A Supervised Classification Approach to Predicting Knee Pain Improvement in Osteoarthritis Patients

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Introduction

• Knee osteoarthritis (OA) is the most widely recognized joint illness of adults around the world.
• Early analysis and treatment of OA could counteract disturbance of symptoms.
• OA-related pain outcome projection is key for opportune and proper treatment.

Problem

• Pain progression is not being projected automatically for doctors.
• Pain levels are self-reported by patients using the Knee Osteoarthritis Outcome Score (KOOS) and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC).
• Current outcome projection methods are statistically heavy – time consuming, complex, and difficult to generalize.
• Physical doctor visits are time consuming.

Objective & Solution

Develop and evaluate the efficacy and feasibility of the application of machine learning for long-term OA-related pain outcome projection.

Methods

• Dataset: Osteoarthritis Initiative (OAI) – 10 year study of OA patients.
• Total patients after data cleaning: 2538 patients.
• Four types of multi-label classifiers:
  - Support Vector Machine,
  - Random Forest,
  - Multi-layer Backpropagation Neural Network, and
  - Recurrent Neural Network.
• Twelve individual supervised ML classifiers (three for each classifier type) that can classify OAI patients based on pain level at each of the 9 years past the baseline has: improved, unchanged, or worsened.
• Labels: KOOS score changes (Figure 3).
• Features include:
  - demographics,
  - related injuries,
  - therapies (excluding medications),
  - overall measures of pain, and
  - physical activity and associated rest.

Results

• Cross validation was performed for hyperparameter optimization and overfitting prevention (Figure 1).
• All classifiers performed at better-than-baseline rates (baseline most-frequent-class gives 0.4 F1), with the recurrent neural network performing the best with over 0.8 F1 (Figure 2)

Conclusion

• Identifying pain trajectories and automatically predicting pain outcomes of OA patients is of critical significance (both conceptual and practical) for the discovery and development of personalized clinical medicine.
• Prediction models can provide early decision-support to practitioners – Time saving to clinicians.
• Further work may aid better analysis of features for their predictivity.
• Our study focused on knee OA patients in the OAI dataset. We outlined a system that medical personnel can use to automatically generate knee OA pain predictions while reducing the need to devote time and other resources.

References


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