IDENTIFYING AVAILABILITY OF CAR PARKING SLOTS USING CCTV CAMERA FOOTAGES

Alagiya Durage Dasun Priyankara

(IT18154672)

B.Sc. (Honors) Degree in Information Technology Specializing in Software Engineering

Department of Computer Science and Software Engineering

Sri Lanka Institute of Information Technology

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Dissertation submitted in partial fulfillment of the requirements for the Bachelor of Science Honorable Degree in Information Technology

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DECLARATION OF CANDIDATE

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Priyankara A. D. D.	IT18154672	

DECLARATION OF SUPERVISORS

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Name of supervisor : Ms. Malgaha Gamage Nadeesa Pemadasa

Name of co-supervisor : Ms. Thamali Dassanayake

Signature of supervisor : Date :

Signature of co-supervisor : Date :

DEDICATION

This research is dedicated to all the people who daily use vehicles for their daily essentials who face several difficulties and uncomfortable situations due to the hardness of finding a parking slot to park their vehicle in urban areas as it is an essential part of their lives. My research is identifying the availability of parking slots inside a parking area which is a win-win solution for both drivers and owners of the car parking areas since it supports the driver and lets owners have a system within a considerably less time and less cost. The purpose of this research is to give the user a better experience while finding an available spot while preserving the physical and mental well-being of the driver.

ACKNOWLEDGEMENT

We would like to give our heartfelt gratitude for the tremendous support, guidance, motivation given by our supervisor Ms. Nadeesa Pemadasa (Lecturer – Faculty of Computing) since the beginning of our research journey and for her dedication and her helpful feedback to make Pay as You Park System from a plan to a reality. Also, we would like to convey our heartfelt gratitude for our co-supervisor Ms. Thamali Dassanayake for the guidance and support given as much as our supervisor did. Also, we would like to appreciate and thanks Mr. Buddhika Sanjeewa, the building service manager of Liberty Plaza Management Corporation (Shopping Complex) for letting us study the current parking concerns and current parking system's issues inside the shopping complex. Moreover, we would like to appreciate the support given by our parents with their time, their support and managing our expenses during the research period. Finally, I would like to give my special gratitude to the fellow members or my research group for the guidance and support given during the research period.

ABSTRACT

The modern human has modern needs. In the present days, private vehicles are being used day to day to day traveling more than private parking. The current Covid-19 global pandemic situation has increased the usage of personal vehicles by a considerable amount. Also, people have comfort and ease of work by using their vehicles. One of the massive problems faced by drivers daily while using personal vehicles is that finding a parking space inside an urban area. Furthermore, even though when a driver has found a car parking area it is a challenging situation to find an available parking slot. These circumstances lead to several personal and social-environmental issues such as wasting valuable personal time, missing some unrecoverable opportunities for individuals, getting late for some occasions, and ultimately burning limited fossil fuels for a considerable time-consuming personal money and releasing a tremendous amount of toxic gases into the environment. Currently, there are several methods to identify an available parking space in some parking areas using devices such as smart sensors, micro-controller unit-based approaches and, ultrasonic sensors. The problematic thing regarding these parking systems is that they sometimes turn out to be inaccurate and sometimes they display faulty results such as indicating the parking slot is available when a vehicle has been parked inside the particular car park and vice-versa. Furthermore, the user does not have a way to find a parking area near him or her and a way to guide to a particular available parking slot inside a parking area which leads to a time-consuming process for the user. Our solution "Pay as You Park" Smart parking system uses already employed surveillance cameras to identify the availability of parking slots inside a parking area. Apart from that user has other special features like finding a parking area nearby the user, finding a suitable car parking slot and, navigating to the available and suitable car parking slot inside the parking area. The user(driver) will have a hassle-free mobile application solution consisting above mentioned features and car parking owners will have a web portal to add their car parking areas and also an admin dashboard to get the availability of parking areas etc. This system will save the time of the users and give a refreshed and sustainable experience about urban car parking.

Keywords: vacant car parking space, available car parking space, smart parking system

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LIST OF ABBREVIATIONS

Abbreviation	Description
LDR	Light Detection Resistors

1 INTRODUCTION

1.1Background and Literature Survey

1.1.1 Background

Drivers in Sri Lanka have been using various types of car parking systems in Sri Lanka. In the early days, car park owners used printed manual tickets to note down the arrival time of a car park and have calculated the parking fees according to the number of hours a vehicle has been parked. But with the impact of computers as a day-to-day machine, car parking has been revolutionized. The car park owners adapted to the computer-based parking systems which gave the capabilities such as printing bills instead of manual writing, calculating the number of hours, and calculate the parking fees using the system itself. Also, some of those systems allowed the car parking management to keep details of the vehicles parked such as vehicle numbers of the vehicles. But as information technology is getting improved day by day parking systems are also getting improved. In Sri Lanka, within recent 2 to 3 years, the country has launched several shopping malls based in Western Province. With the availability of these international-level shopping complexes, the car parking systems in Sri Lanka have been taken to another level. Because those malls have introduced smart parking solutions to the island.

As PcMag explains on its website [4] a smart parking system is a system that supports vehicle drivers (users of a car parking system) to find a free parking spot inside a parking area by identifying a free parking spot using sensor details. A smart parking system usually supports the driver to achieve their goal which is to park the vehicle with less stress and less time period.

Figure 1.1 demonstrates that currently, the vast majority of people possess their own private vehicles rather than relying on public transportation systems such as buses,

trains, and other modes of transportation. According to our user data collection, 89.7% have mentioned that they own a private vehicle. This proves that Sri Lanka needs a proper parking solution.

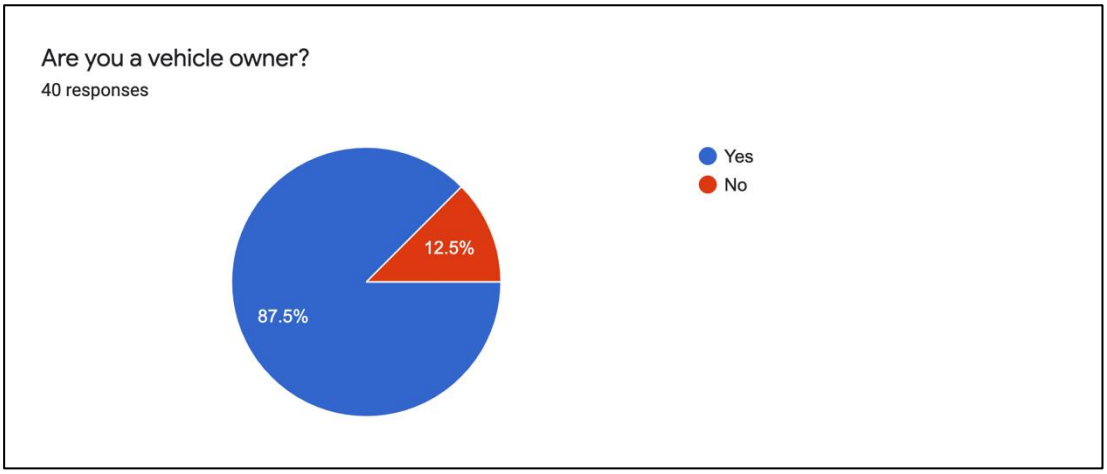

Figure 0.1 How many people own a vehicle

After our potential car park user data collection, as displaying in the figure 1.2 we have found out that 77.5% of users have answered as they use urban car parking areas in their daily lives.

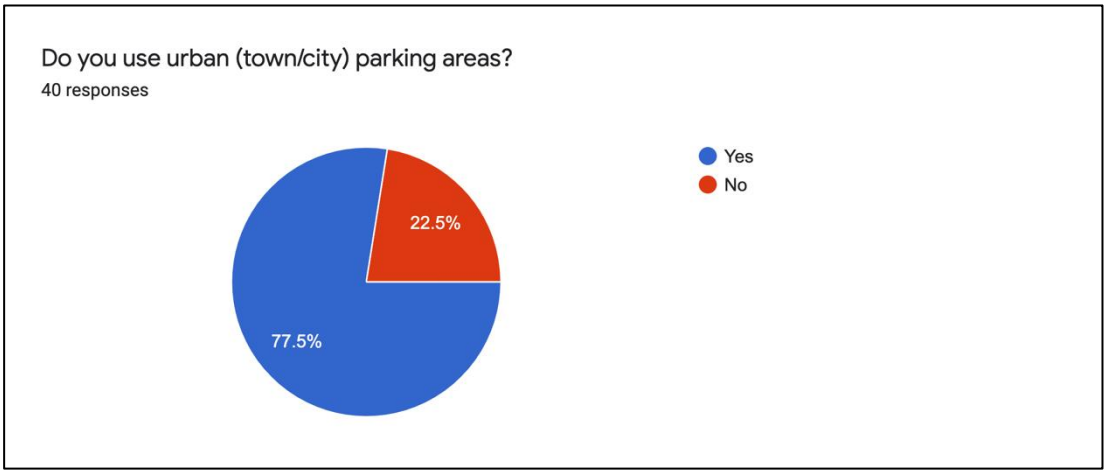

Figure 0.2 Percentage of people using parking areas

As our user data collection is exhibited in figure 1.3 , only 20% of motorists are experiencing car parking as an easy task. Which leads to 80% of motorists experiencing it as an inconvenient process.

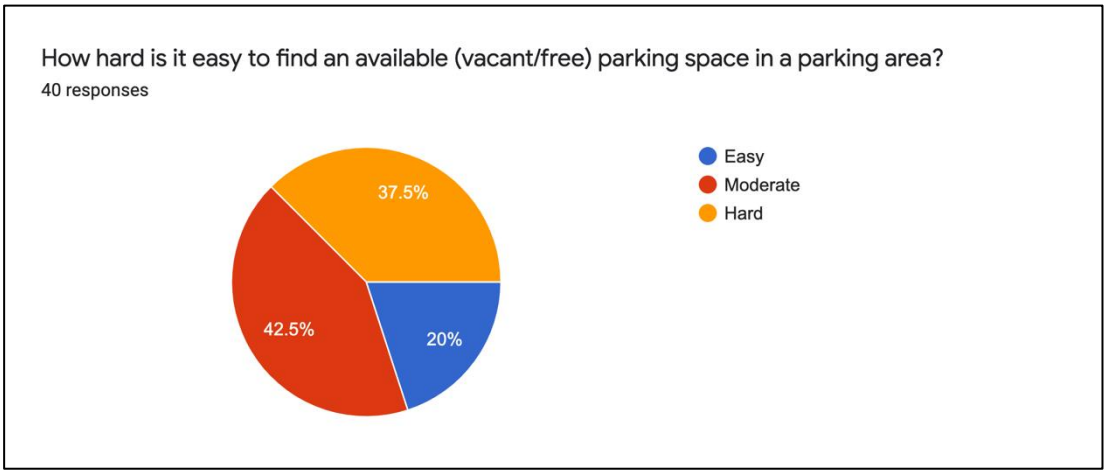

Figure 0.3 Hardness of finding an available parkin slot

One of our main concerns while researching car parking systems was how many opportunities individuals miss due to the inefficiency in car parking areas which leads to daily stress.

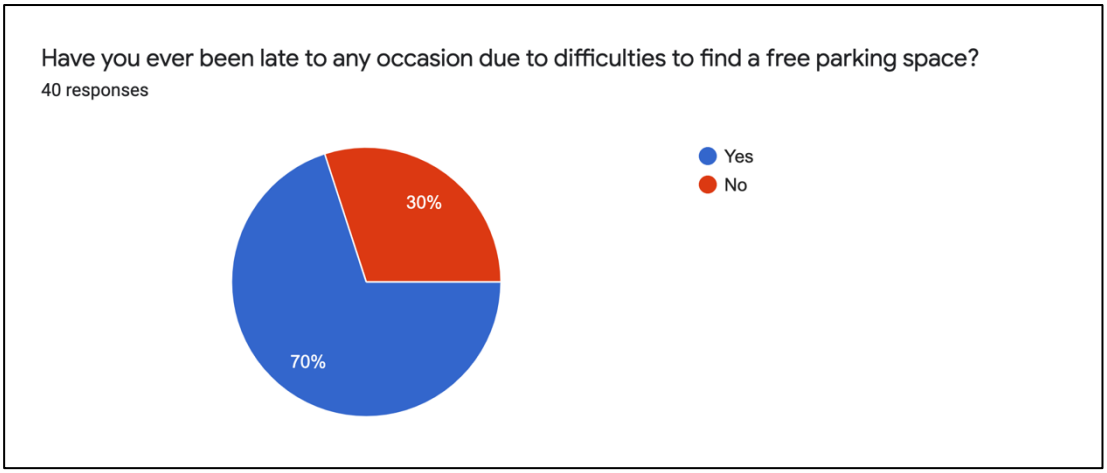

Figure 0.4 Probability of getting late due to car parking process time

Another main concern of us was the duration being used for the parking process. According to our user data collection, it reveals that the majority of the drivers have to spend between 1 minute to 5 minutes to park their vehicles. And 10% of drivers have experienced they had to spend more than 5 minutes for the parking process. This is a major concern that should be addressed since this time consumption leads to various disadvantages. Figure 1.5 shows the data collection result of the potential users.

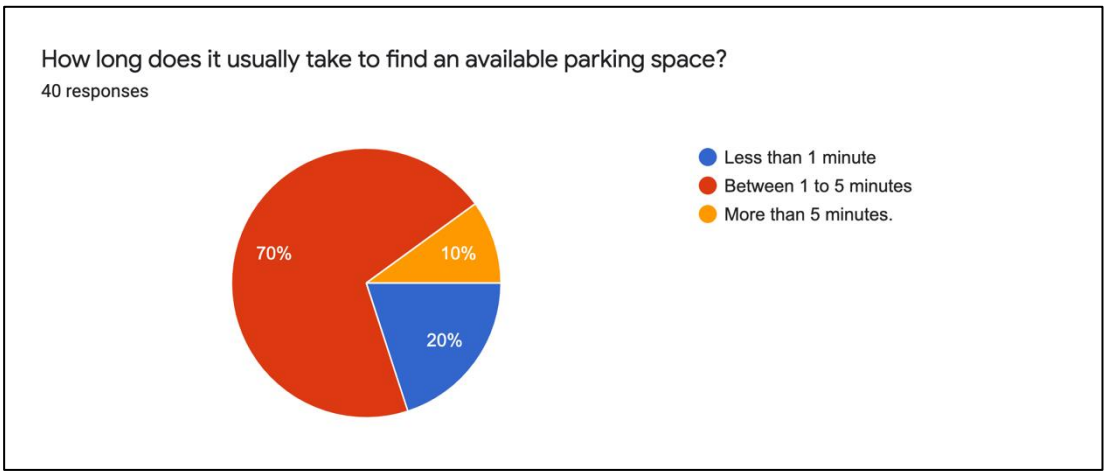

Figure 0.5 The time period takes to park a vehicle

Considering the data I have gathered from users and after referring to research papers I have found out that there are various drawbacks in currently available car parking systems.

1.1.2 Literature Survey

In the literature survey, I have mainly focused on the inefficiencies of the current vehicle parking systems and how they affect the wellness of the drivers' experiences, and how rapidly researchers have been attempted to find a universal answer for it. Specially I have considered about the car parking systems in Sri Lanka due to the island's need of having a proper solution to park the vehicles. The main motive for this smart parking application was to give Sri Lankan drivers a brand new experience which while enhancing their daily life. This app also has several brand new features for the market including the feature of allowing the customer to only pay for the only time he/she parked his/her vehicle.

The number of automobiles on the road is increasing on a daily basis and is expected to continue to rise. [1] As a result, this situation increases the necessity of a competent automobile parking system that displays available spaces in order to avoid traffic and save the time of the consumer. According to the results of research conducted in this sector, the number of automobiles in a public city has increased significantly, and as a result, drivers spend around 30% of their driving time attempting to park their vehicles. [2] According to certain studies conducted on this subject, even drivers take an average of 3.5 minutes to 14 minutes to find a parking space that is free. [3]

There have been several occasions where sensor technologies were used for current parking systems in Sri Lanka and a considerable number of researches have been conducted on sensors and micro-controller-based car parking solutions to identify the availability of a car parking slot. Few of the above-mentioned technologies are,

- Ultrasonic sensors
- Magnetometers
- Infrared Sensors
- LDR - Light Dependent Resistors.

Infrared Sensors - Infrared sensors are now utilized in the systems in two different ways. Active infrared sensors detect changes in the availability of a parking place,

whereas passive infrared sensors emit infrared energy to identify the free space and detect any object in front of it. These sensors are extremely sensitive to changes in the environment, such as rain and snow. These sensors are unreliable because they are sensitive to items such as people and animals. The cost of installation and maintenance is significant since they must be installed in a specific format in parking spots on the ground or in the ceiling. Because these sensors are sensitive to rain, they are not suited for outdoor parking spaces in Sri Lanka, where rain is common during the entire year. [2][3]

Ultrasonic Sensors - Ultrasonic sensors do work in the same principles used in Infrared sensors. But the ultrasonic sensor releases a sound wave between 25 to 50kHz to identify objects instead of an infrared ray. These sensors are low in cost but take a huge cost to installation and once the devices are installed for maintenance. These sensors are also affected by natural environmental changes such as rain and snow. Even though Sri Lanka doesn't have any issues with snow, Sri Lanka has a considerable issue with the rain during the year. Therefore, these sensors are mostly suitable for indoor parking areas in Sri Lanka. [2][3]

Light Dependent Resistor Sensors (LDR) - Light-dependent resistors are based on the shadow detection theory, which is a key principle of operation. When a vehicle is parked over an LDR sensor, the vehicle blocks the source of light from reaching the sensor, which causes the sensor to recognize the vehicle as a shadow. When a parking space is vacant, the sensor is exposed to a light source, which allows it to be recognized as a vacant slot. LDRs detect the presence of an object by measuring the amount of light directed towards the sensor. Natural light conditions vary from morning to evening, and during natural occurrences such as rain and thunderstorms. Additionally, some parking spaces may not have adequate lighting conditions to allow these sensors to function properly at night. As a result, these sensors are not suited for outdoor applications or inside applications where illumination conditions are inadequate. [8] These sensors are simple to use and integrate, which makes them cost-effective.

Magnetometers - An electromagnetic field change is used to determine whether or not a parking place is available using this type of sensor. These sensors must be located close to the car in order to be effective; therefore, they are installed beneath the ground for the greatest results. Because they are not impacted by environmental conditions, they can be used both indoors and outdoors without restriction. The most significant disadvantage of administering this system is the high expense of installing and maintaining these sensors on a big scale.

Researches on these technologies have been conducted locally as well as internationally [3][5][6][7][8] to find out a universal, efficient and sustainable solution that has the potential to solve the problems that arisen by manual systems.
But those researches conveys that current sensors and micro-controller based systems have drawbacks such as,

- not suitable to open-outdoor parking slots due to bad weather conditions and bad lighting conditions,
- object detection is error-prone. In some cases animals, humans have been identified as vehicles and have shown wrong sensor data.
- high power consumption of sensors,

and many other minor concerns. [2][3]

Many research has been conducted on smart parking solutions and the integration of sensors [5][6] into parking spaces, and the examples above illustrate how such sensors have been integrated into parking spaces in Sri Lanka. These systems have demonstrated that having a system improves the driver's overall driving experience.

Ultrasonic sensors, Arduino-based systems, and Microcontroller-based systems are now in use, however, they struggle from accuracy difficulties in a variety of situations, including adverse weather conditions, animals, and other objects. [2][3] Inaccuracies in parking space location, as well as the lack of an efficient method of finding a free spot inside parking space, causing motorists to lose important time as well as money.

1.2 Research Gap

During our site visits to several car parking areas, we have experienced several occurrences which displayed inaccurate sensor data. In some cases, we have driven to the particular parking slot which showed as available and once we reached there we have seen a vehicle has been already parked there. In figure 1.6 displays an occurrence where there is free space but the sensor shows as a vehicle has been parked.

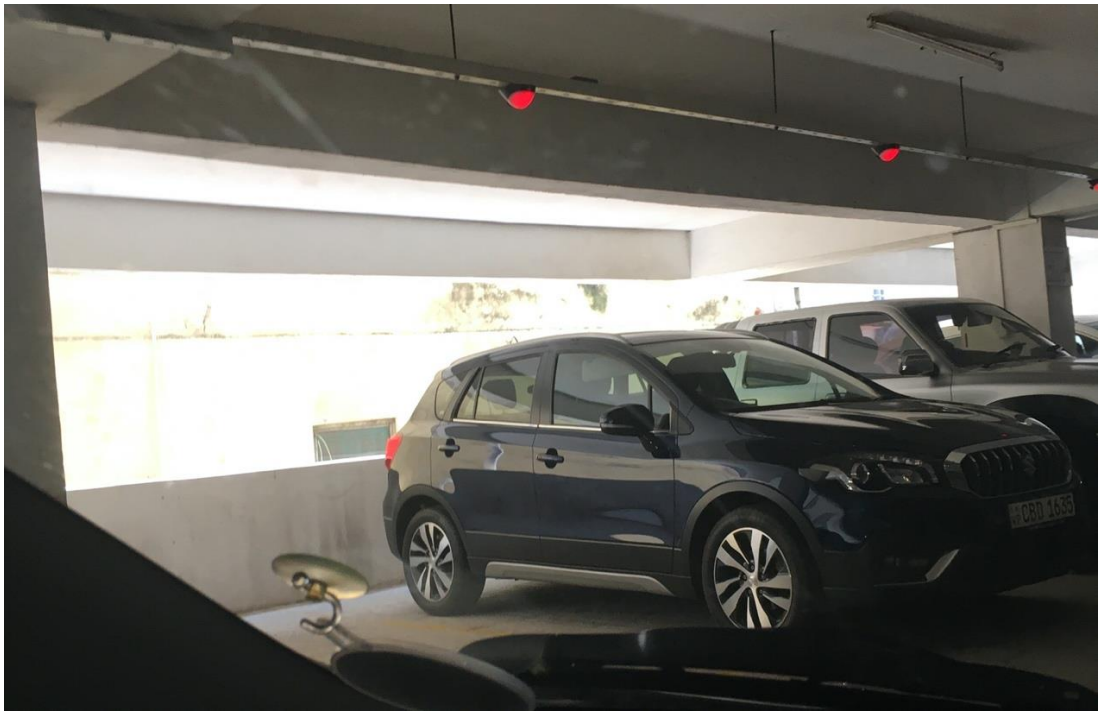

Figure 0.6 Malfunctioning Sensor at Liberty Plaza Colombo 03

Pay as You Park: Image Processing - Image processing is a technique for analyzing, enhancing, compressing, and reconstructing images. It is utilized in a variety of applications. [9] Using computer techniques, this technology takes an image as an input, processes it, and then outputs the desired data. To locate vacant spaces inside a parking lot, the proposed "Pay as You Park" system would make use of security cameras that are already in use in parking lots. The use of existing CCTV (surveillance) cameras rather than a brand-new system allows the car park owner to save money on the initial investment, and even if it is necessary to install CCTV cameras in the event that the car park does not already have a CCTV camera system,

it increases the car owner's sense of security and enjoyment of the car park. Nowadays, most car parking lots are equipped with security cameras for the sake of public safety.

Table 0.1 Comparison of other technologies

Sensor Type	Accuracy	Suitable for bad weather conditions	Investment and maintenance cost	Suitable for indoor parking	Suitable for outdoor parking
Passive Infrared	Poor	No	High	Yes	No
Active Infrared	Poor	No	High	Yes	No
Ultrasonic	Moderate	No	High	Yes	No
LDR	Poor	No	Low	Yes	No
Magnetometer	Moderate	Yes	High	Yes	Yes
Pay as You Go: Image Processing	High	Yes	Low	Yes	Yes

This proposed "Pay as You Park" smart parking system eliminates all the above-mentioned problems and provides a better user experience by saving both time and money for the user while reducing congestion. Because a single CCTV camera can cover a large area, it saves the cost of having a single sensor every single parking space. This also boosts the system's maintainability by reducing the number of sensors required. The data on available parking spaces and used parking spaces will be provided to the next component, which will direct the user to the appropriate parking spot. This approach solves several major problems in current car parking systems.

1.3 Research Problem

In today's world, an urban area has a large number of vehicles entering and exiting the area on a daily basis. Vehicles' ownerships when compared with the population have expanded dramatically over the last few decades, contributing to increased traffic congestion in urban regions and other sub-urban areas. The number of vehicles has increased by more than 50%. Suburban and rural areas are now seeing high levels of traffic as well. [1][2][3]

One of the most crucial things a private vehicle owner requires is a parking spot where to park his or her vehicle in order to meet his or her requirements. According to studies, it takes an average of 3.5 to 14 minutes to find a free parking place, resulting in stressful occurrences for drivers such as car accidents and even missing out on the opportunity to attend a special event or even a business opportunity. [3]

Currently, no parking system in Sri Lanka has the capability of locating specific parking spaces that are available, and even though some systems display available parking spaces on the ceiling, due to the inaccuracy of these displays, drivers may be required to make multiple rounds in order to park their vehicles. Even some parking garages do not allow drivers to return their vehicles in the opposite direction which leads to extra time on the parking process. We have identified several problems in current parking solutions and how they affect the well-being of a driver or a parking area user.

So the problem can be separated into few categories. They are environmental, financial, physical, and emotional. The environmental issue is that keeping the vehicle engines running for a period more than required releases toxic gases into the environment and it leads to natural imbalances, global warmth, and respiratory sickness too. The financial concern is that burning fuel for an extended time costs more fuel to the drivers. And also the time wasted on a particular customer affects the owners' incomes since they have to spend extra time to utilize parking areas for other potential customers. The physical problem is that staying inside a car park may lead to

physical pains for the driver since the car park may be at a high temperature and may lack proper oxygen levels. Finally, the emotional concern is that while staying in a car parking queue for an extended period or while driving around to find a car parking slot, the driver may feel stressed and overwhelmed by the process. This emotional feeling may stay with him/her for the whole day and it may decrease the well-being of the user.

Therefore, I have been concerned about all the problems that arisen daily for a car parking user and an owner and implemented a solution to overcome the main issues of current systems as my research solution. In my research, I have addressed mainly finding availability of parking slots inside a parking area which saves the time of both driver and owner and enrichens their experience on a parking area.

2 OBJECTIVES

2.1 Main Objectives

The primary goal of the Pay as You Park mobile app is to provide users a hassle-free user experience of parking which finds the availability of car parking slots inside a parking area, which saves the time of the user. Apart from time the system saves the fuel of the user which saves the money of the user, which saves the environment and finally limited resources on earth.

Also, with the assistance of the identifying availability of car parking slots, the system will avail to reduce the traffic congestion near car parking areas and inside car parking areas. With this approach, the user will have a stress-free, less tiresome, and less time-consuming parking process which will enhance the physical and mental well-being of the user which will ultimately support the user to have a better mentality after the parking process. Since this approach will help the user to find an available car parking slot, the user will avoid the habits like parking their valuable vehicles in unethical and illegal car parking areas which we hope would increase the daily routine of the users.

2.2 Specific Objectives

- Identify the availability of car parking slots inside a car parking area using CCTV (Surveillance) camera footages.

- Implement the registration of a user to the Pay as You Park system with the required details for the system registration.

- Planning to run the deep learning algorithm on a server setup.

3 METHODOLOGY

At the initial stage of the research process, we wanted to find out what are the difficulties the urban drivers are facing daily while fulfilling their parking needs and how hard the process of management of a parking area due to the difficulties of finding availability of a parking slot and how it affected both parties. Even though there are many approaches like micro-controller-based systems, Infrared sensors, etc, they are not efficient in some cases. Therefore in our research, we have focused on how to avoid those problems arisen on daily basis. As the first step, we have reached to potential customers and done a survey on them to find out how much they are satisfied with current experience and it has revealed that the majority of car parking users are dissatisfied with the available systems. Therefore we have decided to make a proper solution to overcome the above-mentioned issues and to give a user-friendly experience we have identified a mobile application for iOS and Android would be beneficial since it is portable and the mobile phone has become a major part of everyone's life.

- **Identify the availability of car parking slots**

  To identify the availability of the car parking slots which means the occupancy of a car parking slot, we have used ImageNet-VGG-f model, a model which has been trained on the ImageNet dataset. This Pre-trained deep CNNs have five convolutional layers, each of which has 11x11, 5x5, 3x3, 3x3, and 3x3 image kernels. These layers stride over the entire image, pixel by pixel (except for the first layer, where the stride is four pixels), to generate 3D volumes of feature maps (with the exception of the first layer, where the stride is four pixels). The first convolution layer has a width of 64 pixels, while the remaining layers have a width of 256 pixels. Following the first, second, and final convolution layers, there is a max-pooling layer. The last convolution layer is followed by three fully connected layers of 4096, 4096, and 1000 neurons, respectively, and the final output is a layer with a soft-max classifier as its final output. It is fairly similar to the network architecture illustrated in

Figure 1 in terms of its design. Figure 2 depicts a simplified representation of the framework, which consists of two main components: training an SVM classifier and evaluating the classification results of the SVM classifier.

Component Architecture

CCTV captures the footages of the car parking area and the processed images are being further processed using CNN algorithm to identify the availability of the parking slots inside parking area. As the identification process it calls the update service of availability which was developed using Express framework with node.js environment. There are basically 2 services. First service provides the user to get the availability of the parking slots and second service is used to update the services. Both services run on cloud platform.

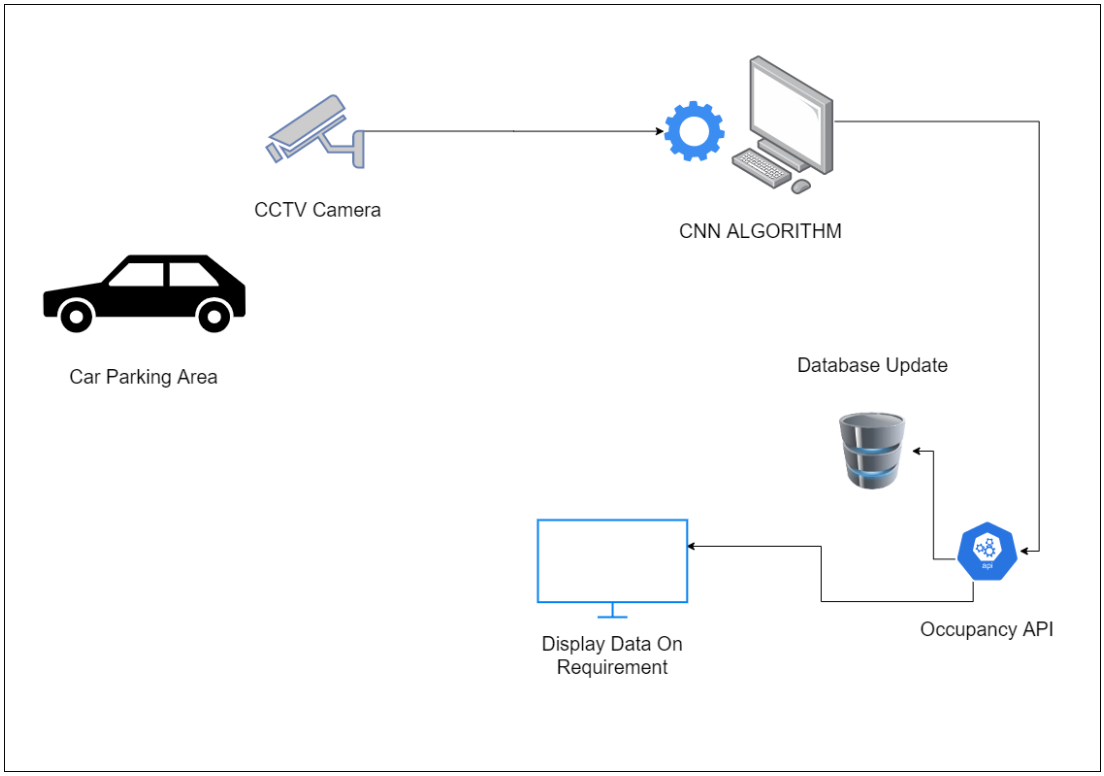

Figure 3.1 Component Architecture

4 TESTING AND IMPLEMENTATION

4.1 Implementation

4.1.1 Availability API

Availability of car parking area is updated and displayed to the car parking owners using two node.js services. The first API updates the availability, and the second API returns availability as a JSON response. The APIs are currently hosted on Heroku App. For the database purpose, MongoDB NoSQL has been utilized since it supports convenient handling than traditional SQL databases for web and mobile applications. ReactJS has been used for the front-end development since the React framework supports various libraries for both user interfaces and back-end service handlings. Also React has a Virtual DOM which is faster than other frameworks.


```
{
  "PID": "P27",
  "Name": "Park Street Car Park",
  "Occupancy": "28",
  "Slots": [
      { "id":"01",
        "availability": true
      },
      { "id":"02",
        "availability": false
      }
      ]
}
```


Figure 4.1 Sample Response

```
const mongoose = require("mongoose");
const Schema = mongoose.Schema;
const ObjectId = mongoose.Schema.Types.ObjectId;

const ParkingAreaSchema = new Schema( definition: {
    user_id:{
        type: ObjectId,
        ref: 'users',
        required: true
    },
    PID: {
        type: String,
        required: true
    },
    Latitude: {
        type: String,
        required: true
    },
    Longitude: {
        type: String,
        required: true
    },
    Name: {
        type: String,
        required: true
    },
    Address: {
        type: String,
        required: false,
        default: ""
    },
    Capacity: {
        type: Number,
        required: true
    },
```

Figure 4.2 Node.js Model

```
    Occupancy: {
        type: Number,
        required: true
    },
    MaxWidth:{
        type:String,
        required: false,
        default: ""
    },
    slots: [{
        slot_id:{
            type: ObjectId,
            ref: 'slot'
        }
    }]
});

module.exports = ParkingArea = mongoose.model( name: "ParkingArea", ParkingAreaSchema);
```

Figure 4.3 Node.js Model

```
const mongoose = require("mongoose");
mongoose.set('useFindAndModify', false);
const Schema = mongoose.Schema;

//create Schema
const SlotSchema = new Schema(
    definition: {
        slotNumber : {
            type : Number ,
            require : true
        },

        availability :{
            type: Boolean ,
            require: false,
            default: false
        }
    },

);

module.exports = Slot = mongoose.model( name: "slot" , SlotSchema);
```

Figure 4.4 Node.js Model

Above figures shows the model of node.js APIs. And figure 4.1 shows the availability of the car parking slots response from the API.

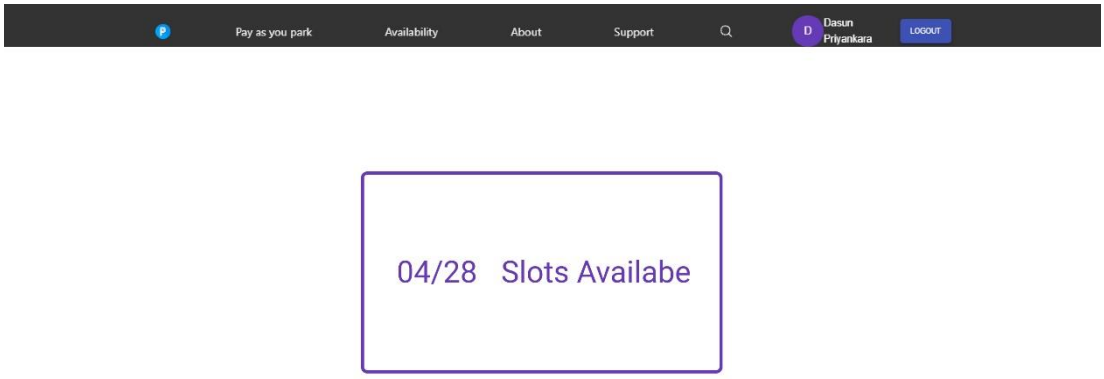

Figure 4.5 Web Application Preview

As in figure 4.5 the car park owner will be able to check the current count of available slots inside his or her car parking area once he is logged in to his registered account.

4.1.2 Availability Detection Using CCTV

To identify the availability of car parking slots inside a car parking area, for the use of driver, car park owner and other members of my research group I have developed an algorithm to afford the target. To process and generate the availability results I have utilized CCTV cameras since most of the car parking areas already have installed CCTV camera systems.

- Deep CNN Implementation

  To identify the availability of the car parking slots which means the occupancy of a car parking slot, we have used ImageNet-VGG-f model, a model which has been trained on the ImageNet dataset. This Pre-trained deep CNNs have five convolutional layers, each of which has 11x11, 5x5, 3x3, 3x3, and 3x3 image kernels. These layers stride over the entire image, pixel by pixel (except for the first layer, where the stride is four pixels), to generate 3D volumes of feature maps (with the exception of the first layer, where the stride is four pixels). The first convolution layer has a width of 64 pixels, while the remaining layers have a width of 256 pixels. Following the first, second, and final convolution layers, there is a max-pooling layer. The last convolution layer is followed by three fully connected layers of 4096, 4096, and 1000 neurons, respectively, and the final output is a layer with a soft-max classifier as its final output. It is fairly similar to the network architecture illustrated in Figure 1 in terms of its design. Figure 2 depicts a simplified representation of the framework, which consists of two main components: training an SVM classifier and evaluating the classification results of the SVM classifier. The MATLAB environment has been used here. To train the model PKLot dataset has been utilized since it holds more than 12,000 car parking CCTV images and more than seven hundred thousand segmented parking slot images. Figure 4.6 and Figure 4.7 displays the process.

```
clear;clc; close all;% clear workspace and command window

if ~exist('MATLABCodeCNNSVM.zip','file')
    disp('Downloading file (218 MB)...');
    URL = 'https://melbourne.figshare.com/ndownloader/files/24726374';
    websave('MATLABCodeCNNSVM.zip',URL);
else
    disp('Zip file exists')
end
```

```
Zip file exists
```

```
unzip('MATLABCodeCNNSVM.zip')
disp('Unzipped files')
```

```
Unzipped files
```

```
addpath('FinalCodeSVM/')
addpath('FinalCodeSVM/SupportingFunctions/')
```

Figure 4.6 Model Loading

```
% Visualise the segmented images of PKLot dataset
% (We sampled 1500 occupied and 1500 Empty spaces)
PKLotEmpty = imresize(imread(...
    'FinalCodeSVM\PKLotSegmentedSampled\Empty\2012-09-11_15_45_57#004.jpg'), [70 50]);
PKLotOccupied = imresize(imread(...
    'FinalCodeSVM\PKLotSegmentedSampled\Occupied\2012-09-11_15_36_32#100.jpg'), [70 50]);
figure
subplot(1,2,1)
imshow(PKLotEmpty);
title ('1500 Empty slots')
subplot(1,2,2)
imshow(PKLotOccupied);
title ('1500 Occupied slots.')
```

Figure 4.7 Visualizing Segment images

Figure 4.8 displays how the model has identified the occupancy of the images using the dataset.

Figure 4.8 Displaying occupancy samples

For the testing purposes a dataset of Barry Street has been used. The code lines in figure 4.9 shows the process of identifying the parking slots using ground truth images and the output is displayed on the figure 4.10.

```
% Load image to train.
BarryStreetImage = imread('FinalCodeSVM\BarryStreetData\DSC_0455.JPG');

% load the parking slot markings and occupancy from ground truth image
load('GroundTruthBarryStreet.mat');

% Visualise Barry Street
figure
BarryStreetImageAnn = insertShape(BarryStreetImage,'rectangle',ParkingSlots,...
    'LineWidth', 2);
imshow(BarryStreetImageAnn);
```

Figure 4.9 Loading images

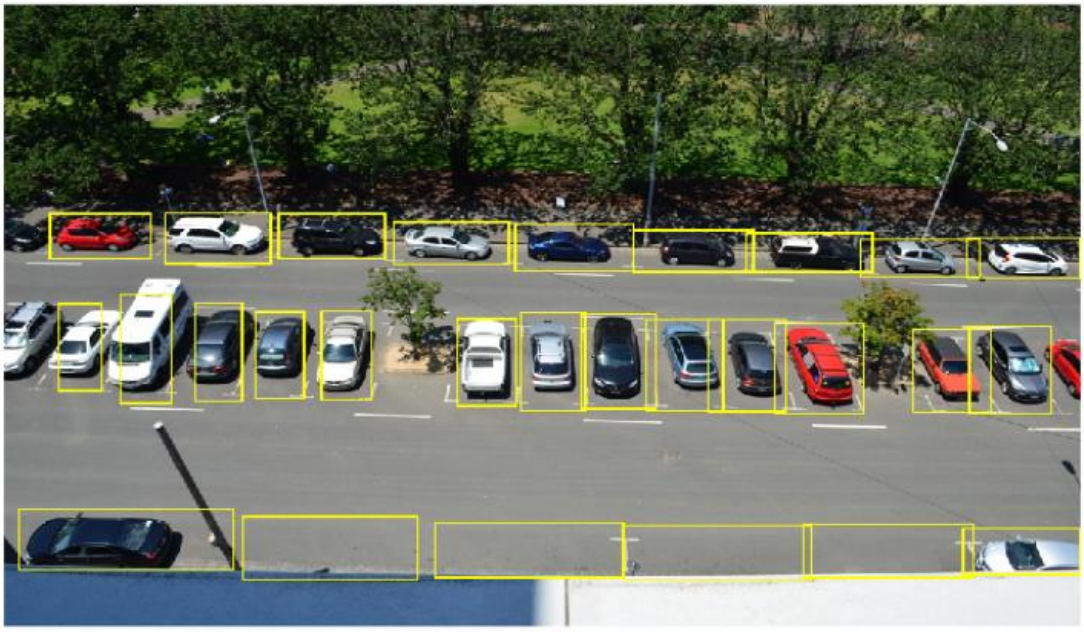

Figure 4.10 Bounding box are shown after identification

```
figure
AnnotatedImage = imread("FinalCodeSVM\BarryStreetData\DSC_0169.JPG");
AnnotatedFinal;
emptySlots = 0;
occupiedSlots =0;

emptySlotArray = [];
occupiedSlotsArray = [];

for n=1:28
    if YpredClass(n) == "Empty"
       AnnotatedImage =  insertShape(AnnotatedImage,'FilledRectangle',...
    ParkingSlots(n,:),'LineWidth', 1, 'Color', "green", 'Opacity', 0.4);
       AnnotatedImage = insertText(AnnotatedImage, [ParkingSlots(n,1) ParkingSlots(n,2)], ...
           n,"FontSize",18,"TextColor","white","BoxOpacity",0.0);
       emptySlotArray = [emptySlotArray, n];
    emptySlots = emptySlots + 1;
    else
       AnnotatedImage =  insertShape(AnnotatedImage,'FilledRectangle',...
    ParkingSlots(n,:),'LineWidth', 1, 'color', "red", 'Opacity', 0.4);
       AnnotatedImage = insertText(AnnotatedImage, [ParkingSlots(n,1) ParkingSlots(n,2)], ...
           n,"FontSize",18,"TextColor","white","BoxOpacity",0.0);
       occupiedSlotsArray = [occupiedSlotsArray, n];
    occupiedSlots = occupiedSlots + 1;
    end


    %disp(ParkingSlots(n,:));
    %disp(ParkingSlots(n,2));
end
imshow(AnnotatedImage)
text (100, 50,['Occupied slots: ' num2str(occupiedSlots)],'Color', 'red','FontSize',20);
text (100, 100,['Empty slots: ' num2str(emptySlots)],'Color', 'green','FontSize',20);
```

Figure 4.11 Getting an output from a parking image

Figure 4.12 Output

Figure 4.12 in the above displays the final outcome of dataset. It takes an image and displays the occupancy of the vehicle parking slots and the id of the particular parking slot. After identification of parking slots, the parking slots occupancy update service will be called and the API will update the mongo DB database's data.

4.2 Testing

Testing is a critical stage on the System development life cycle. We have identified the importance of the accuracy of a parking area's occupancy since it is an essential part of daily life the accuracy was a huge issue. We have tested using CCTV images from a real car parking area.

Table 4.1 Test Result

Function	Issues Yes/No
API testing	No
Availability Testing	No
Integrated Testing	No

5 RESULTS AND DISCUSSION

5.1 Results

My research component from Pay as You Park system was to identify the availability of car parking slots inside a car parking area. While working towards achieving my task I have found out that lighting conditions, weather conditions and distractions like animals and humans' matter to currently available parking systems. After my research I have successfully achieved these results as to improve the well-being of the user and giving them a new experience.

1. The user doesn't need to look for available parking slots after entering the car parking area, since the app will display the data, I am sending as an API
2. The user doesn't have to stay in queues for long to park the vehicle
3. User will not face difficulties like going several rounds to park the vehicle.

As an outcome we could give the user a brand-new experience of parking for both drivers and car park owners.

1. The car park owner can check how many slots available at a particular time.
2. API for both web and mobile application
3. In need the data can be given for third parties as an API service.

```
% train the cubic SVM classifier with 5-fold cross validation, should take
% 6 seconds to train the classifier

tic
% using 5 fold cross validation in the model
[trainedClassifier, validationAccuracy, validationPredictions] =...
    trainClassifier(training_matrix);
toc
```

```
Elapsed time is 4.712597 seconds.
```

```
disp('Training finished for the SVM classifier')
```

```
Training finished for the SVM classifier
```

```
% display the cross-validation accuracy of the trained classifier for the training data
fprintf('The validation accuracy of the classifier %f %%.\n',validationAccuracy*100);
```

```
The validation accuracy of the classifier 99.833333 %.
```

Figure 5.1 Validation accuracy

Figure 5.1 shows that the validation accuracy is around 99.8%.

```
            end
            count=count+1;
        end
    end
    toc
end
```

```
Test Features loaded
Elapsed time is 0.427956 seconds.
```

```
testAccuracy = mean(Occupancy(:) == YPred');
fprintf('The test accuracy of the classifier %f %%.\n',testAccuracy*100);
```

```
The test accuracy of the classifier 98.892857 %.
```

Figure 5.2 Test Accuracy

But as in the figure 5.2 displays the accuracy of test data is gets only around 98.8% which turns out that there's a 1% accuracy loss. And the error rate is around only 1.2%. So, this means that this model gives an output at a high accuracy level.

5.2 Research Findings

Commercialization of the Product

How does the Pay as You Park Smart Parking Solution differentiate from the currently available parking systems?

- Pay as You Smart Parking solution lets users have a subscription-based payment instead of a traditional hourly-based parking fee calculation. It means that the user only needs to pay for the amount of time they have parked his or her vehicle. For an instance, if the user has subscribed to 100 minutes package and the user parks the vehicle for 5 minutes in a parking area that has the Pay as You Park system, the user will only get a deduction of 5 minutes and 95 minutes will be available for further parking needs.

- The user can use the same subscription for all the places that has Pay as You Park parking. It gives the user a seamless experience of parking.

- The car parking area owners can utilize their CCTV (Surveillance) camera systems to identify the availability of car parking slots which will save the owner's initial cost for other sensors.

Considering these advantages for both users and car park owners this system will work as a parking area platform rather than just a system itself.

6 SUMMARY OF THE STUDENT CONTRIBUTION

- Recognizing the most appropriate, feasible, and accurate algorithm to identify the availability of car parking slots inside a car parking area.
- Identifying the need for a proper car parking area in the country.
- Identifying the need for a subscription-based payment scheme instead of traditional hourly payment.
- Design User Friendly and easy to understand UI for availability for car park owners.
- Creating APIs to communicate the availability of parking slots.
- Testing the solution.

7 CONCLUSION

'Pay as You Parking' smart parking solution idea has come into our minds intending to provide a hassle-free, convenient, and user-friendly parking solution for Sri Lankan vehicle owners. Especially for those who use urban areas' vehicle parking and face so many difficulties on daily basis. When we were doing researches and when we visited car parking areas we saw the potential in a smart parking solution for the country. We have experienced how much energy is wasting for the parking process. Sometimes these things are unavoidable due to the lack of a proper system. Here I have concerned about identifying the availability of a car parking slot inside a car parking area. It simplifies the user's most important concerns such as finding an available slot, get to know whether the car parking area has free slots, etc. The data generated by my side will be delivered to the continuity of the process of the Pay as You Park system and the system will provide users a seamless experience for the parking. By identifying the real-time availability of the car parking area, owners will be able to utilize their land efficiently.

To obtain the best user-friendly experience we have used the latest and user-friendly technologies to fulfill all users' expectations and usability. We have used Flutter for mobile application development since it supports both iOS and Android and it will let users have a seamless experience on both platforms. Also for the web application for the car park owners, we have used the React.js framework since it supports a huge number of supportive libraries and supportiveness every platform. Node.js with Express framework has been used for API development since Node.js is fast and efficient than other frameworks. Also to increase the speed and efficiency, we have used MongoDB as our database. The purpose of using above mentioned latest technology stacks is to provide the user with a much better experience.

We hope this Pay as You Park smart parking solution would enhance the well-being of drivers and owners while saving time, fuel, and mental state. This platform will

solve so many daily issues and our vision is to prevent traffic congestions due to car parking blocks and will fulfill users' expectations.

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