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Skolkovo Institute of Science and Technology

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:

I confirm the absence of any conflict of interest	Signature:
	Date: 23-11-2020

Reviewer's Report
PhD thesis reports on Heterogeneous Robotic System for Automated Inventory Stocktaking of Industrial Warehouse. This work includes a number of contributions which makes it non trivial to understand what is the main thesis research contribution and what research problem has been addressed. Obviously, the author has made great efforts to develop the heterogeneous system, but there is a lack of research - the thesis looks like a commercial solution. I would recommend to focus on research, research methods, detailed analysis of the state-of-the-art and discussion of the obtained results with respect to existing solutions.   The quality of publications is fine.   Below I summarize my comments and recommendations.   Abstract. It is hard to follow Abstract. The thesis includes too many contributions that it is hard to understand how are they connected and address the problem as well as what is the exact scientific value of this work.

I strongly recommend to follow this framework when preparing Abstract:

- Context (describes the general area of your research). It is well done.

- Problem (what is the problem you address in this thesis). Seems like the problem is navigation in indoor environment.

- Existing solutions (try to briefly overview existing solutions so that the readers could make an inference on your contribution and novelty).

- What is your solution to address the Problem?

- What is the thesis contribution and novelty?

- What are your key achievements? Discuss some important quantitative results of your research.

Please make sure you follow the rule '1 paragraph = 1 message'. Please re-write Abstract - it must sound as a story line.

p.22, Method 3 - 'manned UAV' = manned Unmanned Aerial Vehicles. 'Manned Unmanned' sounds like an improper phrase.

Section 1.2.5 - 'The main limitations of the stocktaking are the presence of errors...'. Which errors are you referring to? Please specify.

Section 1.3 - Why do you need to calculate the UAV global coordinates via the URG coordinates? Which 'well-known' methods do you use for the URG global coordinates calculation.

Same paragraph: 'In addition, my method does not imply... ' - you have not formulated your method yet. In next paragraph you switch to the problem of bar code scanning. What is the actual problem of UAV localization - is it the localization in space? As far as I understand, you get XY coordinates from the UGR and Z coordinate from the bar codes. What is about wireless technologies for localization, e.g. UWB secures accurate localization. Is a bar code scanning the only option?

Also, you do not need to provide the solution in this section - this section is about Problem. Please break down the problem and discuss it in more details, so that it would be clear what is the exact problem you address in your thesis.

Introduction - What is the exact contribution (move Section 8.2 in Intro) and novelty of your thesis (it is described later on p.68, but must be in Intro)? What do you put on top of the state-of-the-art? I strongly recommend to discuss it in Intro.

Section 2.2 - I hope you are aware of the point that a PhD degree is the academic degree. It is not an engineering/commercial/marketing project - it is about research. I am surprised that the first requirements are identified by a company.

I do not see Literature review. I found just about 6 pages (pp. 54-59). Please make sure that a PhD thesis is about research and it is a good practice when the structured literature review comprises up to 30% of the thesis. Market review etc. is a nice add-on, but not the main part of literature review. Carrying out the literature review helps one to make the conclusions on the novelty and the gap(s) in the state-of-the-art. If the problem is localization you might want to consider various methods based on RFID, UWB, ZigBee, FM radio, video cameras, methods for data processing/analysis, optimization methods, etc.

p.68 - 'The main research issue will be just to study the impact of the proposed system on the stocktaking process'. I am puzzled with this statement.

'Main Research question: How autonomous heterogeneous robotic system will improve quality of stocktaking and decrease it's duration?'. Sounds like the robotic system is not the goal of this work.

I would recommend to title section 3.4 as 'Thesis goal and objectives'. Almost all listed objectives are technical - what are the research objectives?

Figure 4-2 is pointless. It would make sense to put it in Appendix and substitute with a block diagram in Section 4.1.

Section 4.4. Why do you develop VR operation system if the heterogeneous URG-UAV is supposed to be autonomous?

Summary of issues:

1. Re-write Abstract (see recommendations provided earlier in the text).

2. Prepare literature review.

3. Please identify your research problem and make Abstract-Intro-p.68-Conclusions consistent with this respect.

4. Position your thesis as a research work and not as a commercial solution.

5. Address minor comments specified earlier in the review.

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*