CTU
CZECH TECHNICAL UNIVERSITY IN PRAGUE

THESIS SUPERVISOR'S REPORT

I. IDENTIFICATION DATA

Thesis title:	**Object Localization by Spatial Matching of High-level CNN Features**
Author's name:	**Lukáš Majer**
Type of thesis :	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Control Engineering
Thesis reviewer:	Ing. Viktor Kozák
Reviewer's department:	Intelligent and Mobile Robotics, CIIRC

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment — **challenging**

How demanding was the assigned project?

The work was intended to explore the application possibilities of the SSM framework and to apply it to a completely new problem. It required a deep understanding of the previous framework, neural networks, and 3D vision. Since SSM is a novel and complex computer vision method, this was particularly challenging.

Fulfilment of assignment — **fulfilled**

How well does the thesis fulfill 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.

The original assignment was fulfilled completely. Moreover, the student achieved several additional results outside the scope of the original assignment.

Activity and independence when creating final thesis — **A - excellent.**

Assess whether the student had a positive approach, whether the time limits were met, whether the conception was regularly consulted and whether the student was well prepared for the consultations. Assess the student's ability to work independently.

The student was able to work independently and efficiently. The progress and direction of the work were regularly consulted and the student always clearly presented the current progress, encountered problems, and intended work.

Technical level — **A - excellent.**

Is the thesis technically sound? How well did the student employ expertise in his/her field of study? Does the student explain clearly what he/she has done?

The student provided sufficient background for all related fields (neural networks, 3D vision, object localization, and the original SSM framework). He clearly marks his own contributions and the work is well described.

Formal level 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 sufficiently extensive and all formalisms and notations are used properly. The level of English is satisfactory. The organization of the work is a little complicated, however, that is to be expected, since the work draws from a wide range of fields.

Selection of sources, citation correctness — **A - excellent.**

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?

Adequate sources and references to earlier work are provided, and the bibliographic citations meet the standards. The student clearly distinguished his own work.

CTU
CZECH TECHNICAL UNIVERSITY IN PRAGUE

THESIS SUPERVISOR'S REPORT

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.

The overall quality of the thesis is excellent. The developed approach achieved results comparable to some state-of-the-art approaches. During the course of the work, the student not only determined the benefits of the presented approach in object pose estimation but also identified additional characteristics and possibilities in the original SSM framework, which served for its further development and use in other areas. The student gained a deep understanding of relevant fields, without which it would be impossible to complete the work to such extend.

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.

The student produced excellent work which can be further utilized. I especially appreciate his active approach to the task and his numerous innovations during the work.

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

Date: **2.6.2021**

Signature:

CTU CZECH TECHNICAL UNIVERSITY IN PRAGUE

THESIS REVIEWER'S REPORT

I. IDENTIFICATION DATA

Thesis title:	**Object Localization by Spatial Matching of High-level CNN Features**
Author's name:	**Lukáš Majer**
Type of thesis:	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Control Engineering
Thesis reviewer:	Luis Gomez Camara
Reviewer's department:	Perception Team, Inria Grenoble. France

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment — challenging

How demanding was the assigned project?

The project required the full understanding of a complex methodology SSM-VPR, in the area of Deep Learning. It also required profound knowledge in computer vision and 3D geometry. In addition, the projects exploits an original alternative application of SSM for object pose detection, which required skills working with Convolutional Neural Networks as well as a number of image datasets.

Fulfillment of assignment — fulfilled

How well does the thesis fulfill 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.

The student has successfully completed the assigned task, proving the viability of the methodology for the intended application and providing a rigorous description at all times. The results are comparable with the state of the art.

Methodology — outstanding

Comment on the correctness of the approach and/or the solution methods.

The student has shown to be remarkably knowledgeable in the subject of the thesis and has correctly guided the reader through a well developed methodology, pointing out his own contributions and presenting his results as well as comparison with other approaches in a very natural and methodical fashion.

Technical level — A - excellen

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?

The thesis presents the problem at hand at remarkably high technical level. It also provides a correct amount of theoretical background and extensive explanations of the methodology, which evidences the student's expertise in the field.

Formal and language level, scope of thesis — B - very goo

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 presents the methodology with rigorous mathematical formalism at all times. The structure and sequence of chapters is natural and the extension is appropriate for this type of

CTU
CZECH TECHNICAL UNIVERSITY IN PRAGUE

THESIS REVIEWER'S REPORT

work. The English used throughout the thesis is reasonably good considering the student is a non-native English speaker. Some improvement could have been achieved by paying more attention to punctuation and grammatical correctness. At times, the flow of the sentences was a bit more challenging to follow.

Selection of sources, citation correctness A - excellen

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?

I have no complains regarding the bibliography. It is extensive enough and used accurately and appropriately within the text. In particular, and since the methodology is based on the SSM framework, the student references the latter consistently throughout the document and clearly explains what his own contributions and modifications are and which are not. The citations themselves in the bibliography section are written in the standard way in scientific documents.

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.

This is, in my opinion, an excellent thesis. It shows on one hand the student's mastery of the subject and on the other a high degree of originality. It cleverly transfers a methodology that was originally designed for a specific application into a rather different and relevant one, as is the case for object pose estimation in computer vision. His results prove that the approach is valid and comparable with the current state of the art using less computational resources and without the need to train any neural network. I believe its extension and refinement could make for and excellent PhD topic.

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.

In summary, an excellent and innovative work that required deep understanding of state-of-the-art approaches in image matching and retrieval and applied it to a very relevant area in computer vision and robotics: object pose estimation.

The grade that I award for the thesis is A - excellen

Below there are some comments and questions that could be used during the defense:

-*Section 2.2.3 "Such a process is often called supervised learning in literature."*
What process are you referring to as supervised learning, the act of assigning images with objects of known pose to object classes?

-*Section 2.2.5. "Furthermore, the mapping between input and output is highly non-linear."*
Can you elaborate more this statement?

CTU
CZECH TECHNICAL UNIVERSITY IN PRAGUE

THESIS REVIEWER'S REPORT

-Last paragraph page 27 about PCA injection "The third modification comes..."
Can you explain this? it is not clear to me

-Equation (5.1)
What is h_b and w_b? They have not been defined as far as I know

-Last paragraph page 38
I believe references to figures 6.2 and 6.3 should be 6.4 and 6.5, respectively

Comments:

- Section titles are a bit cryptic sometimes, for instance "3.1 Context". Does the student mean "Contests", as this section talks about challenge competitions?
- Better or more extensive introduction of sections in general
- You talk about training in several parts of the thesis to refer to database creation. Since your work is using neural networks, I think that using the term "train" may confuse the reader into thinking you are actually training CNNs. I think it would be beneficial to stress this distinction throughout the thesis somehow.
- In the SSM-VPR original paper it is clearly shown that increasing resolutions also increases accuracy of the image matching. Since low spatial resolution seems to be one of the main problems in your work, why didn't you try higher image resolutions, for instance 448x448?

Date: 05/28/21, 27th May.

Signature: