# TreeBERT: A Tree-Based Pre-Trained Model for Programming Language

## Supplementary Material

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In this supplemental material, we first introduce the code tokenization in Section 1. Second, we provide detailed statistical information of datasets used for the experiment in Section 2. Then, we describe the metrics used to evaluate TreeBERT in Section 3. Finally, we show the detailed results of some experiments in Section 4.

## 1  CODE TOKENIZATION

Due to the strong structure of code, indentation is meaningful in Python, which cannot be removed simply by splitting code. Follow [Rozière et al., 2020], we use "INDENT" and "DEDENT" instead of indentation to indicate the beginning and end of a block of code. "NEWLINE" is used to represent line breaks. Spaces are replaced with "_" in strings, and code comments are removed. An example of a processed Python code snippet is shown in Figure 1.

![Figure 1: Example of code tokenization.](image)

## 2  DATA STATISTICS

Table 1 shows detailed statistics of the four datasets used for code summarization, namely, ETH Py150, Java-small, Java-med, and Java-large. Table 2 shows detailed statistics for two datasets, a Java dataset from DeepCom [Hu et al., 2018] for code documentation and a C# dataset from CodeNN [Iyer et al., 2016] for evaluating the performance of the model on pre-training unseen language.

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Example Number(train)</th>
<th>Example Number(valid)</th>
<th>Example Number(test)</th>
<th>Avg.number of Paths(train)</th>
<th>Avg.path length(train)</th>
<th>Avg.comments length(train)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETH Py150</td>
<td>143,310</td>
<td>33,878</td>
<td>35,714</td>
<td>130</td>
<td>19</td>
<td>3</td>
</tr>
<tr>
<td>Java-small</td>
<td>665,115</td>
<td>23,505</td>
<td>56,165</td>
<td>171</td>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td>Java-med</td>
<td>3,004,536</td>
<td>410,699</td>
<td>411,751</td>
<td>187</td>
<td>23</td>
<td>3</td>
</tr>
<tr>
<td>Java-large</td>
<td>15,344,512</td>
<td>320,866</td>
<td>417,003</td>
<td>220</td>
<td>22</td>
<td>3</td>
</tr>
</tbody>
</table>

## 3  EVALUATION METRICS

In this section, we provide details of the calculation of precision, recall, and F1 score used in the code summarization and BLEU used in code documentation.

### Precision, Recall, F1-Score

In code summarization, we do not use accuracy and BLEU since the generated func-

- [https://www.sri.inf.ethz.ch/py150](https://www.sri.inf.ethz.ch/py150)  
- [https://s3.amazonaws.com/code2seq/datasets/java-small.tar.gz](https://s3.amazonaws.com/code2seq/datasets/java-small.tar.gz)  
- [https://s3.amazonaws.com/code2seq/datasets/java-med.tar.gz](https://s3.amazonaws.com/code2seq/datasets/java-med.tar.gz)  
- [https://s3.amazonaws.com/code2seq/datasets/java-large.tar.gz](https://s3.amazonaws.com/code2seq/datasets/java-large.tar.gz)  
- [https://github.com/xing-hu/DeepCom/blob/master/data/7z](https://github.com/xing-hu/DeepCom/blob/master/data/7z)  
- [https://github.com/sriniiyer/codenn/tree/master/data/stackoverflow/csharp](https://github.com/sriniiyer/codenn/tree/master/data/stackoverflow/csharp)

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Table 2: Statistics for DeepCom’s Java dataset and CodeNN’s C# dataset.

<table>
<thead>
<tr>
<th></th>
<th>Java</th>
<th>C#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example Number (train)</td>
<td>450,124</td>
<td>52,812</td>
</tr>
<tr>
<td>Example Number (valid)</td>
<td>55,310</td>
<td>6,601</td>
</tr>
<tr>
<td>Example Number (test)</td>
<td>54,871</td>
<td>6,602</td>
</tr>
<tr>
<td>Avg. number of Paths (train)</td>
<td>212</td>
<td>207</td>
</tr>
<tr>
<td>Avg. path length (train)</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td>Avg. comments length (train)</td>
<td>12</td>
<td>10</td>
</tr>
</tbody>
</table>

Function names are composed of subtokens and are relatively short (average length of 3 subtokens). Following [Alon et al. 2019b], we use precision, recall, and F1 as metrics. The calculation is as follows.

\[
\text{Precision} = \frac{TP}{TP + FP}
\]

\[
\text{Recall} = \frac{TP}{TP + FN}
\]

\[
F1 = \frac{2 \cdot \text{Precision} \cdot \text{Recall}}{\text{Precision} + \text{Recall}}
\]

When the predicted subtoken is in the function name, we treat it as a true positive (TP). When the predicted subtoken is not in the function name, we treat it as a false positive (FP). When the subtoken is in the function name but is not predicted, we treat it as a false negative (FN). The label “UNK” is counted as FN; thus, the prediction of this word will reduce the recall value.

**BLEU** The BLEU score can be used to measure the similarity between the generated comments and the reference code comments at the token level, and it is calculated as follows.

\[
\text{BLEU} = BP \cdot \exp \left( \sum_{n=1}^{N} w_n \cdot \log p_n \right)
\]

\[
BP = \begin{cases} 
1, & c > r, \\
 e^{1-r/c}, & c \leq r.
\end{cases}
\]

where the upper limit of \(N\) is taken as 4, i.e., at most 4-grams are computed, \(w_n = \frac{1}{n!}\), and \(p_n\) is ratio of the clauses of length \(n\) in the candidate to those also in the reference.

In brevity penalty (BP), \(r\) denotes the length of the reference annotation and \(c\) denotes the length of the annotation generated by the model.

4 **MORE EXPERIMENTAL RESULTS**

Figure 2 shows the visualization results of the F1 score of code summarization. Table 3 gives the detailed results of the ablation study.

**Table 3: Results of the ablation study.**

<table>
<thead>
<tr>
<th>Model</th>
<th>BLEU</th>
<th>ΔBLEU</th>
</tr>
</thead>
<tbody>
<tr>
<td>TreeBERT</td>
<td>20.49</td>
<td>-</td>
</tr>
<tr>
<td>No PMLM</td>
<td>14.12</td>
<td>-6.37</td>
</tr>
<tr>
<td>No NOP</td>
<td>16.71</td>
<td>-3.78</td>
</tr>
<tr>
<td>No Node Position Embedding</td>
<td>20.25</td>
<td>-0.24</td>
</tr>
<tr>
<td>Randomly Masking Nodes</td>
<td>14.81</td>
<td>-2.24</td>
</tr>
<tr>
<td>Only Masking Value Nodes</td>
<td>18.25</td>
<td>-</td>
</tr>
</tbody>
</table>

**References**


