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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:

I confirm the absence of any conflict of interest	**Date: 31-05-2024**

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

The thesis titled "Development of a Wearable Interface with Multimodal Haptic Feedback for Intuitive VR-Based Teleoperation" aims to develop and study the impact of a wearable haptic interface in conjunction with a VR system, to enhance teleoperation quality (quote from 1.4, page 20).

This goal can be broken down into three objectives, based on reviewer's understanding:

1. Development of the wearable haptic interface

2. Its implementation in teleoperation with a suitable (or even better) control scheme

3. User study to evaluate its impact on task performance.

The thesis aligns with these objectives somehow, though item 1 takes several chapters while item 2 not very visible. The research motivation is valid, with some scientific significance, though this could be highlighted more clearly. The results are relevant, but could be detailed further. The publication quality is high, but it focuses mainly on haptic device design. As my background is in robotics, I would be particularly interested in the link between item1) and 2) and a controller. Unfortunately, this aspect has not been discussed in detail.

I have summarized some issues below for consideration before the defense:

Chapter 2: In section 2.1, it would be beneficial to have figures illustrating the different tactile sensors for fingertips and palms. Figure 2-1 only shows a few examples of mechanical stimulation devices for fingertips, while other technologies are mentioned without visual aid. This applies to tactile sensors for other body parts as well. In short, a comprehensive figure showcasing all techniques and designs would help readers understand their pros and cons more intuitively.

Chapter 3: Considering the variety of tactile sensors introduced in Chapter 2, what are the pros and cons that inspired the development of vDeltaGlove in Chapter 3? What are the use cases for different interchangeable end-effector modules? Is Fig. 3-11 supposed to be non-symmetric, given that it is a map of a human palm? What is the relationship between DeltaTouch/FiDTouch and the Glove? Figure 5.3 should be introduced earlier.

Chapter 4: More details could be added regarding the remote control of the robot arm, and position-position/position-velocity modes. Are both controllers activated alternately online? It would be meaningful to connect the haptic signal (the author calls the signal are multimodal) with the robot arm control modes, such as the velocity control mode.

Chapter 5: vDeltaGlove only uses DeltaTouch. What does "multimodal" haptic feedback refer to? In section 5.3.3, only linear velocity is considered, not angular velocity (changing the orientation). This might affect the selection of the tackle signal and control effectiveness.

The entire architecture of the these could be improved, as a lot of small components are weakly linked and not consistent (such as the haptic device used for introduction and experiments). At the moment, introduction level of content takes major space of each chapter while the key scientific parts are hidden or invisible.

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*