Data-Driven Requirements Engineering: The Way Ahead

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Keynote at ENASE’20, May
(virtually) Prague, Czech Republic
RE (still) central in SE

Take-Aways

1. Cost $\approx f(\text{Effort}) \approx f(\text{Size}) \approx f(\text{Complexity})$

2. Requirements understanding and “ilities” are the most influential on cost
RE (still) a problem in SE

Causes of failure

Q: Of the projects started in your organization in the past 12 months that were deemed failures, what were the primary causes of those failures? (Select up to 3)

- Change in organization’s priorities: 39%
- Change in project objectives: 37%
- Inaccurate requirements gathering: 35%

Source: The Standish Group CHAOS Report
The question then is...

How to ensure that a system is delivering the right value to its stakeholders?
From traditional RE...
...to data-driven RE
Data-driven RE

“requirements engineering by the masses and for the masses”
A word of caution
The data-driven RE cycle

Decision making

Decision maker

Product Backlog

Requirements assessment

Strategic dashboard

Feedback gathering and analysis

Development process

Software system

Repositories (software, project)

Runtime data (usage, QoS)

Mined data
EXPLICIT FEEDBACK
Explicit Feedback

- Feedback provided by the user at her will
- Main phases:
  - gathering
  - analysing
  - acting upon
Gathering explicit feedback
Explicit feedback analysis

- Preprocessing
- Categorization
- Sentiment analysis
- Topic modeling
Analysis: Preprocessing

• From text to lexical/syntactical units
  ▪ Tokenization
  ▪ Stemming / Lemmatization
  ▪ Phrasing
    • Part-of-speech tagging

“I have a problem when saving the document, please check it”

I/PRP have/VBP a/DT problem/NN when/WRB saving/VBG the/DT document/NN ,/ , please/VBP check/VB it/PRP
# Analysis: Categorization

- Bug report 🐜 or feature request 🤔

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feature shortcoming</td>
<td>Unsatisfying aspect of an existing feature.</td>
</tr>
<tr>
<td>Feature strength</td>
<td>Satisfying aspect of an existing feature.</td>
</tr>
<tr>
<td>Feature request</td>
<td>Request for a new feature.</td>
</tr>
<tr>
<td>Bug report</td>
<td>Report of an error, flaw, failure or fault.</td>
</tr>
<tr>
<td>Usage scenario</td>
<td>A way to use the software (e.g., recommended way, workaround).</td>
</tr>
<tr>
<td>Hardware constraint</td>
<td>Hardware needed to run the software.</td>
</tr>
<tr>
<td>Software constraint</td>
<td>Software needed to run the software.</td>
</tr>
<tr>
<td>General praise</td>
<td>General appreciation of the software focusing on the whole software system.</td>
</tr>
<tr>
<td>General complaint</td>
<td>General dissatisfaction of the software focusing on the whole software system.</td>
</tr>
<tr>
<td>Advertisement</td>
<td>Promotion of or suggestion to buy the software.</td>
</tr>
<tr>
<td>Dissuasion</td>
<td>Advise against the acquisition of the software.</td>
</tr>
<tr>
<td>Question</td>
<td>Question directly related to the software.</td>
</tr>
<tr>
<td>How to</td>
<td>Explanation to other users how to use the software.</td>
</tr>
<tr>
<td>Feature information</td>
<td>Description of a specific feature without any objective evaluation.</td>
</tr>
<tr>
<td>Software price</td>
<td>Discussion of the price of the software.</td>
</tr>
<tr>
<td>Compliance issue</td>
<td>Dispute over certain terms of agreement or regulations.</td>
</tr>
<tr>
<td>Software extension</td>
<td>Description of (planned) extensions of the software.</td>
</tr>
<tr>
<td>Other product</td>
<td>Reference to another software product.</td>
</tr>
<tr>
<td>Service</td>
<td>Comment on the service provided by the software.</td>
</tr>
<tr>
<td>Social interaction</td>
<td>Description of social/personal issues that arise from using the software (i.e., a software feature).</td>
</tr>
<tr>
<td>Content related</td>
<td>Comment about content that was created or is available through the software.</td>
</tr>
<tr>
<td>Job advertisement</td>
<td>Advertisement of a job available in the company developing the software.</td>
</tr>
<tr>
<td>Noise</td>
<td>Tweet not written in English or containing too many illegible symbols to be understandable.</td>
</tr>
<tr>
<td>Unclear</td>
<td>Tweet written in English, but the meaning of the tweet is ambiguous or unclear.</td>
</tr>
<tr>
<td>Unrelated</td>
<td>Tweet not related to the specific software at all.</td>
</tr>
<tr>
<td>Other</td>
<td>Tweet relevant for the study, but not covered by existing categories.</td>
</tr>
</tbody>
</table>

*Conferences > 2016 IEEE 24th International...*
Analysis: Sentiment analysis

Deciding if a piece of text expresses a particular affect or mood

had fun using it before but now it is really horrible :( help!!
uploading pictures with the app is so annoying! [+1,-3]
pleeeeeease add an unlike button and I will love you forever!! [+5,-1]

But of course, not easy...:

“Great, I like this feature that gives me this lovely headache”
Analysis: Topic modeling

- Identifying topics that best describes a corpus
  - Each topic described by a distribution of words
- Most popular algorithm: Latent Dirichlet Allocation
Putting all pieces together

Pinterest (Android)
show pin
search something
look pin
update search
force close
idea recipe
pin thing
pin board
find thing
use easy

App Features
Appearance frequency
0 20 40 60 80 100 120 140
Negative sentiment
Positive sentiment

Dropbox (iOS)
update time
want upload
move file
take photo
delete photo
pdf view
view file
file name
open file
upload photo

App Features
Appearance frequency
0 50 100 150

How Do Users Like This Feature? A Fine Grained Sentiment Analysis of App Reviews
Putting all pieces together

- Extraction of titles and comments
  - Text feedback
    - Preprocessing
      - POST, stopwords removal, lemmatization
    - Sentiment analysis
      - Sentiment scores for each review
      - Feature-Sentiment estimation
        - Feature-Sentiment scores
          - Topic modeling (LDA) and weighted average
            - High-level features with sentiment score

- Nouns, verbs and adjectives
  - Feature extraction
    - Collocation, aggregation
      - Fine-grained features

How Do Users Like This Feature? A Fine Grained Sentiment Analysis of App Reviews
Challenges with explicit feedback

- MOTIVATION
- PRIVACY
- RELIABILITY

Towards Understanding and Detecting Fake Reviews in App Stores

Daniel Martens · Walid Maalej
IMPLICIT FEEDBACK
Monitoring QoS

Monitoring the service-based system lifecycle with SALMon

Marc Oriol A, Xavier Franch B, Jordi Marco B
Usage logs

- Information about usage of the system

What can be discovered?
- Which functionalities are most used
- Which navigational paths prevail (or not)
- Which calls result often in error codes
- ...
- Especially if QoS also available
Challenges with usage logs

- Data noise
- Incomplete data
- Concept of session
- Evolution
- Anonymization
- ...

ENASE 2020
Xavier Franch
Importance of context

3LConOnt: a three-level ontology for context modelling in context-aware computing
DECISION MAKING
Keys to decision making

software analytics

release planning
Code analytic tools

Valuable, but not strategic enough
Analytic dashboards
Elaborating indicators

Legend

<table>
<thead>
<tr>
<th>Quality Aspect</th>
<th>Product/Process Factor</th>
<th>Assessed Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Data</td>
<td>Data Source</td>
<td></td>
</tr>
</tbody>
</table>

Maintainability

Value = 0.26

\[ w = 0.41 \]

\[ w = 0.59 \]

Class Quality

Code Quality

Blocking Code

AM1: Commented files

AM2: Non-complex files

Absence of duplications

\[ U_1(M1) = 0.5 \]

\[ AM1 = \sum_{i=1}^{M2} U_1(M1) \]

\[ AM2 = \sum_{i=1}^{M2} U_2(M3/M4) \]

M1: Density of comments of a file

M2: Total number of files

M3: Cyclomatic complexity of a file

M4: Number of functions of a file

Static Sw. Code Analysis from SonarQube

Average cyclomatic complexity per function

A Bottom-Up Approach
Techniques

Q-Rapids: Quality-aware rapid software development

Strategic Indicators | Detailed Strategic Indicators | Quality Factors | Metrics

Quality Factor: Product Quality > Testing Status

From: 2015-01-01   To: 2015-05-30

Test Coverage, % Test Done, % Test Passed

Simulate Strategic Indicator values

Current Value | Simulated data

Product Quality Neutral (0-60)
Release planning

- Closing the data-driven RE cycle

\[
F = \{f(1), ..., f(N)\} \\
\text{Set of requirements}
\]

\[
C = \{c(1), ..., c(M)\} \\
\text{Set of constraints}
\]

\[
X = \{x(1), ..., x(N)\} \\
\text{Release plan} \\
x(j) = \text{assigned release}
\]

Maximise some utility or objective function
Release Planning in DDRE
Involving relevant stakeholders

![Image of OpenReq MVP (2019) interface with UNASSIGNED REQUIREMENTS table]

<table>
<thead>
<tr>
<th>ID</th>
<th>Title</th>
<th>Description</th>
<th>Status</th>
<th>Utility</th>
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</thead>
<tbody>
<tr>
<td>R62</td>
<td>Integrate MAUT UI of Siemens Scenario</td>
<td>Discuss it it is necessary and needed by the community. Make a change.</td>
<td>New</td>
<td><img src="#" alt="Click to rate" /> 0 votes</td>
</tr>
<tr>
<td>R18</td>
<td>Basic Planning Poker</td>
<td>Basic Planning Poker Implementation</td>
<td>New</td>
<td><img src="#" alt="Click to rate" /> 0 votes</td>
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<tr>
<td>R4</td>
<td>Dynamic Weighting for MAUT2</td>
<td>Support Stakeholder weights test2</td>
<td>Planned</td>
<td><img src="#" alt="Click to rate" /> 0 votes</td>
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<tr>
<td>R69</td>
<td>Status of Requirements/dfaf</td>
<td>Description</td>
<td>Completed</td>
<td><img src="#" alt="Click to rate" /> 0 votes</td>
</tr>
</tbody>
</table>
Liquid democracy

- Stakeholders can evaluate requirements based on different interest dimensions
  - Most stakeholders might not be appropriate to evaluate all requirements accurately
  - Stakeholders can selectively delegate votes to experts
THE WAY AHEAD
The way ahead

• Six research challenges for data-driven RE
Challenge 1

Seamless integration into existing development processes and software systems
Challenge 1

Seamless integration into existing development processes and software systems
Challenge 2

Collection, processing, and integration of relevant heterogeneous information

Data Acquisition

- End-user
- Host application

Data Storage and Combination

- User feedback
- Runtime events
- Monitoring component
- Feedback component
- Combiner
- Ontology
- Data Lake
- Requirements Engineer
- New Requirement

FAME: Supporting Continuous Requirements Elicitation by Combining User Feedback and Monitoring

10 Author(s) - Marc Oriol; Melanie Stade; Faramaz Fotrousi; Sergi Nadal; Jovan Varga; Norbert Seyff; Alberto Abelló... View All Authors
Challenge 2

Collection, processing, and integration of relevant heterogeneous information
Challenge 3

Context-awareness and adaptability

Adaptive monitoring: A systematic mapping
Self-adapting monitoring

ACon: A learning-based approach to deal with uncertainty in contextual requirements at runtime

Alessia Knauss, Daniela Damian, Xavier Franch, Angela Rook, Hausi A. Müller, Alex Thomo

Information and Software Technology 70 (2016) 85-90
Challenge 4

Provision of actionable feedback
Challenge 5

Gaining users’ trust
Challenge 6

Provision of value for the entire life-cycle
Challenges to adoption

- Organizational
  - Tailoring to the company
  - Integration with company WoW
  - Shared vocabulary

- Value
  - Informativeness
  - Transparency

- Technological
  - Simplify tool installation
  - Efficient tool configuration
Success factors

• Organizational
  ▪ Incremental adoption
  ▪ Monitor progress with strategic indicators
  ▪ Involve experts

• Value
  ▪ Transparency as a business value
  ▪ Tailoring to different scopes

• Technological
  ▪ Single access point to software quality related data
CONCLUSIONS
Data-driven RE

• Offers a great opportunity for delivering more business value to systems’ stakeholders

• Some considerations
  ▪ Not a hammer for every nail
  ▪ Data-driven → needs data
    • Still traditional methods at least to start with
    • The role of traditional RE in the loop is worth considering
  ▪ New, but maybe not as much
    • E.g., compare to experimentation (from lean startup)
      – A/B tests, fake door tests, ...
Images

All other images labelled for reuse

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