

I. IDENTIFICATION DATA

Thesis title:	Anomaly detection in robotic assembly process using force and torquesensors
Author's name:	Aleš Trna
Type of thesis :	bachelor
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of cybernetics
Thesis reviewer:	Ing. Martin Macaš, Ph.D.
Reviewer's department:	CIIRC

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment	challenging
<i>How demanding was the assigned project?</i>	
<p>The project covers both data acquisition from delta robot sensors and the creation of an anomaly detection system from time series. Moreover, cooperation with other students and teams was necessary. Therefore, the assignment of the presented bachelor project was challenging.</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>All assigned tasks were fulfilled. The student conducted a survey of anomaly detection methods and chosen approaches for implementation. Beyond the assigned two methods, he implemented three different methods and their different configurations including offline and online modes. For the testing, he spent a lot of time collecting data and proposed a fair evaluation procedure. Beyond the assignment, he also performed the on-site testing which shows that the system can be utilized in our industrial testbed and offered to companies.</p>	

Activity and independence when creating final thesis	A - excellent.
<i>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.</i>	
<p>The students worked very actively and independently. He spent at least two days of the week in our laboratories and each week we had a long and rich discussion about the thesis topic. Besides that, he spent a lot of time with colleagues from our testbed and with other student and demonstrated his potential to become a real team leader.</p>	

Technical level	A - excellent.
<i>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?</i>	
<p>The student's study branch is cybernetics and robotics, which was very clear in his quick orientation to the related technical issues and ability to find and understand new concepts. The thesis is technically correct. Some</p>	

concepts that he described are quite difficult to explain and thus minor descriptions could be slightly misleading for a reader. I do not feel this as a significant issue in the bachelor level of study.

Formal level and language level, scope of thesis

B - very good.

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 written in a satisfactory English, appropriate to the student's bachelor level. I appreciate the fifty pages of meaningful content, which demonstrates the amount of work the student has done. Most of the content is clear although the understandability of some parts could be slightly improved. Regarding the equations, the student should improve his skills of formal notation of mathematical formulas. For example, in the description of dynamic time warping it is not clear, what is the meaning of notation $d(a,b)$. Nevertheless, I think of it more as a recommendation for a future diploma thesis than as a serious deficiency. The organization of the thesis is adequate consisting of an introduction, data, methods, experimental results and conclusion. I appreciate the rich discussion provided in section 5 and nice conclusions, that provide also links to relevant literature.

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?

The thesis contains 38 references to relevant literature including works published in last years. Related work is sufficiently summarized in chapter 1.1.

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.

In my opinion, the thesis corresponds rather to the standards of a diploma thesis. It described the solution of an anomaly detection process, which has been deployed on a delta robot assembly process in Testbed for Industry 4.0. I appreciate the generality of the implementation which enables to use the methods for the monitoring of other processes, where a stream of multivariate time series is measured. The student was very active and enjoyed his work. His results will be used by CTU European Digital Innovation Hub as a use case demonstrating potential of artificial intelligence in industrial innovations to production companies. I would like to ask the student for publishing some of the results.

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

In summary, the minor shortcomings mentioned above are outweighed by the great activity of the student and by the usefulness and contribution of his work. I confirm that all goals were successfully achieved and recommend the thesis for successful defense.

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

Date: **3.6.2024**

Signature: