Analyzing Software using Deep Learning

Token Vocabulary and Code Embeddings (Part 3)

Prof. Dr. Michael Pradel

Software Lab, University of Stuttgart

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Overview

- **Token Vocabulary problem**
- **Pre-trained token embeddings**
- **Joint embedding space for NL & PL** ←

Recommended papers:

- ”Distributed representations of words and phrases and their compositionality”, NIPS, 2013
- ”Big Code != Big Vocabulary - Open-Vocabulary Models for Source Code”, ICSE, 2020
- ”Deep Code Search”, ICSE, 2018

NL & PL Information

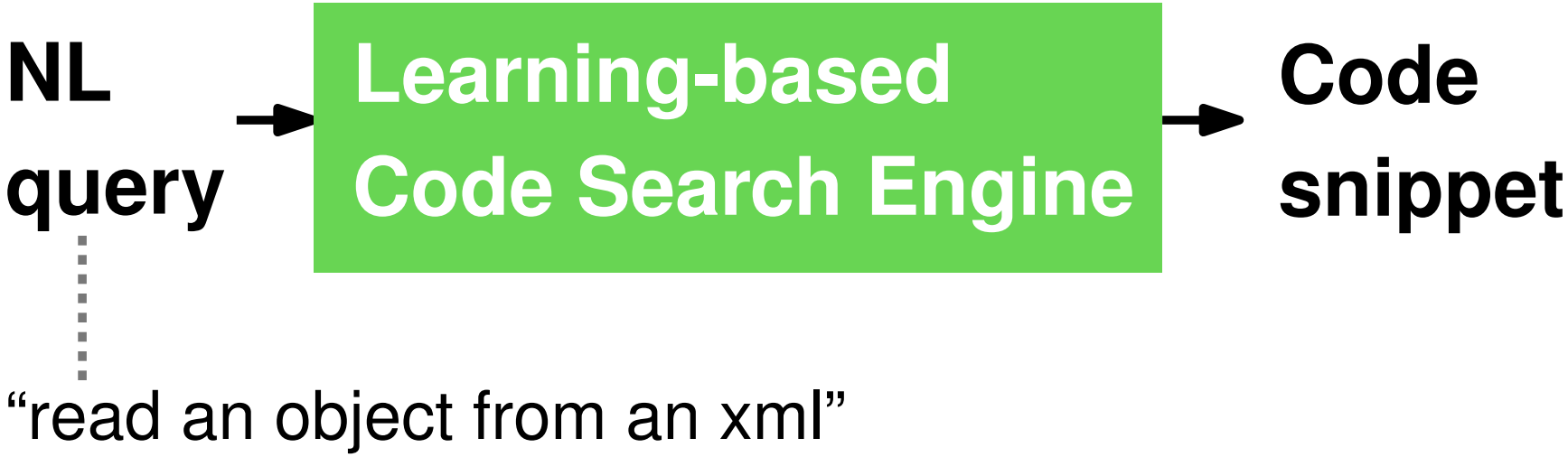
- **Software is not just code**
- **Many natural language artifacts**
- **Applications of reasoning about both PL and NL information**
  - NL-to-code search
  - Predict or check comments
  - Learn from API documentation

Joint Embedding Space

- **How to reason about PL tokens and NL words together?**
- **Idea: Learn embedding that maps both PL tokens and NL words into a single vector space**
  - Goal: Related tokens and words are close-by
  - Model learns how to related PL and NL information to each other

Deep Code Search

Deep Code Search



Deep Code Search

NL query → **Learning-based Code Search Engine** → **Code snippet**

"read an object from an xml"

```
public static < S > S deserialize(Class c, File xml) {
    try {
        JAXBContext context = JAXBContext.newInstance(c);
        Unmarshaller unmarshaller = context.createUnmarshaller();
        S deserialized = (S) unmarshaller.unmarshal(xml);
        return deserialized;
    } catch (JAXBException ex) {
        log.error("Error-deserializing-object-from-XML", ex);
        return null;
    }
}
```

Deep Code Search

NL query → **Learning-based Code Search Engine** → **Code snippet**

"read an object from an xml"

Note: Similar terms, but no the same

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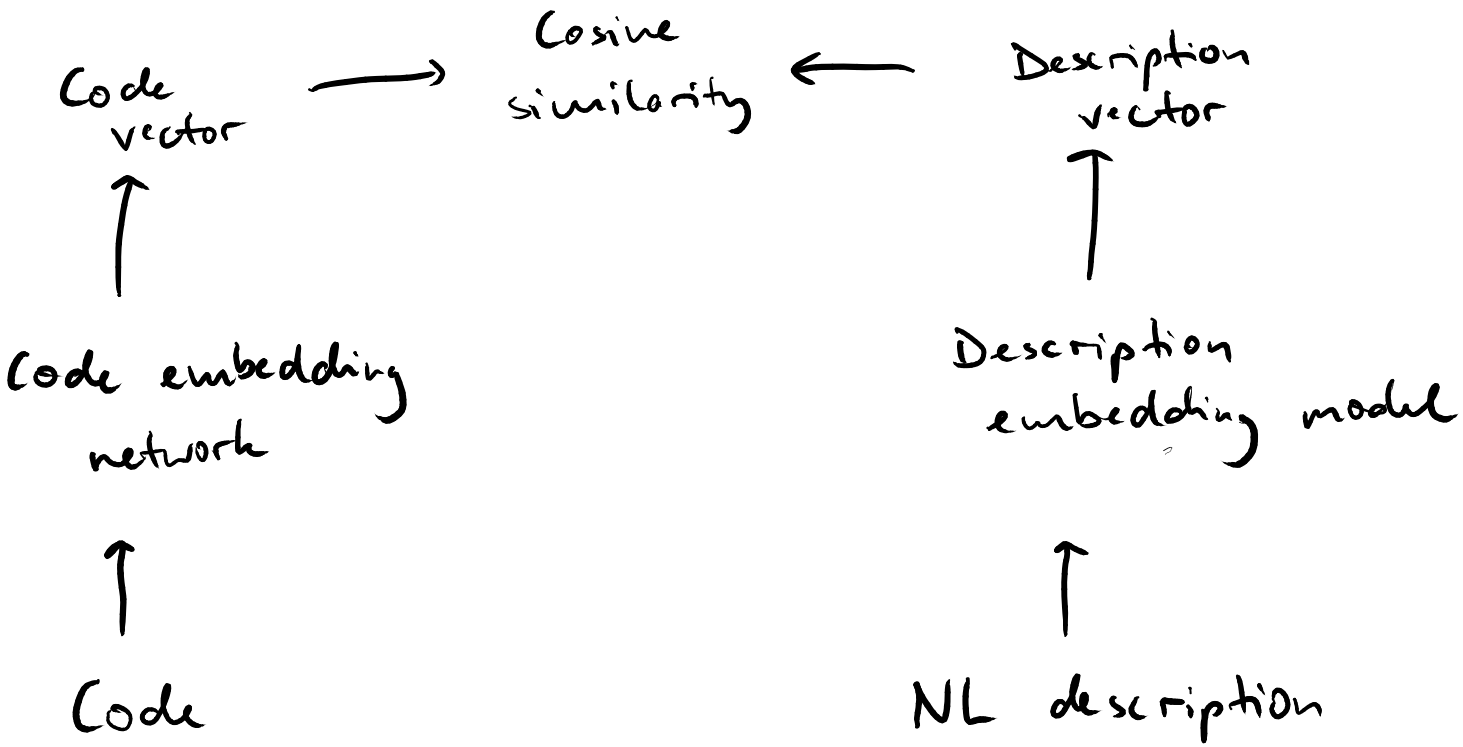
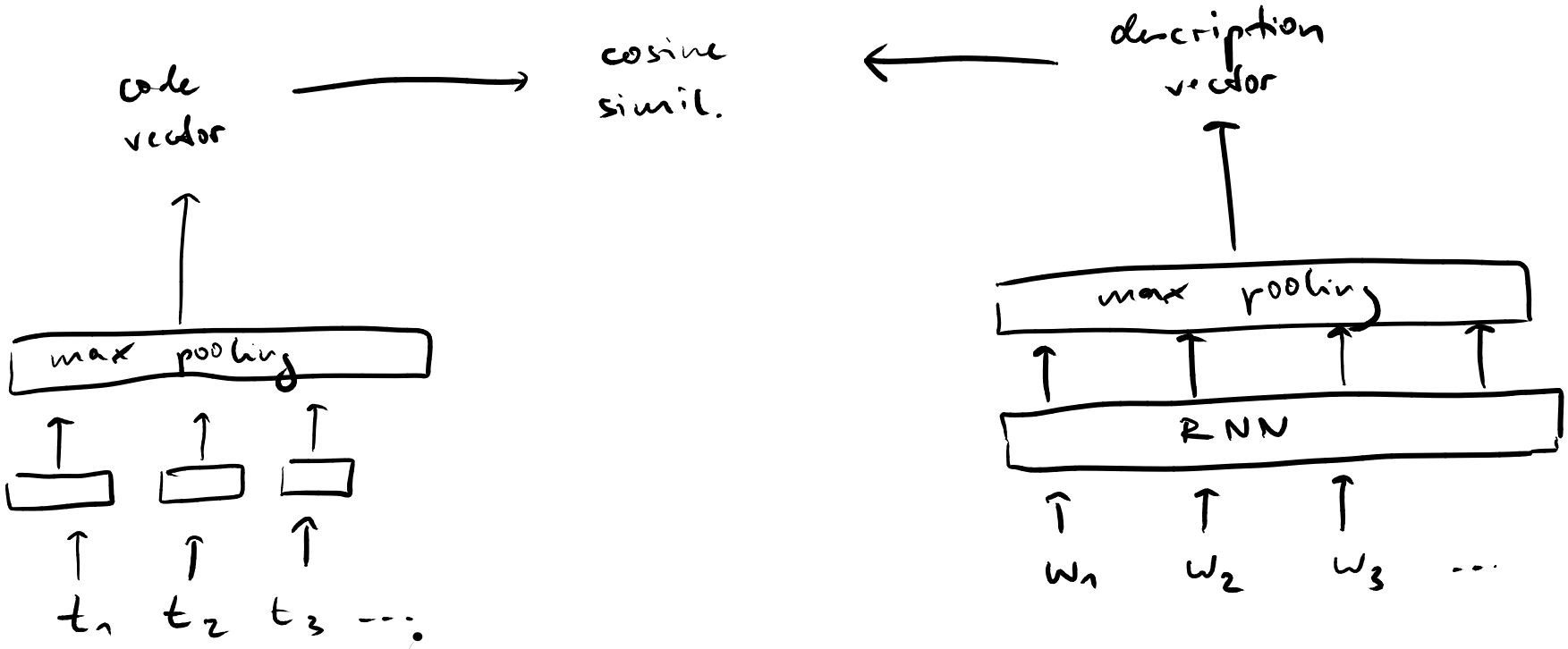
Overview


Code vector
Cosine similarity
Description vector
Code embedding network
Description embedding model
Code
NL description

Neural model



Code : set of tokens

Description : sequ. of words

Training the Model

- **Train with pairs of code snippet c and NL query d**
  - Matching pairs (c, d_+)
  - Non-matching pairs (c, d_-)
- **Loss function:**

$$\mathcal{L}(\theta) = \sum_{<C, D^+, D^->\in P} max(0, \epsilon - cos(\boldsymbol{c}, \boldsymbol{d}^+) + cos(\boldsymbol{c}, \boldsymbol{d}^-))$$

”Deep Code Search” (Gu et al., 2018)

Results

- **Model trained on 18 million Java methods and their comments (as a surrogate for NL queries)**
- **Evaluation with 50 questions from stackoverflow.com**
  - Correct code snippet predicted at position 1 or 2 for most queries