

Automatically Finding Bug Locations

Program Spectra Visualization and Analysis for Fault Localization

Abstract

Spectrum-Based Fault Localization (SBFL) uses the information derived during testing to identify the faults existing in the subject program. However, because of the diversity of real-life programs and faults, current SBFL techniques cannot adapt all the debugging situations. Without knowing how SBFL works, we cannot get sufficient confidence to use it in practice. In our work, we propose a framework that illustrates the spectra distributions of various debugging instances and the performance of SBFL at these instances in a graphical way. Based on visualization, we can get a better analysis and understanding of the rationales of various instances in which SBFL is applied.

Preliminary

Software Debugging:

1. Fault localization:
where is the fault?
2. Understanding:
why is it a fault?
3. Repairing:
how to remove the fault?

Automated Fault Localization

Software Testing

Is there a fault?

Debugging

How to correct the fault?

SBFL and Metrics

PG : the subject program; $s \in S$: statements; s^f : faulty statements; $t \in T$: test cases; $s \in C^t$: statements covered by t ; $o^t \in \{pass, fail\}$: the correctness of t

Subject Program

```

Input (wallDis, objDis){
  double step, ranDegree;
  void (*method)(double, double);
  method = &MRRT;
  ranDegree = 1;
  step = 2;
  if(wallDis < 8){
    step = 2;
    if(wallDis < 5){
      ranDegree = 2;
      if(wallDis < 1.5)
        method = &MRRT;
    }
  }
  else{
    method = &NN;
  }
  if(objDis < 10){
    step = 1;
    method = &MRRT;
    ranDegree = 0.5;
  }
  (*method)(step, ranDegree);
  return;
}

```

Test Info.

tests	t_1	t_2	t_3	t_4
Input:	1.5, 50	10, 5	20, 45	4, 4
Output:	fail	pass	fail	fail
Statements				
S1	.	.	.	.
S2	.	.	.	.
S3	.	.	.	.
S4	.	.	.	.
S5	.	.	.	.
S6	.	.	.	.
S7	.	.	.	.
S8	.	.	.	.
S9	.	.	.	.
S10	.	.	.	.
S11	.	.	.	.
S12	.	.	.	.
S13	.	.	.	.
S14	.	.	.	.
S15	.	.	.	.
S16	.	.	.	.

test t_4 covered stmt s_4

$\rightarrow a_{ep}(s_4^f) = 0, a_{ef}(s_4^f) = 3$

$\rightarrow a_{ep}(s_{10}^f) = 2, a_{ef}(s_8^f) = 0$

test t_3 does not cover stmt s_{14}

$\rightarrow F = 3, P = 2$

Components' Spectra

$a_{ef}(s) = |\{t \in T \mid s \in C^t, o^t = fail\}|$
#(Failure-revealing test cases that Execute s)

$a_{ep}(s) = |\{t \in T \mid s \in C^t, o^t = pass\}|$
#(Passed test cases that Execute s)

Basic Intuitions

- Basic Intuition 1:** Statements covered by more failure-revealing test cases are more likely to be faulty
- Basic Intuition 2:** Statements covered by more passed test cases are less likely to be faulty

Metrics for Scoring Statements $\rightarrow R(s)$

Op: $a_{ef} - a_{ep} / (P + 1)$

Tarantula: $\frac{a_{ef} / F}{a_{ef} / F + a_{ep} / P}$

Ochiai: $\frac{a_{ef}}{\sqrt{F(a_{ef} + a_{ep})}}$

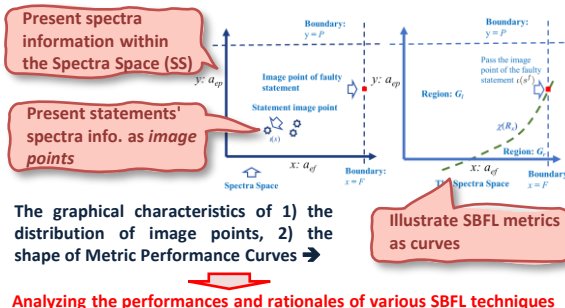
Other Metrics ...

Larger $R(s)$
More likely to be faulty!

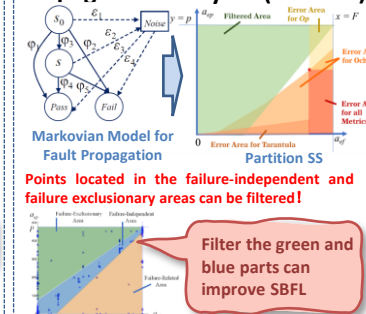
Above case: $R(s_5)$ is the largest. It is indeed the fault!

Research Contents

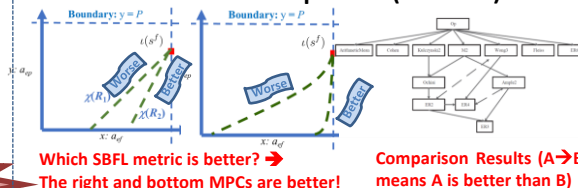
Visualization Framework



Propagation Analysis (EASE'20)



SBFL Metric Comparison (PRDC'19)



Spectra of CPS Components

