Skoltech

Skolkovo Institute of Science and Technology

Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Daria Trinitatova

PhD Program: Engineering Systems

Title of Thesis: Development of a wearable interface with multimodal haptic feedback for intuitive VR-based teleoperation

Supervisor: Associate Professor Dzmitry Tsetserukou

Name of the Reviewer: Assistant Professor Yuhua Jin (CUHK-SZ)

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	Yuhua Jin **Date: 12-06-2024**

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

The doctoral thesis represents a robust and well-structured scholarly work that addresses significant challenges in the realm of human-computer interaction and robotic teleoperation. The thesis is well-aligned with its stated objectives, efficiently bridging the theoretical framework with practical applications and experimental validation.

Evaluation of Thesis Quality and Structure:

- The structure of the thesis is coherent and logically sequenced, progressing from a clear statement of the research problems to the detailed presentation of the developed solutions and their evaluation. This progression ensures that the reader can easily follow the rationale and impact of the research. The dissertation is comprehensive, incorporating extensive reviews of relevant literature, detailed descriptions of experimental setups, and thoughtful discussions of results.

Relevance of Dissertation Topic:

- The topic of the dissertation is highly relevant to current technological needs and scientific inquiry, addressing critical gaps in the field of teleoperation by integrating multimodal haptic feedback into VR environments. This integration is aimed at improving the intuitiveness and effectiveness of remote operations, a subject of increasing importance in robotics and remote handling systems.

Relevance of Methods Used:

- The methods employed in the thesis, including the development of novel wearable haptic interfaces and the use of VR technology, are aptly chosen and represent current best practices in the field. The experimental approach is solid, involving user studies that provide valid and reliable data supporting the thesis's claims.

Scientific Significance of Results:

- The results of the thesis have significant scientific implications, as they advance the understanding and implementation of haptic feedback in teleoperation. The research meets international standards of innovation and contributes new knowledge that enhances the state of the art. The integration of tactile feedback with VR not only addresses existing limitations in teleoperation systems but also opens new avenues for research and development.

Relevance to Applications:

- The practical applications of the research are evident and well-articulated, showing potential for significant impacts in areas requiring precise and safe remote operations, such as surgery, hazardous environment intervention, and complex industrial tasks. This relevance ensures that the thesis is not just academically significant but also of substantial practical value.

Quality of Publications:

- The publications derived from this thesis are of high quality, as evidenced by their acceptance in reputable, peer-reviewed international journals and conferences. This external validation supports the credibility and scientific rigor of the research conducted.

Issues to Address Before/During Thesis Defense:

Before or during the thesis defense, it would be prudent to address certain areas for enhancement:

- Multi-point Stimulation for DeltaTouch:
  The current design of the DeltaTouch provides single-point stimulation, which, while effective, could be enhanced to offer multi-point stimulation. This improvement would significantly expand the interface's functionality and versatility, enabling it to more accurately simulate complex tactile environments. Multi-point stimulation could provide richer information transfer and enhance spatial perception, which is crucial for complex or precision tasks. Discussing this potential enhancement during the thesis defense would encourage the candidate to consider the technical feasibility and potential challenges of such an improvement.
- Latency Issues in Visual and Haptic Feedback Integration:
  Another critical aspect pertains to the latency between visual recognition and haptic feedback. This is especially pertinent in systems aiming for high precision and real-time responses, such as those used in teleoperation. Delays can affect not only the accuracy of operations but also user experience and system reliability. Addressing this issue during the defense could prompt further research into detailed analysis and optimization of system response times. Additionally,

discussing potential solutions, such as more efficient signal processing algorithms or hardware enhancements to minimize delays, would be crucial.

- Possibility of Integration with Additional Sensory Modalities:
  Expanding the system to integrate more sensory modalities such as auditory, olfactory, and even gustatory feedback could significantly enhance the overall immersion and effectiveness of the teleoperation system. By incorporating these additional senses, operators could not only see and feel but also hear, smell, and potentially taste the environment in which the robot operates. This would provide a multi-sensory experience that mimics human sensory interactions more closely.

Including these points in the defense discussion would not only demonstrate a thorough understanding of the thesis content but also contribute significantly to advancing the field. Furthermore, these discussions may lead to new research questions, providing direction for subsequent work and potentially opening up new avenues for technological innovation and improvement.

Conclusion

In conclusion, considering the comprehensive nature, scientific contribution, and practical relevance of this thesis, I thereby highly recommend that Daria Trinitatova should defend the thesis by means of a formal thesis defense. The aforementioned issues should be considered as points for discussion rather than impediments, providing depth to the defense session and offering a platform for showcasing the thoroughness of the candidate's research approach.

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*