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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: Dmitry Yudin**

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| I confirm the absence of any conflict of interest<br><br>(Alternatively, Reviewer can formulate a possible conflict) | <br>**Date: 25-08-2024** |

*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

- **Brief evaluation of the thesis quality and overall structure of the dissertation.**

In general, the dissertation is completed with a sufficient level of quality, the structure of the dissertation contains all the necessary sections:

- Introduction and Conclusion;
- Literature review;
- Six sections with original methods and algorithms developed by the author, each of which contains subsections Motivation, Method Description, Evaluation, Results and Conclusion:
    1) Uncertainty Prediction in Model-Based Motion Prediction,
    2) Hybrid Approaches to Uncertainty Modeling,
    3) End-to-End Trajectory Prediction with Transformers,
    4) Attention-Based Human Trajectory Prediction,
    5) Enhancing Motion Prediction with Generative Models,
    6) Integrating Trajectory Optimization with Deep Learning.

All these sections are directly related to the general topic of the dissertation.

- **The relevance of the topic of dissertation work to its actual content**

Seamless autonomous navigation in dense urban environments is a relevant modern topic. The dissertation presents a set of methods and algorithms developed by the author, which is directly related to this topic and relevant to it.

- **The relevance of the methods used in the dissertation**

In the dissertation, the author describes novel and practically useful methods developed with his participation:

- The author developed the HSFM-ΣNN method (2020, ICRA Workshop paper) that merges traditional modeling with neural networks for motion prediction. This approach overcomes the limitations of classical covariance estimation methods, showing better accuracy and efficiency compared to earlier models like social-LSTM.
- The author proposes the CovarianceNet method (2021, IROS paper), which is designed to improve motion prediction methods using uncertainty. This model uses a conditional generative approach to more accurately predict the uncertainty in future movements, addressing the issue of overconfidence found in many existing methods.
- The author proposes Transformer-based Trajectory Prediction (2021, NeurIPS workshop paper). Exploring transformer neural networks, the author developed a technique that stands out for being both simple and effective, which allowed him to take the first place in the 2021 International Shifts Vehicle Motion Prediction Competition. This method proves the adaptability of transformers in facing the variable challenges of motion prediction.
- The author proposed method for conditioned human trajectory prediction (2022, ICRA paper). He introduced a model that uses attention mechanisms and transformers to predict human movement efficiently. This model matches the performance of more complex systems without requiring intricate architectural elements.
- The author took part in the development of the DDPEN method (2022, IROS Workshop paper) to address local minima challenges in trajectory optimization, aiming for smoother robot navigation. Utilizing synthetic data for training, this model demonstrates its capability to navigate a round various obstacles efficiently.
- The author has developed a method for integrating uncertainty estimation into robot navigation using Model Predictive Control (MPC) (2023, ECMR paper).

- **The scientific significance of the results obtained and their compliance with the international level and current state of the art**

The author demonstrated high quality metrics for the developed methods and algorithms, which possess scientific novelty and, in some cases, exceed the state-of-the-art solutions.

- **The relevance of the obtained results to applications (if applicable)**

The obtained results are convincing and reproducible, since all developed models and methods were tested on open datasets collected from real unmanned vehicles and mobile ground robots. Their potential for application to real navigation systems is high.

- **The quality of publications**

The quality of publications is sufficient, including the author has a number of publications at leading international conferences IROS and ICRA, which emphasizes the significance of the results obtained.

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

In general, the dissertation contains the results of successfully conducted scientific research independently obtained by the author, which have a high potential for practical application.

There are a number of comments on the work:

1) The structure of the dissertation has several separate sections that seem independent of each other (in terms of the formulation of problems and the symbols used). During the defense of the dissertation, it is recommended to clearly reflect the connection between these sections.

2) Some key sections of the dissertation mention solving problems related to object motion prediction, while the title of the dissertation "Towards seamless autonomous navigation in dense urban environments" does not explicitly mention this. It is recommended to clearly note the connection between the conducted research and the chosen title of the dissertation during the defense.

3) The References section of the dissertation lacks a number of references to sources mentioned in the text, for example, Coinbot: Intelligent Robotic Coin Bag Manipulation Using Artificial Brain. During the defense, it is recommended to clearly and correctly indicate references to publications in which the author participated.

In general, these comments do not call into question the novelty, significance and usefulness of the results obtained. A dissertation is an independently completed scientific study with novelty, and its author deserves to be awarded the degree of candidate of sciences.

**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*