

# 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 [17]. Clones are most often the result of code reuse by copying and pasting existing code, among other reasons [15]. Clones are often seen as harmful [9, 13, 15], but can also have positive effects on system maintainability [1, 11, 15].

Clone detection is applied in various domains. This includes (automated) refactoring, education (plagiarism detection) [21], (legacy code) modernization [12] and maintainability analysis [5]. For these varying purposes, many clone detection tools have been proposed: a 2013 survey by Rattan et al. [14] surveyed more than 70 clone detection tools. Comparisons show large differences in recall and precisions of these tools [18].

To allow easy experimentation with code clone definitions 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** [17]: 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** [15]: A set of similar code fragments. The definition of similarity depends on the desired granularity of clones.

**Clone instance** [15]: 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 [18]:

**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 [16]: **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 [18]. 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.

## 4 Language Design

We propose Clone Detection DSL (CDD)<sup>1</sup>, 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, 20]. Other clone detection tools specify the minimum number of tokens [7, 10, 19]. 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 [15]. 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:

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

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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 found in each clone instance

<sup>1</sup>Link to the GitHub repository is omitted to adhere to the double-blind review rules. Link to full source code of the DSL will be included in the camera-ready version.

### 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

## References

- [1] Lerina Aversano, Luigi Cerulo, and Massimiliano Di Penta. 2007. How clones are maintained: An empirical study. In *11th European Conference on Software Maintenance and Reengineering (CSMR'07)*. IEEE, 81–90.
- [2] James R Cordy and Chanchal K Roy. 2011. The NiCad clone detector. In *2011 IEEE 19th International Conference on Program Comprehension*. IEEE, 219–220.
- [3] Stéphane Ducasse, Matthias Rieger, and Serge Demeyer. 1999. A language independent approach for detecting duplicated code. In *Proceedings IEEE International Conference on Software Maintenance-1999 (ICSM'99)'Software Maintenance for Business Change'(Cat. No. 99CB36360)*. IEEE, 109–118.
- [4] Francesca Arcelli Fontana and Marco Zanoni. 2015. A duplicated code refactoring advisor. In *International Conference on Agile Software Development*. Springer, 3–14.
- [5] Ilja Heitlager, Tobias Kuipers, and Joost Visser. 2007. A practical model for measuring maintainability. In *6th international conference on the quality of information and communications technology (QUATIC 2007)*. IEEE, 30–39.
- [6] Yoshiaki Higo and Shinji Kusumoto. 2009. Enhancing quality of code clone detection with program dependency graph. In *2009 16th Working Conference on Reverse Engineering*. IEEE, 315–316.
- [7] Lingxiao Jiang, Ghassan Mishserghi, Zhendong Su, and Stephane Glondu. 2007. Deckard: Scalable and accurate tree-based detection of code clones. In *Proceedings of the 29th international conference on Software Engineering*. IEEE Computer Society, 96–105.
- [8] Elmar Juergens, Florian Deissenboeck, and Benjamin Hummel. 2009. CloneDetective-A workbench for clone detection research. In *Proceedings of the 31st International Conference on Software Engineering*. IEEE Computer Society, 603–606.
- [9] Elmar Juergens, Florian Deissenboeck, Benjamin Hummel, and Stefan Wagner. 2009. Do code clones matter?. In *2009 IEEE 31st International Conference on Software Engineering*. IEEE, 485–495.
- [10] Toshihiro Kamiya, Shinji Kusumoto, and Katsuro Inoue. 2002. CCFinder: a multilinguistic token-based code clone detection system for large scale source code. *IEEE Transactions on Software Engineering* 28, 7 (2002), 654–670.
- [11] Cory Kapser and Michael W Godfrey. 2006. “Cloning considered harmful” considered harmful. In *Reverse Engineering, 2006. WCRE'06. 13th Working Conference on*. Citeseer, 19–28.
- [12] Fanqi Meng, Zhaoyang Qu, and Xiaoli Guo. 2013. Refactoring model of legacy software in smart grid based on cloned codes detection. *International Journal of Computer Science Issues (IJCSI)* 10, 1 (2013), 296.
- [13] J. Ostberg and S. Wagner. 2014. On Automatically Collectable Metrics for Software Maintainability Evaluation. In *2014 Joint Conference of the International Workshop on Software Measurement and the International Conference on Software Process and Product Measurement*. 32–37. <https://doi.org/10.1109/IWSM.Mensura.2014.19>
- [14] Dhavleesh Rattan, Rajesh Bhatia, and Maninder Singh. 2013. Software clone detection: A systematic review. *Information and Software*

- Technology 55, 7 (2013), 1165–1199.
- [15] Chanchal Kumar Roy and James R Cordy. 2007. A survey on software clone detection research. *Queen's School of Computing TR 541*, 115 (2007), 64–68.
- [16] Abdullah Sheneamer and Jugal Kalita. 2016. A survey of software clone detection techniques. *International Journal of Computer Applications* 137, 10 (2016), 1–21.
- [17] Jeffrey Svajlenko and Chanchal Roy. 2019. The Mutation and Injection Framework: Evaluating Clone Detection Tools with Mutation Analysis. *IEEE Transactions on Software Engineering* (2019).
- [18] Jeffrey Svajlenko and Chanchal K Roy. 2014. Evaluating modern clone detection tools. In *2014 IEEE International Conference on Software Maintenance and Evolution*. IEEE, 321–330.
- [19] Warren Toomey. 2012. Ctcompare: Code clone detection using hashed token sequences. In *2012 6th International Workshop on Software Clones (IWSC)*. IEEE, 92–93.
- [20] Md Sharif Uddin, Chanchal K Roy, and Kevin A Schneider. 2013. Simcad: An extensible and faster clone detection tool for large scale software systems. In *2013 21st International Conference on Program Comprehension (ICPC)*. IEEE, 236–238.
- [21] Vera Wahler, Dietmar Seipel, J Wolff, and Gregor Fischer. 2004. Clone detection in source code by frequent itemset techniques. In *Source Code Analysis and Manipulation, Fourth IEEE International Workshop on*. IEEE, 128–135.