Semantic Code Search using Hypergraph Neural Networks

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Aim

Exploring Semantic Code Search using Hypergraph Neural Networks to capture higher-order multi-way relationships between functions and concepts.

Objectives

➢Capture **higher-order relationships** between functions and concepts using Hypergraph Neural Networks.
➢Retrieve **top-k relevant code snippets** for a given natural language query.
➢Learn meaningful function and concept embeddings through **contrastive learning** over hyperpaths.

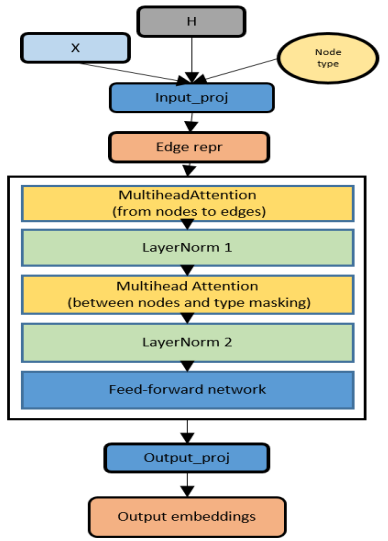
Introduction

- Engineers often struggle to navigate complex tools using traditional documentation.
- Newcomers find it hard to locate code examples that match their intent.
- This project uses Hypergraph Neural Networks for semantic code search to bridge that gap via natural language queries.

Dataset used

- Dataset used for training is the Python subset of CodeSearchNet
- The corpus is a dataset of 2 million (comment, code) pairs from opensource libraries hosted on GitHub
- Out of these, 30000 function-docstring pairs were used for the hypergraph construction.

Model Architecture



Example

Q. How to find synonyms of a word?

```
def findSynonyms(self, word, num):
        """
        Find synonyms of a word

        :param word: a word or a vector representation of word
        :param num: number of synonyms to find
        :return: array of (word, cosineSimilarity)

        .. note:: Local use only
        """
        if not isinstance(word, basestring):
            word = _convert_to_vector(word)
        words, similarity = self.call("findSynonyms", word, num)
        return zip(words, similarity)
```

Results

Metric	HGNN Model	CodeBERT	SBERT	E5-small-v2
NDCG@3	**0.905346**	0.897424	0.894881	0.996800

Table 6.1: NDCG@3 comparison across models

Related work

Title	Publish date	Summary
CodeBERT: A Pre-Trained Model for Programming and Natural Languages	18 September 2020	CodeBERT is a bimodal pre-trained model that uses a masked language modeling (MLM) and replaced token detection (RTD) objective to align code with comments/docstrings.
You are AllSet: A Multiset Learning Framework for Hypergraph Neural Networks	28 March 2022	A framework that models hypergraph propagation using multiset functions rather than traditional adjacency-based methods.

Implementation

•A hypergraph links function nodes (from docstrings) to concept nodes (from TF-IDF keywords) via hyperedges.
•The AllSet Transformer performs attention-based message passing and node aggregation.
•A contrastive loss trains the model to align each function with its concept-based hyperpath.
•At inference, a query is encoded and matched to concept paths to retrieve top-k relevant functions.

Conclusion

•The proposed HGNN-based semantic code search models complex links between functions and conceptual keywords.
•It improves code retrieval, boosts developer productivity, and streamlines API exploration.

References

[1] A. Chien, C. Qian, and C. Shah, ”AllSet: Hypergraph Transformer for Set Representation Learning,” in International Conference on Machine Learning (ICML), 2022.
[2] X. Wang, H. Huang, J. Ye, and E. Xu, ”Multi-Similarity Loss with General Pair Weighting for Deep Metric Learning,” in Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), 2019.
[3] CodeSearchNetChallenge Dataset, GitHub Repository, Available: https://github.com/github/CodeSearchNet.