Retrieving Similar Code Fragments based on Identifier Similarity for Defect Detection

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ABSTRACT

Similar source code fragments, known as code clones, may involve similar defects caused by the same mistake. However, code clone detection tools cannot detect certain code fragments (e.g. modified after copy-and-pasted). To support developers who would like to detect such defects, we propose a method to retrieve similar code fragments in source code based on the similarity of identifiers between a query and a target code fragment. We present two case studies of similar defects in open source systems.

Categories and Subject Descriptors

D.2.5 [**Software Engineering**]: Testing and Debugging—*Debugging aids and diagnostics*; D.2.4 [**Software Engineering**]: Software/Program Verification—*Statistical methods*

General Terms

Algorithms, Experimentation

1. INTRODUCTION

Similar code is generally considered as one of factors that make software maintenance more difficult[1, 2, 4]. If developers modify one of similar code fragments, they have to determine whether or not to apply the same modification to the others. Similar code is also called *code clone* or *duplicated code*. Developers often introduce similar code because of various reasons (e.g. "copy-and-paste")[2, 5]. Especially, large-scale software systems, such as Linux and JDK(Java Development Kit), often involves a large number of similar code fragments[4].

Similar code fragments sometimes involve similar defects caused by the same mistake[6, 7]. Therefore, if one of similar code fragments has a defect, developers have to inspect the others. Figure 1 is an example of such code fragments in Linux 2.6.6. The two fragments involve similar defects caused by accessing incorrect pointer (i.e. &prom_phys_total).

```
(linux-2.6.6/arch/sparc64/prom/memory.c)
for(iter=0; iter<num_regs; iter++) {
  prom_prom_taken[iter].start_adr =
    prom_reg_memlist[iter].phys_addr;
  prom_prom_taken[iter].num_bytes =
    prom_reg_memlist[iter].reg_size;
  prom_prom_taken[iter].theres_more =
    &prom_phys_total[iter+1];
  // should be:&prom_prom_taken[iter+1];
}
```

```
(linux-2.6.6/arch/sparc/prom/memory.c)
for(iter=0; iter<num_regs; iter++) {
  prom_prom_taken[iter].start_adr =
    (char *) prom_reg_memlist[iter].phys_addr;
  prom_prom_taken[iter].num_bytes =
    (unsigned long) prom_reg_memlist[iter].reg_size;
  prom_prom_taken[iter].theres_more =
    &prom_phys_total[iter+1];
  // should be:&prom_prom_taken[iter+1];
}
```

Figure 1: Similar defects

Because type cast operations (e.g. (char *)) are inserted into the lower fragment, code clone detection tools[1, 2, 4] do not treat the code fragments as a pair of code clones. Hence, even if developers find out that one of the code fragments has a defect and perform code clone detection, they cannot detect the other code fragment that has the similar defect.

To detect such similar code fragments involving similar defects, we propose a new approach that retrieves code fragments similar to a query code fragment. Our approach compares a set of identifiers in a query with sets of identifiers in target source code fragments.

2. PROPOSED METHOD

As shown in Figure 2, our method accepts a code fragment as a query and retrieves similar code fragments in target source files. The process comprises three steps as follows.

(1) Lexical Analysis Both the input code fragment and the target source files are translated into token sequences. Then, only identifiers are extracted from each token sequence. Finally, those identifiers are normalized based on several rules (e.g. dividing at underscore, number suffix elimination) and are listed as Identifier Lists.

(2) Comparison We compare the input identifier list with sublists in the target identifier lists. We compute the similarity for each sublist and extract Similar Sublists.

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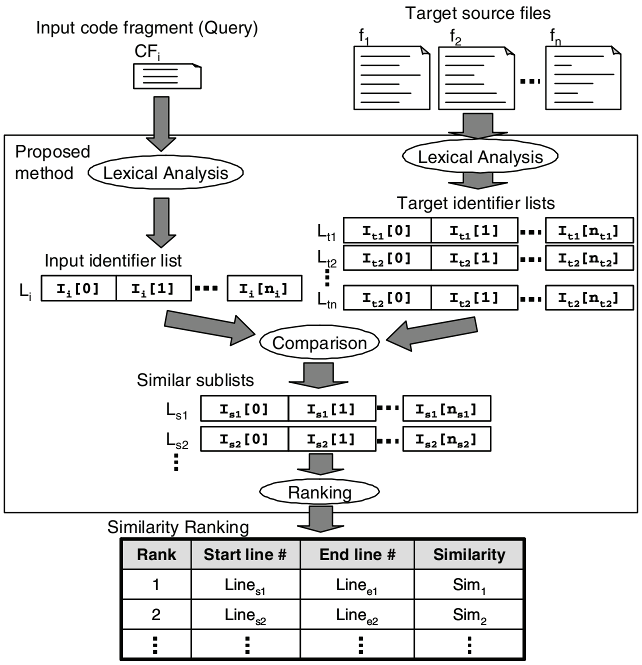

Figure 2: The overview of proposed method

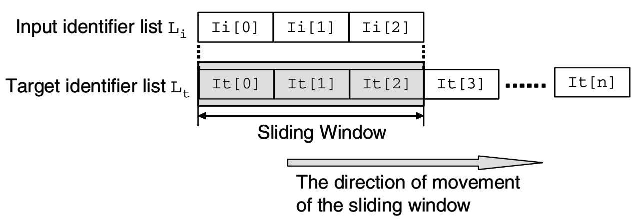

Figure 3: Sliding window

The detail of this step is described later.

(3)Ranking The extracted similar sublists are sorted according to the similarity value. The resultant ranking is the output of our method. We call the ranking Similarity Ranking.

Figure 3 shows the comparison between an input identifier list and a target identifier list. We call the scope of comparison Sliding Window, and it moves through the target identifier list. To reduce computational cost, we fix the length of the sliding window to the length of the input identifier list. Hence, the length of a similar sublist is fixed to the length of the input identifier list.

The definition of the similarity in our method is shown in Equation 1. Let S_i be a set of elements in input identifier list L_i, S_w be a set of elements in the sliding window. Then we define the similarity in our method as $Similarity(S_i, S_w)$:

$$Similarity(S_i, S_w) = \frac{2 * |S_i \cap S_w|}{|S_i| + |S_w|} \quad (1)$$

In the ranking step, since similar sublists are ranked using the similarity score described above, the code fragments which share more identifiers with the input code fragment are ranked higher in the result. Since the ranking involves a huge number of code fragments, developers may investigate similar code fragments according to their resource.

3. CASE STUDY

We performed two case studies of software systems, Linux 2.6.6 and Canna 3.6[3]. At first, we extracted code fragments sharing similar defects from a software system and entered each code fragment into the tool implementing our method. Then, we manually inspected if the similarity ranking ranks highly code fragments involving defects.

The arch directory of Linux 2.6.6 has two similar defects (see Figure 1). We used the two code fragments as queries and then retrieved similar code fragments to each of them in the arch directory. As a result, in both of those queries, the two code fragments in Figure 1 are detected as the top two code fragments in the similarity ranking. If one of those code fragments is given, we can detect the other one having similar defect.

The server directory of Canna 3.6 has 19 buffer overflow errors. Like the case of Linux, we used the 19 code fragments as queries and then retrieved similar code fragments in the server directory. As a result, in all of those queries, 18 or 19 queried code fragments are ranked in the top 30. If one of those code fragments is given, we can detect the almost the other code fragments having similar defect.

4. CONCLUSION

In this paper, we proposed a method to retrieve similar code fragments based on identifier similarity. In the case studies, by providing a code fragment having a defect, we could detect most of similar defects. We need further case studies on other software systems having similar defects.

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