Zurich University
of Applied Sciences

School of
Engineering
IDP Institute of Data Analysis
and Process Design

Deep learning classification of rheumatoid arthritis

Zurich University of Applied Sciences

Author: Janick Rohrbach
Supervisor: Dr. Oliver Dürr
Prof. Dr. Beate Sick
Industrial Partner: Seantis GmbH
External Supervisor: Fabian Reinhard
Dr. Tobias Reinhard
Date: December 12, 2017

Declaration of originality
Project Thesis at the School of Engineering

By submitting this project thesis, the undersigned student confirms that this thesis is his own work and was written without the help of a third party.

The student declares that all sources in the text (including Internet pages) and appendices have been correctly disclosed. This means that there has been no plagiarism, i.e. no sections of the project thesis have been partially or wholly taken from other texts and represented as the student's own work or included without being correctly referenced.

Any misconduct will be dealt with according to paragraphs 39 and 40 of the General Academic Regulations for Bachelor's and Master's Degree courses at the Zurich University of Applied Sciences (Rahmenprüfungsordnung ZHAW (RPO)) and subject to the provisions for disciplinary action stipulated in the University regulations.

City, Date: Signature:

Abstract

Abstract goes here

Acknowledgements

I want to thank...

A list of rheumatology offices and hospitals that are contributing to the SCQM registries can be found on www.scqm.ch/institutions. The SCQM is financially supported by pharmaceutical industries and donors. A list of financial supporters can be found on www.scqm.ch/sponsors.

Contents

1 Introduction

This thesis shows a method for the automated scoring of x-ray images of patients with rheumatoid arthritis.

1.1 Background

Rheumatoid arthritis is caused by a malfunctioning immune system. It is therefore a type of autoimmune diseases. The immune system attacks healthy tissue instead of bacteria and viruses. This causes inflammation in the joints. Irreversible damage to the bone in the joint can occur, if the inflammation lasts for a long time. [1] Rheumatoid arthritis is incurable, merely the symptoms can be treated.

Today, the severity of the bone erosion is assessed by a trained rheumatologist by using x-ray images of hand and feet. This process takes several minutes per patient. Recent advances in computer vision make it possible to automate this task. This leads to time savings which in return helps the rheumatologist to spend more time with the patient.

The Swiss Clinical Quality Management in Rheumatic Diseases (SCQM) Foundation runs a national registry of inflammatory rheumatic diseases. [2] They have collected anonymized patient data for over 10 years and provide us with x-ray images for this analysis.

Seantis GmbH is a Swiss company that develops data driven web applications for medical research, pubic administration and aviation. [3] For their customer SCQM they want to automate the bone erosion assessment. They already have a working algorithm, which detects the body part shown in the x-ray image. A second algorithm detects the joints in the image and extracts them as single images. These images are then used together with the bone erosion scores to train our model.

1.2 Related literature

There are several applications where convolutional neural networks are used in medical research.

A very recent paper from Tajbakhsh et al. [4] investigated whether fine-tuning a pre-trained CNN is better than training a CNN from scratch when applied to medical images. They find that pre-trained networks with fine-tuning always outperformed or at least performed as well as CNNs trained

from scratch. They further recommend a layer-wise fine tuning which seems to outperform shallow and deep tuning.

A report from Chen [5] uses convolutional neural networks on x-ray images of hands to predict the developmental bone age. He achieves a top one and two accuracy of 46 % and 70 % respectively. This result is close to previously used methods which use manual segmentation and handcrafted features.

1.3 Aim and scope of this thesis

The aim of this thesis is to predict bone erosion scores from x-ray images. We further examine how the bone erosion and the disease activity are correlated and use a time series of images to predict the course of the disease.

The work is based on images of the left hand only.

1.4 Outline

section 2 provides...
section 3 describes..

2 Theory

2.1 Convolutional neural networks

Convolutional neural networks take an image as an input. The image then gets passed through several convolutional layers. These layers work as filters and detect different features in the image. The weights of these layers are combined to class scores. Andrey Karpathy provides a good overview over convolutional neural networks in his course notes for the Stanford class CS231n. [6]

2.2 Rau classification

3 Methods

4 Predicting Rau scores

5 Results

6 Discussion

7 Conclusion

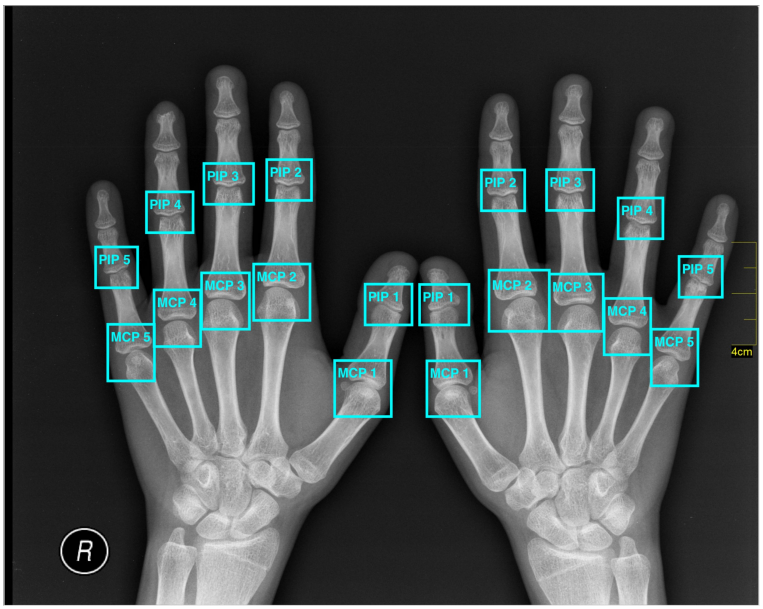

Figure 1: Proximal interphalangeal joints (PIP) and carpometacarpal joints (MCP).

Original image by Nevit Dilmen (CC BY-SA) `https://commons.wikimedia.org/wiki/File:Medical_X\discretionary{-}{}{}Ray_imaging_OPC06_nevit.jpg`

References

[1] American College of Rheumatology. *Rheumatoid Arthritis*. [Online; accessed 26-September-2017]. URL: https://www.rheumatology.org/I-Am-A/Patient-Caregiver/Diseases-Conditions/Rheumatoid-Arthritis.

[2] SCQM. *About Us*. [Online; accessed 11-October-2017]. URL: https://www.scqm.ch/en/ueber-uns/.

[3] Seantis GmbH. *Data Driven Web Applications*. [Online; accessed 12-October-2017]. URL: https://www.seantis.ch.

[4] Nima Tajbakhsh et al. "Convolutional Neural Networks for Medical Image Analysis: Full Training or Fine Tuning?" In: *IEEE Transactions on Medical Imaging* 35.5 (2016), pp. 1299–1312. DOI: https://doi.org/10.1109/TMI.2016.2535302.

[5] Matthew Chen. *Automated Bone Age Classification with Deep Neural Networks*. Stanford University, 2016. URL: http://cs231n.stanford.edu/reports/2016/pdfs/310_Report.pdf.

[6] Stanford University Andrej Karpathy. *CS231n Convolutional Neural Networks for Visual Recognition*. [Online; accessed 26-September-2017]. URL: http://cs231n.github.io/convolutional-networks/.

List of Figures