

## Opponent Review of Doctoral Dissertation

**Applicant: Simon Bilik**

**Title of Dissertation: Anomaly Detection for the Visual Inspection of Industrial and Biological Data**

**Opponent: Professor Joni Kämäräinen**

**Opponent's Department: Computing Sciences, Tampere University**

*In accordance with the Study and Examination Rules of BUT, in his/her review the opponent will mainly comment on:*

- a) the topicality of the dissertation,*
- b) whether the dissertation achieved its given objective,*
- c) the problem-solving procedure and the results of the dissertation along with the concrete contribution of the doctoral student,*
- d) the significance for practical application or the progress in the field,*
- e) formal and language qualities of the dissertation,*
- f) whether the dissertation fulfils the conditions of Section 47 (4) of the Act,*
- g) whether the student proved his/her creative abilities in the given research field and whether the work does or does not comply with the standard requirements placed on the dissertations in the given field. The review is not valid without this conclusion.*

*It is necessary to add a concise commentary to each of the points below.*

### Ad a) Topicality of the dissertation

The topic of the dissertation is very topical.

Comment: Visual inspection is arguably one of the most important commercial application fields of computer vision. Bilik's thesis addresses this topic using a number of real world datasets, a number of well-established methods and approaches, and various different types of annotations for defects or anomalies. This thesis provides interesting and important knowledge to the practitioners.

### Ad b) Objective of the dissertation

The objective of the dissertation was achieved.

Comment: The thesis takes a strong applied research approach and lists four main objectives as 1) new datasets, 2) preprocessing and feature extraction for improved performance, 3) a methodological

framework that could be general for similar problems, and 4) comparison of existing techniques for the problem. All the set objectives were achieved.

**Ad c) Problem-solving procedure and the results of the dissertation and the concrete contribution of the doctoral student**

The problem-solving procedure and the results of the dissertation are above average.  
Comment: The selected approaches for this work, object detectors and reconstruction-based detection, are standard tools for anomaly detection. However, the work is above average in terms of efforts spent in collecting, annotating and curating new datasets. The efforts spent for data collection was away from what was available for the method development and experimental analysis, but data collections must be equally appreciated as there cannot be good experimental findings without good datasets.

**Ad d) Significance for practical application or progress in the field**

The significance for practical application or progress in the field is average.  
Comment: I believe that this work will serve community in the sense that computer vision practitioners can use it as a reference manual for designing anomaly detection data collection, annotation, and method selection for their specific problem. Moreover, it provides a great starting point to deepen fundamental knowledge about anomaly detection.

**Ad e) Formal and language qualities of the dissertation**

Formal and language qualities of the dissertation are average.  
Comment: The thesis is easy to follow and reads quite well.

**Ad f) The dissertation fulfils the conditions of Section 47 (4) of the Act**

The dissertation fulfils the conditions of Section 47 (4)\*) Act No. 111/1998 Sb. Higher Education Act: YES

*(\* (4) Studies are duly finished with a doctoral state exam and dissertation defence, which prove the ability and readiness to work independently in the field of research or development, or in theoretical and creative arts. The dissertation must comprise original and published results or results accepted for*

*publication.*

**Ad g) Creative abilities of the student in the given research field. Compliance with the standard requirements placed on the dissertations in the given field.**

The doctoral student did prove his/her creative abilities in the given research field and the work does comply with the standard requirements placed on the dissertations in the given field.

Comment: According to my experience this thesis work is well aligned with the international standards on PhD theses related to machine vision.

Overall evaluation: The presented PhD thesis is in the field of machine vision (applied computer vision) focusing particularly on anomaly detection in commercial applications or applications serving other fields of science (biology). The candidate met all the set objectives about collecting new datasets, experimenting with data processing and feature extraction techniques, sketching an overall framework for anomaly detection, and finally experimentally investigating available methods.

This thesis, the dataset and results provide a good starting point for more fundamental research that can exploit the available datasets, preliminary results, and findings. For example, by comparing image classification and auto-encoder methods using an increasing number of outlier (anomaly) examples in training. It is clear that with zero anomaly samples only the auto-encoder methods or single-class classifiers can be used, but how many samples are needed until the supervised image classification methods outperform them (they eventually do)? How do single-class classifiers perform as compared to the recent auto-encoder methods? How negative samples can be used in the training of auto-encoder methods? How outlier (anomaly) detection can be added to image classification or detection tasks? And so forth.

Overall the thesis work is acceptable as a PhD thesis.

Opponent's questions:

1. Can you tell during which period these datasets were collected, how much of your research time during the thesis project were devoted to data collection and annotation, and whether these datasets will be publicly available to other research groups?
2. Which of the methods, the detector based or the auto-encoder (reconstruction) based you find the best for anomaly detection applications? Why so?
3. How would the amount of annotated anomaly samples affect to your choice in the question #2 (if at

all)?

4. What best practices you can recommend for the annotation of anomalies?

5. What would be your recommendation if we know that the visual variation of anomalies is huge and we thus cannot annotated any reasonable amount of examples?

6. Can you briefly explain what makes anomaly detection different from other object detection and categorization problems?

I  recommend

do not recommend

the dissertation for the defence.

Date: 01.11.2024

Signature:

