DEGREE PROJECT - OPPOSITION REPORT

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1 OPPOSITION INFORMATION

1.1 Author of the thesis

Mustafa Adnan

1.2 Title of the thesis

Latency-aware edge server for safe autonomous driving

1.3 Name of the opponent

Mustafa Al-Janabi

1.4 Date of the opposition

2021-07-14

2 EVALUATION

2.1 Was it easy to understand the underlying purpose of the project?

The objective of the project was stated explicitly and clearly. The author was aiming to develop two things: 1. An edge server that calculates reachable sets of vehicles on an intersection while taking into account network latency and 2. An obstacle avoidance NMPC controller to achieve safe driving of autonomous vehicles on the intersection. Throughout the thesis, there was no doubt that this was the focus of the project. In other words, the red thread was clear through the entire thesis.

2.2 Do you consider that the report title justly reflects the contents of the report?

For sure. The title used describes the work done in the thesis very well. However, changing the original title "Latency-aware edge server for safe autonomous driving" to also include "using obstacle avoidance nonlinear MPC" may make it clearer for future readers by specifying the control strategy used to achieve safety.

2.3 How did the author describe the project background?

The author described the project background meticulously. The theoretical knowledge needed to understand the work done was described in detail. Each section in the background was thoroughly detailed in a way that made sense to the reader. Furthermore, referencing to the sources was done in a way the made it easy to find further information about a certain topic (more on that later).

2.4 Was there an introduction and general survey of this area?

In the introduction, the author provides an overview of the area of research where the thesis is concerned. Then, he states the problem formulation of the thesis and finishes the introduction by clarifying the scope of the project.

Unfortunately, there is little mention of related work or a general survey of other approaches taken to achieve a solution to the same problem formulation or to similar problems in vehicle autonomy. This would have increased the credibility of the thesis and helped the reader to further appreciate the work done by the author.

2.5 To what degree did the author justify his/her choice of method of tackling the problem?

Through the method description, the author makes sure to provide convincing arguments behind the method choices that were done. For example, the author justifies the choice of the kinematic model by referring to a reference which compared different vehicle models and clearly explains why a certain model choice fits the project more than other available methods. This also holds for the choice of controller where the author states the benefits of using a nonlinear approach. However, the justification for choosing to have an edge server in the first place is missing. This also can be attributed to the fact that a section on related work is missing. Since, perhaps, that would have clarified why this approach makes sense, as opposed to some other network architecture and computational structures. For example, if the communication happens directly between the vehicles and the calculation of the reachable sets are done locally on each vehicle. The choice of having an edge server is not justified.

2.6 Is the method adequately described?

After reading the method, I sense that an independent reader with sufficient knowledge and experience would be able to recreate the work according to the details given in the method. Hence, I conclude that the method is adequately described.

2.7 Did the author present his results clearly and concisely?

The results are presented with well-constructed illustrations and plots. These are then used nicely to convey the results attained by the author.

2.8 Do you consider the author's conclusions to be credible?

In essence, the author concludes that the objective of the thesis was fulfilled. Given the results, this is certainly true. It therefore follows that the author's conclusions are definitely credible.

2.9 What is your opinion of the bibliography? What types of literature are included? Do you feel they are relevant?

The bibliography of the thesis is centered around books, papers and articles about the different topic covered in the report. Looking at the bibliography, it appears to contain all the relevant source information in a correct form. The sources themselves seem to come from well-established literature and peer-reviewed papers from respectable journals. Furthermore, all the references cover a topic that is within the area of the report and all of them are very relevant to the thesis. If anything, I felt like more references would have been needed to improve the quality of the report as sometimes it wasn't clear where some statements originated from. For example, the part in the introduction highlighting the advantages of 5G networks.

2.10 Which sections of the report were difficult to understand?

Most parts were written very clearly and weren't too difficult to follow. The part I struggled the most with was the background. In particular, the section on obstacle avoidance and the section on zonotopes. This could have been circumvented to some degree by slightly clearer writing which doesn't assume too much previous knowledge from the reader. However, the topics are of advanced nature and some different parts will always be challenging depending on the reader's background. In conclusion, I think that the author has done a good job of conveying the important messages of the thesis.

2.11 Other comments on the report and its structure?

In general, the report is well-written with sectionings that make sense and aid the reader's comprehension. However, the report needs to go through some spell checking and refined rewriting on some of its passages. Furthermore, it suffers from punctuation and conjugation inconsistencies. As the content of the report itself is of high quality, taking care of these small details would increase the quality of the report dramatically.

The author will be provided with a separate document highlighting the inconsistencies I found in detail.

2.12 What are the strong aspects of the work/report?

The quality of the work done and the attention to detail mark the major strengths of this thesis. It is clear from the background that the author has thoroughly explored the theoretical knowledge needed to its smallest detail. The benefits of that are then reflected in the quality of the method and the results.

2.13 What are the weak aspects of the work/report?

All room for improvements have already been discussed. In summary, although the flow between the sections in the report are well done and the red thread is clear, the writing within each section suffers from linguistic errors with some expression that interrupt the flow of reading. Furthermore, the missing information on related work mark a weak point of the thesis.

In addition, I found the abstract to be a bit too long. The author might want to consider starting with a broad overview, then briefly discuss what is done in the thesis and, lastly, end with a summary of the results. The current abstract goes into too many details.

2.14 What is your estimation of the news value of the work?

Given the objective of the report, the thesis holds high news value for anyone looking for an implementation of a latency-aware edge server. However, since the problem is confined to simulation with a problem formulation that only involves two vehicles in a very specific scenario, it doesn't hold a high news value for the field of intelligent transport systems as a whole. That said, the thesis definitely provides a major stepping stone for further work and development in the field.

2.15 Summarize the work in a few lines.

The work provides a solution to a scenario where two vehicles end up with overlapping trajectories on an intersection due to a blocking obstacle in the path of one of the vehicles. This is done by providing each vehicle with an obstacle avoidance nonlinear MPC controller that communicates with an edge server which calculates the reachable sets for each vehicle while taking into account the communication latency.

2.16 Questions to author that could be asked at the seminar (please list ca. six questions)

1. How could this work be extended to other situations and scenarios with more than two vehicles?
2. How does the computational complexity increase with the number of vehicles, in other words, what is the computational bottleneck of the implementation?
3. Why did the results for the vehicles in case 2 of the simulation (with the same latency on both vehicles) fail to find a trajectory where each vehicle could pass the obstacle safely?
4. Can you describe the Box methods and the PCA methods?
5. Do you know any related work or other approaches to solve this problem or similar problems?
6. What does the value t_{margin} refer to and how is it chosen?
7. How would an edge server work if each vehicle had a different dynamical model, weight and other parameters?
8. Can you clarify what is meant by G-representation or H-representation?
9. Is it possible to extend this approach to dynamic obstacles? If yes, how?
10. In the abstract it is stated that "autonomous vehicles, that have intersecting paths, enter into unsafe situations if a smart edge server is not considered", how were these results obtained?

2.17 What is your concluding assessment of this Master's project?

It has been an honor to be an opponent for this Master's project. The work holds a very high quality and the attention to detail, both in the theory and implementation, permeates the thesis throughout. The red thread is kept throughout the report and the author provides a nice solution to the initial problem that was formulated.