

Jury Member Report – Doctor of Philosophy thesis.


Name of Candidate: Ivan Kalinov

PhD Program: Engineering Systems

Title of Thesis: Development of a heterogeneous robotic system for automated inventory stocktaking of industrial warehouse

Supervisor: Associate Professor Dzmitry Tsetserukou

Name of the Reviewer: Jun Miura

<p>I confirm the absence of any conflict of interest</p> <p>(Alternatively, Reviewer can formulate a possible conflict)</p>	<p>Signature:</p>  <p>Date: 18-11-2020</p>
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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

Summary:

The thesis describes the development of a team of heterogeneous robots (UGV and UAV) for automated inventory stocktaking. The author analyzed the current status of the stocktaking and raised relevant research questions to pursue. The overall structure of the thesis is good. Analysis of critical factors using reference models is interesting. The author has developed an excellent engineering system for the purpose (automated stocktaking).

The two main methods developed in this research are (1) a robust UAV localization and control using IR markers, and (2) a robust barcode recognition system. These methods are developed by appropriately combining various existing techniques and shown to be effective in real settings.

The work has been presented in a journal and a conference with a good reputation level in this area. Getting a patent is also a good point.

Possible improvements:

Presentation:

- Related robotics and computer vision technologies cited in Sec. 2.6 should be organized using subsections based on the types of technologies (e.g., UAV control, path planning, SLAM, object recognition). Please summarize what technologies are necessary for the specific applications (automated stocktaking) at the end of this subsection.
- Why do you use the abbreviation URG for Unmanned Ground Robot? For the consistency with UAV, 'UGV' (unmanned ground vehicle) looks appropriate ("UGR" is actually used in Fig. 5-7).
- About the notation of citation of papers, [Grisetti et al., 2010] (both in the parentheses) looks better than "Grisetti et al. [2010]".

Methods:

- What is the strategy for covering all the areas of a warehouse? How do the heterogeneous robots operate collaboratively? There is a description of the sequence of robots' movements in p. 134. If this is the strategy, this should appear earlier in the section describing the method(s), not in the section describing experimental results.
- Please describe why you use a segmentation method (U-net) for barcode detection instead of detector-type methods such as SSD.

Experiments:

- Please assess the quality of the generated map by SLAM (e.g., Fig. 5-1).

Since UAVs have a barcode detection ability, the X and Y direction's precise localization may not be necessary. Please describe clearly the required accuracy in localization and assess the experimental results for it. This assessment is also related to showing the advantage of a heterogeneous robot team over a team of (homogeneous) UAVs.

- I do not fully understand the "Localization improvement with active perception." The active perception is for locating the UAV to an appropriate position for barcode recognition. In this case, the absolute localization (in the world coordinate system) does not matter very much. However, in Sec. 7.3.2, the IR-based localization and the active perception-based localization are compared. What does this result show?

- The third objective of the thesis (p. 69) is to ensure a long operating time of the system in terms of repeatability of experiments. Did you conduct experiments to show that?

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