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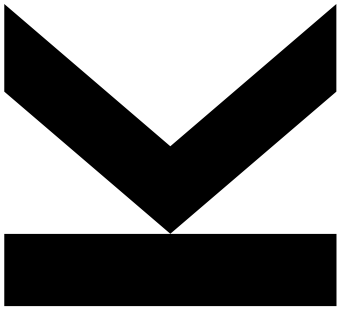
ROBUST DRIVE-BY ROAD SIDE PARKING DETECTION ON MULTI-LANE STREETS USING AN OPTICAL DISTANCE SENSOR



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Affidavit

I hereby declare that the following dissertation "Put your thesis title here" has been written only by the undersigned and without any assistance from third parties.

Furthermore, I confirm that no sources have been used in the preparation of this thesis other than those indicated in the thesis itself.

Linz, on November 1, 2017

Markus Hiesmair

Acknowledgment

Summary

Summary ...

asdf

Abstract

Abstract ...

Contents

To-Do: For now the TOC depth is 5 but will be reduced later

Abbreviations

CAB Compute Aggregate Broadcast (A computing model in parallel computing where computation is strictly partitioned in the three phases compute, aggregate and broadcast)

IaaS Infrastructure as a Service (Cloud computing service layer)

JSF Java Server Faces (Web technology in the arena of Java enterprise)

JSP Java Server Pages (Web technology available in Java Servlet containers)

MPI Message Passing Interface (Standard for implementing parallel algorithms on shared-nothing infrastructures)

OSN Online Social Network (An usually web-based online platform where friends, and acquaintances can connect and share information)

PaaS Platform as a Service (Cloud computing service layer)

SaaS Software as a Service (Cloud computing service layer)

UML Unified Modeling Language

URL Uniform Resource Locator

VM Virtual Machine

WAR Web Application Archive

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Chapter 1

Introduction

To-Do: soll hier ein kurzer überblick über die Arbeit und das Kapitel gegeben werden? Also wo was beschrieben ist usw?

1.1 Importance of Research and Motivation

Traffic congestion in urban areas becomes a bigger problem every year. Increasing traffic causes several issues, for example high monetary and environmental costs by using gasoline and by emitting CO_2 to the environment. There are several strategies to reduce urban traffic to mitigate these problems like new investments in public transport infrastructure. However, the usage of private cars to get to cities won't stop in the next decades **To-Do:** hier vl referenz finden. Therefore, it is important to find ways to reduce traffic in urban areas.

With more vehicles driving to urban areas, there also comes the need for a sufficient number of parking spaces. Finding parking spaces in urban areas can be a really difficult, frustrating and time consuming task for drivers. There often exists some information about the availability of parking spaces in parking garages, but in most cities the situation of road side parking is rather non-transparent. This not only leads to frustrated drivers, who are searching for parking spaces a long time, but again contributes to urban traffic congestion as many cars only go around blocks while searching for free parking spaces.

There are many studies, which show that the searching for parking spaces adds a lot of traffic. In 2013 a study by Nawaz et. al [3] showed that about 30% of traffic congestion is created by drivers looking for free parking spaces. Another study [1] found that alone in 2007 searching for parking spaces caused costs of about 78 billion US dollars by using 2.9 billion gallons of wasted gasoline and 4.2 billion lost hours only in the United States.

Furthermore, this obviously causes a lot of CO_2 emissions which is not only bad for the environment and contributes to climate change but also lowers the quality of living in big cities through the significant amount of air pollution.

One of the most important contributors to high search times for parking spaces is not only the lack of vacant parking spaces, but also the lack of information, if and where free parking spaces are available. Therefore, one way to mitigate many of the above stated problems is to determine the current parking space situation in the city and make it accessible to the public (e.g. via web application), so that drivers can efficiently navigate to a vacant parking space, or even decide if they want to go by car or use public transportation, depending on the number of parking spaces available close to their destination.

Detection of road side parking spaces and their states is a challenging task. Of course an obvious approach to the problem would be to put stationary sensors to every parking space in the city, which check, if the corresponding parking space is occupied or vacant. This, however, has the drawback to be very expensive as, for big cities, thousands of sensors would have to be bought, installed and maintained. Furthermore, because the parking situation does not change often, the high frequency of sensing with such a system would be rather inefficient.

1.2 Drive-By Park Sensing

A promising new option to sense a city's parking situation is the use of mobile sensors instead of static ones. Crowd sensing has the advantage to be usually more cost effective and can provide sufficient accuracy for the purpose of providing parking space availability maps.

There are several approaches to mobile parking availability sensing, which will be discussed in chapter 2. In this thesis a "drive-by park sensing" approach will be implemented, tested and evaluated. The approach works as follows: Several sensing vehicles drive through the city and each of them is equipped with a few sensors, namely a distance sensor to measure the distance to the nearest obstacle on the right side of the road and a GPS receiver which determines the current position of the vehicle. Using these data parking cars should be detected and vacant parking spaces should be derived as well using parking space maps. Figure 1.1 shows a standard scenario of a sensing vehicle which passes two parked cars and a vacant parking space in between them. The distance measurements while passing the parked cars will be much shorter than the measurements while passing the vacant parking space. This should allow a basic algorithm to recognize parking cars and vacant parking spaces.

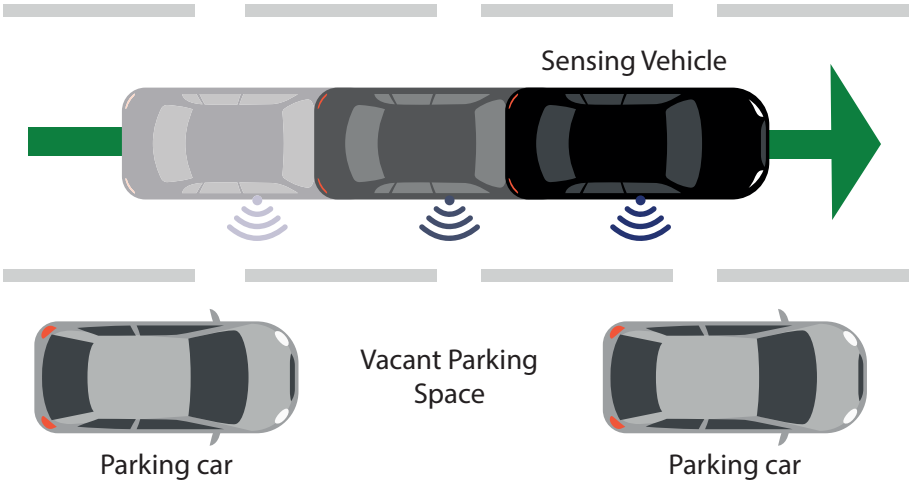

Figure 1.1: The sensing vehicle passes two parked cars and should identify a vacant spot in between using distance and location measurements. **To-Do:** Hier Referenz zu Parknet-Paper??? Ähnliche Grafik...

However, the situation which is shown in figure 1.1 is an idealistic one. In real life traffic, there will be much more complex situations to face, which are not as easily detectable and which might influence the success of the detection. For instance, the sensing vehicle might not drive in the right-most lane, therefore the measured distances will be much longer. Another possible issue are other driving cars, motorcycles or bicycles which the sensing car overtakes. Such overtaking situations have to be filtered out to ensure that there are no false detections.

The high complexity of urban traffic and the many distractions during sensing make it nearly impossible to create a rule set based on the sensor measurements which would be able to detect parking situations at a sufficient accuracy. Furthermore, such rule sets would have to be created for each city individually because of the different nature of the roads and the parking spaces. For instance, the distance between roads and parking spaces can vary highly between two cities. In this thesis, several machine learning techniques are tested and being compared to each other to find out if machine learning can be used to identify complex road side parking situations, to filter out distractions like overtaking situations and to detect vacant parking spaces.

During test runs with a prototype car in Linz, Austria, sample measurements are being recorded, where the focus lies on creating very diverse and realistic situations. The

recorded data is being filtered and pre-processed before it is used as input for the machine learning algorithms.

1.3 Goals

goals...

Chapter 2

Related Work

2.1 ParkNet

parknet...

Chapter 3

Reference Implementation of the Distributed Processing Framework

This is a chapter that references other chapters **??**

Chapter 4

Results and Discussion

Chapter 5

Conclusions and Future Work

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