

I. IDENTIFICATION DATA

Thesis title:	Robust Vision-Based Navigation in Extreme Environments Inspired by the Hippocamal-Entorhinal System
Author's name:	Tomas Musil
Type of thesis :	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Cybernetics
Thesis reviewer:	Torsten Sattler
Reviewer's department:	Czech Institute of Informatics, Robotics and Cybernetics

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment	extraordinarily challenging
<i>How demanding was the assigned project?</i>	
<p>The plan for the Master thesis was very challenging: (1) The student was supposed to familiarize themselves with and review the literature on biologically-inspired SLAM systems. This literature is typically not covered in lectures, i.e., a significant amount of time was needed for the review. (2) The student was supposed to design a simulator for creating scenarios for multi-session visual navigation. The task of creating simulators that are easy to use, customizable, handle large scenes, and support different conditions is challenging in itself. I think this part could have constitute a Master thesis in itself. (3) The student was supposed to design and implement a SLAM-based and biologically-inspired visual navigation algorithm. Again, in my opinion, this could have been a Master thesis in itself.</p>	

Fulfilment of assignment	fulfilled
<i>How well does the thesis fulfil the assigned task? Have the primary goals been achieved? Which assigned tasks have been incompletely covered, and which parts of the thesis are overextended? Justify your answer.</i>	
<p>In my opinion, the thesis clearly fulfills the three main tasks outlined above. Chapter 2 provides a detailed discussion on biologically-inspired SLAM and navigation systems (Task (1)). I very much enjoyed reading this part as it was clearly structured. I feel that I learned new things and it certainly got me to think about my research from a new angle. Chapter 3 describes the developed simulator (Task (2)). Rather than just describing its details, as is often the case in Master theses, the chapter clearly motivates the most important design decisions, including the choice underlying (game) engine. It also discusses the relation between the proposed simulator and existing ones. This part of the thesis was published as a workshop paper at IROS 2023, which shows the quality of the work. Chapter 4 then describes the proposed visual navigation algorithm (Task (3)). The main takeaways from the review in Chapter 2 are used to guide the design of the proposed approach and it is clearly described. Experiments on both real world scenes and scenarios generated by the proposed simulator show the effectiveness of the proposed navigation approach.</p> <p>The original plan for the Master thesis also called for a comparison with ORB-SLAM3. I did not find this comparison in the thesis. However, this task was also the least important one and not including it does not take away from the fact that all the main tasks, which are very challenging, are completely fulfilled.</p>	

Methodology	outstanding
<i>Comment on the correctness of the approach and/or the solution methods.</i>	
<p>The chosen methodology is correct and follows best practices from the field. I think parts of the method described in Chapter 4 (namely depth estimation) could have been made more robust / easier by using visual-inertial odometry / SLAM instead of visual odometry / SLAM, but the design choice made in Chapter 4 are still meaningful. The methodology of each of the main parts is correct. Given the breadth of the tasks and their challenging nature, I think an "outstanding" is warranted given that each part is done very rigorously.</p>	

Technical level	A - excellent.
<i>Is the thesis technically sound? How well did the student employ expertise in the field of his/her field of study? Does the student explain clearly what he/she has done?</i>	
The thesis is technically sound. Each important design decision is clearly motivated and justified based on insights presented	

in the thesis (e.g., the review presented in Chapter 2 informs some design decisions made for the map representation in Chapter 4) or best-practices from the literature. The student clearly explained what they were doing and why they were doing it this way, often discussing alternatives and using these alternatives to justify why the chosen approach was selected. I would have hoped for a more quantitative evaluation of the proposed approach on scenarios created by the simulator (where ground truth is available). However, the presented evaluation is completely sufficient, especially given the breadth of material that the thesis covers.

Formal and language level, scope of thesis

A - excellent.

Are formalisms and notations used properly? Is the thesis organized in a logical way? Is the thesis sufficiently extensive? Is the thesis well-presented? Is the language clear and understandable? Is the English satisfactory?

The thesis is very well-structured and the relation between the individual parts are very clear. The thesis is well-written in high-quality English and it is easy to follow technical details. Formalisms and notations are properly used. The thesis describes each part in sufficient detail.

Selection of sources, citation correctness

B - very good.

Does the thesis make adequate reference to earlier work on the topic? Was the selection of sources adequate? Is the student's original work clearly distinguished from earlier work in the field? Do the bibliographic citations meet the standards?

The thesis makes adequate references to existing work on the topic. However, there is a related line of work based on topometric maps (locally metric maps that are organized topologically instead of using a single map), e.g., the representations advocated by Paul Newman and his group, that is missing. Yet, this is not a critical flaw, especially given that the focus of the thesis was elsewhere. The thesis clearly describes the contribution the thesis makes over prior work and thus distinguishes the work done in the thesis from prior work. The bibliographic citations meet the standard in the field.

Additional commentary and evaluation (optional)

Comment on the overall quality of the thesis, its novelty and its impact on the field, its strengths and weaknesses, the utility of the solution that is presented, the theoretical/formal level, the student's skillfulness, etc.

I very much enjoyed reading the thesis. I am impressed by the quality of the work and the breadth of topics the thesis covers. As stated in the thesis, the simulator has already led to a publication and the student is currently working on a potential submission for the proposed approach. The review in Chapter 2 might well be the foundation for a review paper. Overall, this is an excellent thesis that has the potential to impact the field.

III. OVERALL EVALUATION, QUESTIONS FOR THE PRESENTATION AND DEFENSE OF THE THESIS, SUGGESTED GRADE

Summarize your opinion on the thesis and explain your final grading. Pose questions that should be answered during the presentation and defense of the student's work.

As detailed above, this is an excellent thesis, in terms of the amount and quality of the work, the challenging nature of the assignment, and the quality and clarity of the thesis document itself.

I propose the following questions:

- How does the SLAM system described in Chapter 4 of the thesis relate to prior work on topometric representations for SLAM, place recognition, and visual localization?
- Why not use 3D points obtained by a visual-inertial odometry or SLAM system to ensure that depth are provided in a metric system?



THESIS REVIEWER'S REPORT

- What are the most challenging scenarios for existing navigation systems that can be generated by the proposed generator.

The grade that I award for the thesis is **A - excellent**.

Date: **22.1.2024**

Signature: