**CHAPTER 2**

**LITERATURE REVIEW**

We did an overall research on the topic and have read through several articles that raise the same issues in our problem domain. The current transportation infrastructure and car parking facilities are deemed insufficient in sustaining the influx of vehicles on the road.

Therefore, problems such as traffic congestion and insufficient parking space inevitably crops up. In metropolitans area, the situation is made worse by the fact that the roads are significantly narrow compared to the West. Various measures have been taken in the attempt to overcome the traffic problems. Although, the problem can be addressed via many methods, the paper focuses on the car park management system introduced, which is the smart parking system. This literature review will discuss the evolution of vehicle detection technologies as well as the detection systems developed over the years.

The industrialization of the world, increase in population, slow paced city development and mismanagement of the available parking space has resulted in parking related problems. There is a dire for a secure, intelligent, efficient and reliable system which can be used for searching the unoccupied parking facility, guidance towards the parking facility, negotiation of the parking fee, along with the proper management of the parking facility.

The smart parking system implemented mainly in the Europe, United States and Japan is developed with the incorporation of advanced technologies and researches from various academic disciplines. With its deployment in the car parking, it is hoped that it would solve the aforementioned problems faced by the patrons within the car parking.

The smart parking system is considered beneficial for the car park operators, car park patrons as well as in environment conservation. For the car park operators, the information gathered via the implementation of the Smart Parking System can be exploited to predict future parking patterns. Pricing strategies can also be manipulated according to the information obtained to increase the company’s profit. In terms of the

environment conservation, the level of pollution can be reduced by decreasing vehicle emission (air pollutant) in the air. This can be attributed to the fact that vehicle travel is reduced. As fuel consumption is directly related to vehicle miles travelled, it will be reducing as well.

Patrons are also able to benefit from smart parking system as parking space are able to be fully utilized with a safer, optimized and more efficient system implemented; The system is made more efficient as vehicle travel time and search time are significantly reduced due to the information provided by the smart parking system. With the information provided, drivers are able to avoid car park that are fully occupied and locate vacant parking spaces with ease elsewhere. The number of vehicles parked illegally by the roadside which leads to traffic congestion is also reduced as it is absorbed into the car parks. Most importantly, traffic congestion can be reduced. All this would eventually lead to convenience for the patrons.

The services which the smart parking system should provide in the future can be:

* The parking availability information system and parking reservation system should provide advanced navigation services.
* The mobile electric commerce system and the continuously working gate system should collect the tool charges electrically.
* An automated navigation system should assist in safe driving.
* As in-facility navigation system should provide the best possible traffic management.
* Provisions of effective security for the safety of cars.
* Provision of strong functions for facilitating administrators and mangers in the management of the parking facility.

Categories of smart parking system are:

The smart parking system can be divided into five major categories: namely, Parking Guidance and Information System (PGIS), transit-based information system, smart payment system, E-parking and automated parking.

* **Parking Guidance and Information System (PGIS)**: It encompasses two major categories. The PGIS can either include the entire city area or function only within the car parking facility. Both provides information which aids the

decision making process of the drivers in reaching their destination location and aids them in locating a vacant parking space within the car park facility. The city wide PGIS is indeed helpful in assisting drivers to car park with vacant parking spaces via the information occupancy status for various car parks around the city as well as other relevant information. On the other hand, guidance in locating the vacant parking space within the car park is ultimately provided by PGIS implemented within the car park. PGIS can be summarized as consisting of 4 major components: namely, information disseminating mechanism, information gathering mechanism, control center and telecommunication networks. Static/dynamic Variable Message Signs (VMS) have been used in providing drivers with direction either on the road or within the car park.

Mobile phones can also be used for guidance based on the research conducted which utilizes Global Positioning System (GPS) for vehicle detection. A map of the driver’s current position based on the GPS data along with the status of three of the nearby car park are sent to their mobile phones based on the patron’s current location. Besides that, the parking guidance system developed based on web and GIS technology are able to disseminate information to the users via internet, mobile phones and/or PDA. The guidance system can be with the conventional parking management system as well. In order to guide the patrons effectively, the car park map is printed on the parking ticket equipped with Radio Frequency Identification.

Vehicle detection sensors are commonly installed at entrances, exits and/or individual parking space to detect vehicle occupancy. Indicator lights integrated with sensors are also sometimes installed at every individual parking space within the parking facility. The occupancy status detected by the sensors can either be occupancy of each individual parking space or in terms of vehicles counts in the car park depending on the installation of the sensors.

Moving on, the control center gathers and processes the traffic and occupancy information as well as controls the display of information for drivers whereas the telecommunication network facilitates the transfer of information among the other three modules. With the advent of advanced technologies, the implementation of devices such as microcontroller and Field Programmable

Gate Array (FPGA) are incorporated for faster information that, the telecommunication networks no longer dependent on conventional electrical wiring but wireless technologies are able to be utilized. Researchers have all used wireless network for data transfer in the implementation of their proposed parking guidance system.

* **Transit Based Information System**: It is actually similar to PGIS. The difference exists in the fact the Transit Based Information System concentrates on guiding user to park-and-ride facilities. It provides real-time information on the status of each car park and public transportation such as the schedules and traffic condition to the public.

The additional information provided enables the patrons to plan for transit in advance without getting into any inconvenience. Among its benefits includes increase in the utilization of public transportation as the primary means of transportation as they can leave their vehicle in the car park and switch to public transportation with ease. This will indirectly lead to an increase in the transit revenue.

* **The Smart Payment System**: It is implemented in the effort to overcome the limitation of the conventional payment methods by revamping the payment method via parking meter and introduce new technologies. This is because the conventional method causes delay and inconvenience for the patrons as they have to deal with cash. It also reduces maintenance and staffing requirement for payment handling purposes as well as traffic control.

In general, the Smart Payment System implemented consists of contact method, contactless method and mobile devices. While the contact method involves the use of smart cards, debit cards and credit cards, the contactless method involves the use of contactless cards, mobile devices as well as Automated Vehicle Identification (AVI) tag whereby RFID technologies are utilized.

* **E-parking**: It provides an alternative for patrons to enquire the availability and/or reserve a parking space at their desired parking facility to ensure the availability of vacant car park space when they arrive at the parking facility. The system can be accessed via numerous methods such as SMS or through the internet. Some of the additional benefits of using the E-parking system aside from those collectively gained by smart parking system are that it can be

extended easily to incorporate the payment mechanism of smart payment system whereby payments by the patrons are made hassle free using the technologies discussed previously. Customized information can also be provided to the patrons either before or during their trip to the car park.

* **Automated parking**: It involves the use of computer-controlled mechanism, which allows patrons to drive up to the bay, lock the cars and let the machines automatically place the vehicle in the allocated space. This type of car park offers maximum utilization of space as it is machine controlled unlike conventional car park where space is needed for navigation of vehicle within the car park. Among its benefits are that the implementation works great in locations, where there are limited room for expansion due to its structure. Besides that, the Automated Parking System also offers efficiency in car storage as it allows car stacking and the patron does not even need to go into the car park which indirectly provides extra safety measures which covers both the vehicles and patrons.

The smart parking system relies heavily on the car park occupancy information as it is not only used in assisting the drivers on the road, but in the management within the car park as well. There is abundance of sensor system that can be installed to provide this crucial piece of information. Having said that, there are many factors which can affect the occupancy detection such as sensor chosen car park type and layout, to name a few.