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[1].
- 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)[2].
- Current outcome projection methods are statistically heavy – time consuming, complex, and difficult to generalize[3].
- Physical doctor visits are time consuming[4].

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.

Algorithm	Classifier	Average
Support Vector Machine	improved	0.553
	unchanged	0.631
	worsened	0.627
Random Forest	improved	0.733
	unchanged	0.698
	worsened	0.826
Backpropagation Neural Network	improved	0.725
	unchanged	0.729
	worsened	0.819
Recurrent Neural Network	**improved**	**0.812**
	unchanged	**0.882**
	worsened	**0.856**

Figure 1. Average cross validation results during the training phase

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 F_1), with the recurrent neural network performing the best with over 0.8 F_1 (Figure 2)

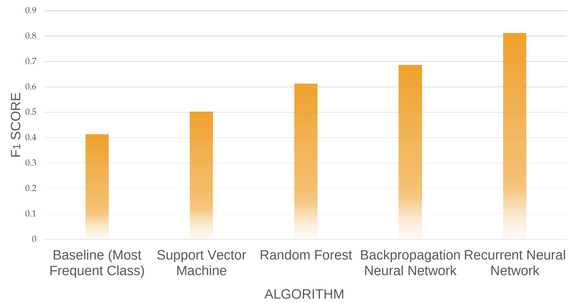
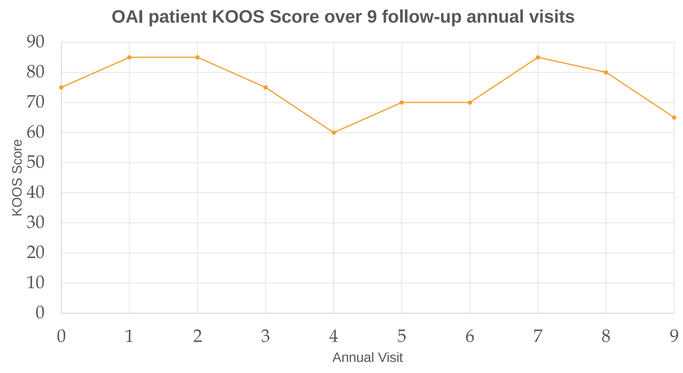


Figure 2. OA Patient at Physical Examination



Improved	1	0	0	0	1	0	1	0	0
Unchanged	0	1	0	0	0	1	0	0	0
Worsened	0	0	1	1	0	0	0	1	1

Figure 3. Example KOOS score progression over 10 years. Arrays below graph show label vectors for the three classifiers within each ML type

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.

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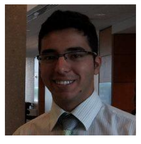

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