JOHANNES KEPLER
UNIVERSITY LINZ

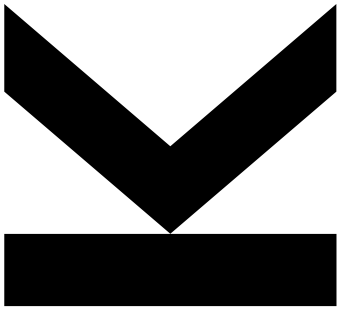
Author
Markus Hiesmair

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 October 29, 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

List of Figures

List of Tables

Chapter 1

Introduction

1.1 Importance of Research and Motivation

Currently the road side parking situation in most cities is rather untransparent. Except from parking garages and the like information about the availability of parking spaces is rarely available. However, finding parking spaces in urban areas can be a really difficult, frustrating and time consuming task for drivers. Furthermore, information about free parking spaces can help to reduce traffic by a tremendous amount. Studies have shown that in urban areas about 30% of traffic congestion is created by drivers looking for free parking spaces [3] and that in 2007 a loss of about $78 billion U.S. dollars was created by the use of about 2.9 billion gallons of gasoline alone in the USA [1]. Obviously this causes a lot of CO^2 emissions which are bad for the environment and furthermore about 4.9 billion hours were wasted by drivers while looking for parking spaces during that year.

1.2 Problem Definition

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 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.

Another promising 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. There has already been done some research on cars which analyze parking availability while they drive through the city. For instance, Mathur et al. [2] developed a system which uses distance information from the vehicle to the right side of the road to reason about parking spaces. Another approach, which was done by Zhou et al. [4] looks for car bumper shaped signal parts in the distance measurements to identify parking cars.

However, all of the mentioned mobile sensing approaches only work in single lane scenarios. Multi lane streets bring much more complexity in the recognition of parking spaces. There are many special cases which have to be addressed to work properly on multi lane roads. For example, the recognition of other driving vehicles and the recognition of the lane the sensing vehicle is on at the moment.

1.3 Detailed Approach and Goals

The overall aim of this thesis is to evaluate if it is possible to reach a sufficient high accuracy in road side parking detection on multi lane roads using a sensing vehicle which drives through the city and senses parking spaces while driving by. For the parking detection an optical distance sensor will be used to measure the distance to the nearest obstacle on the right side of the road (in many cases a parking car). This sensor will be mounted on the co-driver's side of the car and will continuously measure the distance while the car is driving. Furthermore, a GPS sensor will be used to include the spatial information of the vehicle. Using these measurements, the prototype should support accurate detection of free parking spaces in challenging road situations. Potential challenges for road-side parking detection are:

- multi-lane detection
- handling inaccuracies in GPS measurements
- differentiation of free parking spaces and other free spaces
- varying vehicle speed
- differentiation between perpendicular/parallel parking spaces

In a first step, after the sensors have been mounted on a car, test measurements will be collected while driving through some selected streets in Linz, Austria. The test scenes should include single lane- as well as multi lane streets and measurements in all streets should be done several times. To determine the ground truth of the parking availability

a camera will be used, which takes pictures of the parking situation at the street during the tests.

After these measurements have been taken, the measurements should be analyzed, pre-processed, and then an algorithm should be developed (or learned) to classify the current parking situation. An important part of the algorithm will be the handling of multi lane roads, because there are many special cases which have to be considered. First of all, the lane in which the sensing vehicle is going has to be detected and has to be incorporated in the algorithm. Furthermore, the system should also detect when the car overtakes another driving car, because this could lead to falsely detected parking spaces.

In a final step, possible approaches should be evaluated, which can further enhance the results. For example, the cooperation of multiple sensing vehicles which are going at the same time at the same street can maybe help to increase the parking detection accuracy. Finally, the results of single- and multi lane detection should be evaluated and compared in terms of parking space count accuracy and parking occupancy rate accuracy.

Chapter 2

Related Work

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

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.