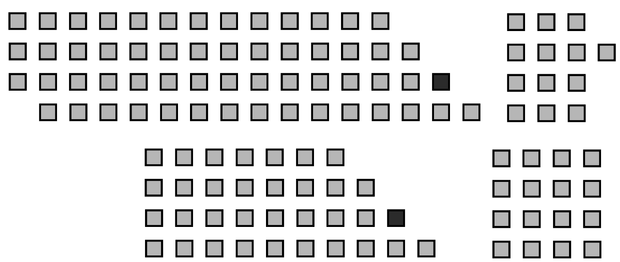
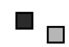
Renieris and Reiss’ Localization

- Basic idea (over-simplified)
  - We have lots of test cases
    - Some fail
    - A much larger number pass



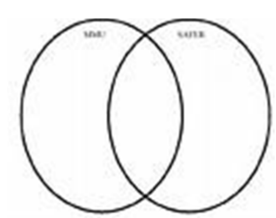


“nearest neighbor”

  - Pick a failure
  - Find most similar successful test case
  - Report differences as our *fault localization*

Renieris and Reiss' Localization

- Collect *spectra* of executions, rather than the full executions
  - For example, just count the number of times each source statement executed
  - Previous work on using spectra for localization basically amounted to set difference/union – for example, find features unique to (or lacking in) the failing run(s)
    - Problem: many failing runs have *no such features* – many successful test cases have **R** (and maybe **I**) but not **P**!
      - Otherwise, localization would be very easy



Renieris and Reiss' Localization

- Some obvious and not so obvious points to think about
  - Technique makes intuitive sense
  - But what if there are no successful runs that are very similar?
    - Random testing might produce runs that all differ in various accidental ways
    - Is this approach over-dependent on test suite quality?

Renieris and Reiss' Localization

- Some obvious and not so obvious points to think about
  - What if we minimize the failing run using delta-debugging?
    - Now lots of differences with original successful runs just due to length!
    - We could produce a very similar run by using delta-debugging to get a 1-change run that succeeds (there will actually be many of these)
      - Can still use Renieris and Reiss' approach – because delta-debugging works over the inputs, not the program behavior, spectra for these runs will be more or less similar to the failing test case

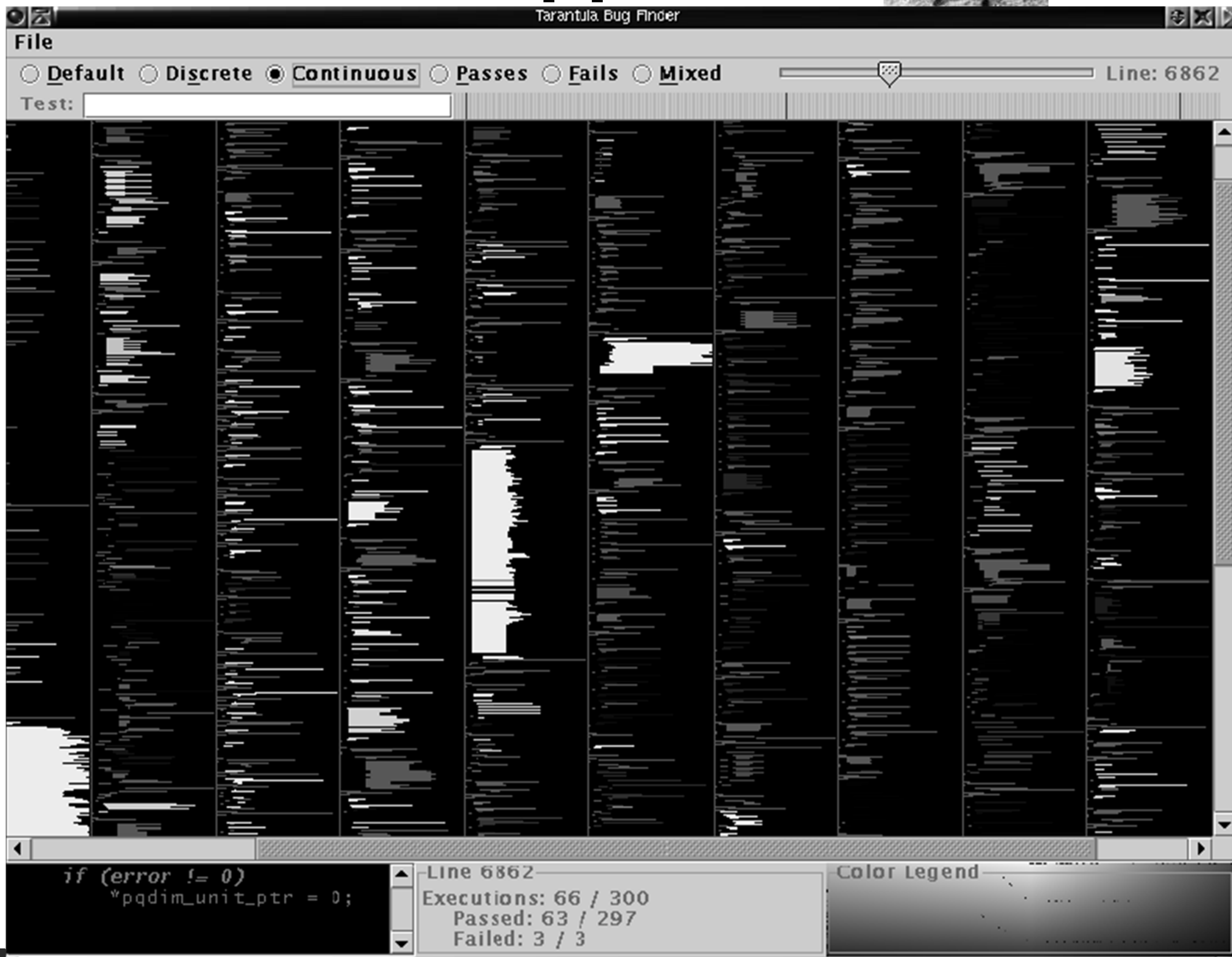
Renieris and Reiss' Localization

- Many details (see the paper):
  - Choice of spectra
  - Choice of distance metric
  - How to handle equal spectra for failing/passing tests?
- Basic idea is nonetheless straightforward

The Tarantula Approach

- Jones, Harrold (and Stasko): Tarantula
- Not based on distance metrics or a Lewis-like assumption
- A “statistical” approach to fault localization
- Originally conceived of as a visualization approach: produces a picture of all source in program, colored according to how “suspicious” it is
  - [redacted]

The Tarantula Approach



The Tarantula Approach

- How do we score a statement in this approach? (where do all those colors come from?)
- Again, assume we have a large set of tests, some passing, some failing
- "Coverage entity" e (e.g., statement)
  - *failed(e)* = # tests covering e that fail
  - *passed(e)* = # tests covering e that pass
  - *totalfailed, totalpassed* = what you'd expect

The Tarantula Approach

- How do we score a statement in this approach? (where do all those colors come from?)

$$suspiciousness(e) = \frac{\dfrac{failed(e)}{totalfailed}}{\dfrac{passed(e)}{totalpassed} + \dfrac{failed(e)}{totalfailed}}$$

The Tarantula Approach 

$$suspiciousness(e) = \frac{\dfrac{failed(e)}{totalfailed}}{\dfrac{passed(e)}{totalpassed} + \dfrac{failed(e)}{totalfailed}}$$

- Not very suspicious: appears in almost every passing test and almost every failing test
- Highly suspicious: appears much more frequently in failing than passing tests

The Tarantula Approach

$$suspiciousness(e) = \frac{\frac{failed(e)}{totalfailed}}{\frac{passed(e)}{totalpassed} + \frac{failed(e)}{totalfailed}}$$

```
mid()
     int x, y, z, m;
     read (x, y, z);
     m = z;
     if (y < z)
       if (x < y)
         m = y;
       else if (x < z)
         m = y;
     else
       if (x > y)
         m = y;
       else if (x > z)
         m = x;
       print (m);
```

Simple program to compute the middle of three inputs, with a fault.

The Tarantula Approach

$$suspiciousness(e) = \frac{\frac{failed(e)}{totalfailed}}{\frac{passed(e)}{totalpassed} + \frac{failed(e)}{totalfailed}}$$

Run some tests. . .

Look at whether they pass or fail

Look at coverage of entities

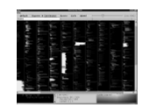
	mid()	(3,3,5)	(1,2,3)	(3,2,1)	(5,5,5)	(5,3,4)	(2,1,3)	
	int x, y, z, m;							
1	read (x, y, z);	●	●	●	●	●	●	0.5
2	m = z;	●	●	●	●	●	●	0.5
3	if (y < z)	●	●	●	●	●	●	0.5
4	if (x < y)	●	●			●	●	0.63
5	m = y;		●					0.0
6	else if (x < z)	●				●	●	0.71
7	m = y;	●					●	0.83
8	else			●	●			0.0
9	if (x > y)			●	●			0.0
10	m = y;			●				0.0
11	else if (x > z)				●			0.0
12	m = x;							0.0
13	print (m);	●	●	●	●	●	●	0.5

Compute suspiciousness using the formula

Fault is indeed most suspicious!

The Tarantula Approach

- Obvious benefits:
  - No problem if the fault is reached in some successful test cases
  - Doesn't depend on having any successful tests that are similar to the failing test(s)
  - Provides a *ranking* of every statement, instead of just a set of nodes – directions on where to look next
    - Numerical, even – how *much* more suspicious is X than Y?



  - The pretty visualization may be quite helpful in seeing relationships between suspicious statements
  - Is it less sensitive to accidental features of random tests, and to test suite quality in general?
  - What about minimized failing tests here?

Evaluating Fault Localization Approaches

- So, how do the techniques stack up?
- Tarantula seems to be the best of the test suite based techniques
  - Next best is the Cause Transitions approach of Cleve and Zeller (see their paper), but it sometimes uses programmer knowledge
  - Two different Nearest-Neighbor approaches are next best
  - Set-intersection and set-union are worst
- For details, see the Tarantula paper