# Semantic Approaches to Software Component Retrieval with English Queries

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## Introduction

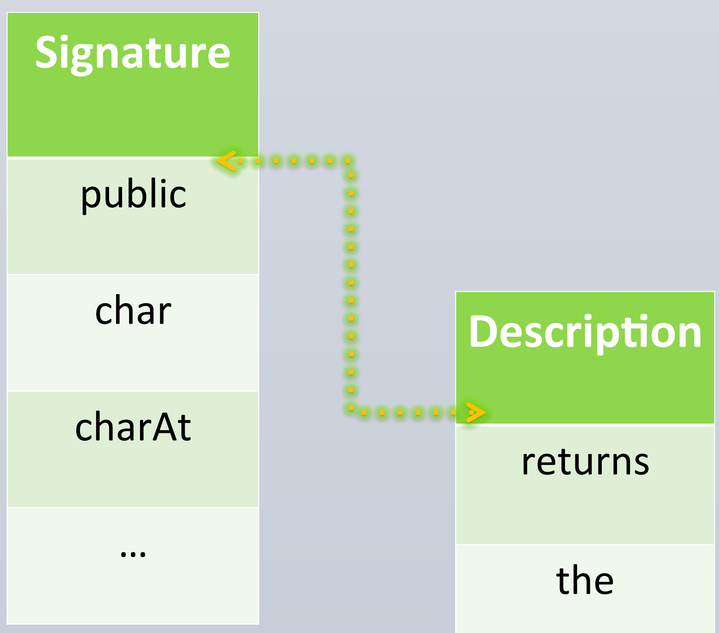
- Enabling code reuse is a major goal in software engineering, and it depends crucially on effective code search interfaces.
- We propose to ground word meanings in source code and use such language-code mappings to make possible a programming library search interface where users can pose queries in English.
- We exploit the fact that there are large programming language libraries which are documented both via formally specified function or method signatures as well as descriptions written in natural language.
- We applied different models to learn the language-signature relation, enabling effective Java methods signature retrieval with English queries.

## Example Data

- Javadoc documentation for method *charAt* in the class *java.lang.String*:

> **Class:** java.lang.String
> **Signature:** public char charAt(int index)
> **Description:** *Returns the char value at the specified index*. An index ranges from 0 to length()-1. The first char value of the sequence is at index 0, the next at index 1, and so on, as for array indexing.

- We collected such Javadoc documentation of the Java Standard Library.
- **To Simulate the queries, we take the first sentence of each description, e.g. "**Returns the char value at the specified index**".**
- **We aim to build a mapping between the terms of Signature and the terms of Description to enable method signatures retrieval using queries formulated in English.**




## Models

- To retrieve method signatures using English queries, we rank signatures according to the probability of the method signature ***d*** given query ***q (unigram language model)***:

$$p(q|d) = \prod_{w \in q} p(w|d)$$

- **Baseline**: term-matching model, where we set ***p(w|d)*** to the maximum likelihood estimate (MLE) with Jelinek-Mercer smoothing:

$$p(w|d) = (1-\lambda) f(w|d) + \lambda f(w|D)$$

  - ***f(w|d)***: relative frequency of ***w*** in method signature ***d***
  - ***f(w|D)***: relative frequency of ***w*** in the whole method collection ***D***

- **PLDA model:**

$$p(q|d) = \prod_{w \in q} \left[ \sum_{t \in T} p(w|t) p(t|d) \right]$$

  - ***p(w|t):*** word distribution of topic
  - ***p(t|d):*** topic distribution of document
  - ***T*** represents for all topics

- **Interpolated PLDA model:**

$$p(q|d) = (1-\alpha) \times p_{plda}(q|d) + \alpha \times p_{baseline}(q|d)$$

- **IBM model:**

$$p(w|d) = (1-\lambda) \left[ \sum_{u \in d} p(w|u) f(u|d) \right] + \lambda f(w|D)$$

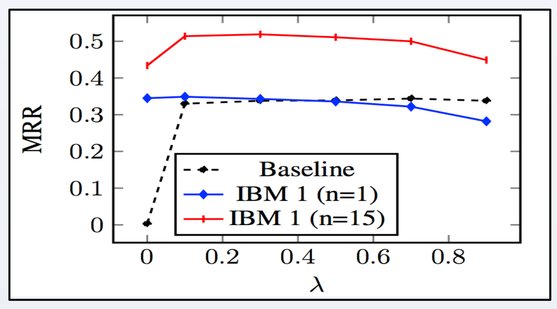
  - ***p(w|u)***: probability of translating from term ***u*** to ***w***; ***u*** is one term from signature and ***w*** is a term from description
  - The translation probability is derived from the parallel corpus of method signatures and descriptions.

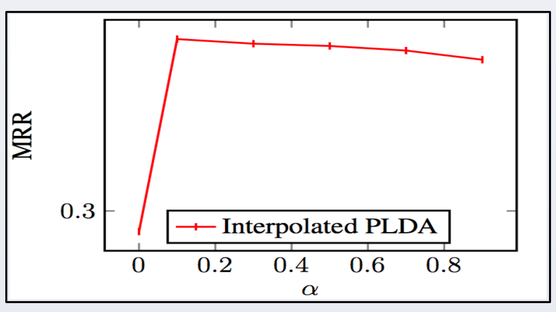
## Experiment

- Data: documentation of 6 packages from the Java standard library (Standard Edition 6 API Specification ): io, lang, math, net, text, util.
- Split data into training set (60%), validation set (20%), test set (20%).
- To simulate queries, we take the first sentence of descriptions in the test (or validation) set (see Example Data).
- we use mean reciprocal rank (MRR) as our evaluation metric.

## Results

- **Results on validation data**




- **Results on test data**

| Model | MRR | Acc@1 | Acc@10 |
|---|---|---|---|
| Baseline (λ = 0.7) | 0.332 | 0.223 | 0.530 |
| Interpolated PLDA (α = 0.1) | 0.352 | 0.242 | 0.562 |
| IBM model 1 (λ = 0.3) | **0.493** | **0.339** | **0.793** |

## Conclusion

- Our research demonstrates that a user-friendly natural language API search interface can be built by exploiting naturally occurring language-code parallel data to ground word meanings.
- The level of performance we have seen is already useful for a real-world application: 80% of queries receive the correct answer within top 10 results.
- Together with this paper we release the data and code developed for this work: ***bitbucket.org/gchrupala/codeine***.
- For future work, we would like to evaluate our approach on real user queries. It would be also interesting to see how our method generalizes to other programming languages.

## References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