Author
Markus Hiesmair

Submission
Institute of Telecooperation

Thesis Supervisor
Karin Anna Hummel

February 2018

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

Master's Thesis

to confer the academic degree of

Master of Science

in the Master's Program

Computer Science

JOHANNES KEPLER UNIVERSITY LINZ
Altenberger Str. 69
4040 Linz, Austria
www.jku.at
DVR 0093696

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 2, 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

GPS Global Positioning System

LIDAR Light detection and ranging

List of Figures

List of Tables

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.

However, 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 state of parking parking spaces does not often change, the high frequency of sensing with such a system would be rather inefficient.

1.2 Drive-By Park Sensing

A promising novel approach 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. This thesis will focus on "drive-by park sensing". The idea behind the drive-by sensing approach is that there are sensing vehicles which are driving through the city and collecting data of their environment through mounted sensors. Using the collected data parking cars should be detected as well as vacant parking spaces. There already exists a prototype implementation of such a system. In 2013, Mathur et al. [2] presented their system, called ParkNet, which continuously measured the distance to the nearest obstacle on the right side of the road, as well as the location of the sensing vehicle through a GPS sensor. Using these data, they used thresholding to detect parking cars and vacant parking spaces. A more detailed description of their work is being described in section 2.1.

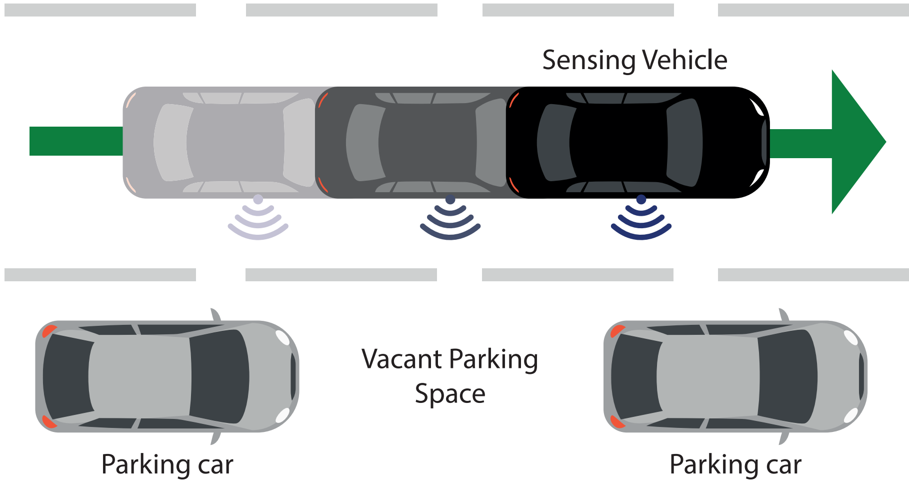

Figure 1.1: The sensing vehicle passes two parked cars and should identify a vacant spot in between using distance and location measurements. **To-Do:** Hier Referenz zu Parknet-Paper??? Ähnliche Grafik...

Figure 1.1 shows a standard drive-by scenario of a sensing vehicle which passes two parallel 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 taken while passing the vacant parking space. This should allow a basic algorithm to recognize parking cars and vacant parking spaces.

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. There are many of such distractions which have to be filtered out to ensure that there are as few false detections as possible. The existing ParkNet prototype does not take any of such situations into account, because it was only evaluated on parallel parking cars on single lane roads.

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. Therefore, simple thresholding as applied in the ParkNet prototype will not work in real life traffic scenarios. 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. Thus, to be able to detect parking situations, new methods have to be found, which should be more flexible to distractions and changes in the environment.

1.3 Research Goals

The overall goal of this thesis is to determine which accuracy can be achieved for detecting the parking space situation in urban real world traffic scenarios using drive-by park sensing. Furthermore, distracting situations should be identified and strategies to cope with them should be found to be able to keep the detection accuracy high.

To achieve this goal, the following steps will be executed:

Building a test bed First, a test bed has to be built, which is able to access the two required sensors to record all the necessary data. A Raspberry PI will be used as processing device because of its popularity and the many compatible sensors which work with this platform. It is connected to a LIDAR-Lite v3 sensor which continuously measures the distance to the nearest obstacle on the right side of the read. A GPS receiver will track the location of the sensing vehicle and a camera will be used to record the ground truth for evaluation purposes only.

Chapter 2

Related Work

2.1 ParkNet

parknet...

Chapter 3

Prototype Implementation

blabblabla

3.1 System Architecture

3.2 Test Bed Description

3.3 Preprocessing and Filtering Sensor Data

Chapter 4

Results and Discussion

Chapter 5

Conclusions and Future Work

Bibliography

[1] Texas Transportation Institute. Urban mobility report. 2007.

[2] Suhas Mathur, Tong Jin, Nikhil Kasturirangan, Janani Chandrasekaran, Wenzhi Xue, Marco Gruteser, and Wade Trappe. Parknet: Drive-by sensing of road-side parking statistics. In *Proceedings of the 8th International Conference on Mobile Systems, Applications, and Services*, MobiSys '10, pages 123–136, New York, NY, USA, 2010. ACM.

[3] Sarfraz Nawaz, Christos Efstratiou, and Cecilia Mascolo. Parksense: A smartphone based sensing system for on-street parking. In *Proceedings of the 19th Annual International Conference on Mobile Computing & Networking*, MobiCom '13, pages 75–86, New York, NY, USA, 2013. ACM.

[4] J. Zhou, L. E. Navarro-Serment, and M. Hebert. Detection of parking spots using 2d range data. In *2012 15th International IEEE Conference on Intelligent Transportation Systems*, pages 1280–1287, Sept 2012.