VarCLR: Variable Semantic Representation Pre-training via Contrastive Learning


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Variable Names are an Important Part of a Project

Variable Names are Important to Human Programmers

```
def minimumTotal(self, t):
    return reduce(
        lambda a, b: [f + min(d,
e) for d, e, f in zip(a, a[1:],
b)], t[::-1]
    )[0]
```

120. Triangle

Medium 4795 380 Add to List Share

Given a `triangle` array, return *the minimum path sum from top to bottom*.

For each step, you may move to an adjacent number of the row below. More formally, if you are on index `i` on the current row, you may move to either index `i` or index `i + 1` on the next row.

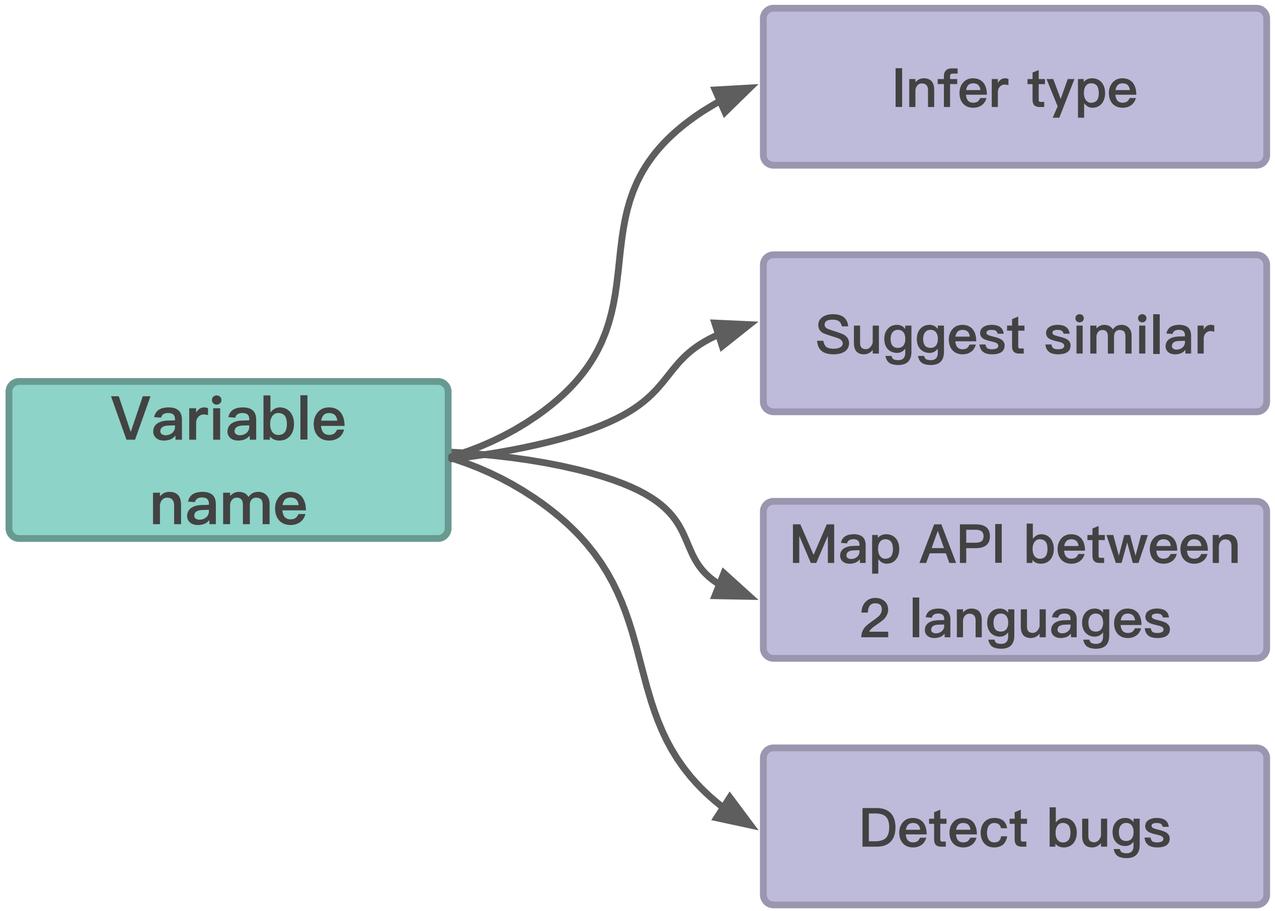
Example 1:

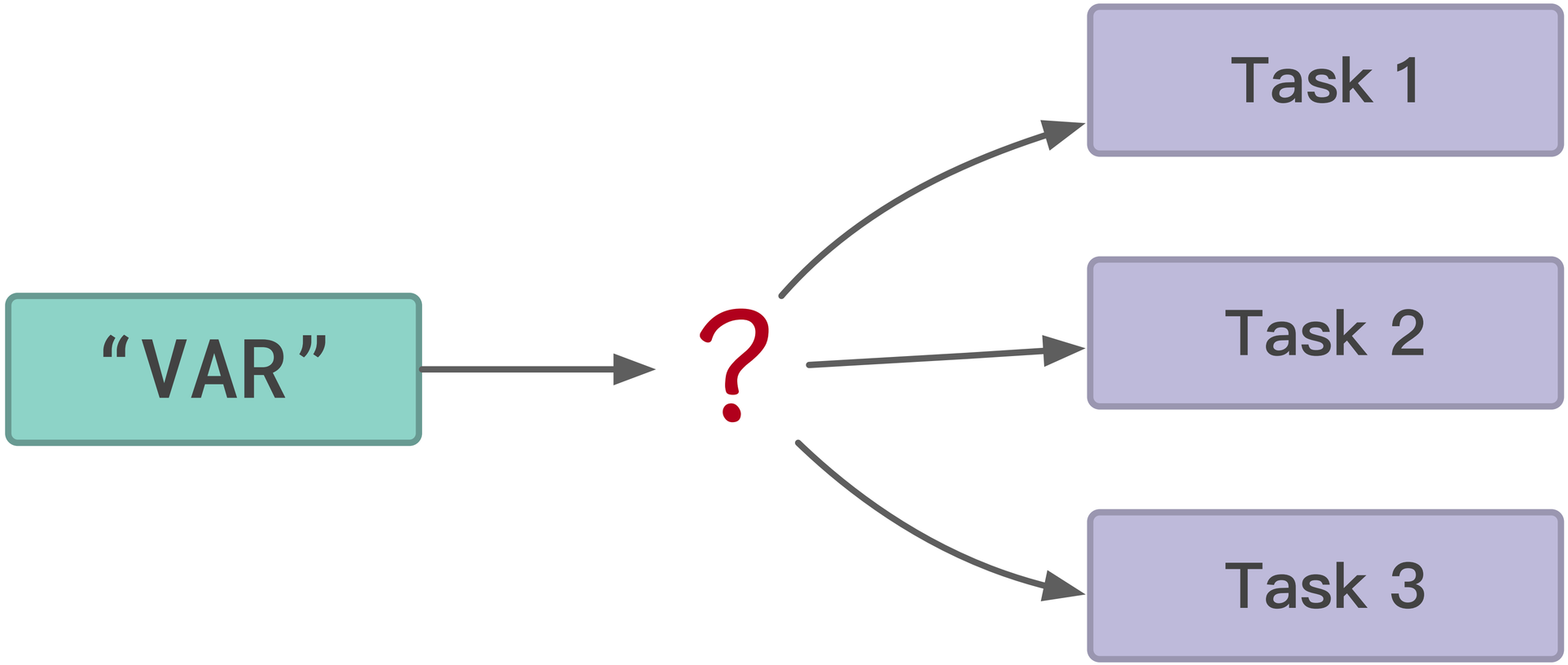
```
Input: triangle = [[2],[3,4],[6,5,7],[4,1,8,3]]
Output: 11
Explanation: The triangle looks like:
   2
  3 4
 6 5 7
4 1 8 3
```

“Full word > abbreviation >> single character”
(128 participants)

–Lawrie et al., 2006, “What’s in a Name?”

Variable Names are Important to Name-based Analysis Tasks



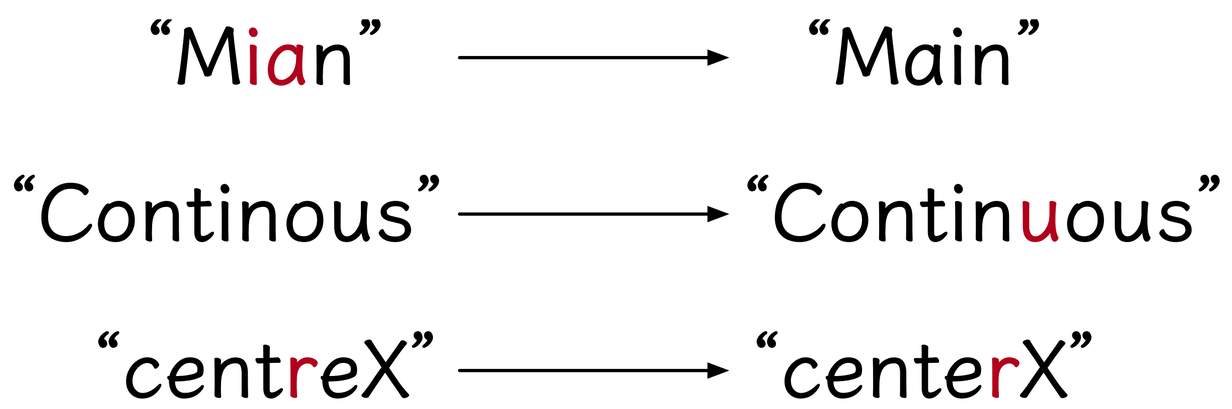


This variety of applications have a shared underlying problem:
Variable Representation

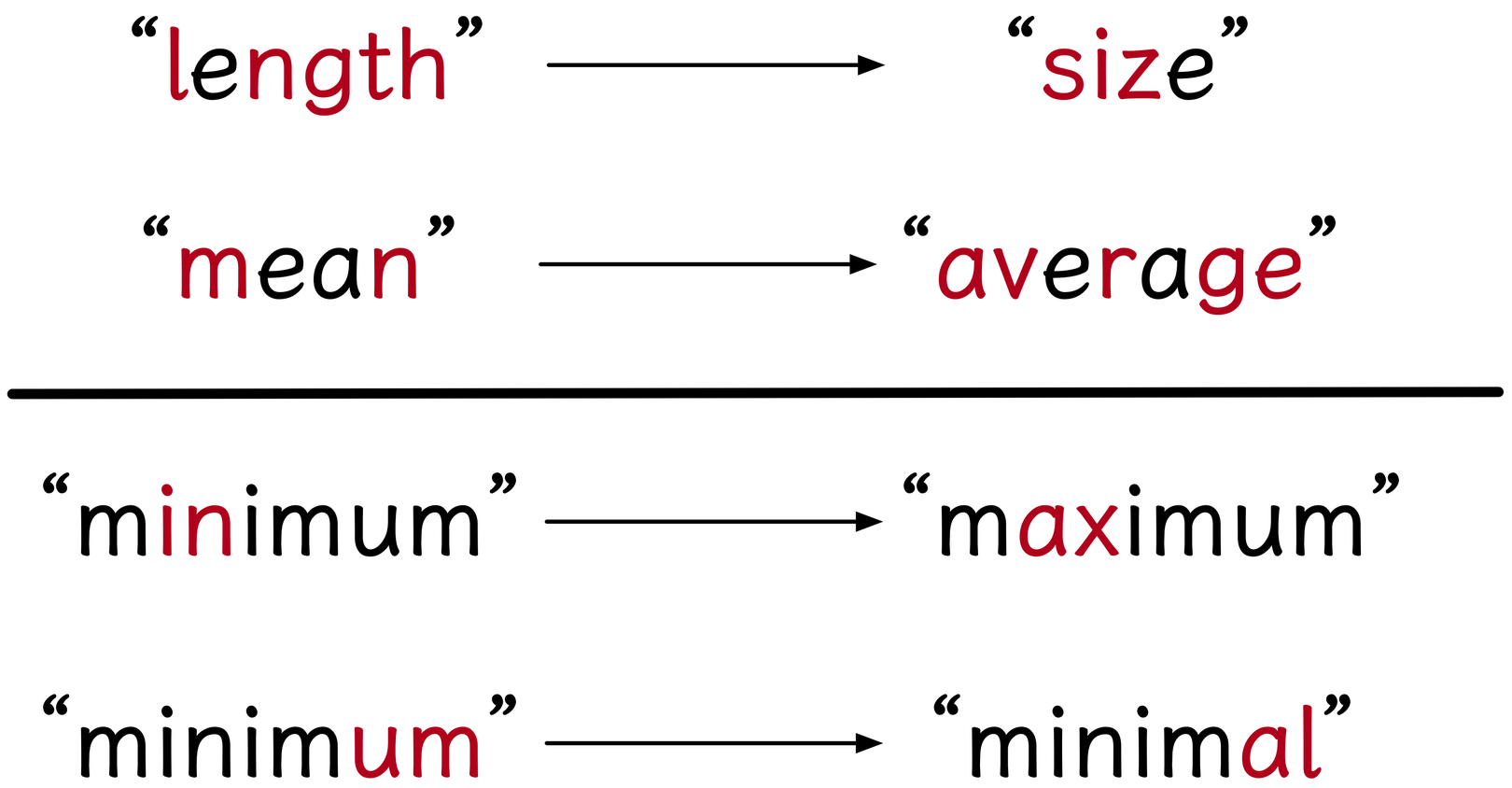
What Properties Make Good Variable Representations?

- Character similarity
- Open vocabulary
- Subword importance and order
- ⭐ **Relatedness**
- ⭐ **Similarity** **(interchangeability)**

Desired Property of Variable Representation: Character Similarity



Character Similarity Is Not Enough and Can Be Misleading

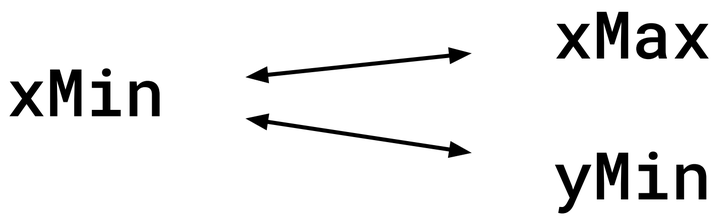


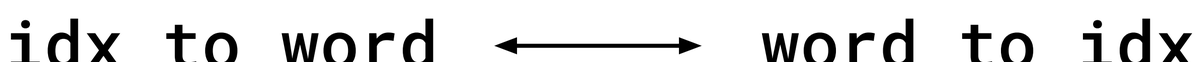
Desired Property of Variable Representation: Open Vocabulary

- Variables are like languages with no whitespaces
  - `arrayListCompletedFromForm_withoutDuplicate`
- Split by `camelCase` or `snake_case`?
- Arbitrary abbreviations and contractions
  - `filenames, fnames, displayMessage, displayMsg`

Desired Property: Subword Importance and Order

- Subword importance
- Subword importance can change dynamically
- Subword order affects the meaning





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Desired Property of Variable Representation: Relatedness

Relatedness: The Distributional Hypothesis

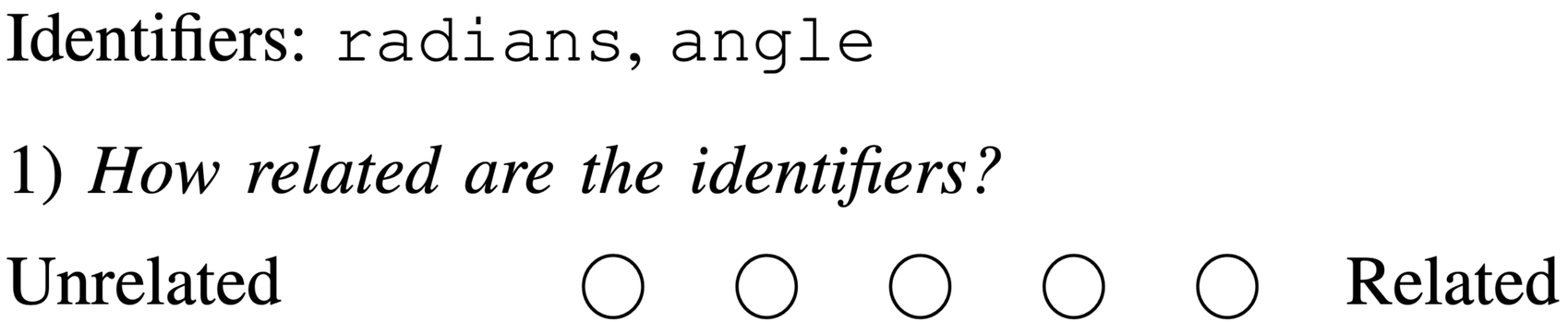
- Words that occur in the same contexts tend to have similar meanings (Harris, 1954)
- “A word is characterized by the company it keeps" was popularized by (Firth, 1957)

J. R. Firth, English linguist

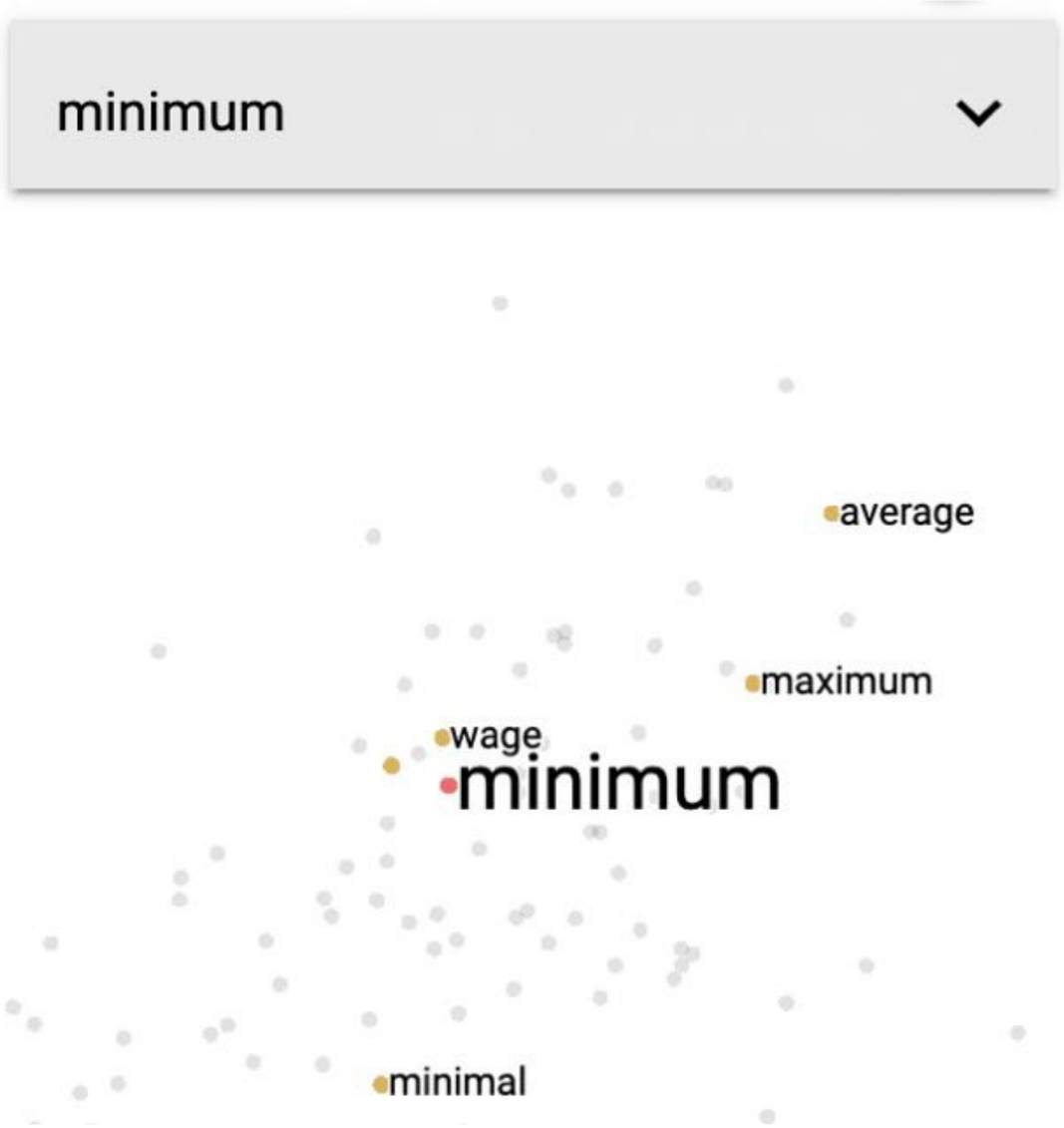
Relatedness: Evaluation Benchmarks and State-Of-The-Art Methods

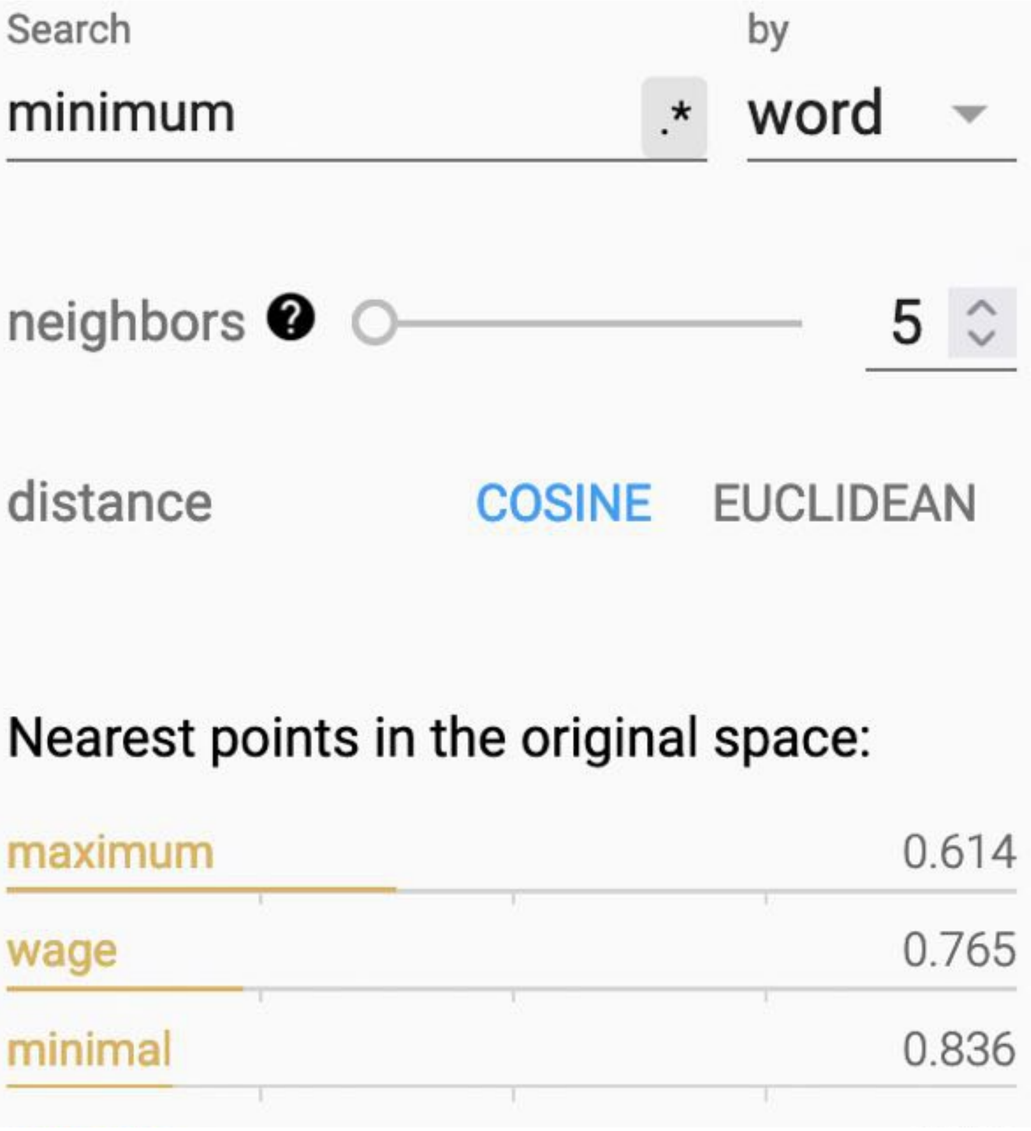
- **IdBench** (Wainakh, et al., ICSE 2021)
  - Word2vec
  - FastText
  - Path-based

Current Methods Are Effective at Representing Relatedness!



Limitation of Relatedness: It Is Not All You Need





https://projector.tensorflow.org/

Desired Property of Variable Representation: Similarity (substitutable)

Desired Property of Variable Representation: Similarity (substitutable)

	FastText (IdBench)	Human
`IdBench(`paddingTop`,`paddingRight`)` ⟶	0.89	0.07
`IdBench(`minText`,`maxText`)` ⟶	0.95	0.05

Beware of the underlying assumption when borrowing ML methods as a black box!

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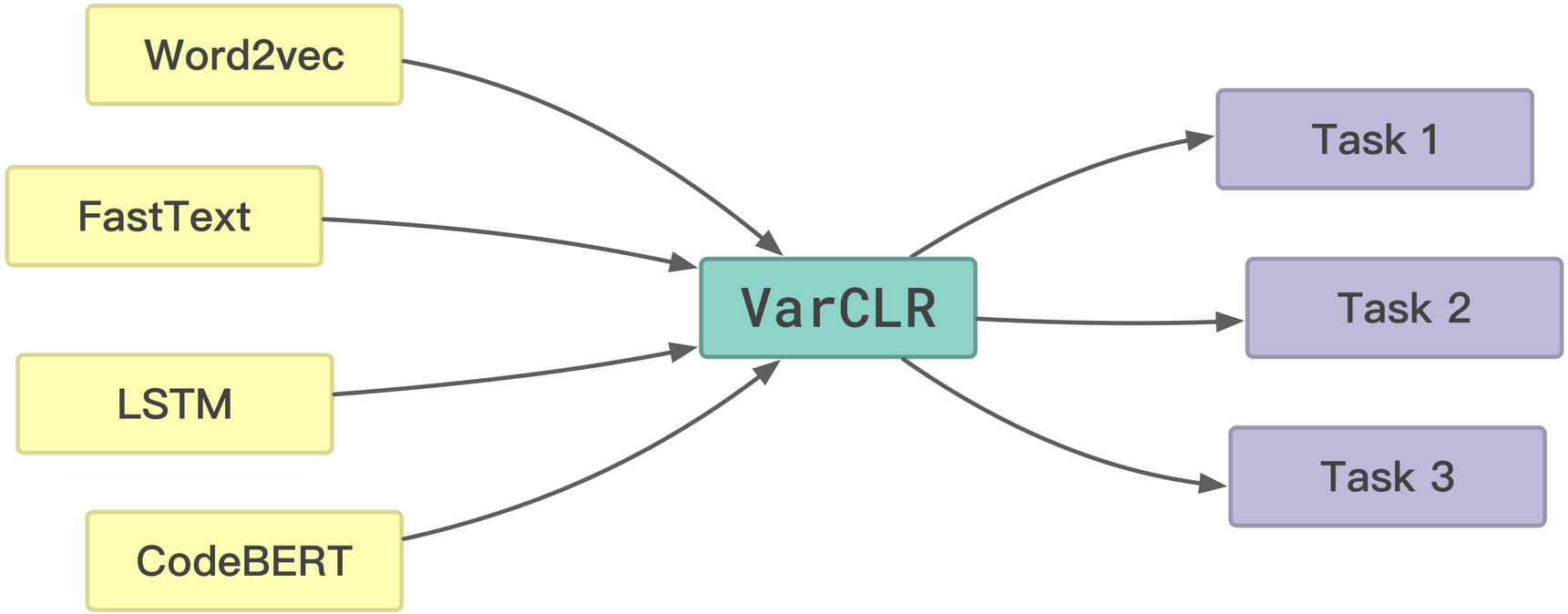
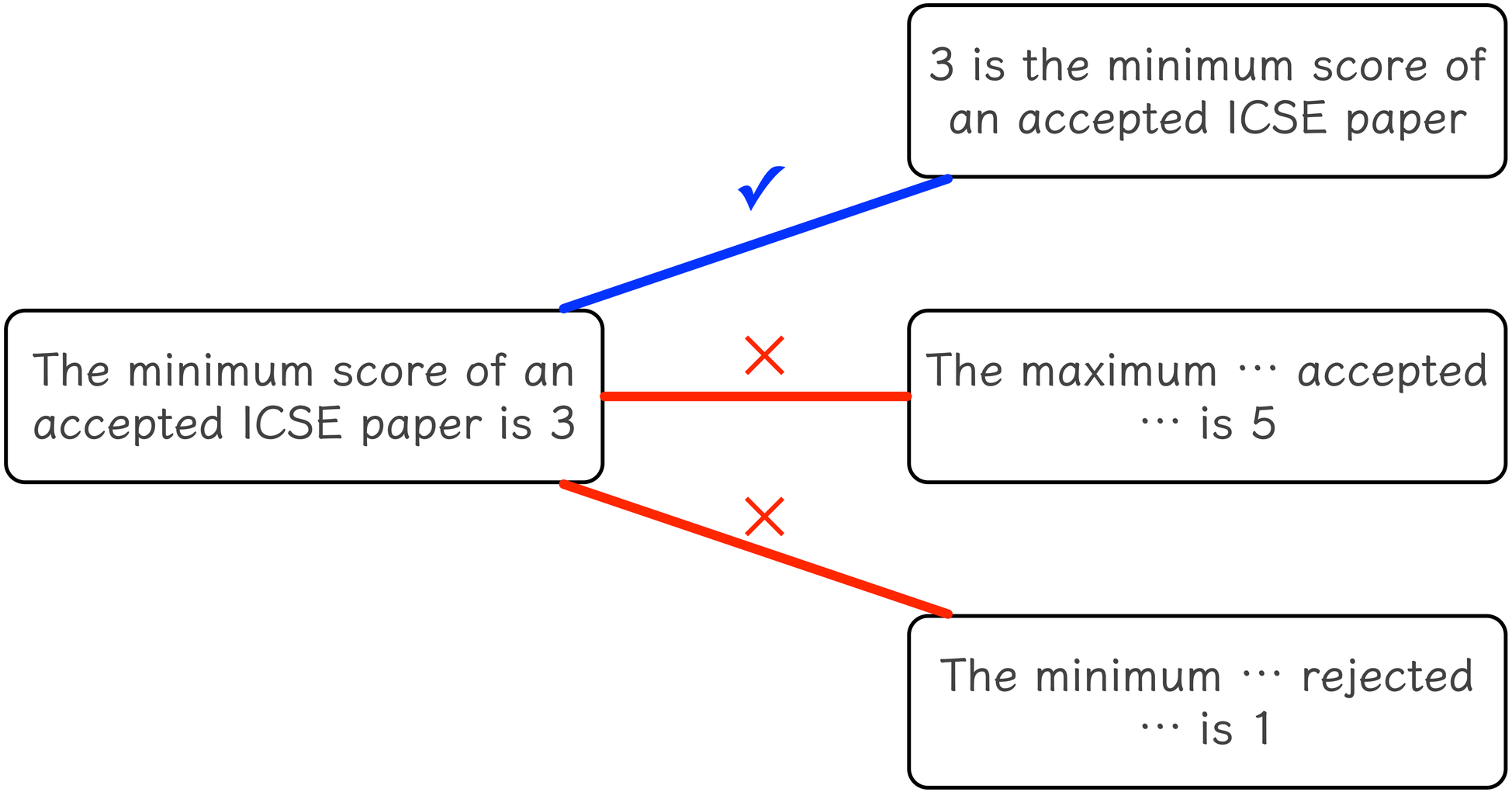
VarCLR: Towards Better Variable Representations

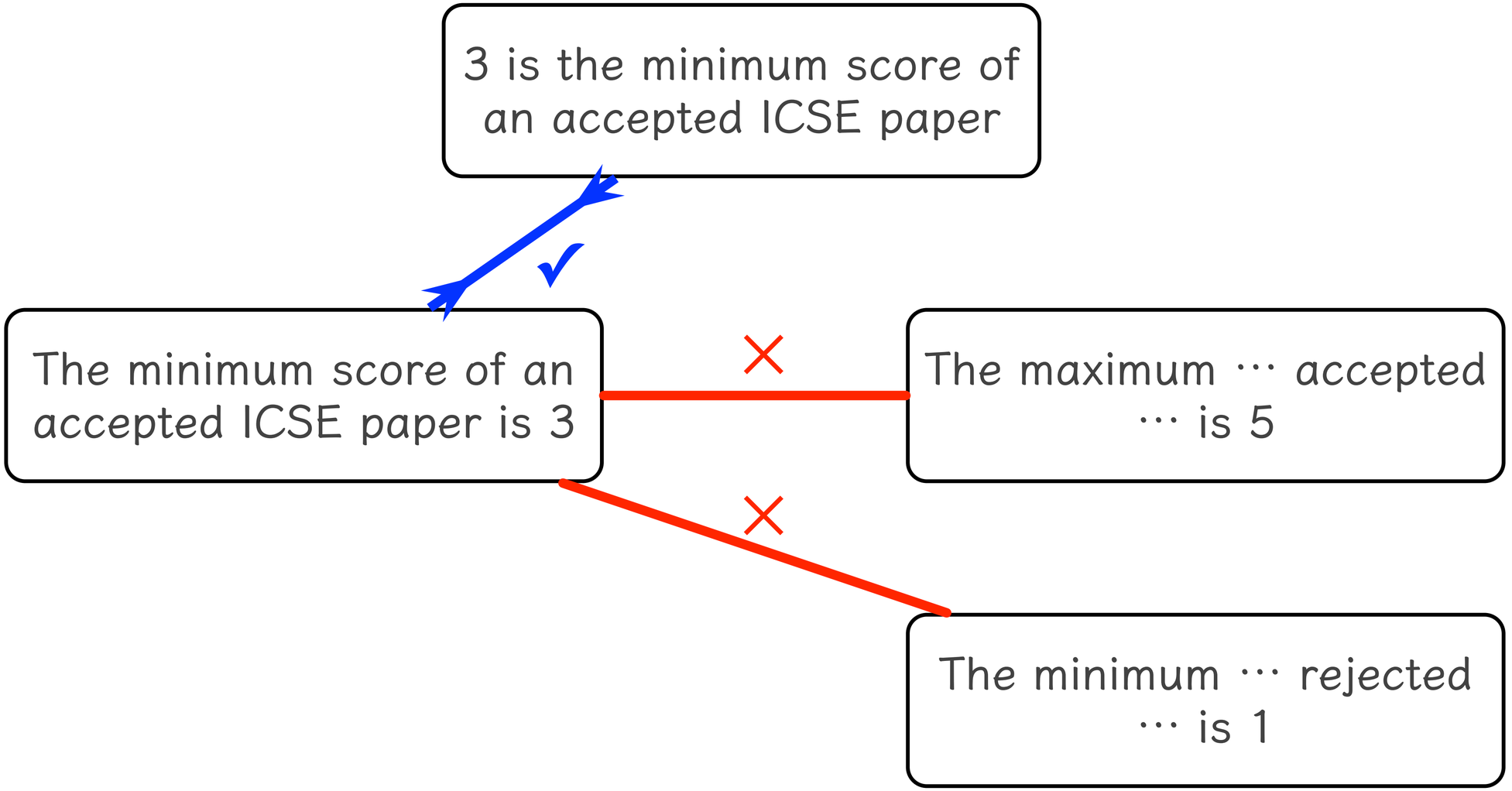
- Built on these SOTA approaches and improve the representations



With significantly improved similarity!



Contrastive Learning: A Motivating Example



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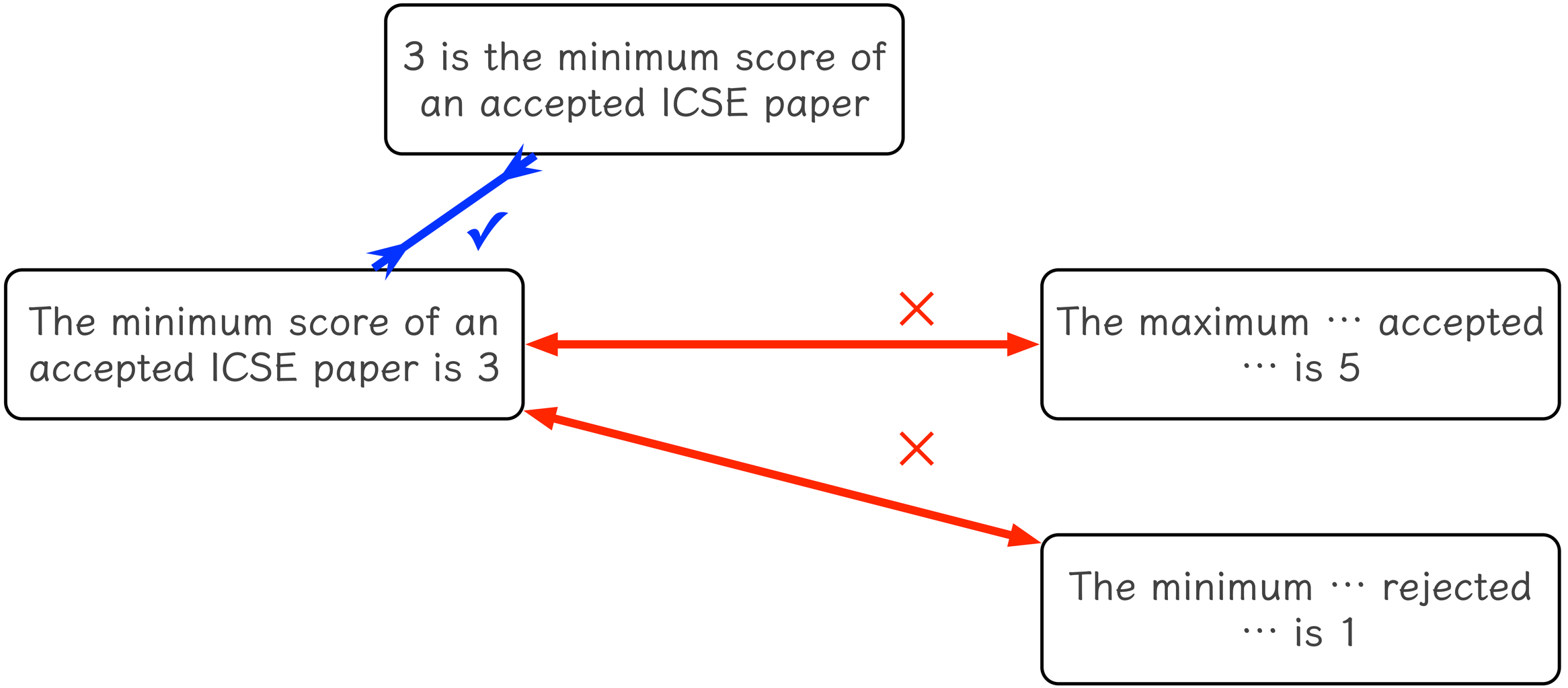
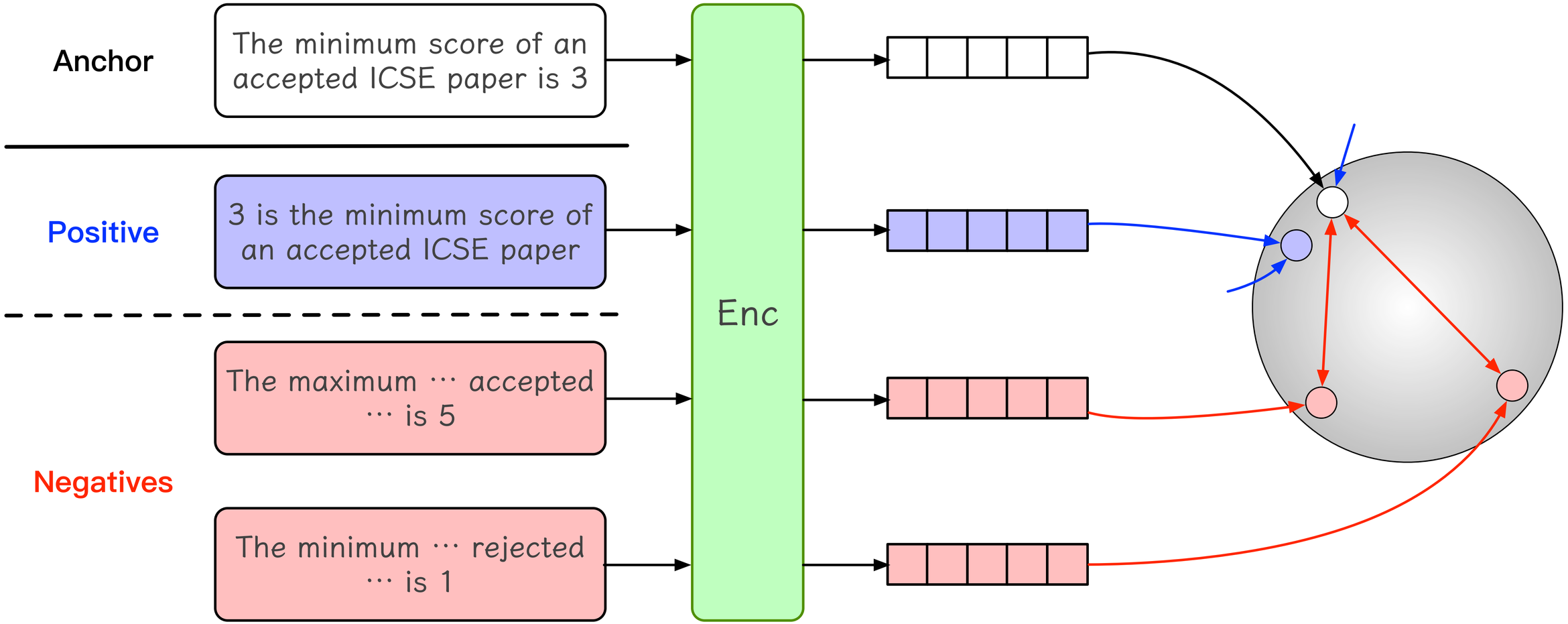


Contrastive Learning: A Motivating Example

What Is Contrastive Learning

- Given similar (and dissimilar) pairs
- Learn an embedding space where similar sample pairs are close to each other while dissimilar ones are far apart



Contrastive Learning: A Motivating Example

Fantastic Positive Pairs and Where to Find Them

- Image: augmentations (random crop, resize, clip, color jittering)
- Text: word dropouts, NLI labels (entailment / contradiction)
- Image-text: captions (OpenAI CLIP)

VarCLR GitHubRenames: Collecting Positive Variable Name Pairs

- Collected 66,855 pairs from 568 high star C# projects
- Where the only change in a diff block is the variable name

VarCLR GithubRenames: Example

6 docs/samples/Microsoft.ML.Samples/Static/FastTreeRegression.cs

Viewed

```
@@ -38,9 +38,9 @@ public static void FastTreeRegression()
38  38                      .Append(r => (r.label, score: mlContext.Regression.Trainers.FastTree(
39  39                                                    r.label,
40  40                                                    r.features,
41      -                                                 numTrees: 100, // try: (int) 20-2000
42      -                                                 numLeaves: 20, // try: (int) 2-128
43      -                                                 minDatapointsInLeaves: 10, // try: (int) 1-100
        41 +                                              numberOfTrees: 100, // try: (int) 20-2000
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44  44                                                    learningRate: 0.2, // try: (float) 0.025-0.4
45  45                                                onFit: p => pred = p)
46  46                      )
```
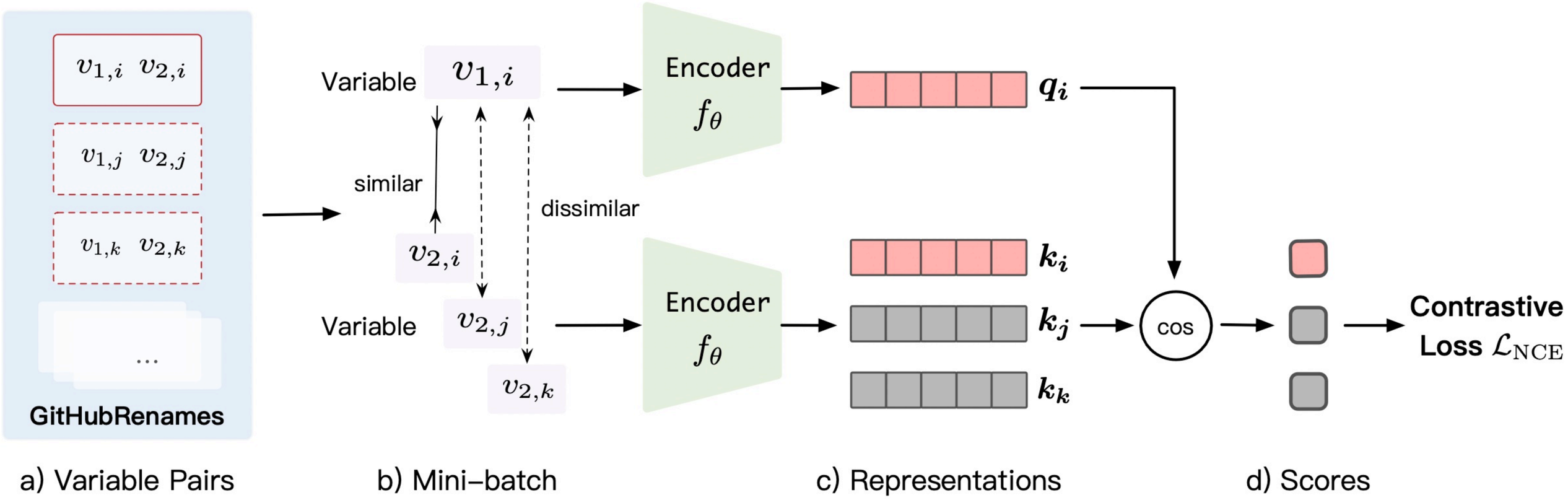

VarCLR: Overview



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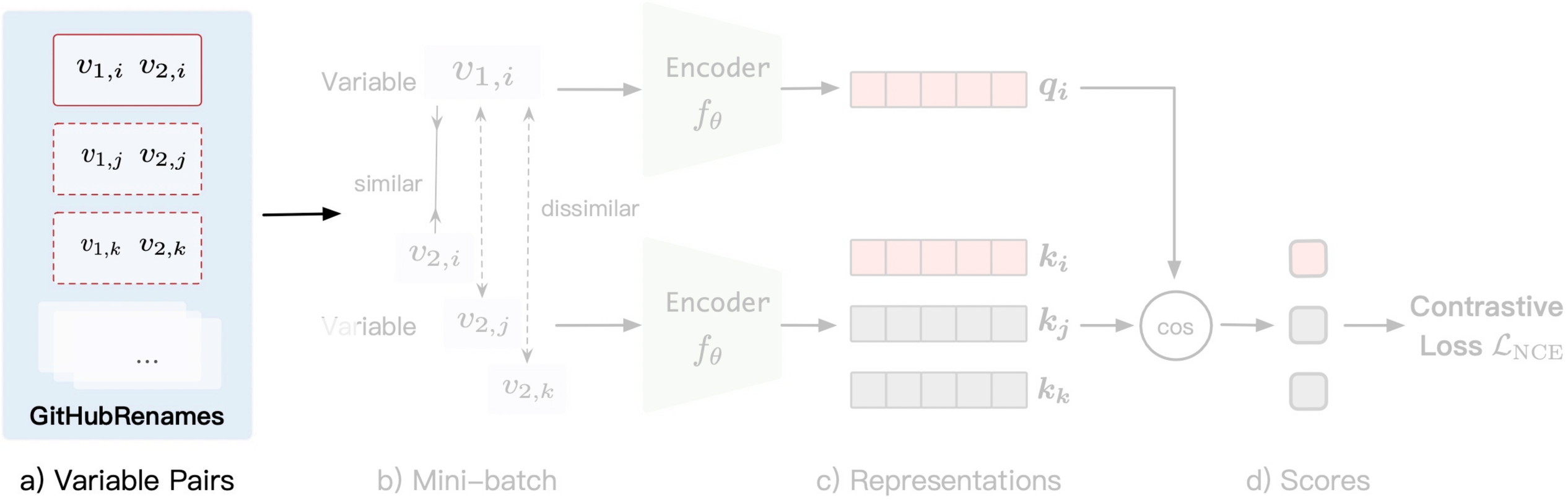
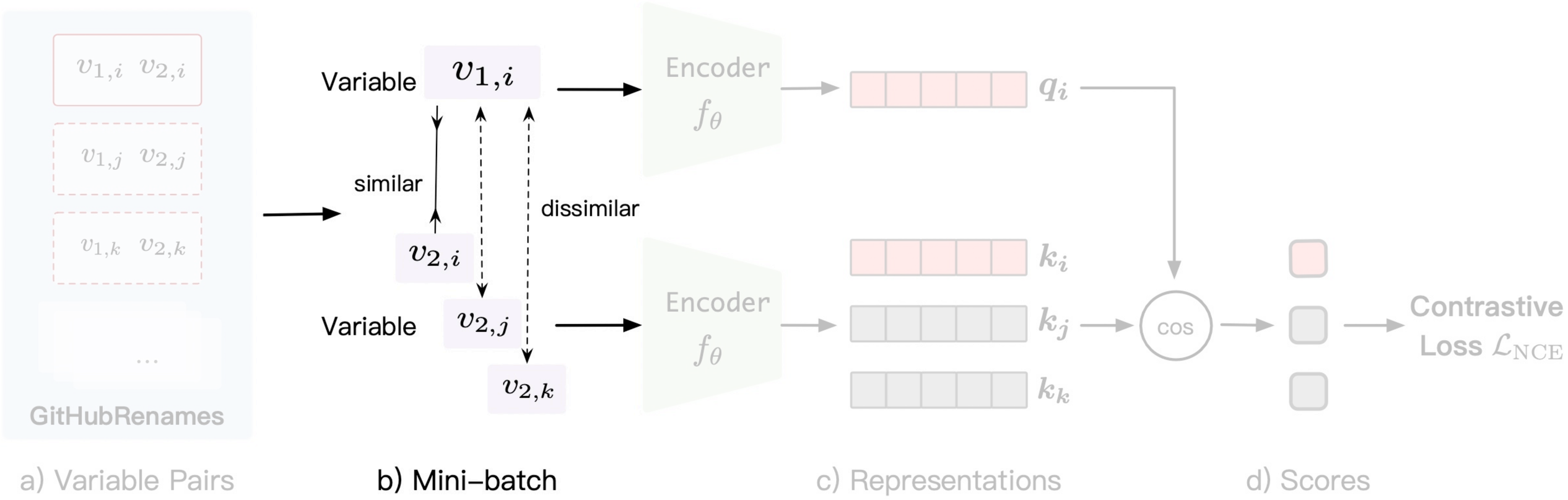


positives

VarCLR: Overview



positives in-batch negatives

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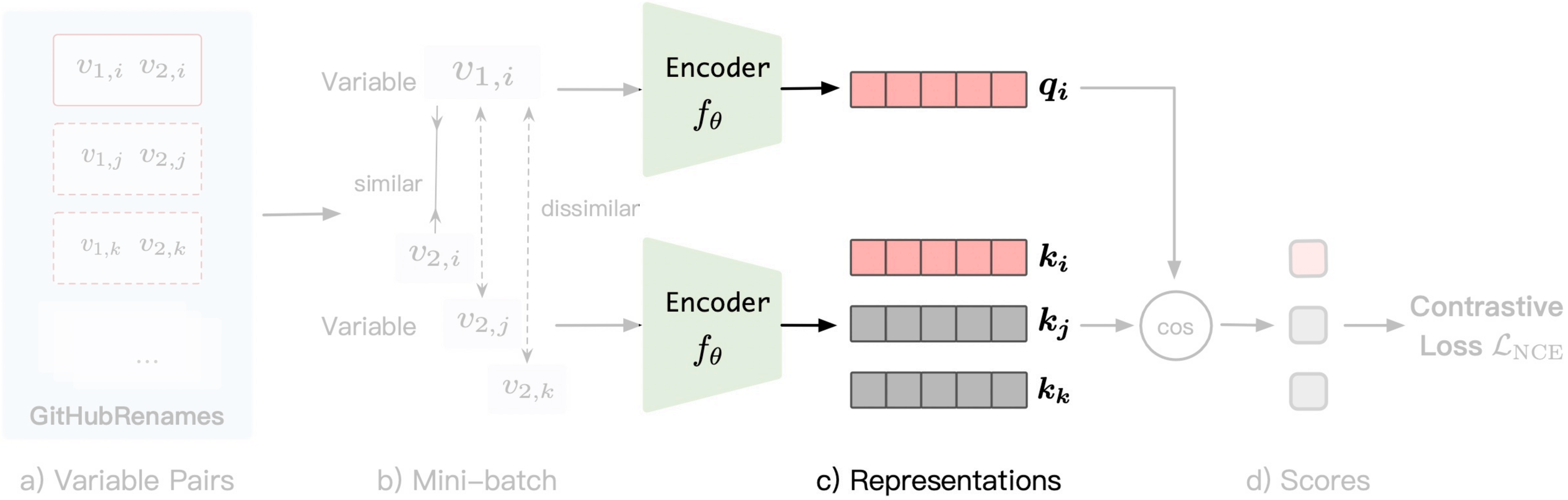

positives in-batch negatives encoders

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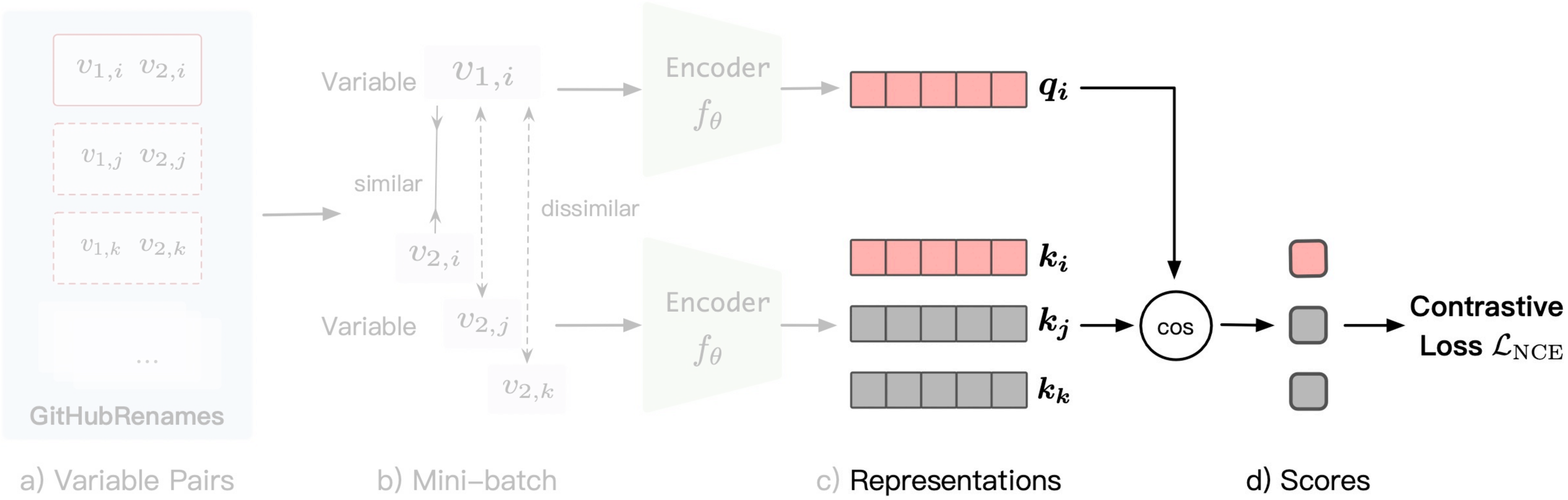


positives in-batch negatives encoders InfoNCE objective

VarCLR: Experiment Setup

- Benchmark: IdBench
  - Relatedness vs. Similarity
  - Small/Medium/Large
- Metric: Spearman’s rank correlation
- IdBench baselines
  - Levenshtein distance, Word2vec, FastText, Path-based
- VarCLR Model Choices
  - Word2vec, LSTM, CodeBERT

VarCLR Results: Improving Relatedness

0.73 ⟶ 0.80

SCAN ME

IdBench-Large

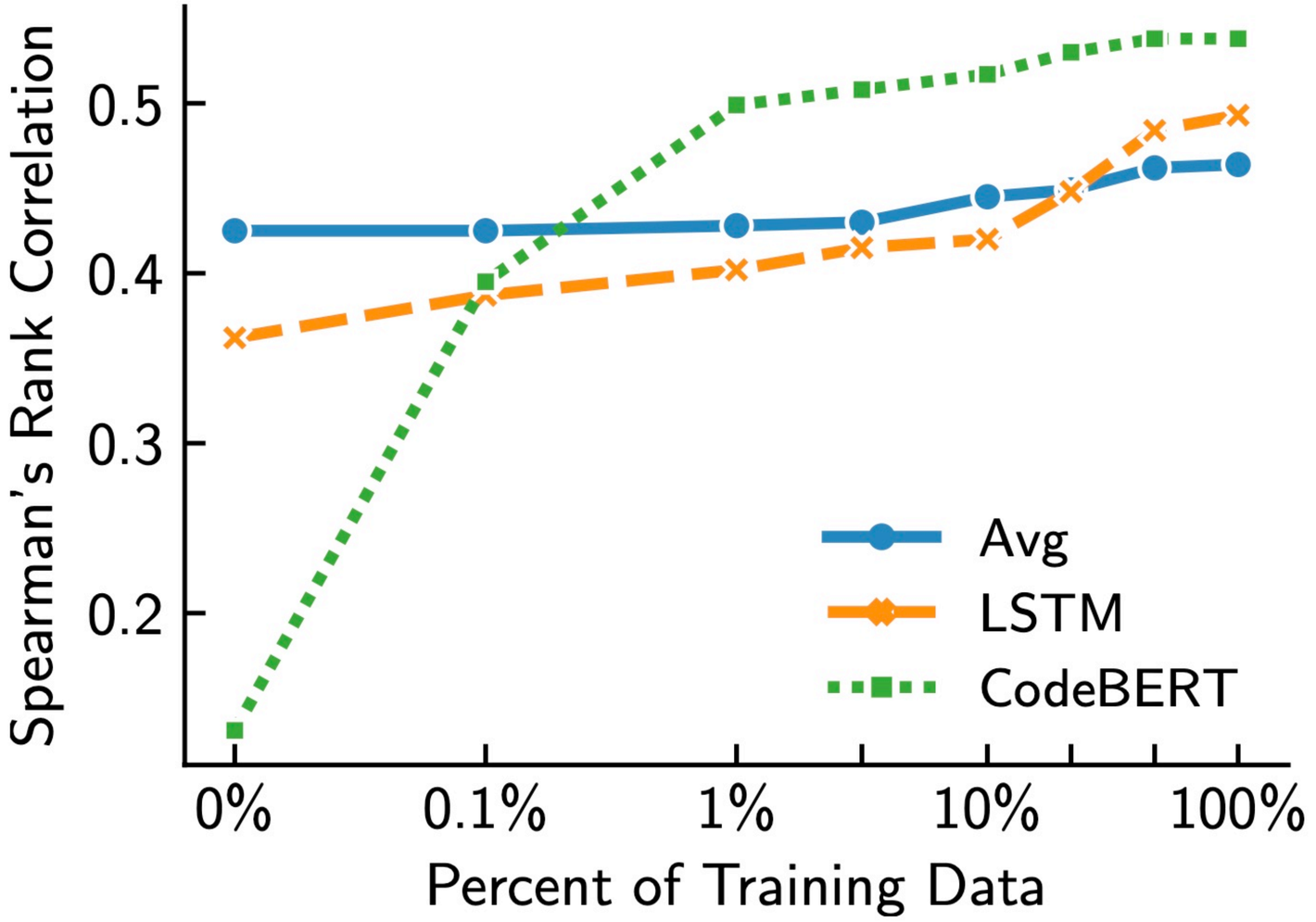
VarCLR Results: Improving Similarity

0.35 ⟶ 0.53

SCAN ME

IdBench-Small

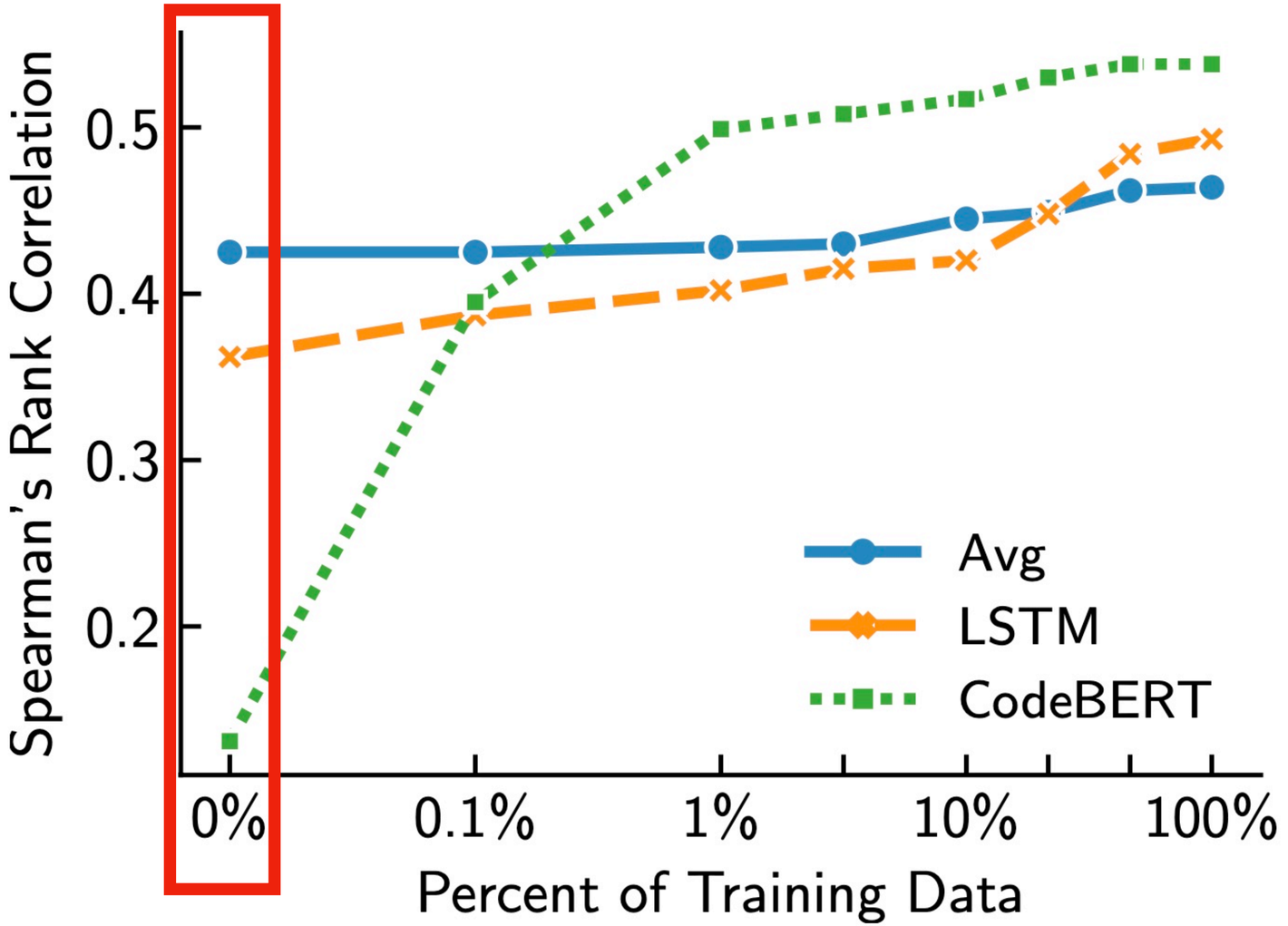
VarCLR: Effect of Contrastive Training



Paper

SCAN ME

VarCLR: Effect of Training Data



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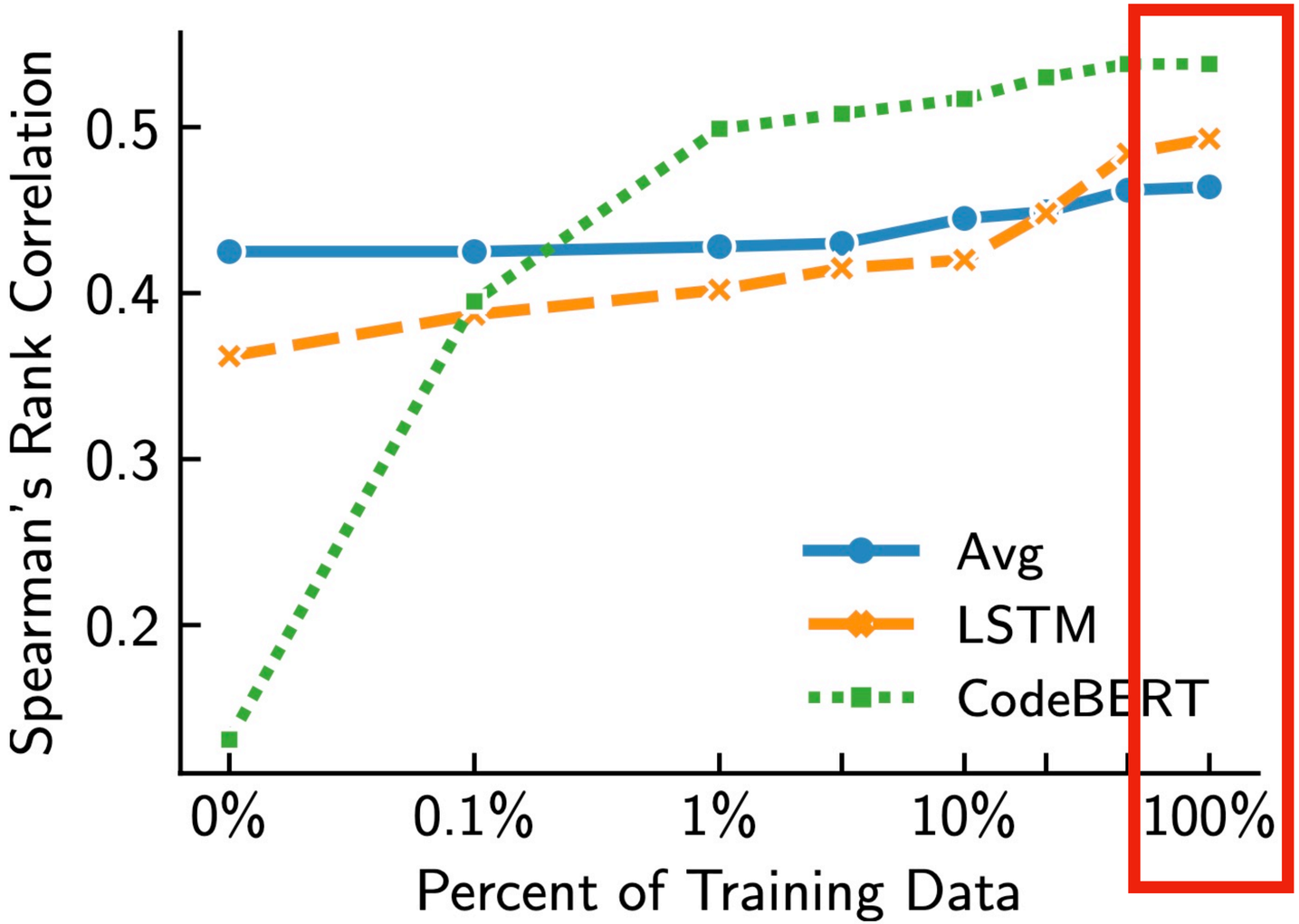
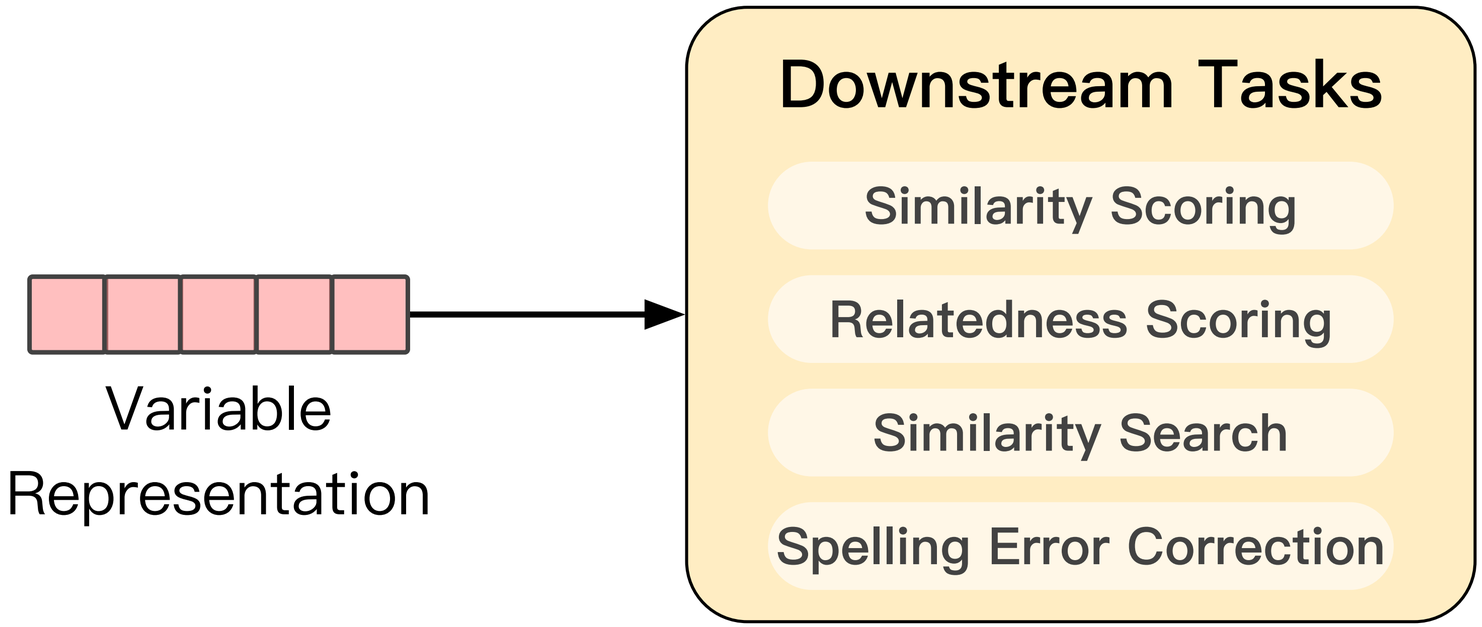


Paper

SCAN ME

More Tasks: Similarity Search and Spelling Error Correction



Paper

SCAN ME

VarCLR Is Easy to Use!

Code

SCAN ME

build passing | stars 22 | license MIT | code style black

VarCLR: Variable Representation Pre-training via Contrastive Learning

New: Paper accepted by ICSE 2022. Preprint at arXiv!

This repository contains code and pre-trained models for VarCLR, a contrastive learning based approach for learning semantic representations of variable names that effectively captures variable similarity, with state-of-the-art results on IdBench@ICSE2021.

- VarCLR: Variable Representation Pre-training via Contrastive Learning
  - Step 0: Install
  - Step 1: Load a Pre-trained VarCLR Model
  - Step 2: VarCLR Variable Embeddings

Off-the-shelf pre-trained embeddings and models!

No GPU required!

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VarCLR: Towards Better Variable Representations

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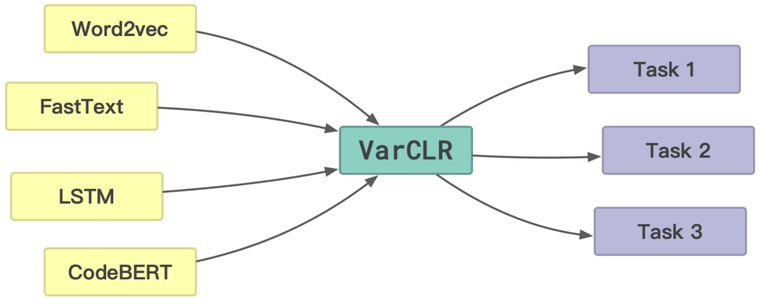

With significantly improved similarity!

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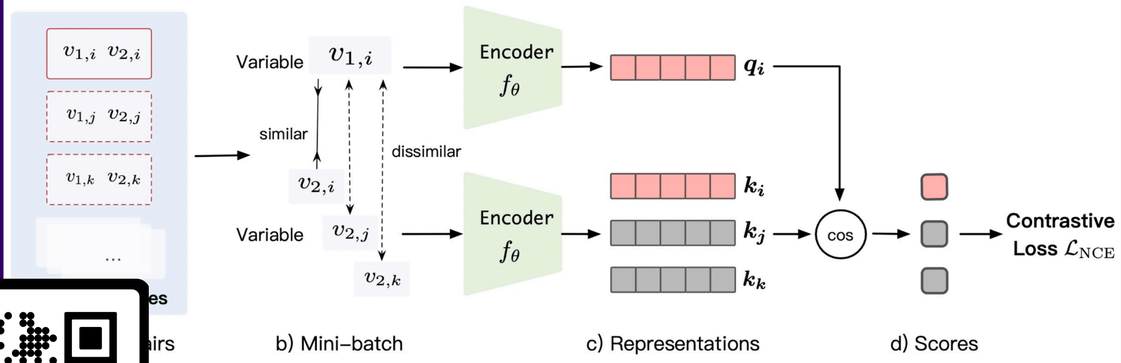

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STR… SOCIO-TECH… USING DATA…

Paper

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