



**FACULTY  
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**MASTER THESIS**

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**Automatic generation of medical  
reports from chest X-rays**

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Study programme: Computer Science

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Abstract: This thesis deals with the problem of automatic generation of medical reports in the Czech language based on the input chest X-ray images using deep neural networks. The first part deals with the analysis of problem itself including comparison of existing solutions from several common points of view. In order to interpret medical images in the Czech language we present a fine-tuned a Czech GPT2 model specialized on medical texts based on the original pre-trained English GPT2 model along with its evaluation. In the second part the created Czech GPT2 is used for training neural network model for generating medical reports. The training was conducted on freely available data along with data pre-processing and their adjustment for the Czech language. Furthermore the model results are discussed and evaluated using standard metrics for natural language processing to determine the performance.

Keywords: natural language processing, image captioning, x-ray, medical report generation

# Contents

<b>Introduction</b>	<b>2</b>
<b>1 Problem Analysis</b>	<b>4</b>
1.1 Problem definition . . . . .	4
1.2 Methods of generation . . . . .	4
1.3 Data . . . . .	4
1.3.1 Existing datasets . . . . .	4
1.3.1.1 OpenI . . . . .	4
1.3.1.2 MIMIC-CXR . . . . .	4
1.3.2 Czech data . . . . .	4
1.3.3 Translators . . . . .	5
1.3.3.1 DeepL . . . . .	5
1.3.3.2 Google Translate . . . . .	5
1.3.3.3 CUBBITT . . . . .	5
1.4 Language models . . . . .	5
1.4.1 GPT2 . . . . .	5
1.5 Related work . . . . .	5
<b>2 Title of the second chapter</b>	<b>6</b>
2.1 Title of the first subchapter of the second chapter . . . . .	6
2.2 Title of the second subchapter of the second chapter . . . . .	6
<b>Conclusion</b>	<b>7</b>
<b>Bibliography</b>	<b>8</b>
<b>List of Figures</b>	<b>9</b>
<b>List of Tables</b>	<b>10</b>
<b>List of Abbreviations</b>	<b>11</b>
<b>A Attachments</b>	<b>12</b>
A.1 First Attachment . . . . .	12

# Introduction

In hospital, inspecting the X-rays and writing a corresponding medical reports is a hard work that requires experienced specialized doctors, of which there are not many. A great deal of people visit hospitals daily and X-rays are taken for many of them. Automatic interpretation of X-ray image has a great potential to improve health care and it could be particularly helpful to doctors in order to distinguish serious cases from the ordinary ones and overall accelerate and improve their work.

Medical image interpretation is a subset of a general problem called Image Captioning, i.e. generation of captions to input images. Image captioning is a combination of Natural Language Processing and Computer Vision areas, experiencing a lot of progress in the last years. Most often the Image Captioning problem is solved using Deep Learning techniques. The specificity of this subset is that we do not want to generate just a general caption of the image, but the exact description of all findings contained in the given medical image. There were done multiple studies for this task in other languages but none in the Czech language.

Deep learning by its very nature has wide range of uses in a medical sector as it can capture complex relations in any kind of data with excellent performance results. Nevertheless in the medical environment the accuracy of predictions is crucial in order to determine the final diagnosis. Therefore, we should not consider the models as such as something that is unmistakably true, but as an auxiliary tool that should help doctors to examine X-rays.

Inasmuch as it is not so challenging to detect fractures on the limbs, this area is less interesting than others which have a variety of diverse possible problems. One of these areas is chest for which there exists multiple freely accessible datasets containing full textual medical reports. However, all these available datasets have one common downside, they are not in the Czech language. The natural question arises, where do we obtain these much needed data? We have to face and solve this core problem in our thesis.

## Goals

First of all, we will take a closer look at the problem itself. This includes breaking down the problem and analyzing all its parts individually together with presenting possible existing alternatives for each part.

Our first goal is to fine-tune a language model directly for Czech language. The language model will be specialized directly to medical texts in order to capture the essence of the problem. Fine-tuning will be based on the original English GPT2 model presented in Radford et al. [2019].

Finally, we want to utilize our fine-tuned language model for training neural

network model interpreting chest X-rays images and generating corresponding medical reports to them in multiple setups. All possibilities will be evaluated to determine their final performance.

## **Thesis structure**

In the very first chapter we present a detailed description of our problem. Every aspect of our problem is introduced and all existing solutions or possibilities are discussed with their pros and cons. Moreover we introduce there some of the important related works.

Following chapter is dealing with the design of solution to our problem, with all reasonings and decisions made. This includes not only the final neural network model, but also the language model fine-tuning and data preparation.

All experiments done with our models take their part in the third chapter. Describing all used scripts and different setups together with data variations.

Whole fourth chapter is then dedicated to evaluation of experiments done in the preceding part. Furthermore our models will be compared to the performance of other existing solutions.

Finally, in epilog we discuss what we have accomplished in the thesis, what the resulting consequences are and what the future possibilities are.

# 1. Problem Analysis

This chapter deals with the overall analysis of the problem itself. In the very beginning we present the definition of the problem. Every aspect of the problem is further discussed in detail along with a comparison of possible solutions. Moreover, the next section of the chapter describes data we work with and their alternatives. The final part of this chapter presents some of the important related works.

## 1.1 Problem definition

## 1.2 Methods of generation

## 1.3 Data

In previous part we talked about possible methods of generation. Another crucial aspect we need to discuss are data, which are a basic building block of our thesis. This part focuses on the analysis of the data we used in our thesis, but also on their alternatives.

In order to solve our task and train neural network we need to get dataset containing the X-rays images along with their textual descriptions and optionally some other attributes of the examined X-rays. Moreover, the fundamental feature we need is that the data must be in the Czech language.

### 1.3.1 Existing datasets

Medical environment provides a plenty of diverse potential problems, which can be researched. As already mentioned, in this thesis we focus specifically on the X-ray images. Because it is not so hard to detect fractures on the limbs, this area is not as interesting as others. One area that is rich in its diversity is the chest. As a result, this area is explored the most and therefore there exists multiple datasets with full textual medical reports. In the following section we describe some of them.

#### 1.3.1.1 OpenI

OpenI dataset description

#### 1.3.1.2 MIMIC-CXR

MIMIC-CXR dataset description

### 1.3.2 Czech data

All freely available datasets presented in the previous part have one common downside, namely they are not in the Czech language. As a part of elaboration of



this thesis an intensive communication with real czech hospitals and other possible sources of real data took place. The goal of this communication was to create the very first open czech dataset of this kind. Processing of this kind of data would mean not only preparing the data into suitable format but also it would include proper anonymization of any personal information about the patients within the data.

However, inasmuch as the authentic patients data from hospitals are subject to strict privacy rules and we are not employees of any hospital, the institutions decided that they cannot provide the data in any way without the conscious permission of patients given before the examination. With this result we need to find a different way how to obtain this much needed czech data.

### **1.3.3 Translators**

In the previous sections we discovered that there is no dataset in the Czech language for our problem and there is no easy way how to get access to the real data. The only thing left is to create a new artificial dataset using an automatic translation. We will compare different freely accessible translators and choose the right for our needs.

#### **1.3.3.1 DeepL**

DeepL description

#### **1.3.3.2 Google Translate**

GT description

#### **1.3.3.3 CUBBITT**

CUBBITT description

## **1.4 Language models**

### **1.4.1 GPT2**

## **1.5 Related work**

The last section of this chapter is dedicated to description and comparison to some of the related works that solve identical or similar problem as we do.

## 2. Title of the second chapter

2.1 Title of the first subchapter of the second chapter

2.2 Title of the second subchapter of the second chapter

# Conclusion

# Bibliography

Alec Radford, Jeff Wu, Rewon Child, David Luan, Dario Amodei, and Ilya Sutskever. Language models are unsupervised multitask learners. 2019.

# List of Figures

# List of Tables

# List of Abbreviations

# A. Attachments

## A.1 First Attachment