

Kernel Density Adaptive Random Testing

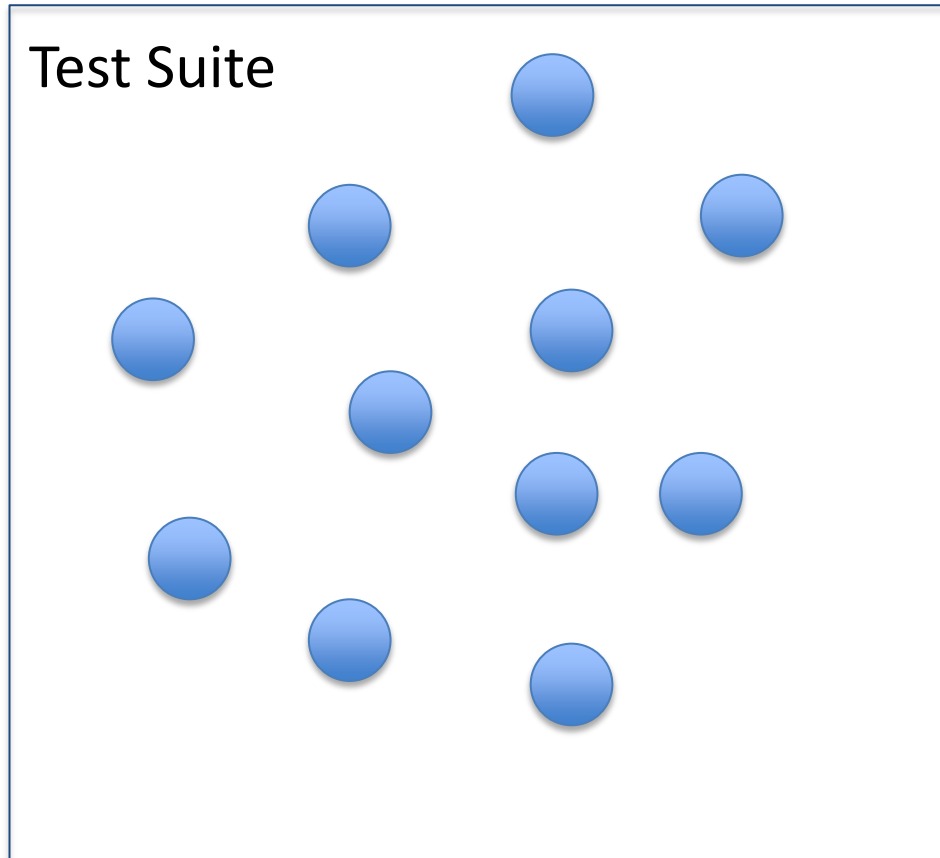
Matthew Patrick and Yue Jia

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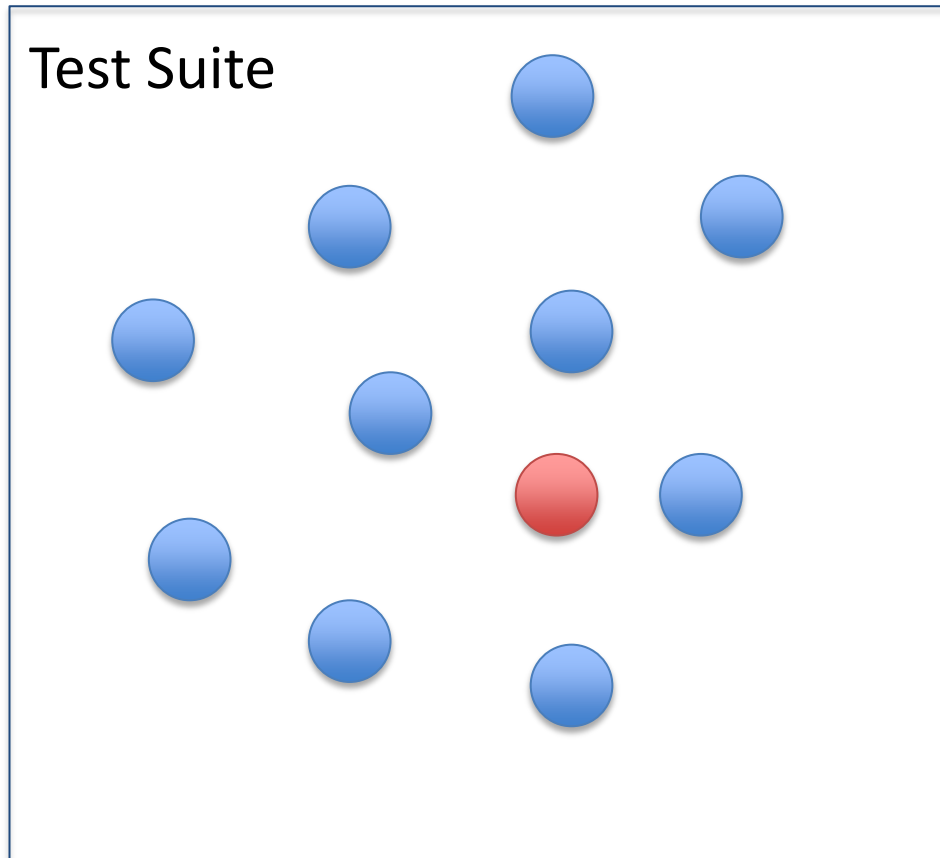
Outline

- Diversification and Intensification
- Kernel Density Adaptive Random Testing (KD-ART)
- Is KD-ART more effective than ART?
- Finding the optimal switch point
- Conclusions

Mutation based Test Selection

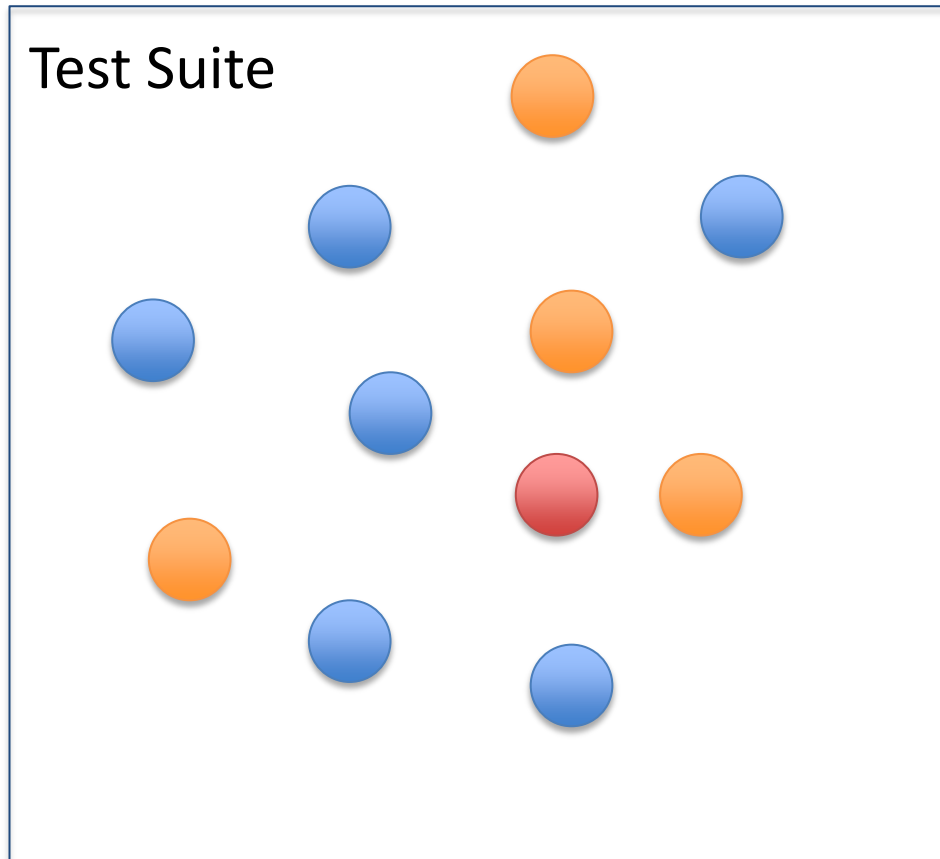


Mutation based Test Selection



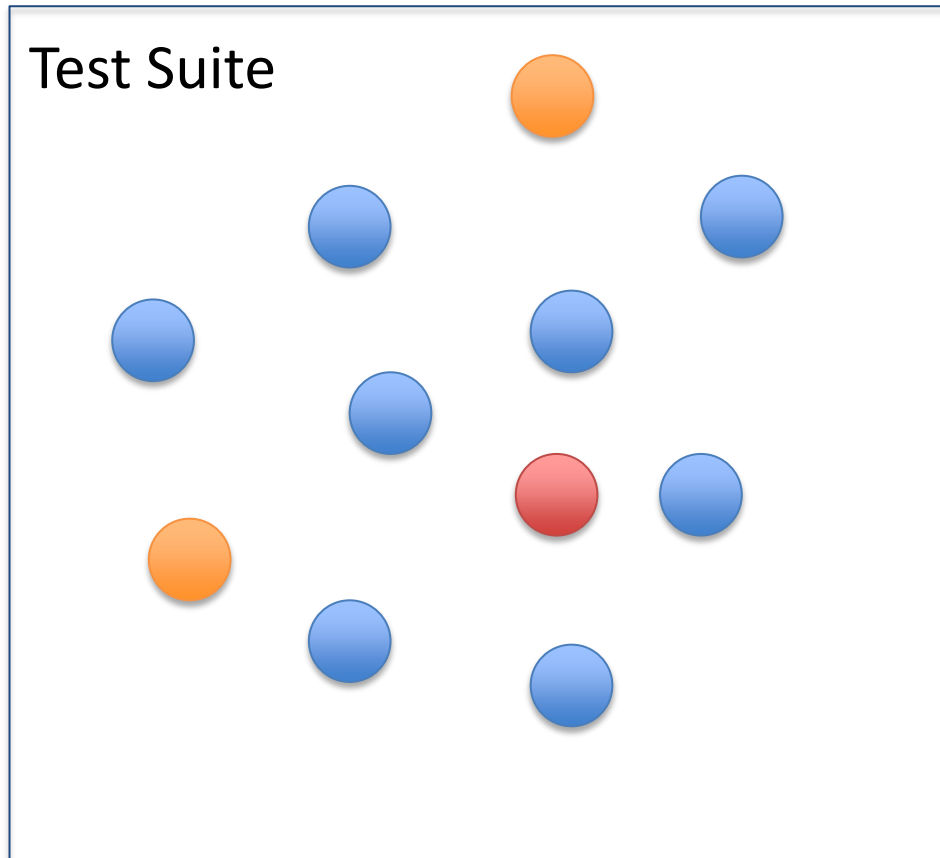
Suppose we selected the red test suite, and found it is good at killing mutant

Mutation based Test Selection



Which test should be execute next ?

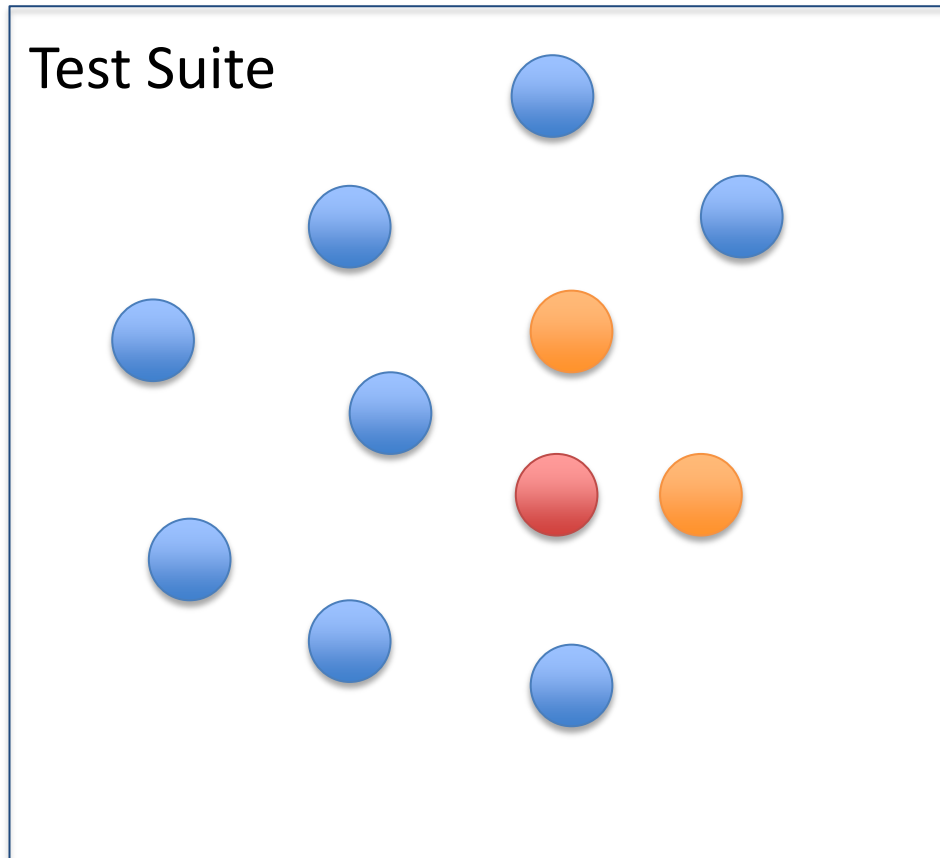
Mutation based Test Selection



Diversify:

Use a wide range of test inputs to increase the chances of killing new mutants

Mutation based Test Selection



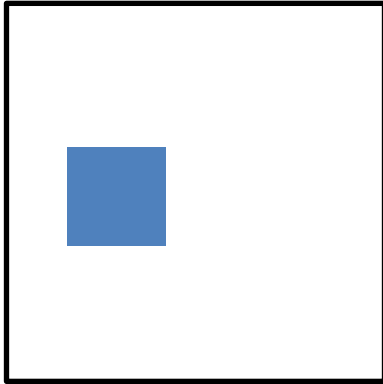
Intensify:

Select test inputs which are similar to those previously shown to be successful

Adaptive Random Testing (ART)

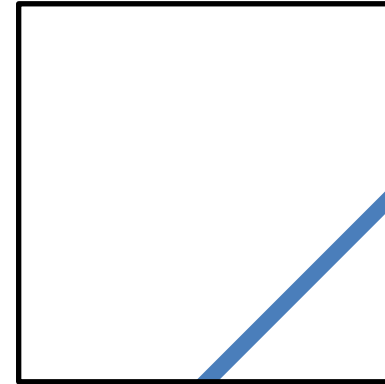
- Generate test cases evenly over the input domain, so as to diversify the test selection
- Select test cases that maximise the (Euclidean) distance to the previously selected test cases

Failure Patterns



Block pattern:

```
if (x >= 10 && x <= 12) && (y >= 8 && y <= 11)
  z = x / 2 * y; // 2 should be 7
else
  z = x * y;
return z;
```

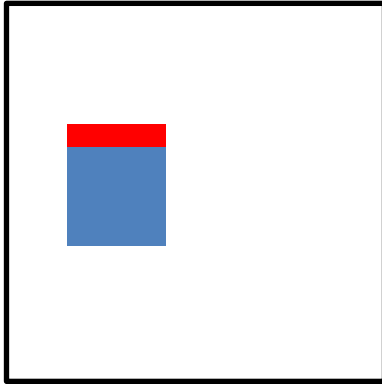


Strip pattern:

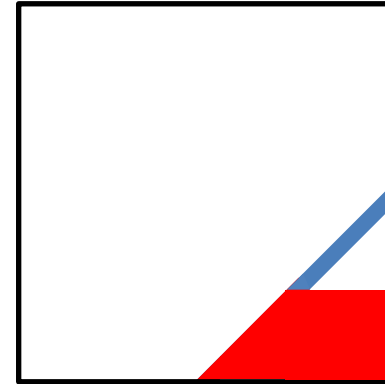
```
if (2 * x - y > 10) // 10 should be 18
  z = x / 2 * y;
else
  z = x * y;
return z;
```

Diversification may be more effective

Compound Failure Patterns



Block and strip pattern: // 11 should be 12
if (x >= 10 && x <= 12) && (y >= 8 && y <= 11)
 z = x / 2 * y; // 2 should be 7
else
 z = x * y;
return z;



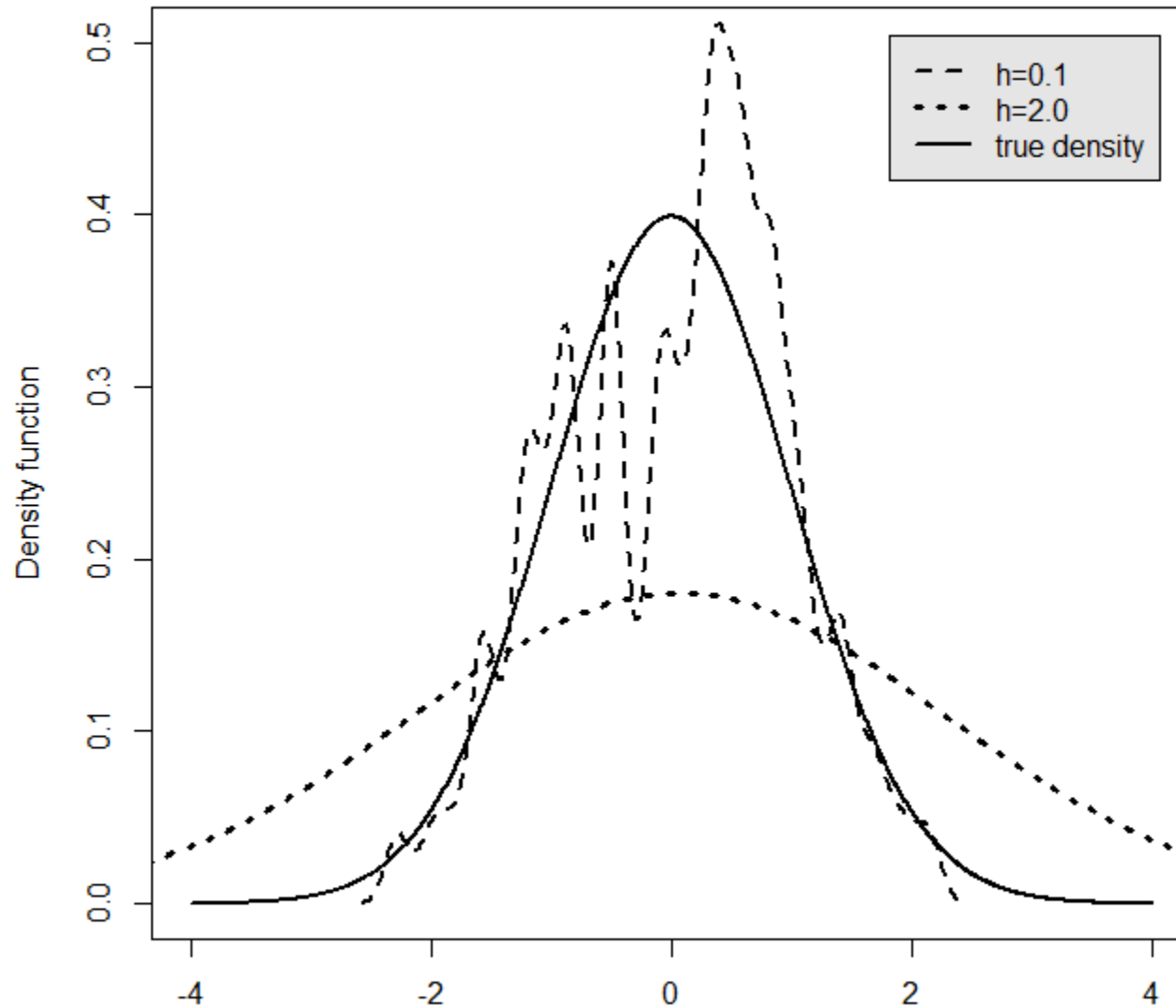
Strip and block pattern:
If (2 * x - y > 10) // 10 should be 18
 z = x / 2 * y; // also need && y > 7
else
 z = x * y;
return z;

Intensification may be more effective

Kernel Density Adaptive Random Testing (KD-ART)

- Generate test inputs according to the distribution of successful test cases
- Use Kernel Density Estimation to interpolate the test case values evaluated

Kernel Density Estimation



Sampling strategy

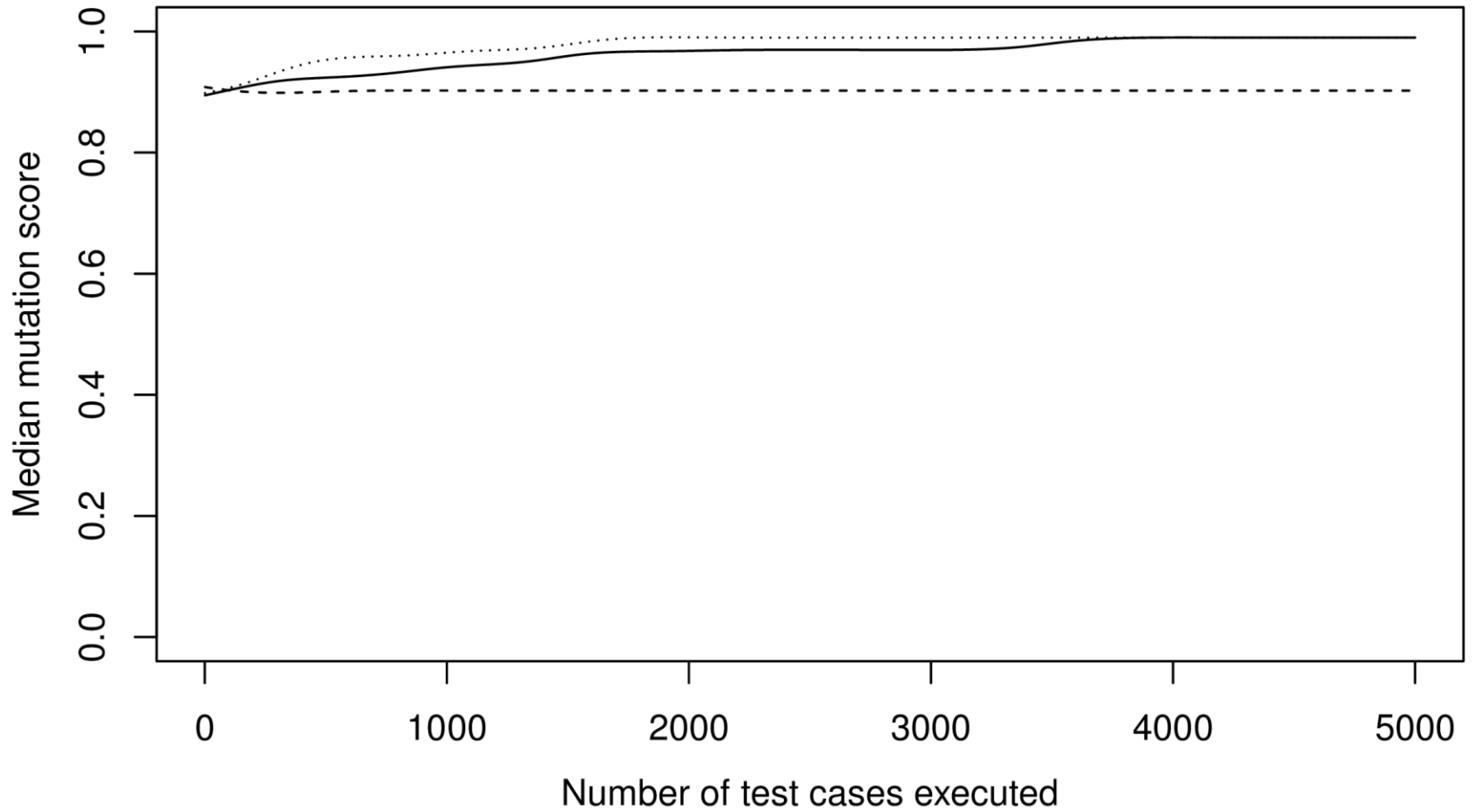
- Sample ten test cases for every one selected
- KD-ART (intensify) maximises the density
- KD-ART (diversify) minimises the density

Experimental setup

- Eight C programs, used before in ART research
- Selective set of mutation operators (MILU)
- 20 trials of 5000 candidate tests: use ART and KD-ART to select one test case from every ten

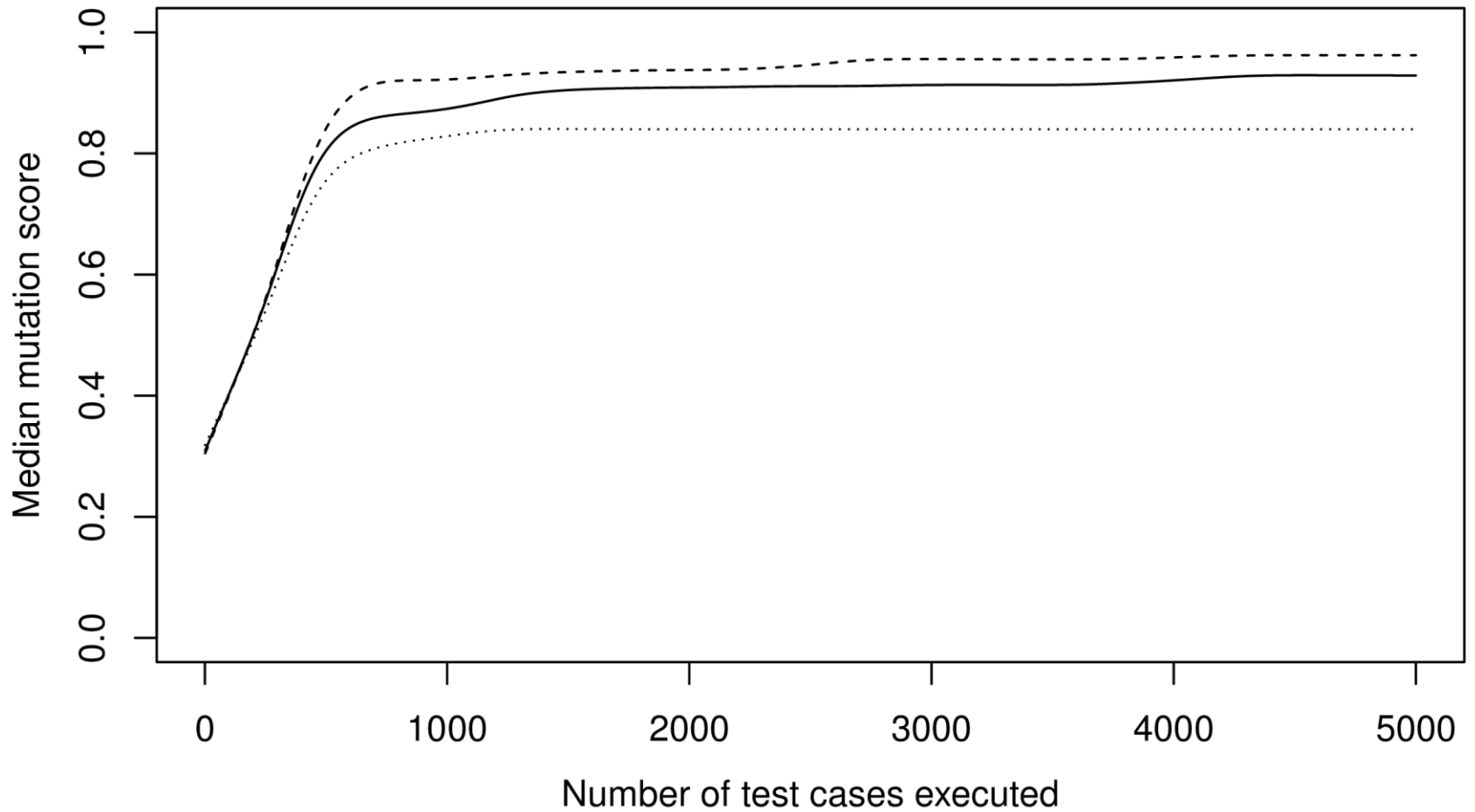
IS KD-ART MORE EFFECTIVE THAN ART?

plgndr



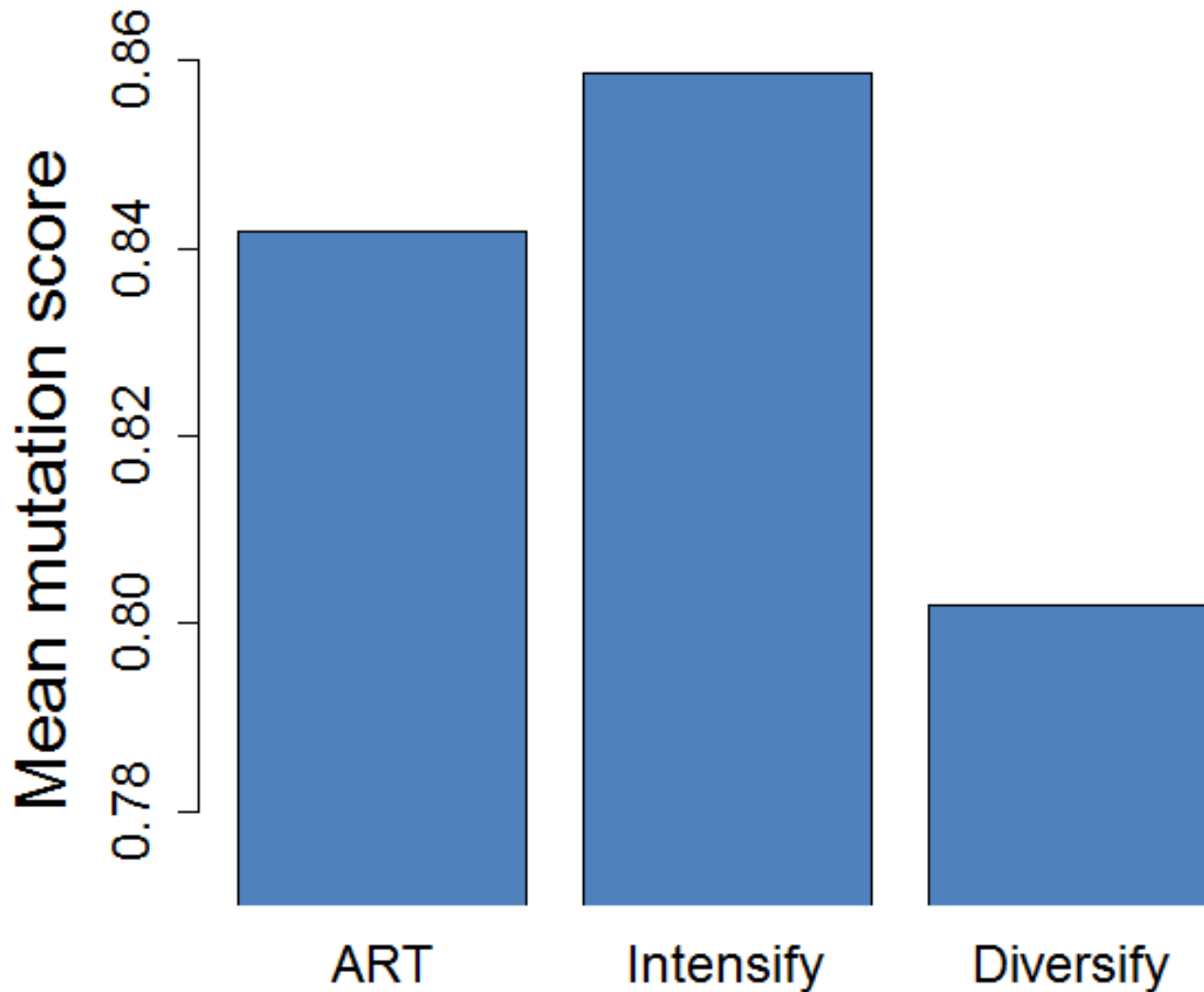
— ART (baseline) - - - - KD-ART (intensify) ····· KD-ART (diversify)

bessj0



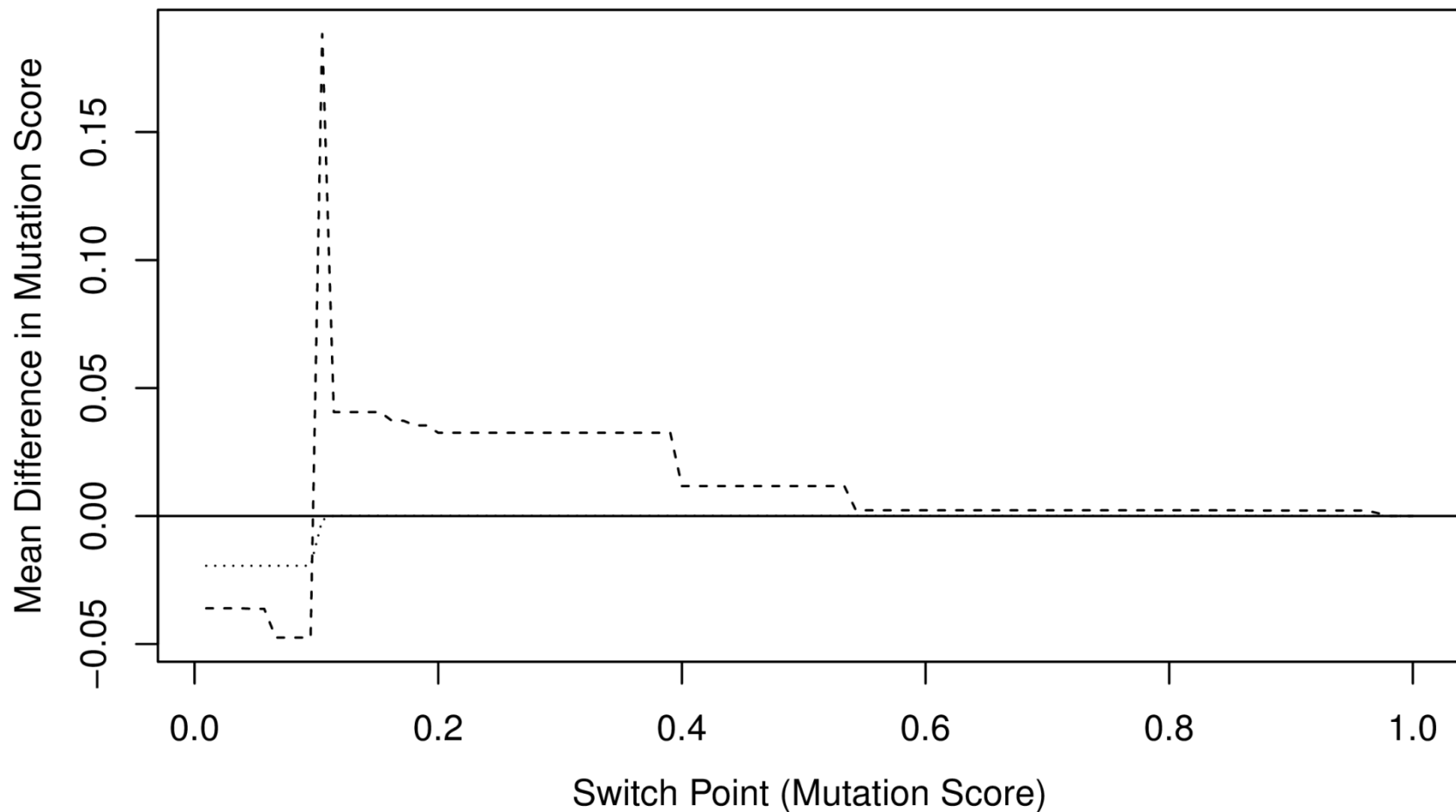
— ART (baseline) - - - - KD-ART (intensify) ····· KD-ART (diversify)

Averaged over eight programs



FINDING THE OPTIMAL SWITCH POINT

erfcc switch

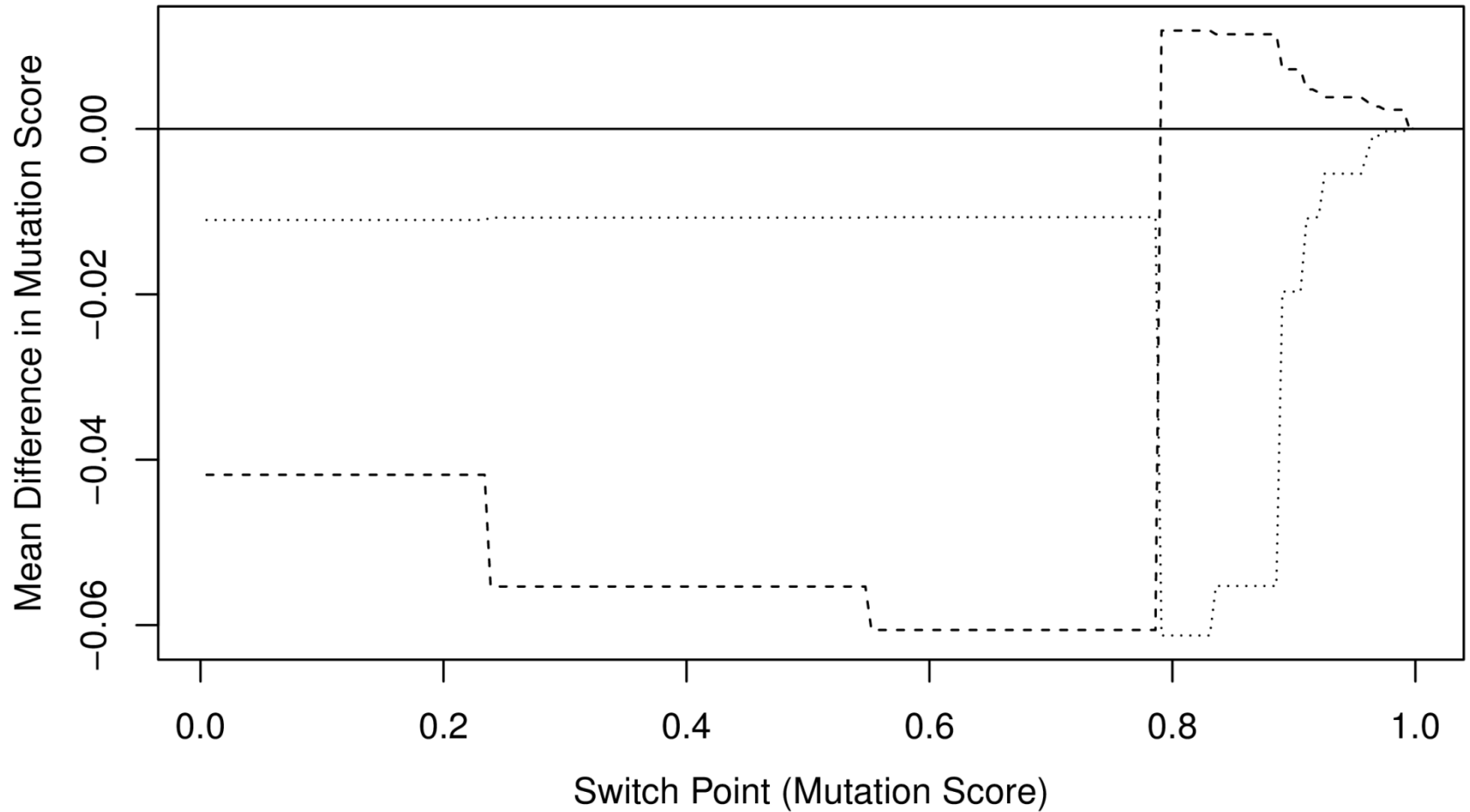


— ART (baseline)

- - - KD-ART (intensify)

..... KD-ART (diversify)

Airy switch



— ART (baseline) - - - - KD-ART (intensify) ····· KD-ART (diversify)

PROGRAM PROPERTIES AND OPTIMAL SWITCH POINT

	KD-ART (intensify)		KD-ART (diversify)	
	Pearson's r	p-value	Pearson's r	p-value
Mutants	0.768	0.013	0.171	0.342
LOC	0.529	0.089	0.315	0.224

Conclusions

- It is not always best to diversify the test suite, sometimes intensification should be used too
- The switch point between traditional ART and KD-ART has a significant effect on the results
- The optimal switch point can be predicted using easily calculable program properties

ANY QUESTIONS?

AVERAGE TIME TAKEN TO RUN KDT AND ART (IN SECONDS)

Program	Selecting test inputs			Running mutants
	KD-ART (intensify)	KD-ART (diversify)	ART	
erfcc	0.878	0.890	1.132	104.3
probks	0.954	0.970	1.079	74.48
bessj0	0.328	0.350	1.209	192.6
plgndr	0.350	0.345	1.593	260.0
airy	0.265	0.268	1.284	269.6
triangle	0.485	0.479	2.160	314.1
gammq	0.397	0.434	1.411	330.2
tcas	0.480	0.505	61.01	99.37