Ontology Evolution and Regression Analysis

Insights into Ontology Regression Testing

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Uli Sattler
Motivation

Current studies of Ontology Evaluation tend to:

- Focus on individual ontology versions
- Focus on shifts in the gross statistics

In either case we don’t get objective and systematic evaluations of the life span of the ontology
Our goal is to extract insightful and useful information out of all the existing versions of an ontology
Ontology Testing Challenge

– How do we systematically identify test areas?

– How do we systematically analyse change impacts to the ontology?

How can we effectively minimise testing efforts and cost and still achieve adequate testing coverage
Software Testing
Software Regression Testing
What is it?

• It is a test activity to systematically re-test existing components after software changes

• It test against current and updated requirements
Software Regression Testing
Testing Aspects

• Testing at the functional requirements
  – Unit Level
  – System Level

• Testing at the non-functional requirements
Software Regression Testing
Testing Plan

• Defines testing criteria
• Identifies test area or components
• Test execution strategy
• Test evaluation strategy
• Updates test and other relevant documentation
Software Regression Testing Process

1. Change Detection
2. Impact Analysis
3. Define Test Plan
4. Build Test Suite
5. Run Test
6. Evaluate Results
7. Report Results
Ontology Regression Testing?
Change Detection

• Explicit Changes
  – Asserted logical and annotation axioms
  – Properties
  – Classes

• Implicit Changes?
  – Subsumption changes
  – Entailment changes
Impact Analysis

• Previous Version or all versions?
  – Intentional Difference analysis?
  – Justifications analysis?

• Information Content?
  – Asserted content?
  – Entailed content?

• Requirements Impact?
  – Functional and Non-functional?
  – Which ones do we test?
Define Test Plan

• Test criteria?

• Test area? Do we have test areas?

• How can the test be systematically run?

• Can results be interpreted?
Can we systematically:

- Build test suites?
- Run tests?
- Evaluate results?
- Re-run tests if necessary?
Manual vs. Automated Test Suites

• Manually test cases
  – Check against a methodology
  – Eyeballing

• Automated test cases
  – Satisfiability
  – Inconsistency
Manual vs. Automated Test Suites

- **Manually test cases**
  - Time consuming
  - Subjective
  - Unsystematic

- **Automated test cases**
  - Reasoner based
  - Limited in scope
Can we expand the range of automatic test suites?
YES

By Analysing Ontology Dynamics
What are Ontology Dynamics?

- Periods of growth, decline, and stability
- Axioms presence
- Types of axioms presence (e.g. continual, interrupted)
- Sequence editing types and patterns
Axiom Life Span - We expect: Axioms with Constant Unchanged Presence

\[ \alpha_i \]

Ontology Versions

\[ O_1 \quad O_i \]
Axiom Life Span - We expect:
Axioms that are Modified

Ontology Versions

Split or Merge

$\alpha_i$

$O_1$ $O_i$ $O_{i+n}$
Axiom Life Span - We expect: Axioms that Enter and Leave the Ontology
NCIt Ontology Dynamics
National Cancer Institute Thesaurus (NCIt)

- The National Cancer Institute (NCI) is a U.S. government funded organisation for the research of causes, treatment, and prevention of cancer

- The NCIt is an ontology written in the Web Ontology Language (OWL) which supports the development and maintenance of a controlled vocabulary about cancer research

- Multiple publications about process, quality control, usage, and critiques

- Publicly available monthly releases and concept change logs

**Rich source of ontology evolution data**
NCIt Dynamics – Axioms Life Span Analysis

Asserted Axioms Frequency Distribution
### Top Ten Frequency Distributions

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NCIt Axiom Life Span:
Axioms with Constant Unchanged Presence

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NCIt 2003 – 2012
103 Versions

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Effectually Removed: $O \nmodels \alpha_i$

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</tbody>
</table>
NCIt Regression Analysis – Main Finding

*This means that we are able to identify ‘bugs’, the sequence pattern of these bugs, and their location!*
NCIt Regression Analysis:
Indicative of Faults In Sequence of Changes

NCIt 2003 – 2012
103 Versions

Effectually Added
Effectually Removed
\( O_1 \neq \alpha_i \)
Effectually Added
Effectually Removed
\( O_{i+n} \neq \alpha_i \)

\( \alpha_i \)
\( \checkmark \) ?

\( O_1 \)
\( O_i \)
\( O_{i+n} \)
\( O_k \)
\( O_{k+n} \)

NCIt 2003 – 2012
103 Versions

Effectually Added
Effectually Removed
\( O_1 = \alpha_i \)
Ineffectually Removed
\( O_{i+n} = \alpha_i \)
Effectually Removed
Effectually Added
\( O_k = \alpha_i \)
\( O_{k+n} \)

\( \times ? \)
\( \checkmark ? \)
NCIt Regression Analysis: Suggestive of Faults In Sequence of Changes

Effectually Added

\[ \alpha_i \]

Ineffectually Removed

\[ O \rightarrow \alpha_i \rightarrow O_k \rightarrow O_{k+n} \]

NCIt 2003 – 2012
103 Versions

Refactoring
NCIt Regression Analysis:
Suggestive of Faults In Sequence of Changes

NCIt 2003 – 2012
103 Versions

Effectually Added
\(O_i\)

Ineffectually Removed
\(O_{i+n}\)

Ineffectually Added
\(O_k\)

NCIt 2003 – 2012
103 Versions

Ineffectually Added
\(O_{i+n}\)

Ineffectually Removed
\(O_i\)

Effectually Added
\(O_k\)

\(O_{i+n}\)

\(O_i\)

\(O_k\)

\(O_{i+n}\)
From Change Dynamics to Ontology Regression Testing
Systematically Build Test Suites

Indicative of Faults In Sequence of Changes
Automated Test Suites - Fault Detection

- It provides systematic regression test for all versions of the ontology.
- It conclusively identifies content regression and content refactoring.
- It suggests other faults based on regression sequence.

*It is efficient and cheap to run*
And there are still more potential benefits ...
Automated Test Suites - Fault Detection

- Entailment Set Studies
- Sub Domain Dynamics
- Ontology Classes Dynamics
Thanks
References

- http://owl.cs.manchester.ac.uk/research/topics/ncit/regression-analysis/
Graphs Key

- Axiom's presence in the assert and entailments sets (effectual addition)

- Axiom's presence only in the entailment set or the asserted set (ineffectual addition)