Skoltech
Skolkovo Institute of Science and Technology

Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Evgeny Tsykunov

PhD Program: Engineering Systems

Title of Thesis: Human-swarm interaction for the guidance and deployment of drones using impedance control and tactile feedback

Supervisor: Associate Professor Dzmitry Tsetserukou

Name of the Reviewer:

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Signature:**  **Date: 14-01-2021**

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

Brief evaluation of the thesis quality and overall structure of the dissertation

The dissertation deals with the Human-Swarm-Interaction. An approach for control of swarm of drones was developed, implemented using micro drones and evaluated in different flight experiments. The motion control of drone formation as well as the interaction with the human operation by means of small vibrators were investigated. The presented research work is well structured and divided into the three topics or, as formulated by the author, into the three research questions: how to control the movement of the group of drones, how to provide the high dimensional state of the swarm to the operator and how to support the deployment of micro-quadrotors using tactile feedback. The author combines these three different topics into one application making the developed particular solutions as parts of one single system. In my opinion, such structure of the thesis makes sense. The proposed solutions for the first two research questions can

be applied not only to micro-quadrotors but also to general multi agent systems. The solution for the third research question relates mostly to micro-quadrotors.
The overall structure of the dissertation and the presented materials are well written and easy to understand. Several important results were achieved and are properly presented. The quality of the dissertation is very good.

The relevance of the topic of dissertation work to its actual content
The presented work matches the topic of dissertation. In chapter 3, the goals of the research work are well described and the applied methods as well as the achieved results are well summarized. In the following chapters the methods and results are described in more detail.

The relevance of the methods used in the dissertation
In the dissertation, the usage of well-known methods, impedance control and potential fields are combined with novel ideas for control of drone swarms or, in general, for HIS. Especially, I like the idea of using finger vibrators to represent the state of a multiagent system. The candidate made a very good choice of methods to achieve the results corresponding to the formulated goals in given time and with available resources. I would like to highlight the large amount of experimental work performed during the research which guided the author to interesting results and increases the confidence in the presented conclusions.

The scientific significance of the results obtained and their compliance with the international level and current state of the art
The obtained results are at the current international level and provide valuable contribution to the current state of the art. The results were published in high-ranking international journals and at conferences.

The relevance of the obtained results to applications (if applicable)
Many tasks or jobs executed today by one or two drones can be executed in a more efficient way by a swarm of drones. Therefore, the achieved results will be relevant for the real-world applications. Some of the examples for such applications are tracking of multiple targets at different locations, taking measurements at different locations at the same time, fast mapping of the environment.

The quality of publications
The publications are of high quality. The publications were made in well-known, high-ranking conferences and journals. The number of publications is over the average.

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*