A Code Clone Detection DSL for Java

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Abstract

Duplication in source code is generally considered an undesirable pattern, because it unnecessarily increases system volume and is prone to cause bugs. Many studies propose definitions and techniques to detect such duplication issues. The clones detected by these definitions and techniques differ greatly. This is because there is a trade-off between completeness and number of false-positives. Additionally, clone detection may have different purposes, which may require different clone detection techniques.

We propose a DSL for clone detection, that allows for the specification of clone definitions. Using this DSL, code clone definitions can be easily expressed, whilst not having to worry about the actual clone detection algorithm and its optimization. Our DSL allows to exclude expressions, statements and declarations from clone matching. Our DSL supports line-based and AST-based clone detection approaches. The DSL can also take into account context information of expressions.

We use the DSL to express type 1, 2 and 3 clone definitions. We then use these definitions to validate the DSL over a corpus of open-source Java projects. We compare these results with established clone detection tools. We find that our DSL matches the output of the control tools, while allowing for a much wider spectrum of configurations.

Keywords   clone detection, domain specific language, language engineering, meta-programming

1 Introduction

Code clones argue about the duplicate code present in the source code of software systems. An abundant number of clone detection tools and techniques have been proposed in the literature due to the many applications and benefits of clone detection [18]. Clones are most often the result of code reuse by copying and pasting existing code, among other reasons [16]. Clones are often seen as harmful [9, 14, 16], but can also have positive effects on system maintainability [1, 11, 16].

Clone detection is applied in various domains. This includes (automated) refactoring, education (plagiarism detection) [22], (legacy code) modernization [13] and maintainability analysis [5]. For these varying purposes, many clone detection tools have been proposed: a 2013 survey by Rattan et al. [15] surveyed more than 70 clone detection tools. Comparisons show large differences in recall and precisions of these tools [19].

To allow easy experimentation with code clone defitions and methods, we propose a DSL to configure clone detection.

2 Background

We describe terminology, definitions and techniques that are commonly used in code clone detection.

2.1 Code clone terminology

To argue about code clones, we use the following terminology:

Code fragment [18]: A continuous region of source code. Specified by the triple (l, s, e), including the source file l, the start line and column s, and the end line and column e.

Clone class [16]: A set of similar code fragments. The definition of similarity depends on the desired granularity of clones.

Clone instance [16]: A cloned code fragment that is part of a clone class.

2.2 Clone type definitions

Most modern clone detection tools detect clones by the following clone type definitions [19]:

Type 1: Code fragments that are syntactically identical, except for differences in white space, layout and comments.

Type 2: Code fragments that are syntactically identical, except for differences in identifier names, literal values, white space, layout and comments.

Type 3: Code fragments that are syntactically similar with differences at the statement level. The fragments may differ by the addition, removal or modification of statements.

2.3 Clone detection techniques

Different clone detection techniques have been proposed in literature [17]: **Textual**: Code lines are textually compared. Advantages are that textual approaches are often simpler, easier to implement and are independent of language. Disadvantages are that it is harder to exclude certain constructs from matching.

Lexical (Token): Lexical approaches first tokenize the source code, so certain groups of tokens can be excluded from matching [19]. The disadvantage is that tokens must be specified for each language.

Syntactic (Tree): AST-based approaches first parse the source code into an AST. This allows for subtree based comparison and mapping context of clones [4].

Syntactic (Metric): In metric-based clone detection techniques, a number of metrics are computed for each fragment of code to find similar fragments by comparing metric vectors instead of comparing code or ASTs directly.

Semantic (Graph): A graph-based clone detection technique uses a graph to represent the data and control flow of a program.

Semantic (Hybrid): Hybrid approaches use a combination of before-mentioned techniques to speed up detection of clones and find clones with a variety of characteristics.

3 Clone Detection Techniques Survey

As an initial step towards creating a clone detection DSL, we survey clone detection techniques and tools to extract common functionalities.

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4 Language Design

We propose the Clone Detection DSL (CDD)[1], a DSL that allows to build a clone detection script to analyze Java systems.

4.1 Clone Size

An important feature of many clone detection tools, to be able to find clones that have a high relevance, is to be able to configure what characteristics clones should have for them to be considered. Some clone detection tools use a threshold that specifies the minimum number of lines [2, 3, 8, 21]. Other clone detection tools specify the minimum number of tokens [7, 10, 20]. Some AST-based clone detectors use the minimum number of statements [6].

Based on such thresholds, clones that are too small are filtered. How these thresholds are configured has a big impact on the results and their relevance [16]. Our DSL allows for any combination of metric values to configure the minimum size of a clone. For this, we introduce the **Size** keyword. This is an example of how the **Size** keyword can be configured:

```
Size (4 lines & 50 tokens) | (6 lines & 40 tokens)
```

In this example, we seek clones that either have many tokens but fewer lines, or many lines but fewer tokens. We allow the following keywords to be used in the condition of the **Size** threshold:

- *lines*: Number of lines in clone instance
- *tokens*: Number of tokens in clone instance
- *statements*: Number of statements in clone instance
- *declarations*: Number of declarations in clone instance
- *complexity*: The cyclomatic complexity [12] found in a clone instance.

Normally, these keywords denote the value of the metric of each clone instance. However, when prepended by *"class_"*, they denote the value of the metric for all clone instances in a clone class combined. This means that *lines* specifies the minimum number of lines in each clone instance, and

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[1]Link to the GitHub repository is omitted to adhere to the double-blind review rules. Link to full source code of the DSL would be included in the camera-ready version.

class_lines specifies the minimum number of lines in all clone instances of a clone class combined.

This allows for easy experiments of combinations of metrics to determine whether a clone should be considered.

4.2 Match Granularity

4.3 Exclusions

4.4 Compare Rules

5 Example scripts

6 Results

7 Discussion

8 Conclusion

8.1 Threats to validity

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