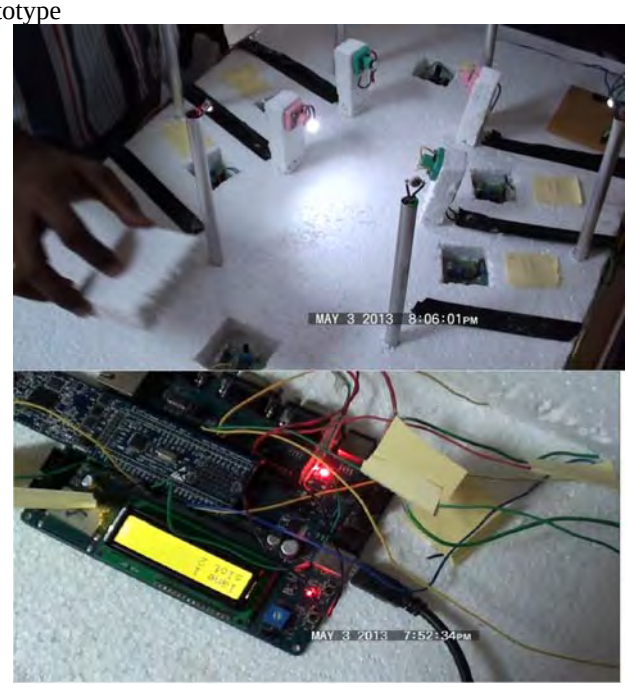
The driver might park the car in a slot other than the slot allotted. The system tracks for these errors and checks if the slot has been occupied or not. If the car hasn't occupied its slot, it allots that slot to the car coming next.

"Parking full" is displayed when there is no vacant slot available. The surrounding lights are on and off when required in all the above cases.



Prototype of the system

Working model of the prototype



When a car arrives at the entry Lane 1 Slot 2 is displayed as it is nearest to the entrance and the corresponding indicator lamp is switched ON and the lights surrounding the area are also switched ON since the car is in motion

Lane 1 Slot 2 and Lane 2 Slot 2 are occupied and the next incoming car is allotted lane 1 slot 1.

CONCLUSION

Model cars have been used for testing and based on the results obtained, it can be understood that this method is very much feasible and efficient. The results suggest that it is a robust system as it worked accurately when tested on a miniature model. This system can be implemented in real time at multi level parking lots with the driver himself parking it manually. It is ideal to install such a system in underground parking areas in Metros, commercial buildings etc. This system can be expanded to more number of lanes and hence be modified when required. This system can further be made space efficient by designing slots of different size. It is possible to measure the breadth of a car and allot a slot according to its size thereby efficiently utilizing the space.

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