Project Title: Multi-storey car parking

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Brief description:

1. Introduction

Multi-storey car parking is becoming increasing popular as they enable to conserve space [1]. However parking on multiple floors brings it's own challenges such as need of using lift mechanism for moving the vehicle from one floor to another, co-ordination between the vehicle and the lift mechanism, co-ordination between parking and un parking of vehicle etc. The aim of this project is to identify the issues and challenges in development of such a system by implementing a prototype using Firebird IV as automated self parking vehicles.

1.1 Scope of the Development Project

As stated the aim of the project was to implement a multi-storey car parking system using the capabilities of Firebird IV robots. Likewise firebird robot was used for the both purposes, i.e. as self parking automated vehicles, and as a lift controller co-ordinating the movement of the vehicle from one floor to another. The infra red sensors of firebird were used to detect obstacles and accordingly identify the empty slot available for parking. Similarly the motors of the firebird were used as a lifting mechanism to elevate the lift while zigbee module installed in the firebird was used for communication between the lift controller and the vehicle. Also, white line sensors were used for sensing the dead end of the given floor and hence communicating with the lift controller the need to move up the floor.

The limitation of the system is that currently only car parking is supported and not un parking of vehicles. However, un parking of vehicles can be easily incorporated due to modular design of the system with added functionality of synchronization which can be easily handled by the central co-ordinator. Also since DC geared motors of the Firebird are being used to move the lift up and down and as these posses limited torque, moving of the lift is currently accomplished with human assistance.

1.2 Definitions, Acronyms, and Abbreviations

MSCPS	Multi-Storey Car Parking System
ACPS	Automated Car Parking System

1.3 References

1. **http://en.wikipedia.org/wiki/Multi-storey_car_park**

2. Overall Description

As stated we have implemented MSCPS using FireBird IV robots. Currently for demonstration we have implemented car park system with two storeys, ground and first floor, however it can be easily extended to multiple storeys with minor changes. Firstly as the robot enters the parking arena, it enquires of the central co-ordinator (which is also the lift controller in our case) for the parking space availability and if parking space is available it ventures to park itself. Accordingly it first searches for parking space on the ground floor and if no space is available it then proceeds to move to the first floor. Accordingly it requests the central-coordinator for the lift to be sent to the ground floor and when the lift becomes available on the ground floor, the robot on climbing into the lift again informs the central co-ordinator for lift to be moved up the floor. And on the reaching the first floor the robot after taking 180^0 turn again ventures to park itself.

For detecting the obstacle and hence identifying the empty slot we have IR sensors of the robot. When no obstacle in found in left, or right direction for 80 mm (which is half the robot width), robot takes left or right turn accordingly and parks itself moving forward a distance of 140mm which we have considered as road margin. At the end of the floor just before the lift, there is a whiteline. So if the robot encounters the whiteline, it realizes that the end of the floor is reached without parking space being available. It then accordingly informs the central co-ordinator of the same and proceeds to move to the first floor to search for parking space. The diagram for MCSPS can is as shown in Figure 1. The communication that ensues between robot and central co-ordinator assumes following form, when robot first enters parking arena it sends,

Robot sends 0x11 – To enquire if parking space is available

Central Co-ordinator replies 0x21 – if parking space is available

0x22 – if no parking space is available.

If no parking space is available, then robot takes no action. On reaching the end of floor when robot senses whiteline, it sends

Robot sends 0x13 – request to central co-ordinator to send lift down

Central Co-ordinator replies 0x23 – on moving the lift to ground floor

Then on reciving 0x23, robot climbs into the lift and sends,

Robot sends 0x15 – request to central co-ordinator to move lift up

Central Co-ordinator replies 0x24 – on moving the lift to first floor.

Finally when lift reaches first floor, it takes 180^0 and then starts searching for parking space again.

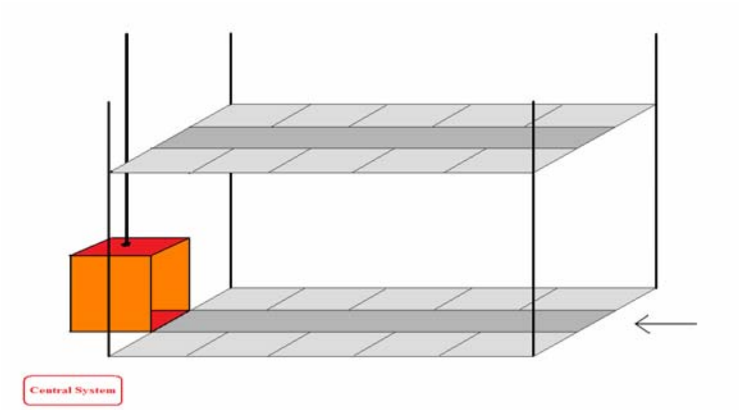

Figure 1 Multi-Storey Car Parking System

2.1 State chart/ state machine of the project design

Please see comm_prot.jpeg

2.2 Hardware and software requirements

2.2.1 Hardwire Requirements

The hardware that was primarily made use of for the project was Firebird IV. The functionality of the firebird robot that was made use of includes,

1. Left IR sensor,
2. Right IR sensor
3. Front IR sensor

4. Whiteline sensor
5. 802.15.4 zigbee communication module used for synchronization between central co-ordinator (which is lifting mechanism as well), and the automated vechicle.
6. DC geared motors for moving the vehicle as well as moving the lift up and down.

2.2.2 Software Requirements

The program to carry out the required tasks was primarily implemented in µC/OS real time kernel. So µC/OS kernel was the primary requirement for the project along with the IDE WinAVR that was used to generate the required executables and avrdude which was used to load the program in Firebird IV.

Also a light weight module with functionality was implemented in programming language esterel. Accordingly the software requirements for the same were IDE, kontrollerlab available for compiling the esterel programs for Firebird IV.

2.3 Communications Interfaces

Communication using zigbee protocol was extensively used for synchronization between the central co-ordinator (which is also lift controller in this case) and the automated car parking vehicle. As mentioned communication was acheived using zigbee protocol, which is low power protocol based on 802.15.4 standard for wireless sensor networks. The data transfer rate of 9.6 kbps was used for the purpose and as data being exchanged did not hold any critical significance, no encryption was used.

2.4 Design steps

The design steps that were followed for the implementation of the project can be described as,

1. Identifying the requirements for implementation of multi-storey car parking system. These primarily include,

(i) Use of automated car parking vehicle,

(ii) Use of central co-ordinator for book-keeping, such as availability of the parking space etc.

(iii) Lifting mechanism for moving the vehicle from one floor to another.

2. Realizing the requirements using the hardware available. Accordingly it was conceptualised to use FireBird IV as automated car parking system, using the infra red sensors of it to detect the obstacle and hence identify the empty slot. Also it was decided to use DC geared motors of firebird as lift mechanism due to unavailaibility of external powerful motor.

3. Design of program for µC/OS and esteral. The required functionalities were mapped in software using features of µC/OS and esteral likewise. Accordingly, for µC/OS, the required functionality was achieved by dividing it into following sub tasks,

1. SensorTask, that makes use of IR sensors for sensing various obstacles, as well as whiteline sensor for sensing that the end of the current floor has been reached and signaling the lift controller for sending the lift down.

2. DistanceTask, which keeps track of the empty distance for identifying the empty slot.

3. VelocityControlTask, which assigns the appropriate velocity and direction of the vehicle motion, for moving forward, taking 90^0 right turn, etc.

4. WirelessTask, used for communication between vehicle and lift controller.

2.5 Design and Implementation Constraints

One of the design constraint it that the vehicle identifies that the end of the current floor is reached, with no parking space left is when it encounters white line. So, if there is white line on the floor midway along the path of the vehicle, it will be wrongly identified as the end of the floor.

Another implementation constraint is that due to unavailability of the powerful motors, DC geared motors of Firebird IV used for locomotion were used as lift mechanism. And as this vehicles lack the ability to generate the torque required to lift the weight of the vehicle, lift mechanism is currently accomplished with human assistance.

2.6 Design and implementation challenges

The primary challenge was in realization of the lift mechanism using the hardware available. As the DC geared motors are not powerful enough to lift the weight of the firebird robot, it was conceptualized to use the external motors interfaced with firebird as lift mechanism.

As regards implementation of the required program in µC/OS, the primary design challenge was in the division of the required functionalities into appropriate sub tasks and assigning priority to these. Accordingly the required functionality was sub divided into tasks mentioned with sensing task being given the highest priority, while velocity control task, distance task and wireless task were given priority in that order.

2.7 Performance metrics

Primarily the major concern of ACPS is safety ie. no damage should be done to vehicles ie. vehicle which is parking itself or already parked vehicle. Secondly the performance can also be gauged based on how efficiently the vehicle is parks itself ie. how much parking space it occupies.

3. List concepts/modelling tools etc. learnt in cs684 course that could be applied in design and implementation of project

As the project was implemented in µC/OS, the concepts of scheduling policies and priority assignment taught in the course were helpful in assigning the priorities to the task. Also while designing emphasis was laid on making the design as modular as possible.

4. Code structure

For µC/OS, there are two main files, Car.c which implements the functionality of automated car parking system and Controller.c which implements the functionality of the lift controller as well as central-cordinator. The different tasks for Car.c are as described before,

(i) SensorTask, that makes use of IR sensors for sensing various obstacles

(ii) DistanceTask, which keeps track of the empty distance for identifying the empty slot.

(iii) VelocityControlTask, which assigns the appropriate velocity and direction of the vehicle motion, for moving forward, taking 90^{0} right turn, etc.

(iv) WirelessTask, for communication with the controller

For Controller.c there is only task, MainTask which performs the taskSx` of controlling the lift and bookkeeping, along with communication with the automated vehicle.