preha

Establishing Precision Rehabilitation with Visual Analytics

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Conventional Rehabilitation

- Assessment
- Evaluation
- Intervention
- Assignment

Renata Raidou
Challenges:
- Data
- Resources
- Users
- Tasks
**Contribution**

**preha**: a new approach to tackle the analysis of precision rehabilitation data.

Two main components:

1. A detailed data–users–tasks analysis
2. A visual analytics dashboard approach within **preha**
Data–Users–Tasks Analysis

46,000 cases
2012 – 2019

large – heterogeneous – high-dimensional\(^1\) – inconsistent\(^2\) – missing\(^3\)

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Medical</th>
<th>Therapy(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Sex</td>
<td>Zip Code</td>
</tr>
<tr>
<td>67</td>
<td>male</td>
<td>1234</td>
</tr>
<tr>
<td>85</td>
<td>female</td>
<td>1235</td>
</tr>
<tr>
<td>47</td>
<td>female</td>
<td>1236</td>
</tr>
</tbody>
</table>
Data–Users–Tasks Analysis
Data–Users–Tasks Analysis

Interviews

30-50 minutes
semi-structured

Abstract Tasks

typologies
for each task
Data–Users–Tasks Analysis

Eng1: Provide meaningful data partitions
Eng2: Prepare templates for patient assessment
Eng3: Prepare templates for clinical benchmarking
Eng4: Predict rehabilitation outcome

Exp1: Show rehabilitation outcome to patients
Exp2: Perform clinical benchmarking
Exp3: Explore clinical datasets
Exp4: Analyze data for clinical studies
Exp5: Intervention planning
Eng1: Provide meaningful data partitions
Eng2: Prepare templates for patient assessment
Eng3: Prepare templates for clinical benchmarking
Eng4: Predict rehabilitation outcome

Exp1: Show rehabilitation outcome to patients
Exp2: Perform clinical benchmarking
Exp3: Explore clinical datasets
Exp4: Analyze data for clinical studies
Exp5: Intervention planning
Eng4: Predict Rehabilitation Outcome

[inspired by Brehmer et al. 2013]
Typologies for All Tasks

Eng1
- produce
- filter
- input: total underlying data → output: subcohort

Eng2
- produce
- change
- annotate
- arrange
- filter
- input: scores and demographic data → output: dashboard template

Eng3
- produce
- import
- annotate
- aggregate
- filter
- change
- input: scores and clinical effort → output: dashboard template

Eng4
- discover
- filter
- input: total underlying data → output: predicted outcome
  - browse
  - aggregate
  - identify
  - derive

Exp1
- present
- select
- lookup
- navigate
- summarize
- input: dashboard template → output: rehabilitation outcome

Exp2
- select
- discover
- lookup
- navigate
- filter
- aggregate
- input: dashboard template → output: benchmarks

Exp3
- enjoy
- arrange
- encode
- identify
- aggregate
- input: total underlying data → output: insight

Exp4
- discover
- select
- navigate
- filter
- compare
- aggregate
- input: data from visual queries → output: analysis outcome

Exp5
- discover
- filter
- input: all scores in total cohort → output: prediction outcome
  - browse
  - identify/compare
  - derive
preha

EHR Data → Preprocessing → Storage
- Profiling
- Wrangling
- Cleansing

Dashboards Editor

Predictive Analytics
* if required by task
EHR Data → Preprocessing
- Profiling
- Wrangling
- Cleansing → Storage

Dashboards Editor → Predictive Analytics
Preprocessing

- Rule-based approach, done once: easy to introduce new rules
- Profiling: identification and communication of quality problems
  - Set of regular expressions/rules defined by the users
  - Whatever doesn’t match these $\rightarrow$ “dirty”
- Wrangling: modifying structure to make it suitable for processing
  - Standardization of tables and scores
  - Each patient is assigned one (non-redundant) row in a data table
- Cleansing: correcting dirty data
  - We know how correct data should look like
  - Cleansing programs/rules to match this appearance
EHR Data → Preprocessing → Storage

- Profiling
- Wrangling
- Cleansing

Visualization

Dashboards Editor

Predictive Analytics
Visualization

- Flexible, reusable, adaptable, expressive

**Kibana** framework:
- All basic visualizations
- Extensible through d3.js
- Supports multiple linked views
- Interaction functionality
- Predictive analysis support
Eng4: Predict Rehabilitation Outcome

[inspired by Brehmer et al. 2013]
Filter

Visualize interesting characteristics of cohort

Predict assessment scores

Visualize interesting characteristics of cohort

Visualize interesting characteristics of cohort
Predict assessment scores

Visualize interesting characteristics of cohort

Filter

Visualize interesting characteristics of cohort

Visualize interesting characteristics of cohort
Filter

Visualize interesting characteristics of cohort

Visualize interesting characteristics of cohort

Visualize interesting characteristics of cohort
Filter

Visualize interesting characteristics of cohort

Visualize interesting characteristics of cohort
**Filter**

Treemap showing the ICD10 diagnosis structure:

- Osteoarthritis of knee (M17)
- Osteoarthritis of hip (M16...)
- Dorsalgia (M54)
- Other chronic obstructive disease (M49.8)
- Thoracic, thoracic...

*Prediction of the WOMAC AT1 Discharge Score:*

- Predicted value: 41.50
- Prediction accuracy: 80.46%
- Prediction error: 15.81

*Distribution of the WOMAC AT1 Admission Score:*
Eng4: Use machine learning to predict rehabilitation outcome.
Dashboards for All Tasks

Renata Raidou
Pilot Study

- Introduce preha to four potential users

- Provide a set of small assignments to complete

Findings:

(+) Flexibility, adaptability to own working style

(-) Documentation/language, more digestible for domain experts
Conclusion and Future Work

- **Design study** for the workflow of precision rehabilitation
- Development of a **dashboard-based strategy**

- Extend evaluation to domain experts
- **Predictive analytics extension**
- **Guided analytics incorporation**
Thank You! Questions?

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