Information Retrieval Support for Software Engineering Tasks

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Short Bio
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 75%
Software Change is Difficult

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

• Developed by large, distributed 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  – Bad, missing, or out of date documentation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
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

<table>
<thead>
<tr>
<th>No confirm for delete in folder view</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reported by:</strong> trellmor</td>
</tr>
<tr>
<td><strong>Priority:</strong> normal</td>
</tr>
<tr>
<td><strong>Component:</strong> FileZilla client</td>
</tr>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>If you try to delete a folder by “right click -&gt; delete” in the remote folder window, it won’t ask for confirmation.</td>
</tr>
</tbody>
</table>
1. `getRemoteFolder()`
   - get remote folder destination

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

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

+ words in **documents**
  - +get
  - +remote
  - +folder
  - +destination

- words in **documents**
  - -view
  - -confirm

**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)

• 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

MODEL
- Query properties
- Best reformulation

New query

LEARN
Evaluation

• Empirical evaluation 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)

• 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

• 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
• 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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Solutions

- Query reformulation

- Identifying and renaming bad identifiers

- Automatic code summaries

Results Presentation