



Opposition Report

**Thesis: Application of Geofence for Safe Interaction
with Emergency Vehicles**

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1 Abstract

The master thesis presented by Tereza deals with the question of the application of geofencing in order to improve the overall safety not only of drivers of passenger vehicles, but also of drivers of emergency vehicles. The thesis also deals with improving the passability of emergency vehicles in order to reduce the overall response time. The problem presented extends to the question of whether the use of in-vehicle HMI can be perceived to have a positive effect on driver behaviour in situations that require interaction between these entities.

To find the answers to the research questions presented in this thesis, several steps were taken. A workshop was carried out with authorities and organizations which expertise on several topics related to this work. The aim of the workshop was to get feedback on the application of geofencing in the interaction between private and emergency vehicles. Furthermore, the use cases were presented and feedback was collected which determined the future use cases tested on a driving simulator.

Another practical part of this thesis was conducting a driving simulator experiment with use cases selected based on the theory and the consultation and feedback from the workshop. A use case of one off-ramp car accident scenario and one urban intersection were simulated on a driving simulator with a respectable number of participants. To gain full understanding from the participants, a questionnaire assessing subjective perceptions of the experiment was collected and evaluated.

The measured data from the experiment and from the questionnaire were evaluated and conclusions were drawn. The findings state that the use of geofencing for those purposes have a positive impact for drivers giving them instructions and informing them about the incoming emergency vehicle. The distraction from driving is not significant, therefore, the use of geofencing is not dangerous. This has been proven by both use cases presented.

2 Chapters evaluation

2.1 Introduction

- Well made!
- Gives nice overview of what is included in the thesis and what to expect
- I have two small problems
 - In the Methodology part (p. 2-3, 1.2) where you summarize the methods in bullet points, I found it a little bit repeating and extra. You give a nice explanation of each method used for different parts of your thesis and then you repeat them again with more information added. Maybe try to merge those paragraphs with those bullet points together?
 - Extend the methodology chapter with a statement that one of the method used was a literature review since you did a little bit of a research in the first chapter. I was missing that there.

2.2 Background and Theory

- Very nicely structured chapter that presents necessary information and background for your work
- In the first section, an overview of accidents involving emergency vehicles is presented in numbers and statistics. An interesting fact you found is that number of accidents involving these vehicles is still in hundreds, which I found quite a lot. That gives you a good basis for this thesis.
- I really liked that you mention factors of accidents between vehicles and emergency vehicles and then the typical environment where those accidents usually happen
- Important information about geofence are presented together with related work and other similar systems working on a similar idea, like Emergency vehicle approaching warning system. Still, I found it a little bit vague since this is the main method you are testing/using.
- You did not forget to define human-machine interaction field with description of used technology. I really liked the recommendations for HMI design on page 11 with a nice summary of most faced problems when designing such system. At the end you provide information about HMI testing and how is it done.
- What I find missing a little bit is whether there was recently some geofencing testing. Is the HMI geofencing testing relatively new? If not, include it in chapter: "HMI Testing"

2.3 Workshop

- Workshop chapter provides information about the workshop with traffic authorities and organizations
- In total 6 entities participated in this workshop where the main topics surrounding geofencing for emergency vehicles were discussed. I found it very helpful for you to talk with these experts about this problem and in the work it can be also seen that you knew what to talk about with them, so good job with conducting an experiment, must had been pretty complicated, but beneficial.
- Second half of the chapter introduces all the use cases designed for this work and which were discussed during the meeting
- Before proposing the use cases, several underlying assumptions and principles are listed for applying geofence in defined use cases
- Then, each individual use case is presented together with description of a geofence location (fixed, moving) and the scenario which would the driver have taken, as well as HMI figure showcasing the visual form of the received warning
- Good that you mentioned all your use cases!
- Feedback from the workshop was collected and results were discussed for each use case. The evaluation from the workshop shows the promising factor for continued research of geofencing, as seen by the participants of the workshop
- I did not find anything what I would have problems with, it was well structured and self-explaining

2.4 Driving Simulator Experiment

- Presented the process of choosing the use cases and their detailed description
- Other information like how were the participants recruited, and what simulator was used are presented as well.
- The procedure explaining how was the experiment conducted with figures, together with collected data give an adequate background for the experiment.
- The Collected Metrics subchapter could be a little bit longer explaining why do you need/use those type of data for evaluation. What is the methodology behind measuring those metrics you used in the work?
- Technical parameters of the equipment and technical specifications about the simulations are missing. I think it should be important to list them since the experiment should be replicable. Add them to the appendix.

2.5 Analysis of Data

- Nicely structured chapter explaining the measured results and gathered information from the questionnaire, very easily presented with scientific approach and evaluation of those results
- A number of 69 participants participated in the experiment which is quite a good sample of respondents

- Discussion about participants' background was presented which gave the necessary information for the experiment's purpose
- Results from use cases show significant results towards geofencing, both groups that received warning reacted accordingly to the shown messages, which is really good!
- The subjective results the participants are inclining towards a good experience and acceptance of having this kind of system in their car, at least for people who experienced the experiment with geofencing
- I was missing a comparison in between participants who drive "Daily". Or according their driving experience question.
- No negative comments about this chapter.

2.6 Discussion and Conclusion

- Very interesting secondary finding about the fact that people do not usually know what to do in such situations and how to react properly according to the traffic and safety rules
- Finally, three questions were presented and answered in conclusion.
- The first question was fully answered on the basis of the findings from the simulator proving the timely and correct reaction of the drivers.
- The second question has been answered. The results confirm the fact that the use of geofencing has an impact on an emergency vehicle and therefore its use reduces the response time. This is supported by the results of the Intersection use case.
- The third question was also answered with claiming the significance of positive attitude from the questionnaire towards receiving geofence instructions in the future when interaction with emergency vehicles

3 Overall Summary

This thesis was very easy to follow, structure of the whole work was very carefully maintained. The purpose of the master thesis was fulfilled and aim was met. Application of knowledge gained from courses and by self-study and research publications was on high level with respect to the best practices of conducting experiments. Not only is the thesis build upon driving simulator experiment, but workshop was carried out to further support the outcomes by opinions from experts. The major contribution can be seen in the fact that there are not many similar experiments dealing with this topic. The work can thus serve as a basis for further scientific research in this area. In terms of formal aspects the work is written in good English with some minor typos and grammar mistakes, not downgrading the overall experience.

Opponent Questions

1. chapter 2.1, page 5: *"Although some differences can be seen between the statistics of different countries and some of them manage to achieve lower accident rates involving emergency vehicles, ..."*
 - What country is the most progressive in this area – achieving lower accident rates? What is their approach?
 - How is it with the Czech Republic and its state regarding the use of geofencing or other measures?
2. 2.2, page 7: *"The term geofence is currently not legally defined"*
 - You stated that the term "geofence" is not currently legally defined. What in your opinion is the biggest reason of not officially defining it on the European level?
 - What must be done in your opinion in order to fully integrate geofencing into the real world? What is the biggest obstacle that prevents geofencing being used in today's cars?
3. chapter 2.2, page 9: Emergency Vehicle Approaching Warning
 - You present EVA as a similar solution to geofencing. What are the main differences between those two systems? Is the difference mainly in the technical part or in the principle of notifying the driver? -> follow-up: Could they be integrated into a one system, and if so, how would you say it would work?
4. Chapter 3.2, page 14: *"The following points highlight underlying assumptions and principles of applying geofence in the presented use cases"*
 - How did you come up with these assumptions? What is it based on?
 - Could you tell which ones are most crucial for conducting your experiment - meaning are there any principles that could be left out while keeping the reliability of the experiment high?
5. Chapter 4.3, page 34: *"A fixed-base driving simulator was used for the experiment"*
 - What led you to choose this type of vehicle simulator method?
 - Have you considered using different vehicle simulator visualization methods (Projection screens, VR headset)
 - What were the technical limitations of the simulator? Did it have an effect on number of tested use cases (only 2)
6. Chapter 4.3, page 34: *VTI simulation software was used to model the driving scenarios*
 - Could you elaborate a little bit more on what simulation environment software was used? You said that the VTI software was used..what are its characteristics?
7. Did your experiment went according your expectations? Did something interesting happen?

8. In table 5.4, page 51: since the p value of Measure "The voice instruction was helpful" was so significant:
 - What sound system were you using?
 - Do you think that if you had used different sound settings and/or tools (like headphones, surround music, etc.), the results would have been different?
9. Chapter 6.1, page 57: *"Some participants mentioned that they would have appreciated a different location for the instructions, e.g., a head-up display or a central infotainment system"*
 - According your observations from the experiment, research and your opinion, should the warning be located on the instrument cluster display or on the display serving as an infotainment panel? Why?
10. Chapter 7, page 60 (RQ3): *"The overall evaluation showed that, on average, drivers found the geofence instructions easy to follow and had no problems trusting the instructions. However, modifications need to be carried out to the HMI of geofence instructions in terms of user friendliness."*
 - Should car manufacturers be in charge of adapting HMI instructions for geofencing, or should there be a similar systemic approach based on EU regulations and standards?