Information Retrieval Applications in Software Engineering

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Short Bio
What is Software Engineering?
How about Software Engineering Research?
Information Retrieval Applications in Software Engineering

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What is Information Retrieval?
SE Tasks Supported by Information Retrieval

- Concept/Feature Location
- Impact Analysis
- Traceability Link Recovery
- Code Reuse
- Bug Triage
- Program Comprehension
- Architecture/design recovery
- Quality Assessment
- Software Evolution Analysis
- Automatic Documentation
- Requirements Analysis
- Defect Prediction and Debugging
- Refactoring
- Software Categorization
- Licensing Analysis
- Clone Detection
- Effort Estimation
- Domain Analysis
- Web Services Discovery
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Software Changes

- Adding new features
- Modifying existing features
- Fixing bugs
- Improving performance
- Adapting to changes in hardware
- Refactoring
- Etc.

Software Costs

- Initial Development: 25%
- Software Maintenance & Evolution: 75%
Software Change is Difficult
(because software is hard to understand)

• Millions of lines of code
  – S-class Mercedes-Benz: 20 million
  – OpenOffice: 30 million
  – Windows XP: 45 million

• Developed by large, distributed, and diverse teams

• Developers have to change software with:
  – Limited domain knowledge
  – Absence of the original developer
  – Bad, missing, or out of date documentation
Concept Location

- Finding the implementation of a concept in the code, i.e., a place in the source code where to start a change.

- Sources of information:
  - *Structure* - the structural aspects of the source code (e.g., control and data flow, class diagrams)
  - *Dynamic* – behavioral aspects of the program (e.g., execution traces)
  - *Text* - captures the problem domain and developer intentions (e.g., identifiers, comments) -> Text Retrieval
Text Retrieval for Concept Location

Query ➔ TR Engine ➔ Relevant Code Elements ➔ Source Code Text

INPUT

<table>
<thead>
<tr>
<th>#</th>
<th>Method</th>
<th>Class</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>getFace</td>
<td>org.eclipse.ui.JFace</td>
<td>0.99</td>
</tr>
<tr>
<td>2</td>
<td>nextEntry</td>
<td>org.eclipse.jdt.IndexBlock</td>
<td>0.96</td>
</tr>
<tr>
<td>3</td>
<td>getSeparator</td>
<td>org.eclipse.jdt.core.Util</td>
<td>0.95</td>
</tr>
<tr>
<td>4</td>
<td>validate</td>
<td>org.eclipse.jface.IDialog</td>
<td>0.87</td>
</tr>
<tr>
<td>5</td>
<td>setTextDlg</td>
<td>org.eclipse.ui.Text</td>
<td>0.86</td>
</tr>
</tbody>
</table>
Problems

- Developers have a hard time formulating good queries in unfamiliar software systems
- The results of TR depend on the quality of identifiers found in the source code
- The presentation of the results does not offer enough information to understand if the results are relevant
Problem #1

Query

Problem

• Developers have a hard time formulating good queries in unfamiliar software systems

Research Questions

• How can query formulation be made easy for developers?
• How can bad queries be improved?

Solution

• Automatic query reformulation
Approaches

• **Semi-automatic**: Relevance feedback
  – People can not always express well what they are looking for, but can recognize it when they see it
  – Developer provides feedback about relevance of search results and query is automatically reformulated

• **Fully automatic**: Learning the best reformulation for each query
  – Developer needs not be involved
  – Use machine learning techniques to learn the best reformulation for queries based on their lexical properties
### FileZilla Bug Report #3272

**No confirm for delete in folder view**

<table>
<thead>
<tr>
<th>Reported by:</th>
<th>trellmor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority:</td>
<td>normal</td>
</tr>
<tr>
<td>Component:</td>
<td>FileZilla client</td>
</tr>
</tbody>
</table>

**Description**

If you try to delete a folder by “right click -> delete” in the remote folder window, it won’t ask for confirmation.
1. `getRemoteFolder()`  
   get remote folder destination

2. `viewUserSettings()`  
   view user settings pane cache

3. `confirmFileTransfer()`  
   confirm file transfer popup window

Initial Query

confirm delete folder view

Reformulated Query

get remote folder destination delete folder
Evaluation

• Empirical evaluation - locating bugs in code based on text found in bug reports

• Patches in bug reports used for identifying buggy methods

• 3 large software systems, 18 queries
  – Eclipse – IDE for Java (2500 KLOC)
  – jEdit – programming editor (300 KLOC)
  – Adempiere – enterprise resource planning (330 KLOC)

• Results: 72% of cases queries reformulated using relevance feedback led to better results
Refoqus: Automatically Determining the Best Reformulation

• In relevance feedback, developers need to spend time providing feedback - automated solution desirable

• Queries are different - different types of queries may require different reformulation approaches (query expansion, query contraction, etc.)
Refoqus

Training queries
• Query properties
• Best reformulation

New query
• Query properties

MODEL

Best reformulation
Evaluation

• Empirical evaluation - locating bugs in code based on text found in bug reports

• 6 software systems, 30 queries each
  – Adempiere (330 KLOC)
  – jEdit (300 KLOC)
  – Atunes (80 KLOC)
  – Mahout (110 KLOC)
  – FileZilla (240 KLOC)
  – WinMerge (410 KLOC)

• **Results:** Refoqus outperformed any individual reformulation technique; 85% of cases improved results of TR-based concept location
Problem #2

Source Code Text

Problem

- The results of TR depend on the quality of identifiers found in the source code

Research Question

- How can we improve the results of TR-based concept location when bad identifiers are present?

Solution

- Identifying and renaming bad identifiers
Lexicon Bad Smells

- Poorly named identifiers can be misleading and impact the results of TR techniques

- Defined a catalog of bad smells in identifiers

- Proposed a set of renaming operations to fix bad smells

- Empirical evaluation on concept location

- **Results**: improved TR-based concept location after removing bad smells
Problem #3

Results Presentation

Problem

• The presentation of the results does not offer enough information to understand if the results are relevant

Research Question

• How can the results of TR-based concept location be presented in a more informative way?

Solution

• Automatic code summaries
Code Summaries

• Brief but relevant descriptions of source code entities (methods, classes, etc.)
• Text retrieval and text summarization techniques extract most representative information from code
• User evaluation for method and class summaries
• **Results**: users agreed with the summaries created (score 3.2 out of 4)

• Current work: people summarize code differently - user studies
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- Relevant Code Elements
- TR Engine
- Source Code Text

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Solutions

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- Identifying and renaming bad identifiers
- Automatic code summaries

Results Presentation