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An Intelligent Approach in Parking System for Car Parking Guidance and Damage Notification based on GPS

Aswathy Natesh [1], Sudhi Sudharman[2]

[1]Student, Department of Electronics and Communication Engineering,
Sree Buddha College of Engineering for Women, Kerala, India
aswathynatesh1993@gmail.com
[2]Asst. Prof, Department of Electronics and Communication,
Sree Buddha College of Engineering for Women, Kerala, India
er.sudhi@gmail.com

Abstract: *Every motorist dreams for a vehicle which can park itself with minimal assistance from the driver. This paper presents an intelligent approach in parking system (IPS) that has two functions: Car parking guidance and car damage notification. IPS is an advanced automatic driving system which provides oriented assistance for drivers while parking. IPS has some interesting functionalities that ensure an easy parking, by enabling GPS based application that runs on a PDA and it allows drivers to find a closest parking space, without damages, parking within less time in any suitable spots and getting a notification if the parked car has been scratched or damaged while the driver is not in the car. During the parking process, the driver is alerted by visual and sound signals. The damage notification system consists of car-camera shock sensors placed in the front and rear of the vehicle that record the incident when the driver is not in the car.*

Keywords: *Control Car System; path planning; client device; damage notification.*

1. INTRODUCTION

With the advancement in modern life, the amount of cars is growing rapidly and parking for these becomes a problem in the crowded urban areas. The public parking space cannot satisfy the increasing demand.

Nowadays vehicles are using modern electronic technologies such as GPS connections that help a lot in improving the driver parking skills and reduce the risk for car damages. This paper suggests an innovative and smart parking system which is the intelligent parking system that has functionalities of oriented-guidance parking and damages notification for vehicles incidents. This system involves three main mechanisms which are the control car system, the algorithmic move car system, and the damage notification system in order to have a safe and secure parking process without damages, as well as getting notified when the car is damaged while parked in an uncontrolled area.

With the introduction of GPS and the growing popularity of mobile devices, the need for location-based applications has increased [1]. GPS is available to all anywhere and any weather condition without any charges. If the driver is having GPS receiver in his phone then he can easily determine his current position on earth. It tells the exact position of the car. The GPS represents the position in terms of latitude and longitude values. For an example, when a user wants to park his car at a near space to him using any mobile application, it is necessary to first determine the current location and then discover all the nearest services to that position. Visual and sound signals alert the driver during parking process. The visual signal that appears in the dashboard computer system, instructs the driver how to move into the spot. From the sound signal, he can know whether the car is near to boundaries or not. Damage notification system can be processed by installing the car camera shock sensors to the front and rear of the car. When the driver starts the car, it will emit a red light. The driver can access the notification via a display unit in the dashboard system.

2. RELATED WORK AND MOTIVATION

Existing self parking cars projects have already proposed an Intelligent Parking System and Damage Notification. Here a GPS unit is incorporated into this system for locating user's current location. Several vehicle manufacturers such as BMW, Mercedes, Valeo and Siemens had started including modern technologies within cars for parking guidance [2].

2.1 BMW's Self-Parking System

Using the parking-assist technology the car can park without any help from the driver. But this technology has a limitation that it does not work everywhere, because some components are required to be installed in the car and some in the designated parking spot [3]. A reflective lens has to be installed against the wall of the parking space and a video camera on the car's front windshield for measuring the distance and angle of the car in relation to the lens, while other sensors ensure that there are at least 8 inches of space on the left and right sides of the car.

2.2 Toyota's Intelligent Parking Assistance

Toyota's *Intelligent Parking Assistance* consists of accurate oriented car guidance and a tracking algorithm that controls efficiently the vehicle parking [4]. The system works using four ultrasonic wave sensors installed into the corners of the bumper. A steering-sensor and a camera are installed in the rear of the vehicle. After detecting the obstacle, the driver gets notified with a sound and visual signal shown by a lamp alerts. The steering-sensor uses the steering angle to detect the distance of nearby obstacles and notifies the driver by a sonar indication. The driver can view the parking garage through display unit in dashboard computer system by installing a camera. The system gives parking car guidance to the driver by assisting the steering wheel operation. Thus this system provides an automated parking system that helps drivers to fit the car into parking spots accurately without any damages.

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2.3 Valeo's Parking Slot Measurement System

Valeo has developed parking slot measurement system based on sensor, by applying its Ultrasonic Park-Assist (UPA) technology [5]. The system can evaluates the length of a parking space and length of the driver's car to indicate if the car will fit into the space. The parking slot measurement system consists of two ultrasonic sensors. These sensors are installed into the left and right hand side of the front bumper of the car and the driver communicates with the requested parking slot measurement information via a display unit located on the dash board. The system measures the size of the space as the car approaches the parking space at a distance less than 0.5 meters. If the car fits into a position, driver will simply maneuver by employing UPA technology.

2.4 Siemens Park-Mate

The Park Mate system of Siemens can monitor both sides of the street by mounting ultrasonic sensors, when the vehicle is traveling at speeds less than 35km/h [6]. When a large enough parking spaces is reached, the driver is instructed to stop and the Park Mate checks to confirm that it has identified a parking space rather than an intersection or side street. Once the parking process has begun, the system tells the driver via a display unit and gives instructions via voice output. All steering maneuvers are then conducted automatically. Ultrasound sensors implemented on the front and rear bumpers determine the distance to other vehicles and objects. Therefore the driver only needs to operate the accelerator and brake pedals. An audio signal warns if the vehicle gets too close to other objects.

2.5 Motivation

Searching parking spaces in an urban area has become a widely discussed and very political issue. The existing self-parking cars projects have already proposed an Intelligent Parking System and Damage Notification. The proposed extension build upon the previous work is about developing an intelligent parking system that not only would orient the driver while parking but also search a closest parking space and notify the driver about any damages or scratches done in the car, when the driver is away or while the car is parked in an uncontrolled area.

The Benefits: Here we can see the benefits of introducing a GPS into the intelligent system:

- It saves time and energy for the client in search of parking space.
- It directly leads the driver quickly to the first available space.
- Reduces congestion in the parking facilities
- Minimizes pollution
- Potentially stress full situation are minimized
- Helps to plan for rush hours
- Decreases the management cost

3. INTELLIGENT PARKING SYSTEM DESIGN

In this section, we describe the overall configuration of the Intelligent Parking System. Our system monitors the occupancy of the parking lots, and with the help of a Wi-Fi based background, wireless infrastructure tracks the position of the vehicle entering the parking garage and navigates the driver to an appropriate free parking lot**.** This system also notifies the driver about any damages or scratches done in the car while he is away. Figure 1 illustrates the block diagram of the system design of IPS. The elements of each subsystem are as follows:

- GPS Unit
- Ultrasonic Sensors
- Buzzer Unit
- Display Unit
- Actuators
- Move Car System
- Car Camera shock sensor

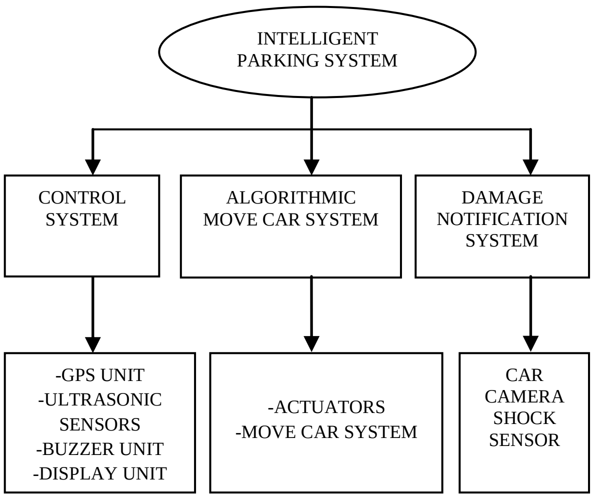

Figure 1: Block diagram of the proposed Intelligent Parking System

3.1 *Control Car System*

The control car system controls forward/backward and left/right movement and this system contains a GPS enabled system, the hardware (Ultrasonic sensors, Distance sensors and Buzzer unit) and its associated software (Display unit) [7]. The system begins to operate by detecting the closest parking space and checks whether the space is large enough to park and whether there are no obstacles. Once the driver finds a potential spot, the control car system starts the process of detecting object detection and oriented guidance for the parking process.

3.1.1 GPS Enabled System Design

According to Gonzalo Mendez, Pilar Herrero and Ramon Valladares, SIAPAS system has been divided into a set of modules [1]. They are:

(a) Communications

This module consists of two parts: a client and a server. They communicate with each other through a Wi-Fi network. The server side manages the clients' petitions to block and release parking spaces. The client can request for a parking space or to block a space so that no other user can occupy his space. The server monitors the occupancy of the parking space via ultrasonic sensors; continuously collects Wi-Fi signal strength information of the visiting mobile devices via access points; calculates the positions of the mobile nodes to be tracked; and sends back the information to the visiting device of the client, via the Wi-Fi infrastructure. The visiting device is mainly a smart phone or mobile equipped with PDA.

Figure 2: Major components of communication modules

(1) Wi-Fi Access Points

Wi-Fi access points collect the necessary data about the parking state, for the position estimation algorithm, then send the collected data to the central server and connect the client devices to the background infrastructure. Finally it forwards the computed position estimation back to the client devices. The clients can thus block the parking space they want to use so that no other driver can use it. The client runs in the driver's PDA, and it starts working as soon as the GPS detects that the car is inside the parking lot. It first requests for the parking state, and then it blocks the parking space to be used to park the car.

(2) Client Devices

Here the client device is a mobile equipped with PDA, capable to monitor signal strength data; to receive current position information; to display the garage map; and to run the navigation software. The users' interactions are handled via Wi-Fi access.

(b) GPS

GPS module is in charge of receiving data from GPS system. It usually updates the state of close parking lots and update driver's current position inside parking.

(c) Voice

The Voice module was originally part of the Inside Parking Manager. It can be divided in two sub modules. The first one analyzes the path for the driver to follow and create a list of events where some instruction must be told to the driver. These events include turning left and right and parking. The second sub module activates the speech synthesizer when the car is close to a mark and provides some instructions. All these are done after checking whether a GPS signal is received.

(d) GUI

This module provides a graphical user interface for Inside and Outside Parking Managers. The GUI for the Outside Parking Manager is the default screen which user can see which are the closest parking's, how far they are from the user and in what direction. As for the Inside Parking Manager, the necessary data to draw the parking's are stored in ontology in this module. These data are related to the parking itself and to the vehicle's position. Figure 3 shows the screen, where the user can typically see:

- ***Brown*:** Parking lanes
- ***Green*:** Free parking spaces
- ***Grey:*** Route to the closest free parking space
- ***White circle with an arrow***: Vehicle is moving
- ***Red*:** Spaces which are occupied
- ***Maroon:*** Spaces which are blocked
- ***Dot:*** Vehicle is stopped

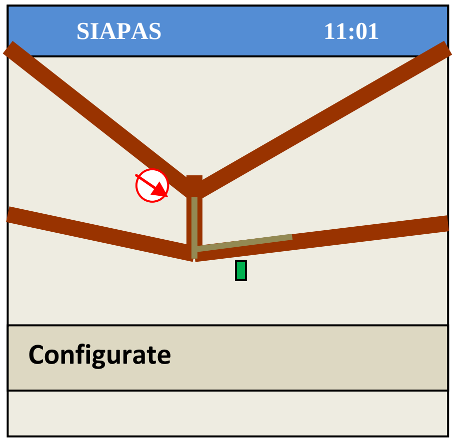

Figure 3: Inside Parking Manager GUI

(e) Outside Parking Manager

This module maintains the ontology that stores the information about the parking's that can work with the SIAPAS system. The ontology stores the name, location and size of the parking and it is used to infer where the closest parking is or how to get there. The ontology is updated every time the driver is close to a parking. In addition, inferences are carried out after a predefined time (currently, 3 seconds) when a GPS signal is received, so the current distance or location of all parking's can be updated.

(f) Inside Parking Manager

The Inside Parking Manager controls what happens inside a parking. This module starts its execution when the car is close to a parking and it uses a slight variation of Dijkstra's algorithm to figure out the most suitable parking space. Once it has been found, the Inside Parking Manager checks periodically that the driver is following the right route. If this is not the case, it calculates a new route to the parking space.

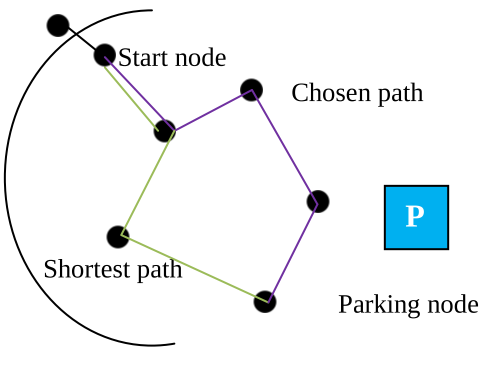

Figure 4: Dijkstra's algorithm search path

3.1.2 Ultrasonic sensors

The PING))) ™ Ultrasonic Distance Sensor is an all-in-one module that accurately measures distances between itself and objects nearby [8].

Sensor initiates object detection or distance measurement by sending a short high frequency (40 kHz) tone from the PING))) module. The time it takes to detect the return echo represents the distance between the PING))) module and any objects in front of it. Then we can convert the amount of delay of the echo to inches or centimeters. Ultrasonic sensors work as detectors at low level of accuracy that are placed in the front/ back and left/right of the car. The main goals of the ultrasonic sensors are as follows.

- It detects nearby objects at a range of 1 inch to 10 feet
- Measures distances using high frequency sound
- Measuring the distances to nearby objects at low level.
- Checking the obstacles using the echo time formula to display the distance of how far they are [7]. The echo time represents the difference between the time of pulse transmission and detection of the reflected signal to calculate the distance which is given by

$$d = v.\,\Delta t, \qquad (1)$$

where d = distance to the obstacle,
v= speed of the sound wave signal,
Δt=difference between the time pulse transmission and detection of the reflected signal.

3.1.3 Display Unit

Display Unit is used to indicate the availability of parking spaces within a certain lane or lanes associated with the display. The display includes a set of three arrows of green light emitting diodes (LEDs) –LEFT, STRAIGHT and RIGHT - and a single cross of red light emitting diodes (LEDs). The arrows indicate the direction in which there are available spaces by illuminating one of the arrows or any combination thereof.

Figure 5: Display Unit

3.1.4 Buzzer Unit

Using buzzer unit driver is alerted by an audible signal that is represented by beeps that are continuously heard during parking process. As the distance between car and boundaries is extremely close, then the frequency of the beeps increases [10]. Therefore, the frequency of the beeps depends on the distance to the obstacle retrieved from (1) and is given by

$$f = k.\,d \qquad (2)$$

where f is the frequency of the beeps, k is the proportional factor and d is the distance to an obstacle.

3.2 Algorithmic Move Car System

Algorithmic Move Car System gives an oriented assistance to the car and implements its directions movement which is shown in the display unit [9].Block diagram shown in figure 6 represents the connection between control car system and microcontroller.

3.2.1 Actuators

An actuator is responsible for moving or controlling a mechanism or system. It works based on a source of energy, typically electric current and converts that energy into motion. Here the used actuators are motors that are linked to the brakes, the throttle and the steering that would monitor the low level control of these devices. The brakes, the throttle and the steering actuators would be connected to the control system changing the direction or movement of the car when it gets near an obstacle. He starts turning the wheels of the car and regulating the speed of the vehicle by pressing and releasing the brake pedal. Moving forward until the vehicle's rear bumper passes the rear wheel of the car parked in front of the parking spot [11].

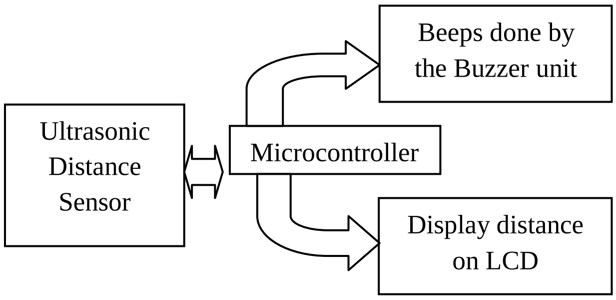

Figure 6: Block diagram of Algorithmic Move Car System

3.2.2 Move Car System

Move Car System (MCS) contains a microcontroller for controlling the steering wheel and the brakes. Once a parking space has been detected, the parking algorithm is called. The parking algorithm gives the steps to the driver that he should follow to have a good parking without any damages and scratches [12]. After detecting an obstacle by the sensors, the brake, throttle, and the steering actuators allow the MCS to change the movement and direction of the vehicle as needed. Once the ultrasonic and distance sensors emit a digital signal to the Move car system, the received values will determine the direction of the wheels. The MCS that works with an algorithm which processes the received data from the sensors, and convert it to the buzzer unit and the display unit.

3.3 Damage Notification System

The damage notification system (DNS) consists of car-camera shock sensors installed in the front and rear of the car. Figure 7 illustrates the block diagram of car camera shock sensor [13]. All the elements such as central electrical contact, cylinder, secondary electrical contact and metal ball are linked to a camera. When the car is hit or vibrated, sensor moves from its resting position and the metal ball rolls in the cylinder. As it rolls, it breaks the connection between the central electrical contact and the secondary electrical contact which closes the switch notifying the computer dashboard

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system of a shock. Based on this notification, the camera starts recording a 10 seconds video of the incident.

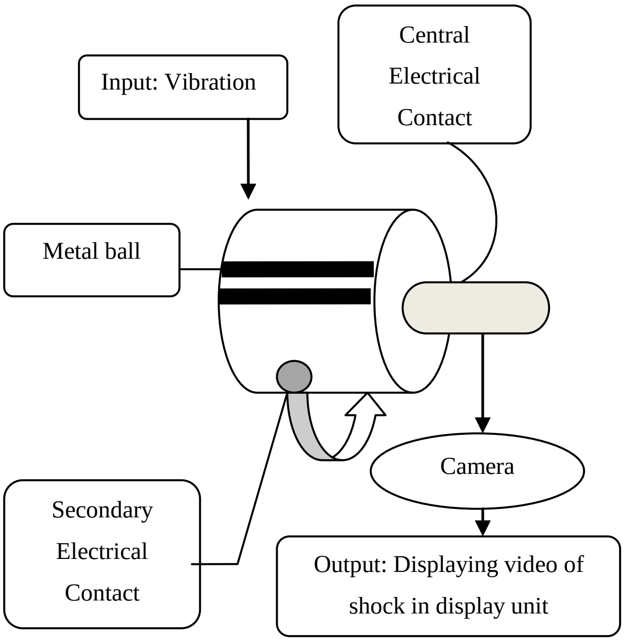

Figure 7: Block diagram of Car Camera Shock Sensor Cylinder.

4. CONCLUSION

This paper has proposed an intelligent approach in parking system. The aim of this study is to develop an automated system parking aid device and a damage notification system. We have been successful in achieving not only this objective but have also been able to add an extra feature into the circuit design, i.e., a GPS based application that allows a user to quickly locate and drive to an available parking space. Our solution is achieved by equipping drivers with a PDA to navigate in the area. Once the control car system starts, our system based on Wi-Fi network, tracks the position of the vehicle entering the parking garage and navigates driver via his/her smart phone to an appropriate free parking lot ,then parking surrounding is scanned using ultrasonic sensors. This scanned information is processed by the algorithmic move car system to identify the parking directions of the vehicle. The novel contribution of the paper includes the damage notification system for incidents notifications. The system is implemented using a car camera shock sensors placed in the front and rear of the vehicle. The car camera shock sensors emit a signal to the computer dashboard depending on the intensity of the damage. As soon as the driver starts the car, the computer dashboard system shows a warning red light, and then displays a video of 10 seconds of the shock within the display unit.

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