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Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Aleksei Postnikov

PhD Program: Computational and Data Science and Engineering

Title of Thesis: Towards seamless autonomous navigation in dense urban environments

Supervisor: Associate Professor Gonzalo Ferrer

Name of the Reviewer:

I confirm the absence of any conflict of interest	**Date: 16-09-2024**

The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.

If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.

Reviewer's Report

Reviewers report should contain the following items:

- Brief evaluation of the thesis quality and overall structure of the dissertation.
- The relevance of the topic of dissertation work to its actual content
- The relevance of the methods used in the dissertation
- The scientific significance of the results obtained and their compliance with the international level and current state of the art
- The relevance of the obtained results to applications (if applicable)
- The quality of publications

The summary of issues to be addressed before/during the thesis defense

A brief evaluation of the thesis quality and overall structure of the dissertation: *The thesis presents a detailed investigation into the challenges of autonomous navigation in dense urban environments. It is organized into seven chapters, each focusing on a specific contribution and accompanied by experimental evidence. While the structure is generally clear, the number of chapters may feel excessive, with some overlap in content that could have been consolidated for greater clarity and conciseness. The work highlights the author's engineering advancements and provides a comprehensive overview of the current state-of-the-art. However, a more streamlined approach might have enhanced the overall coherence and focus of the dissertation.*

The relevance of the topic of the dissertation work to its actual content: *The thesis topic is highly relevant to the dissertation's content. The thesis thoroughly addresses the complexities of navigating dynamic, densely populated urban areas, focusing on key challenges such as predicting human behavior, obstacle avoidance, and trajectory planning. The work aligns well with the stated goal of seamless navigation, exploring various techniques to improve safety and decision-making in autonomous systems. The chapters provide concrete contributions toward enhancing motion prediction and path planning, which are central to achieving seamless navigation. However, while the research addresses significant aspects of the topic, the breadth of approaches explored could have benefited from a more concentrated focus on integration and real-world application in dense urban settings.*

The relevance of the methods used in the dissertation: *The methods employed in the dissertation are highly relevant to the challenges of autonomous navigation in dense urban environments. Moreover, they are close to those presented in the state-of-the-art literature on the topic. For example, we consider specifically chapter 6, There, the use of cross-attention mechanisms and transformer-based architectures allows for effective processing of complex, multi-modal input data, including trajectory history, environmental context, and agent interactions. These methods are well-suited for predicting human motion, particularly in dynamic settings where the behavior of multiple agents must be considered. The integration of bird's-eye view (BEV) images and the use of positional encodings to preserve temporal information further enhance the model's ability to make accurate and context-aware predictions. The two-step decoding process, which separately predicts goals and trajectories, reflects a thoughtful approach to handling the inherent uncertainty in human motion prediction. So, the methods are well-aligned with the objectives of achieving seamless and safe navigation, offering robustness and adaptability in real-world scenarios, advancing existing approaches, being suitable for the considered thesis.*

The scientific significance of the results obtained and their compliance with the international level and current state of the art: *The scientific significance of the dissertation lies in its contributions to improving motion prediction in autonomous systems, particularly in dense urban environments. The thesis introduces advancements such as CovarianceNet for uncertainty characterization and a transformer-based approach for trajectory prediction, addressing key challenges like overconfidence in existing models. The work further develops goal-conditioned trajectory generation and integrates cross-attention mechanisms, enhancing predictive accuracy and robustness. These innovations align with the international state of the art and contribute valuable insights into improving the safety and reliability of autonomous navigation in complex, real-world scenarios.*

The relevance of the obtained results to applications (if applicable): *The results obtained in the dissertation are highly relevant to practical applications in autonomous navigation and*

robotics. The advancements in human trajectory prediction, particularly through uncertainty-aware models and cross-attention mechanisms, have direct implications for improving the safety and efficiency of autonomous vehicles in urban environments. These methods enable more accurate prediction of pedestrian and vehicle movements, which is crucial for collision avoidance and decision-making in real-time. Additionally, the techniques developed for trajectory optimization and goal-conditioned motion planning are applicable in robotics, where safe and efficient navigation in shared spaces is essential. Overall, the results are well-suited for integration into real-world autonomous systems, contributing to advancements in both transportation and service robotics.

The quality of publications:

The publications' quality aligns with the requirement of PhD degree.

The summary of issues to be addressed before/during the thesis defense:

1. *The abstract does not have a flow, being a list of items with small paragraphs that are not very connected. A better structure is expected.*
2. *The thesis mentions seven objectives, which is too much. The research should focus on the part of these contributions that are the most significant and connected. You should also state a clear research goal with the objectives supporting it. A good idea is to create a picture that schematically illustrates your research.*
3. *Given the size of chapters in the literature review, they should be paragraphs.*
4. *More attention is required to the text structure. E.g. in the chapter 7.1. paragraphs seem to repeat each other instead of following the general structure of the introduction with a general application description, existing works, the gap and the proposed solution flow.*
5. *These shortcoming are relevant to the presentation as well, and should be taken into account to make the thesis better.*

Provisional Recommendation

☐ *I recommend that the candidate should defend the thesis by means of a formal thesis defense*

+ I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report

☐ *The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense*