Quality Assessment for Requirements based on Natural Language Processing

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Motivation

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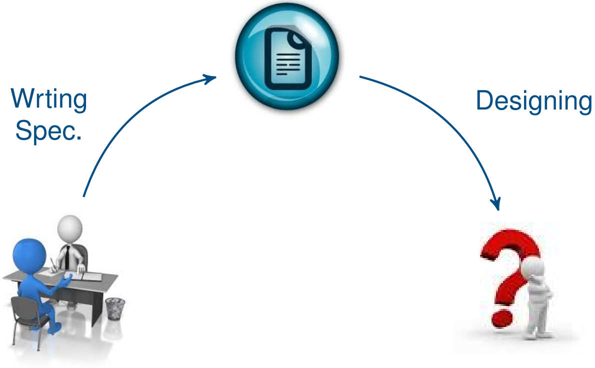

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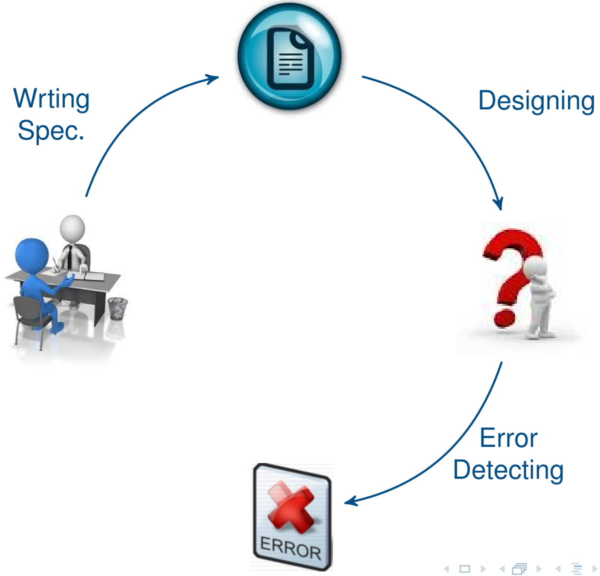

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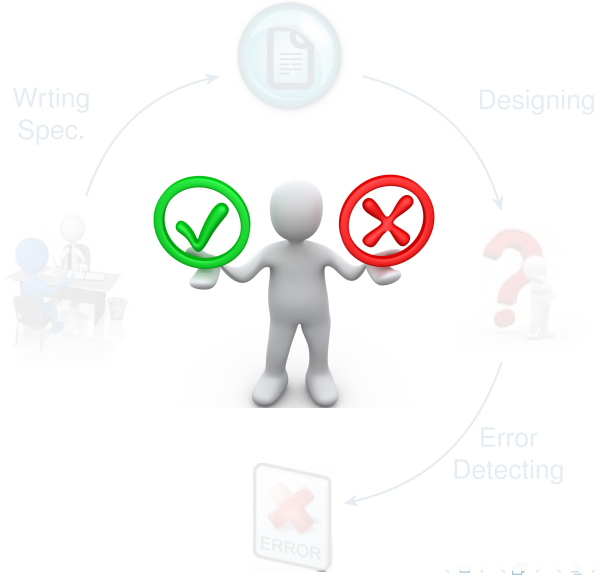

Solution

Writing Specification

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Quality Validation

Consequences

Better Writen specification will:

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- improve the comprehensibility of the designer

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- enhance the quality of automatic extraction approaches

Approaches

1. Requirement quality based on:

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   - Syntactic Quality

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   - Semantic Quality

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   - Semantic Quality
2. Assertions translation approach

Static Sentence Analysis

Problem (Sentence quality)

Given an English sentence, the sentence quality problem asks to determine a quality measure indicating whether the sentence is good, medium, or bad in terms of comprehension.

Syntactic Quality Analysis

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- Calculation based on phrase structure trees
- *Isomorphic subtrees*
- *Sentence length penalty*

Semantic Quality Analysis

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- A word is ambiguous if it has more than one *synsets* in the WordNet dictionary
- A *synsets* is a set of cognitive synonyms

Semantic Quality Analysis

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Then the basic semantic quality is given by:

$$q_{\text{sem}} = a + b \cdot \frac{m}{\sum_{i=1}^{m} k_i}. \tag{1}$$

Requirements Database

The requirements database is taken from:

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Experimental Evaluation

Quality predicate	Algo.	Subj.	Matches	Misses dist. 1	Misses dist. 2	Matching percentage
good	32	26	20	8	4	62.5 %
medium	53	41	29	24	×	54.7 %
bad	37	55	31	4	2	83.8 %
total	122	122	80	36	6	65.6 %

Guidelines Validation

Problem (Guideline checking)

Given a set of rules from guidelines how to write requirements and a natural language requirement R, the guideline checking problem asks whether R adheres to the rules.

Guidelines Validation

Requirement quality Evaluation based on:

Guidelines Validation

Requirement quality Evaluation based on:

- Rule based approach

Guidelines Validation

Requirement quality Evaluation based on:

- Rule based approach
- Stanford CoreNP
- Scala programming language

Rules

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- NASA guidelines
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- "Writing Better Requirement", I. Alexander and R. Stevens

Rules

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4. Each requirement must contain a subject and a predicate.
5. Avoid let-out clauses (unless, except, if necessary, but, when, unless, although).
6. Avoid expressing suggestions or possibilities (might, may, could, ought, should, could, perhaps, probably).

Rules

7. Avoid weak phrases and undefined terms (adequate, as a minimum, as applicable, easy, as appropriate, be able to, be capable, but not limited to, capability of, capability to, effective, if practical, normal, provide for, timely, tbd, user-friendly, versatile, robust, approximately, minimal impact, etc., and so on, flexible, to the maximum extent, as much as possible, minimal impact, in one whack, different, various, many, some of, diverse)

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8. Do not speculate (usually, generally, often, normally, typically).

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10. Define verifiable criteria.

Implementation

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the system is reset at start-up.

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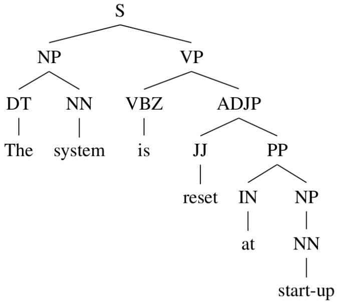
```
(ROOT
  (S
    (NP (DT the) (NN system))
    (VP (VBZ is)
      (ADJP (JJ reset)
        (PP (IN at)
          (NP (NN start-up)))))
    (. .)))
```

Implementation

R1. Define one requirement at a time.

the system is reset at start-up.



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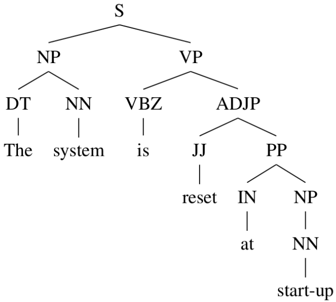

Cheeking the phrase structure tree whether it has two sentences related directly to the root.

Implementation

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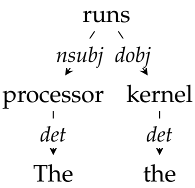
Active voice



Implementation

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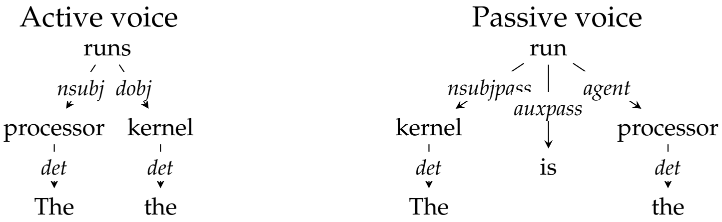

Requirements Database

The requirements database is the same as the one used in the first approach.

Experimental Evaluation

Rules	M. Class.		A. Class.		Classifier Evaluation					
	T	F	T	F	SA	TP	TN	FP	FN	Acc.
R1	88	15	61	42	70	58	12	30	3	67.96%
R2	84	19	89	14	80	75	5	9	14	77.67%
R3	90	13	89	14	86	81	5	9	8	83.50%
R4	102	1	92	11	93	92	1	10	0	90.29%
R5	94	9	95	8	102	94	8	0	1	99.03%
R6	92	11	85	18	92	83	9	9	2	89.32%
R7	102	1	103	0	102	102	0	0	1	99.03%
R8	103	0	103	0	103	103	0	0	0	100.00%
R9	9	17	18	8	13	7	6	2	11	50.00%
Total	826	127	772	181	811	728	83	98	44	82.48%

Experimental Evaluation for Infenion

Rules	M. Class.		A. Class.		Classifier Evaluation					
	T	F	T	F	SA	TP	TN	FP	FN	Acc.
R1	52	32	54	30	76	49	27	3	5	90.48%
R2	68	16	35	49	45	32	13	36	3	53.57%
R3	31	53	19	65	62	14	48	17	5	73.81%
R4	76	8	76	8	80	74	6	2	2	95.24%
R5	77	7	75	9	80	74	6	3	1	95.24%
R6	65	19	61	23	78	60	18	5	1	92.86%
R7	82	2	80	4	82	80	2	2	0	97.62%
R8	84	0	84	0	84	84	0	0	0	100.00%
R9	26	8	27	7	19	19	0	7	8	55.88%
Total	589	201	541	249	680	510	170	79	31	84.28%

Notations

- SA= Number of the Same annotated requirement
- TP+FP= Number of manual True annotated requirements
- TN+FN= Number of manual false annotated requirements
- Acc=$\frac{\mathrm{TP+TN}}{\mathrm{TP+TN+FP+FN}}$

Automating the Translation of Assertions

Proposed flow

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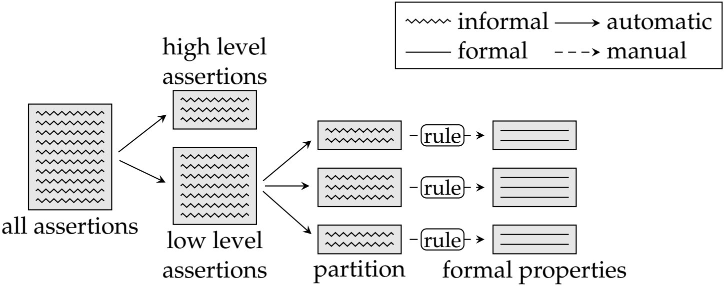

Algorithm

1. Abstraction Level Classification

Algorithm

1. Abstraction Level Classification
2. Partitioning based on Sentence Similarity

Algorithm

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3. Assertion Generation

Abstraction Level Classification

Using A SPARQL query to partition the assertion into

Abstraction Level Classification

Using A SPARQL query to partition the assertion into

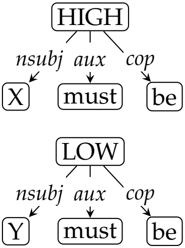
- high abstraction level subsets

Abstraction Level Classification

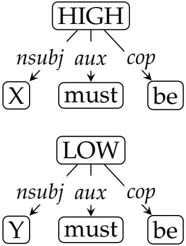
Using A SPARQL query to partition the assertion into

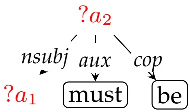
- high abstraction level subsets
- low abstraction level subsets

Partitioning based on Sentence Similarity



Partitioning based on Sentence Similarity





Assertion Generation

1. an assertion template is generated for each cluster

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2. the assertion template is populated for each natural language assertion in the cluster.

Experimental Evaluation

The algorithm is applied to the assertions is taken from:

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- AMBA 3 AXI Protocol Checker user guide containing 145 assertions

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Requirement quality Evaluation based on:

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Requirement quality Evaluation based on:

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- JENA API for the triple store based information extraction

Experimental Evaluation

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   - From 145 assertions 100 have been classified as low level assertions

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Experimental Evaluation

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   - From 145 assertions 100 have been classified as low level assertions
2. Partitioning based on Sentence Similarity
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   - 11 SystemVerilog assertion templates were generated

Experimental Evaluation

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   - From 145 assertions 100 have been classified as low level assertions
2. Partitioning based on Sentence Similarity
   - 11 clusters are found
3. Partitioning based on Sentence Similarity
   - 11 SystemVerilog assertion templates were generated
   - Each is applied to all elements of the corresponding cluster

Summary

Two Requirement evaluation approaches

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- Static Sentence Analysis

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- Guidelines Validation

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Assertions translation approach