

## I. IDENTIFICATION DATA

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| <b>Thesis name:</b>             | <b>Deep multiple-instance learning for detecting multiple myeloma in CT scans of large bones</b> |
| <b>Author's name:</b>           | <b>Vojtěch Mach</b>  |
| <b>Type of thesis :</b>         | master   |
| <b>Faculty/Institute:</b>       | Faculty of Electrical Engineering (FEE)  |
| <b>Department:</b>              | Department of Computer Science   |
| <b>Thesis supervisor:</b>       | Dr. rer. nat. Jan Hering   |
| <b>Supervisor's department:</b> | Department of Cybernetics  |

## II. EVALUATION OF INDIVIDUAL CRITERIA

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| <b>Assignment</b>   | <b>challenging</b> |
| <i>Evaluation of thesis difficulty of assignment.</i>   |                    |
| <p>The thesis deals with the challenging multiple-instance learning and aims at constructing a computer-aided diagnosis system for bone lesion detection in low-dose CT images. Application of deep-learning methods to medical images poses an additional challenge, as data collections available are limited in size and come typically with only weak labels. To properly evaluate the examined methods, a crafted augmented dataset has to be constructed and used in the experiments.</p> |                    |

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| <b>Satisfaction of assignment</b>   | <b>fulfilled with minor objections</b> |
| <i>Assess that handed thesis meets assignment. Present points of assignment that fell short or were extended. Try to assess importance, impact or cause of each shortcoming.</i>  |  |
| <p>The thesis meets the assignment very good, even though the last point of the original assignment was not fulfilled. The experiment on the full clinical dataset was not conducted, as the MIL method failed unexpectedly already on the augmented dataset – in contradiction to the results reported in the literature. On other hand, the point of crafting realistic augmented data has proven to be more challenging as the available dataset lacked a sufficient level of standardization and this issue was successfully resolved by thorough (and time-costly) data preprocessing.</p> |  |

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| <b>Activity and independence when creating final thesis</b>   | <b>A - excellent.</b> |
| <i>Assess that student had positive approach, time limits were met, conception was regularly consulted and was well prepared for consultations. Assess student's ability to work independently.</i>   |                       |
| <p>Mr. Mach was working independently, with regular (remote) consults. He was very keen to properly understand the background, including the medical aspects of the datasets. It was Mr. Mach's attention to detail and rigorous work that revealed the problems with the clinical dataset and he also proposed many of the data cleaning procedures. I am certain Mr. Mach would have also finished the experiments on the full clinical dataset if it were not for the delay caused by the necessary preprocessing of the data.</p> |                       |

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| <b>Technical level</b>  | <b>A - excellent.</b> |
| <i>Assess level of thesis specialty, use of knowledge gained by study and by expert literature, use of sources and data gained by experience.</i>   |                       |
| <p>Mr. Mach proved a high-level of understanding of modern deep-learning methods and specifically in multiple-instance learning. He also demonstrated his competence to implement such methods.</p> |                       |

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| <b>Formal and language level, scope of thesis</b>   | <b>A - excellent.</b> |
| <i>Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.</i>   |                       |
| <p>The thesis is written in a very good English language, in an easy-to-understand matter. The comprehensive background on medical imaging and machine learning also allows readers from distant research areas to follow. It is well structured, formal notations are correct.</p> |                       |

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

*Present your opinion to student's activity when obtaining and using study materials for thesis creation. Characterize selection of sources. Assess that student used all relevant sources. Verify that all used elements are correctly distinguished from own results and thoughts. Assess that citation ethics has not been breached and that all bibliographic citations are complete and in accordance with citation convention and standards.*

Relevant existing works are cited, used sources are properly distinguished from own results. The list of used references copes with the scope and aim of the thesis.

**Additional commentary and evaluation**

*Present your opinion to achieved primary goals of thesis, e.g. level of theoretical results, level and functionality of technical or software conception, publication performance, experimental dexterity etc.*

Overall, I am satisfied with the outcome of the thesis, despite the experiment on the full clinical data not being performed. Instead, the necessary time was invested into proper data preprocessing. Further, methods for constructing the augmented dataset were developed and a recent MIL-pooling method was implemented and evaluated on the augmented dataset. I would also like to praise the quality of the software that Mr. Mach wrote. Such well written code base is of high value, as it can be used directly for follow-up projects or continuation on the bone lesion detection.

**III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION**

*Summarize thesis aspects that swayed your final evaluation.*

I evaluate handed thesis with classification grade **A - excellent**.

Date: **27.8.2020**

Signature: