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 symptoms3.
• OA-related pain outcome projection is key for opportunite 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 generalize3.
• Physical doctor visits are time consuming4.

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.

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<thead>
<tr>
<th>Algorithm</th>
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<tbody>
<tr>
<td>Support Vector Machine</td>
<td>unchanged 0.631</td>
<td>improved 0.653</td>
<td>unchanged 0.567</td>
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<tr>
<td>Random Forest</td>
<td>unchanged 0.698</td>
<td>improved 0.733</td>
<td>unchanged 0.627</td>
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<td>Backpropagation Neural Network</td>
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<td>improved 0.729</td>
<td>unchanged 0.678</td>
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<tr>
<td>Recurrent Neural Network</td>
<td>unchanged 0.812</td>
<td>improved 0.812</td>
<td>worsened 0.819</td>
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</tbody>
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Figure 1: Accuracy 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 F1), with the recurrent neural network performing the best with over 0.8 F1 (Figure 2)

References


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