Systematic Mapping Studies

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Presentation Overview

1. Motivation
2. Systematic Mapping Studies
3. Comparison to Systematic Reviews
4. Guidelines
**Task:** Get an overview of a certain research area and how far it’s covered in research.

**Approach:** Study the research field by using methods from information retrieval and statistical analysis.
Creating systematic reviews is an established method in evidence based medicine.

Common in the field of software engineering.\(^1\)

\(^1\)Kitchenham & Charters 2007
Systematic Review : Goal

- Go through existing primary reports
- Review the primary reports
- Describe their methodology and results
Systematic Mapping Studies are an established method in evidence based medicine.

Even though it seems to be faithful there, it gets neglected a lot in the field of software engineering.

Less common in the field of software engineering than systematic reviews.
Systematic Mapping Studies: Goals

- Build a classification scheme and structure a field of interest.
- Structure of the type of research and results by categorizing a field.
- Show frequencies of publications for categories in the scheme.
- Determine coverage in a certain field.
- Combine the results to answer more specific research questions.
- Provide a visual summary by mapping the results.
- In general it tries to provide a more coarsed grained overview
There exist various quality assurance techniques.
Most of these are often applied in isolation.
But a combination of various quality assurance techniques promises to exploit synergy effects.
Classification and thematic analysis of existing approaches, which try to exploit a combination.

Include reported effects, characteristics and constraints.

Result is an overview of existing approaches and a suitable basis for identifying future research directions.
Systematic Mapping Studies: Process

**Process Steps**
- Definition of Research Question
  - Review Scope
- Conduct Search
  - All Papers
- Screening of Papers
  - Relevant Papers
- Keywording using Abstracts
  - Classification Scheme
- Data Extraction and Mapping Process
  - Systematic Map

**Outcomes**
Define the research question  
⇒ Review Scope

Conduct a search  
⇒ All Papers

Screen the papers  
⇒ Relevant Papers

Assign keywords to each papers by using the abstract  
⇒ Classification scheme

Data extracting and mapping process  
⇒ Systematic map
Task 1: Define the research questions

- Find out, what you want to accomplish
- Find out, where you want to search for your informations.
  ⇒ Identify forums for research areas.
## Task 1: Example part 1

<table>
<thead>
<tr>
<th>Nr.</th>
<th>Question</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1</td>
<td>What are existing approaches that combine static and dynamic quality assurance techniques and how can they be classified?</td>
<td>The first research question defines the basis of this systematic mapping study and provides an overview of the existing approaches that combine static and dynamic quality assurance techniques.</td>
</tr>
<tr>
<td>RQ2</td>
<td>In which sources and in which years were approaches regarding the combination of static and dynamic quality assurance techniques published?</td>
<td>The second research question indicates whether there are specific publication channels and when effort regarding this research area was made.</td>
</tr>
<tr>
<td>Nr.</td>
<td>Question</td>
<td>Rationale</td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RQ3</td>
<td>Is any kind of evidence presented with respect to the combination of</td>
<td>The third research question shows whether the approaches were empirically evaluated or whether just initial ideas are presented. This information was used to evaluate the maturity of the approaches.</td>
</tr>
<tr>
<td></td>
<td>quality assurance techniques and if so, which kind of evidence is given?</td>
<td></td>
</tr>
<tr>
<td>RQ4</td>
<td>What are the objectives of combined quality assurance approaches?</td>
<td>The fourth research question provides detailed information what the purpose of each approach is and what is addressed and improved when applying a combined approach.</td>
</tr>
</tbody>
</table>
### Task 1: Example part 3

<table>
<thead>
<tr>
<th>Nr.</th>
<th>Question</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ5</td>
<td>Which static and dynamic quality assurance techniques are used in combined quality assurance approaches?</td>
<td>The fifth research question presents the <strong>concrete static and dynamic QA techniques</strong> that are combined.</td>
</tr>
<tr>
<td>RQ6</td>
<td>Which <strong>input</strong> is used for static and dynamic quality assurance techniques in combined quality assurance approaches?</td>
<td>The sixth research question gives information about the <strong>data or information needed</strong> to apply the combined approach, with respect to both static and dynamic QA techniques.</td>
</tr>
</tbody>
</table>

⇒ Four reference databases: Inspec, Compendex, IEEE Xplore, and ACM Digital Library
1. Define the research question
   ⇒ Review Scope

2. Conduct a search
   ⇒ All Papers

3. Screen the papers
   ⇒ Relevant Papers

4. Assign keywords to each paper by using the abstract
   ⇒ Classification scheme

5. Data extracting and mapping process
   ⇒ Systematic map
Task 2: Search for primary studies

- Use information retrieval methods
- browse manually in journals etc.
- Use search strings in scientific databases
  - search-string creation by structuring in terms of population, intervention, comparison and outcome
  - search-string driven by research question
  - search-string from each aspect of the structure
- If one only considers certain types of studies, the overview will become biased and the result map is incomplete
Task 2: Example

- **Search-String:** (inspection or review or “static analysis” or “static quality assurance”) AND (test* or “dynamic quality assurance” or “dynamic analysis”) AND software AND (combin* or integrat* or synergy or “trade off”)

- Was applied to check keyword, title, and abstract fields within the corresponding databases.
Systematic Mapping Studies: Process

1. Define the research question
   ⇒ Review Scope

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   ⇒ All Papers

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Task 3: Screening of papers

- Define inclusion and exclusion criteria
- The criteria should be derived from the research questions.
Task 3: Example

I. Selection process (SP)

- Search string
  - Phase 0
  - Exclusion of duplicates
    - Phase 1
    - Exclusion based on title and year
      - Phase 2
      - Exclusion based on abstract
        - Phase 3
        - Exclusion based on full text

II. Cross-check

- IEEE Xplore
  - Adapted search string
    - N=263
  - Subset of studies from SP (no new studies)
  - 47 primary studies
  - 1 secondary study

- ACM Digital Library
  - Adapted search string
    - N=223

51 primary studies
Systematic Mapping Studies: Process

1. Define the research question ⇒ Review Scope
2. Conduct a search ⇒ All Papers
3. Screen the papers ⇒ Relevant Papers
4. Assign keywords to each paper by using the abstract ⇒ Classification scheme
5. Data extracting and mapping process ⇒ Systematic map
Task 4: Keywording of abstracts

- Reviewers read abstracts.
- Look for keywords and concepts
- Reflect the contribution of a paper
- Identify contexts
Task 4: Keywording of abstracts

- Put all keywords together from all found papers
- Develop higher level view on the research
- Helps with defining categories representing the underlying sets of papers
- When abstracts don’t contain enough information, the introduction and conclusion are reviewed as well.
- The final set of keywords is used to cluster and form categories
Task 4: Building the classification scheme

- Abstract
- Keywording
- Classification Scheme
- Article
- Update Scheme
- Sort Article Into Scheme
- Systematic Map
Task 4: Example

Combination of static and dynamic QA techniques

Category
- Compilation of static and dynamic analyses
- Integration of static and dynamic analyses
- Misc

Sub-category
- Static & dynamic analyses
- Inspection & testing techniques
- Other
- Static & dynamic analyses
- Inspection & testing techniques
Systematic Mapping Studies: Process

1. Define the research question ⇒ Review Scope
2. Conduct a search ⇒ All Papers
3. Screen the papers ⇒ Relevant Papers
4. Assign keywords to each paper by using the abstract ⇒ Classification scheme
5. Data extracting and mapping process ⇒ Systematic map
Frequencies can be derived from a final classification table.

This shows the latest research focus and possible research for the future.

Different facet combinations are possible

→ e.g. Context facet + research facet or contribution facet
Figure 3: Number of articles per category and references

- Compilation of static & dynamic analyses: 14% [5, 20, 28, 33, 35, 42, 66]
- Compilation of inspection & testing techniques: 25% [6, 7, 8, 9, 10, 11, 23, 25, 30, 31, 59, 62, 63]
- Compilation of other QA techniques: 12% [1, 3, 22, 40, 44, 72]
- Integration of static & dynamic analyses: 35% [4, 13, 14, 15, 16, 17, 18, 19, 26, 27, 36, 43, 50, 51, 53, 67, 68, 70]
- Integration of inspection & testing techniques: 10% [12, 38, 39, 41, 45]
- Misc: 4% [46, 54]
## Task 5: Example part 2

<table>
<thead>
<tr>
<th>Source</th>
<th>Publication channel</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>International Conference on Software Engineering</td>
<td>Conference</td>
<td>3</td>
<td>5.9</td>
</tr>
<tr>
<td>Annual IEEE International Computer Software and Applications Conference</td>
<td>Conference</td>
<td>2</td>
<td>3.9</td>
</tr>
<tr>
<td>IEEE Software</td>
<td>Journal</td>
<td>2</td>
<td>3.9</td>
</tr>
<tr>
<td>International Symposium on Empirical Software Engineering and Measurement</td>
<td>Symposium</td>
<td>2</td>
<td>3.9</td>
</tr>
<tr>
<td>International Symposium on Software Reliability Engineering</td>
<td>Symposium</td>
<td>2</td>
<td>3.9</td>
</tr>
<tr>
<td>ACM Conference on Object-oriented Programming Systems Languages and Applications</td>
<td>Conference</td>
<td>1</td>
<td>2.0</td>
</tr>
<tr>
<td>Aerospace Software Engineering for Advanced Systems Architectures</td>
<td>Conference</td>
<td>1</td>
<td>2.0</td>
</tr>
</tbody>
</table>
Figure 4: Number of articles published per year
Combined quality assurance approaches (51)

- Indirect combination (13)
  - Non-evaluated approach (13)
  - Evaluated approach (0)
- Direct combination (38)
  - Non-evaluated approach (14)
  - Evaluated approach (24)

Figure 5: Number of articles that provide evidence, respectively provide no evidence
Figure 9: Overview of inspection and testing techniques that are applied in combination
Discussion!
What are your thoughts on a comparison?
The methods are different in terms of goals, breadth, validity issues and implications.

They should be used complementarily.
## Comparing the goals

<table>
<thead>
<tr>
<th>SR</th>
<th>SMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Focus on establishing the state of evidence</td>
<td>- Focus on classification, thematic analysis and identifying publication fora</td>
</tr>
<tr>
<td>- Mostly used to identify best practises based on empirical evidence</td>
<td>- Can’t show, that evidence is missing or insufficient</td>
</tr>
<tr>
<td>- Shows where evidence is missing or where it’s insufficient</td>
<td>- Identify research gaps</td>
</tr>
<tr>
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</table>
Comparing the process

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>- Quality is evaluated</td>
<td>- Quality is not evaluated</td>
</tr>
<tr>
<td>- Meta analysis</td>
<td>- Thematic analysis</td>
</tr>
</tbody>
</table>

⇒ Both require a different level of data extraction.
Comparing breadth and depth

<table>
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<tr>
<th>SR</th>
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</thead>
<tbody>
<tr>
<td>- States outcome and quality as its major focus</td>
<td>- Reflects based on search strings and inclusion criteria</td>
</tr>
<tr>
<td>- Increased depth and effort</td>
<td>- Covers a higher breadth. More articles can be covered</td>
</tr>
<tr>
<td>- Fewer studies can be included</td>
<td>- Can structure a larger field</td>
</tr>
</tbody>
</table>
Comparing classification

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>- Mentions lack of methodological precision in primary studies(^3)</td>
<td>- Doesn’t restrict itself to such small portions</td>
</tr>
<tr>
<td>- A bias might be introduced by a SR</td>
<td>- Overview is more complete</td>
</tr>
<tr>
<td>- More fine grained categories are possible</td>
<td>- High level categories</td>
</tr>
<tr>
<td>- Especially concerning e.g. research methods and research approaches</td>
<td></td>
</tr>
</tbody>
</table>
Comparing validity

A major problem
Some terms might be used in different meanings. (e.g.: "experiment")

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>- Takes details into account.</td>
<td>- Doesn’t go into details,</td>
</tr>
<tr>
<td>The thread of false classification is minimized.</td>
<td>which might lead to wrong classification.</td>
</tr>
</tbody>
</table>
## Background

We want to give a good introduction to a field.

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>- It's more difficult to access results</td>
<td>- Easier to spark interest</td>
</tr>
<tr>
<td>- Results might be too detailed, though details might be important to practitioners.</td>
<td>- It is probably visually more appealing</td>
</tr>
<tr>
<td>- The visual appeal should be changed</td>
<td></td>
</tr>
</tbody>
</table>
User’s guide

- Complementary use is helpful
- Take an adaptive reading depth for classification
- Also Classify papers based on evidence and novelty
- Visualize your data
Summary

1. Motivation

2. Systematic Mapping Studies

3. Comparison to Systematic Reviews

4. Guidelines