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Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Mikhail Kurenkov

PhD Program: Engineering Systems

Title of Thesis: Neural field-based optimal motion planning method for differential drive robots with nonholonomic constraints, robots in dynamic environment and swarm of robots

Supervisor: Associate Professor Dzmitry Tsetserukou

Name of the Reviewer: Tatiana Podladchikova

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Date: 27-10-2024**

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 thesis is well-structured and meticulously documents the motivation, background, methodology, and experimental validation of the proposed Neural Field Optimal Motion Planner (NFOMP). It begins with a comprehensive introduction to challenges in optimal motion planning, followed by a literature review, and a detailed breakdown of the research questions. The writing is clear and informative, though the extensive technical detail may benefit from additional summarization to support broader comprehension.

- **The relevance of the topic of dissertation work to its actual content**
  The topic aligns closely with the content and meets current demands in robotics, focusing on enhancing motion planning for differential-drive robots in complex environments. The research directly addresses known limitations in existing motion planning techniques, such as handling U-

shaped obstacles, dynamic environments, and multi-robot systems, and aligns well with the goal of advancing autonomous robotics applications.

- **The relevance of the methods used in the dissertation**
  The methodological approach of using neural fields for adaptive obstacle modeling and real-time trajectory optimization is innovative and well-suited to the challenges outlined. NFOMP's adaptation of CHOMP and incorporation of Lagrange multipliers for non-holonomic constraints demonstrates a solid grasp of both classical and contemporary techniques, with enhancements that improve path smoothness and computational efficiency.

- **The scientific significance of the results obtained and their compliance with the international level and current state of the art**
  The dissertation makes a meaningful scientific contribution by presenting an adaptive neural field approach, which is validated against state-of-the-art methods such as CHOMP and GPMP2. The proposed method's superior performance in terms of path smoothness and efficiency under non-holonomic constraints marks it as a valuable addition to the field, particularly for applications in dynamic and swarm robotics.

- **The relevance of the obtained results to applications (if applicable)**
  The results hold strong potential for practical applications, particularly in environments where real-time motion planning and adaptability to dynamic obstacles are critical. The extensions of NFOMP for multi-robot coordination in warehouse scenarios and drone formations further emphasize its applicability in industrial robotics, logistics, and autonomous navigation.

- **The quality of publications**
  The author's research has been published in IEEE Robotics and Automation Letters and presented at prominent robotics conferences, affirming the quality and recognition of the work within the scientific community. The breadth of publication topics, from path planning algorithms to visual localization, reflects a robust and well-rounded research portfolio.

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

1) **Further clarification on model limitations:** While NFOMP is well-documented, a more explicit discussion on its potential limitations, especially in highly cluttered or unpredictable dynamic environments, could enhance the robustness of the thesis.
2) **Additional experiments in real-world scenarios:** If feasible, results from real-world testing or simulations more closely mimicking real-world environments would strengthen the application relevance.
3) **Consideration of computational constraints:** Given that NFOMP is computation-intensive, a clearer analysis of its feasibility on resource-constrained hardware, such as embedded systems, would be beneficial.
4) **The abstract** would benefit from a clearer, more precise statement of the problem, highlighting the novelty, relevance, and central positions of the research to strengthen its impact and set a well-defined context for defense. Likewise, **the conclusions** could be refined to explicitly underline the achievements, with an emphasis on the novelty and broader implications of the results for the field, ensuring that the contributions and outcomes are well-positioned within the landscape of contemporary robotics research.

In summary, this thesis provides a substantial contribution to optimal motion planning, especially for complex robotic applications. Addressing the noted issues would further enhance the impact and applicability of the research.
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*