



## I. IDENTIFICATION DATA

Thesis name:	Communication Infrastructure Building in Mobile Robot Exploration
Author's name:	Bc. Martin Zoula
Type of thesis :	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Computer Science
Thesis supervisor:	prof. Ing. Jan Faigl, Ph.D.
Supervisor's department:	Department of Computer Science.

## II. EVALUATION OF INDIVIDUAL CRITERIA

<b>Assignment</b> <i>Evaluation of thesis difficulty of assignment.</i>	<b>extraordinarily challenging</b>
The studied topic is related to a relatively broad field of autonomous robotic exploration, communication signal propagation, and modeling. The assignment is also ambitious in experimental verification to make the results and conclusion realistic that expect a large data collection because no suitable dataset has been available. The signal availability prediction has been aimed at extrapolation scenarios that can be considered a challenging problem itself. Due to the complexity of the environment characterization, the prediction performance might likely fail in such scenarios. It is because the environmental similarity assumptions are not fulfilled. The expectations in the assignment can be considered very ambitious, with a relatively small chance of perfectly working prediction we expect from machine learning methods, specifically in extrapolation scenarios. Therefore, the assignment is extraordinarily challenging.	
<b>Satisfaction of assignment</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>	<b>fulfilled</b>
In the thesis, the student elaborated on the existing solutions, proposed data collection equipment and performed several data collection campaigns with thousands of measurements that required the development of a suitable data processing framework. On top of the experimental data, modeling of the signal availability has been studied, and several methods have been proposed and evaluated. Furthermore, the developed modeling and prediction framework has been integrated into autonomous exploration and deployed in a real underground environment of the abandoned gold adit.	
<b>Method of conception</b> <i>Assess that student has chosen correct approach or solution methods.</i>	<b>outstanding</b>
The student has become familiarized with existing solutions used in autonomous robotic exploration missions in communication-denied environments. Based on the prior work, the focus has been on modeling and predicting the signal attenuation for which suitable real measurements have been collected. Then, signal propagation methods have been studied, and novel models have been proposed and properly examined. The student proactive searched related literature and proposed the next steps. During the thesis effort, he realized the necessity for a proper evaluation framework due to the excessively large dataset. He then switched the focus to implementing a suitable software framework that further allows the deployment of the developed solution in real exploration missions. The framework allowed necessary data normalization and regularization that helped understand the principles and evaluate the methods.	
<b>Technical level</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>	<b>A - excellent.</b>
During the thesis writing, the first revision of the text included a huge literature review that was later reduced to balance between the details and focus on the core parts that make the text readable and relatively easy to follow. Since the text writing has been an iterative process, new findings on the model performance have been utilized to improve the model properties' exposition and use of evaluation techniques. Systematic error identification provides realistic expectations of the model's performance. Here, I specifically acknowledge the focus on extrapolation scenarios since the interpolation does not provide the added value as existing methods can be utilized.	

**Formal and language level, scope of thesis**

**A - excellent.**

*Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.*

The text typesetting meets the standards of the thesis, and illustrative figures and readable presentations accompany it.

**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.*

The text refers to relevant sources, albeit the number of references has decreased between the text revisions, and several general references might not be necessarily referenced. There is a typo in the reference [137] that should point to a GitHub repository; however, it can be easily resolved.

**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.*

The proposed solutions build on existing work on autonomous robotics exploration, where the studied signal availability prediction modeling is added in an incremental way allowing possible usage of further, eventually more complex, exploration strategies. The student thus focused on the important problem and developed solutions for general use. The problem of signal availability prediction in extrapolation scenarios is challenging and ambitious. It is ill-conditioned because it lacks suitable data for precise signal availability prediction. However, a precise prediction in interpolation scenarios does not fit the motivational problem of communication infrastructure building in an autonomous exploration of unknown environments.

The student proposed several novel solutions and evaluated their performance. Specifically, the examined environment characterizations represent groundwork for future research. Besides, the created dataset allows the evaluation of the studied methods in realistic setups. The developed software framework allows further evaluations that will be exploited in the follow-up research and enlarging dataset repository from other sites.

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

*Summarize thesis aspects that swayed your final evaluation. Please present apt questions which student should answer during defense.*

The master thesis is based on a detailed literature review, and a suitable problem formulation focused on signal availability modeling and prediction. The developed solution is based on real data measurements and their processing by the developed evaluation framework that further allows deploying the developed prediction methods in real autonomous exploration experimentally deployed in the abandoned gold adit. The proposed method and developed solutions are presented in a suitable form in the text of the thesis, and I have no doubt that the student has demonstrated the ability to independently study the problem, design his solution, and verify and present the achieved results in the actual text of the thesis.

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

Date: **24.1.2023**

Signature: