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Wireless Protection of Vulnerable Road Users

Seminar Thesis in Master's Computer Science

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Wireless Protection of Vulnerable Road Users

Seminar Thesis in Master's Computer Science

submitted by

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born on March 31, 1994
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created in the Working Group

Distributed Embedded Systems
(CCS Labs)

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Submission date:	**31. Dezember 2017**

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Ich versichere, dass ich die Arbeit ohne fremde Hilfe und ohne Benutzung anderer als der angegebenen Quellen angefertigt habe und dass die Arbeit in gleicher oder ähnlicher Form noch keiner anderen Prüfungsbehörde vorgelegen hat und von dieser als Teil einer Prüfungsleistung angenommen wurde.
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Declaration

I declare that the work is entirely my own and was produced with no assistance from third parties.
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(Philip Frerk)
Paderborn, 31. Dezember 2017

Abstract

about 1/2 page:

1. Motivation (Why do we care?)
2. Problem statement (What problem are we trying to solve?)
3. Approach (How did we go about it)
4. Results (What's the answer?)
5. Conclusion (What are the implications of the answer?)

Protecting vulnerable road users is a very important task as in roughly 50 % of all traffic accidents vulnerable road users are involved. Vulnerable road users are pedestrians or drivers of two-wheeled vehicles.

A technology is needed that warns both the vulnerable road user and the car driver if an accident between them is likely to happen. This is not an easy challenge because the warnings have to be sent in time and also it has to ensured that no people are warned who are not really affected by the approaching car.

To achieve that goal, wireless networks, GPS and sensor perception will be used.

Results show that the number of accidents with vulnerable road users involved can be reduced dramatically.

Therefore, much more work will be put into this topic, because it is already shown that the technologies can potentially prevent many traffic accidents.

Kurzfassung

Gleicher Text (sinngemäß, nicht wörtlich) in Deutsch

Contents

The table of contents should fit on one page. When in doubt, adjust the `tocdepth` counter.

Chapter 1

Introduction

umstrukturieren, vielleicht doch keine sektionen!

1.1 Motivation

Within the last century the usage of motorized vehicles has grown rapidly. While this fact brings the great benefit of full mobility, it does not come without its downsides. One of them is the high number of traffic accidents. According to **v2pcomm** in roughly half of all traffic accidents, Vulnerable Road Users (VUs) are involved. Hence, there is huge potential to prevent injuries or even deaths of many people. This thesis will give you an overview of the current state of research in this area. While there are many approaches beyond the discipline of Wireless Networking (e.g. Computer Vision for pedestrian recognition), this thesis will focus mainly on how to prevent traffic accidents by using wireless network technology. However, the other areas will also be explained briefly since they often work hand in hand with Wireless Networking.

1.2 Structure of the Thesis

The thesis is structured as follows. First, in chapter 2 we will look at so called Vehicle to Pedestrian Communication Systems (V2PCs) which use wireless networks in order for pedestrian and vehicles to communicate so that accidents between them can be prevented.

Second, in chapter 3 we will look at detecting VUs by using perception of cars. We will only shortly dive into this topic, because it is not directly connected to Wireless Networking. Nevertheless, it is necessary to know the basics in order to understand chapter 4.

There, a combination of V2PCs and perception will be used to improve the protection of VUs.

Finally, in chapter 5 all the approaches will be summarized and also we will see what future tasks are still left in this area to make it usable in the real world.

Chapter 2

V2P Communication Systems

1. erst das standard zeug
2. dann das mit beacon weil es besser ist
3. am ende noch erwähnen dass es trotzdem noch nicht reicht wegen unpräzisem GPS

The basic idea behind V2PCs is that a driving vehicle (most often a car) and a VU (most often a pedestrian) exchange messages over a wireless network in order tell each other their positions. By doing that, accidents between them can be prevented because both the car driver and the pedestrian can react to the received messages.

There are several approaches to implements such a system and they will be discovered in this chapter.

2.1 With special Device

First, we will look at such communication systems which use a special device for the VU in order to send his messages. In **v2pprotection** and **watchover** such systems have been proposed.

The device from **v2pprotection** can be seen in the bottom of figure 2.1. In the top of figure 2.1 you can see the warning unit that will be installed in the car.

The task of the device for the pedestrian is to periodically send “Hello”-Messages including the pedestrian’s position so that the warning unit in the car can receive those messages and detect a probably dangerous situation. Then the warning unit sets itself into a warning status (which can be seen in figure 2.1).

It is very important that the car driver does not get too many warning messages because otherwise he would loose sensibility for the warning. Therefore, a key issue is to ensure that only warning are created if the distance between car and pedestrian decreases gradually.

Figure 2.1 – The Warning Unit for Cars and the Warning Device for Pedestrians from **v2pprotection**

Figure 2.2 shows the ratio of meaningful warnings divided by the number of all warning which is roughly 50% because in this test scenario only one pedestrian is present. That ratio is not satisfying, but is only because of the low number of pedestrians.

In figure 2.3 you see the same statistics, but for a scenario with 10 pedestrians. Here the same ratio is almost 100%.

hier fehlt noch warum die ratios so sind

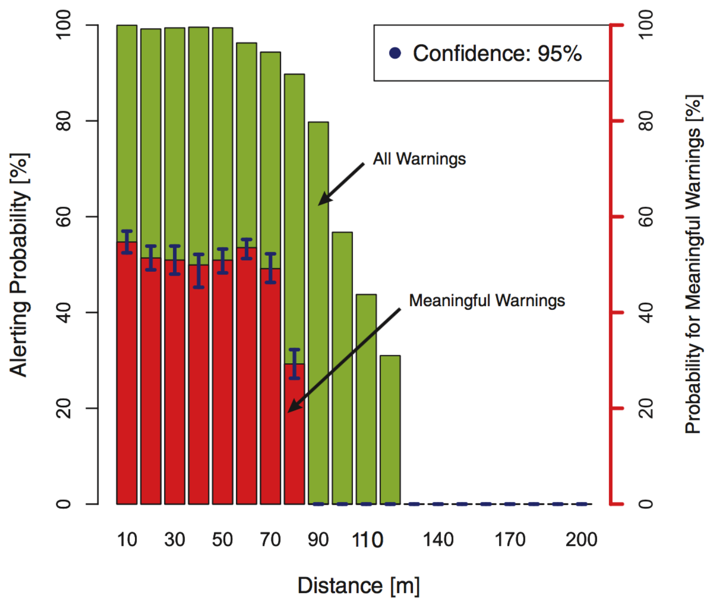


Figure 2.2 – Warning statistics in a test scenario with one pedestrian from **v2pprotection**

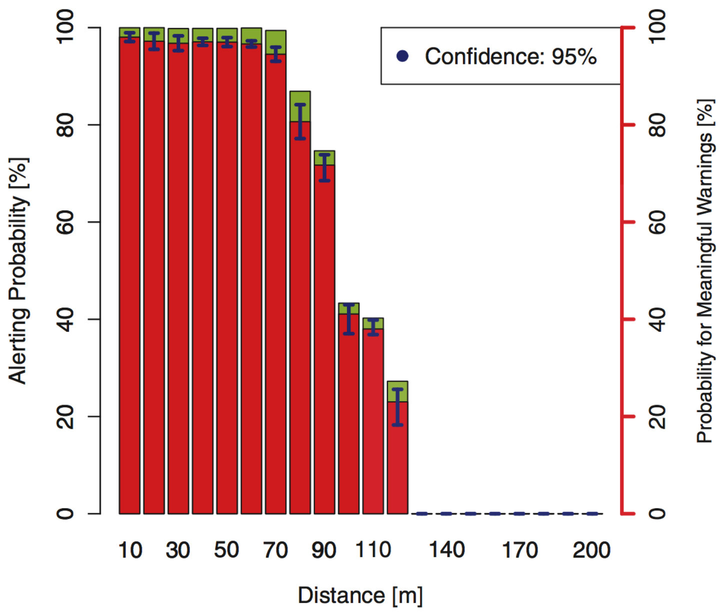


Figure 2.3 – Warning statistics in a test scenario with 10 pedestrians from **v2pprotection**

grafiken noch genauer erklären, vor allem mit der distanz

2.2 Using Smart Phones

In **v2pcomm** another approach has been developed which is based on the same idea as **v2pprotection** but it is more detailed. Moreover, it has the great benefit that no additional device for the VU is needed because in this system a smart phone or tablet will be used as the warning device for the pedestrians.

The approach is more detailed, because it formulates precise requirements that an implementation of a V2PC should have in order to be able to work in reality. The requirements basically boil down to the following: One has to calculate the distance at which the warning messages are to be delivered. In section 2.1 we have already seen that this distance should not be too big, because otherwise too many meaningless warning would be received. But accordingly, the distance must not be too small, because the pedestrian and the car driver must have enough time to react to the messages.

To calculate this distance, the authors of **v2pcomm** have taken into consideration many parameters, e.g. the velocity of the car, the reaction time of the pedestrian, the expected positioning error of GPS (which is approximately 10m), the expected packet transmission time of Wi-Fi and so on. As an example, we take a look at equation 2.1 where the lower bound d_{min} of the distance is written down.

$$d_{min} = v \times (t_p + t_r + t_{tx}) + gnss_{err_{car}} + gnss_{err_{ped}} \tag{2.1}$$

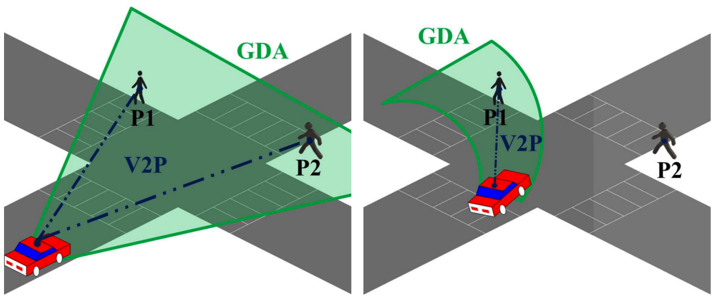
Here v is the car's velocity. Moreover, t_p is the time for perception of the pedestrian, t_r is the reaction time of the pedestrian, and t_{tx} is the packet transmission delay. $gnss_{err_{car}}$ and $gnss_{err_{ped}}$ are the positioning errors of the car and the pedestrian, respectively.

For simplification, we will not look in every detail of this calculation as it is very detailed. But in principle it is crucial to computer a lower and upper bound for the distance at which the warning messages should be sent. Because you can then check whether your system always fulfills these bounds which the system from **v2pcomm** does.

Finally, the distance calculated is 39.5, 52.3, and 72.0 m, when the velocity of the car is 30, 50, 80 km/h, respectively.

Another important concept in this context of when to send warning messages is the so called Geographical Destination Area (GDA). You can understand the concept by considering figure 2.4. In (a) a car is approaching to pedestrians, P1 and P2. As the car is yet far away from P1 and P2 it is possible that both P1 and P2 could be involved in an accidents with the car, therefore both of them are in the GDA.

In (b) the car has already come nearer to P1 and P2 and is currently turning left. Due to that fact, it is no longer possible for the car to approach the position of P2. So, P2 is no longer in the GDA of the car and P2 will not receive a warning message because of the car, only P2 will get one.



(a) Vehicle is moving straight. (b) Vehicle is turning.

Figure 2.4 – The Geographical Destination Area of a moving car at two different points in time, from **v2pcomm**

The GDA of a car will be computed periodically and this makes sure that even less meaningless warning messages will be sent. The GDA can be computed by taking several parameters (e.g. the car's yaw rate) into account.

2.3 Beacon

Chapter 3

Detecting Pedestrians by using Perception

Hier kommt nur ein kleiner Ausblick hin, da es nicht direkt etwas mit Wireless Networking zu tun hat

Chapter 4

Fusion of Perception and V2P Communication

Chapter 5

Conclusion

- summarize again what your paper did, but now emphasize more the results, and comparisons
- write conclusions that can be drawn from the results found and the discussion presented in the paper
- future work (be very brief, explain what, but not much how, do not speculate about results or impact)
- recommended length: one page.

List of Abbreviations

GDA	Geographical Destination Area
V2PC	Vehicle to Pedestrian Communication System
VU	Vulnerable Road User

List of Figures

Todo list