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Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Viktor Rakhmatulin

PhD Program: Engineering Systems

Title of Thesis: DNN-driven robotic system for automatic charging of electric vehicles in complex lighting conditions and human presence

Supervisor: Associate Professor Dzmitry Tsetserukou

Name of the Reviewer: Jiwen Lu

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Date: 12-11-2024**

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

Overall Recommendation:

This thesis is a new contribution to the field, addressing key challenges in autonomous EV charging and human-robot safety. I recommend it for acceptance, pending minor revisions that would enhance the depth of the literature review, robustness in methodology, and practical insights on scalability and long-term reliability.

1. Scope and Originality

The thesis explores a timely and relevant issue in robotics and autonomous systems, focusing on an automatic charging system for Electric Vehicles (EVs) that operates under complex lighting conditions and ensures safety in human-robot interactions. This focus on enhancing plug-in accuracy under varied conditions and safety mechanisms for human presence reflects a solid contribution to the fields of robotics and human-robot interaction (HRI). The research questions are well-articulated, aligning with significant gaps in current autonomous EV charging solutions.

2. Literature Review

The thesis provides a comprehensive review of relevant literature, particularly in pose estimation and safety approaches in HRI. The examination of classical and learning-based methods, as well as safety standards like ISO/TS 15066, demonstrates a deep understanding of the state of the art. However, a more detailed discussion on the limitations of specific existing methods in complex outdoor lighting conditions would enhance the depth of the review, establishing a stronger foundation for the research gap this thesis aims to address.

3. Methodology

The methodological framework is well-structured, involving both pose estimation and safety enhancement mechanisms. The decision to employ a Deep Neural Network (DNN) for pose estimation with an automatic annotation method is a particularly innovative approach to address lighting and feature complexity. The methodology for testing safety through haptic and non-wearable air pressure feedback systems is also highly relevant and demonstrates the author's commitment to addressing real-world deployment challenges.

The robustness of the approach could be further evaluated by considering additional, uncontrolled lighting conditions, such as sudden changes in lighting or high-reflective surfaces. Including these would offer insights into how well the system can adapt in diverse, dynamic outdoor environments.

4. Experimental Design and Results

The experiments are well-designed to assess both the Insertion Success Rate (ISR) and safety aspects of the proposed system. The reported success rates of 97.5% for plug-in accuracy and the demonstrated improvement in safety distances indicate that the system performs effectively under laboratory conditions. The ablation studies and comparative results add value by isolating the contributions of different system components.

One limitation is the limited discussion on system performance over prolonged usage or in large-scale deployments. Adding data on system reliability over extended periods and potential challenges during long-term operation would add further practical insights.

5. Contributions and Impact

The thesis makes several noteworthy contributions, including a reliable DNN-based pose estimation approach and a novel haptic feedback safety system for HRI. The development of a non-battery-dependent feedback system for human-robot safety interactions is a notable addition to the field, addressing a crucial gap in safety for untrained users. These contributions are highly valuable and have strong potential for future applications in autonomous systems for urban settings.

Future studies could explore system scalability, especially in urban settings with multiple robots or more complex human activity around charging stations. Analyzing the scalability of the proposed system will determine its feasibility for broader urban deployment.

6. Writing and Structure

The thesis is well-organized, with clear articulation of research objectives, background, methodology, and results. The writing is generally clear and professional, with detailed descriptions of experiments, results, and statistical analyses. Minor language enhancements and additional explanations for technical terms would improve readability, especially for a non-specialist audience.

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*