Automated Techniques for Finding and Maintaining Traces

Group 1

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Overview

- Preliminary Remarks
- 2 Methodology
- Studies
- 4 Discussion

The Need for Automatisation

Traditional requirements tracing is

- slow
- expensive
- prone to non-completeness (missing links)

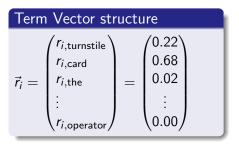
 \Rightarrow Indicators for automation potential

How to Find Links?

- Relevancy likelihood estimation is a basic task in computational linguistics.
- Basically a search engine where everything's a query and everything's a document.
- One possible technique: term vectors.

Term Vectors

How relevant is a specific term to an artifact?



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Term Vector structure $\vec{r}_{i} = \begin{pmatrix} r_{i,\text{turnstile}} \\ r_{i,\text{card}} \\ r_{i,\text{the}} \\ \vdots \\ r_{i,\text{operator}} \end{pmatrix} = \begin{pmatrix} 0.22 \\ 0.68 \\ 0.02 \\ \vdots \\ 0.00 \end{pmatrix}$

TF-IDF
$$r_{i,j} = tf_{i,j} \cdot \log \frac{1}{df_j}$$

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How relevant are two artifacts to each other?

Cosine Similarity

$$\mathit{rel}_{\vec{r}_1, \vec{r}_2} = \cos(\vec{r}_1 \angle \vec{r}_2) = \frac{\vec{r}_1 \cdot \vec{r}_2}{|\vec{r}_1| \cdot |\vec{r}_2|}$$



What to do with this information?

- We have an automatically generated relevancy likelihood extimation for each pair of trace artifacts.
- Two options:
 - **①** Register all traces with a similarity $> \theta$ and be done with it.
 - 2 Present higher-probability links to human analyst for validation.
- Option 2. Definitely option 2.
- Therefore recall must be optimised over precision.

Learning

- Automatic relevancy vectors are unreliable.
- Let's steal some stuff from computational linguists again!
 - Weight matrices are useful!

Adding a weight vector

$$\vec{r}_{\text{doc}} \cdot \vec{w} = \begin{pmatrix} r_{\text{turnstile}} \\ r_{\text{card}} \\ r_{\text{the}} \\ \vdots \\ r_{\text{operator}} \end{pmatrix} \cdot \begin{pmatrix} w_{\text{turnstile}} \\ w_{\text{card}} \\ w_{\text{the}} \\ \vdots \\ w_{\text{operator}} \end{pmatrix} = \begin{pmatrix} 0.22 \\ 0.68 \\ 0.02 \\ \vdots \\ 0.00 \end{pmatrix} \cdot \begin{pmatrix} 0.75 \\ 2.00 \\ 0.25 \\ \vdots \\ 1.00 \end{pmatrix}$$

 Weights can be uniformly initalised and later modified according to feedback from human analysts.

Hayes et al. 2007

- RETRO system
 - Facilitates tracing for human analysts
 - Intended for vertical tracing ('high-level' to 'low-level' artifacts)

| | Recall | Precision | Time [min] |
|------------------|--------|-----------|------------|
| Manual group | 0.33 | 0.24 | 120.67 |
| RETRO group | 0.70 | 0.13 | 41.88 |
| T test (p value) | 0.001 | 0.01 | 0.0004 |

Huang et al. 2007

- Poirot System
 - Smarter parsing
 - (Programming) stopword removal
 - Normalisation of conventionallyStyledNames();
- Achieved 90% recall and about 30% precision
- Deduced nine 'best practices'

Huang's Best Practices

- Trace for a purpose
- Define a suitable trace granularity
- Support in-place traceability
- Use a well-defined project glossary
- Write quality requirements
- Construct a meaningful hierarchy
- O Bridge the intradomain semantic gap
- Create rich content
- Use a process improvement plan

Discussion