Prediction Of Accelerated Knee Osteoarthritis Using a Convolutional Neural Network

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State of the art: There is no method to predict Accelerated Knee Osteoarthritis (AKOA) using a baseline X-ray image.
Research Question: "Is it possible to classify **Knee Osteoarthritis (KOA)** progression into **fast** and **slow** progression (defined as Joint Space Narrowing (JSN) per year) using **Convolutional Neural Networks (CNN)**?"
Contribution: As a first study I considered only slow- and fast-progressing KOA in a classification model. This in comparison to previous studies is clinically more relevant due to the low availability of knee radiographs of non-progressing patients.

Methods: To train the CNN, I used two different approaches to defined the ground truth. The models were evaluated with the Area Under the Receiver Operating Characteristic Curve (AUC - ROC), where 100% is the best result.

Image data:
X-ray

Numeric data:
- Gender
- Body mass index (BMI)
- Age
- WOMAC (Western Ontario and McMaster Universities Arthritis Index) score
- KL (Kellgren-Lawrence) -grade
- Contralateral KOA

CNN, based on a Residual Network 50 (1), pre-trained from Image Biopsy Lab

< 20% JSN → Class 0

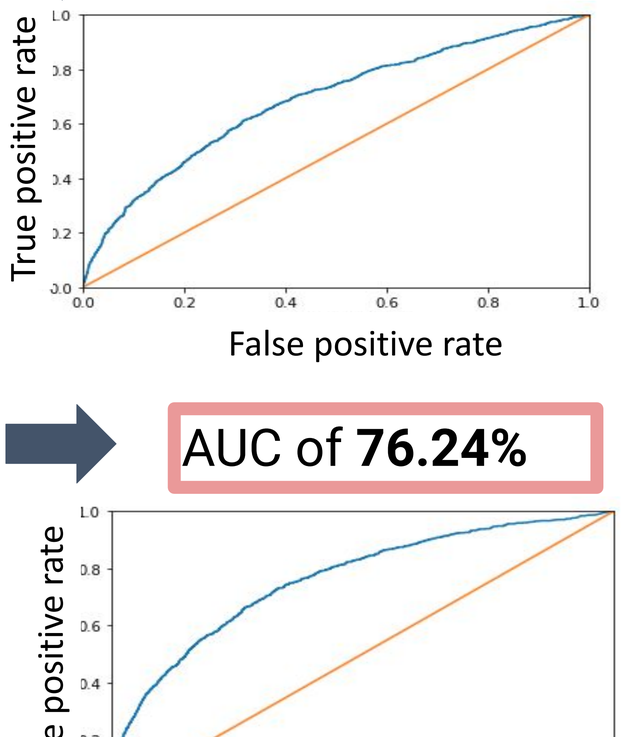
> 20% JSN → Class 1

KOA class definitions:
- Non-progressors: remaining KL-grade during study period
- Slow-progressors: < 20% JSN
- Fast-progressors: > 20% JSN

Approach 1: Excluding non-progressors, according to my research question

Non-progressors	**Slow**-progressors	**Fast**-pro-gressors
	Class 0	Class 1

AUC of **68.78%**



Approach 2: Including non-progressors in order to compare my models with previous studies

Non-progressors	**Slow**-progressors	**Fast**-pro-gressors
Class 0		Class 1

AUC of **76.24%**

Main Findings:
- **Best practice** of the CNN model to classify between slow and fast progressing KOA is an **AUC of 68.78%**
- Better result when **including non-progressors**, due to higher amount of image data and higher image entropy, but clinically more irrelevant

Conclusions:
The models I investigated in this thesis can serve as a supportive decision tool for physicians in diagnosis with an AUC of at least 68.78%. Although previous studies achieved higher results (2,3) when including non-progressing patients, not differentiating non-progressors is clinically more relevant due to the low availability of knee radiographs of the group of non-progressing patients.

(1) Viso AI. https://viso.ai/deep-learning/resnet-residual-neural-network/, accessed: 2021-10-08.
(2) Aleksei Tiulpin et al. "Multimodal machine learning-based knee osteoarthritis progression prediction from plain radiographs and clinical data". In: Scientific reports 9.1 (2019), pp. 1–11.
(3) Bochen Guan et al. "Deep learning risk assessment models for predicting progres- sion of radiographic medial joint space loss over a 48-MONTH follow-up period". In: Osteoarthritis and cartilage 28.4 (2020), pp. 428–437