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Research Interests – Software Testing, Metrics for Quality Assurance, Optimising Software Energy Consumption

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The Problem
Software testing is time consuming

Functional testing

The test suite of a non-trivial system:
- could have **thousands** of test cases
- could take **hours, days** or even **weeks** to execute
Software Testing

• Widespread and applied to software of any size
• Major problems with the efficiency and effectiveness of testing in its current form in practice. (Annual costs in the US run up to $59.5 billion [NIST])
• Software is getting larger and more complex

12 Million Lines of Code 61 Million LOC 14 Million LOC

• The global cost of software bugs is estimated at 312 billions of dollars annually.
Why is Software Testing Hard

Input/state space

public Line(int x0, int y0, int x1, int y1)

- Input per int: $2^{32}$ different values:
- $2^{32} \times 2^{32} \times 2^{32} \times 2^{32}$ different values

1000 lines per second: $10^{28}$ years

Execution Sequences

for (int i=0, i < n; i++) {
    if (a.get(i) == b.get(i)) {
        x[i] += 100;
    } else {
        x[i] /=2;
    }
}

$2^n$ paths with $n$ iterations
Systematic Partition Testing

- Failure (valuable test case)
- No failure

The space of possible input values (the haystack)

- Failures are sparse in the space of possible inputs ...
- ... but dense in some parts of the space

If we systematically test some cases from each part, we will include the dense parts

Functional testing is one way of drawing pink lines to isolate regions with likely failures
Research Problem

Generating software test cases using a combination of machine learning and program analysis techniques.
Ever increasing computing power

Only about 20% of the available power resources is getting used!
The Problem
Software testing is time consuming

Characteristics:
1. Executions are independent
2. Executions are data parallel
Research problem

How do you cluster tests for parallel execution on multiple cores?

Dynamic Analysis

Gather data on test executions

Create clusters of tests

Launch each cluster on a single CPU
Factors Affecting Energy in Software
Our Empirical Study

Estimate Energy

Identify

Understand

Both Software and Hardware factors.
Approach
Data Collection – Metrics

Hardware Features
- Performance
  - CPU cycles, task clock...
- Branch Instructions
  - #executed branch instructions...
- Cache
  - #load/store misses...
- Page Faults
  - #minor/major page faults...

Dynamic Program Features
- Program Instructions
  - #executed program instructions...
- Memory Instructions
  - #read/writes, #malloc/calloc...
- Processor Registers
  - #read/writes to processor regs...
- Halstead Metrics
  - #operators, program length...

Static Program Features
- Cyclomatic Complexity
- Other
  - #pointer references...
Feature Selection

• A machine learning technique.
• Selects a subset of statistically relevant features for use in model construction.
Evolving Software

Large software systems are usually built incrementally:

- **Maintenance** - fixing errors and flaws, hardware changes
- **Enhancements** - new functionality, improved efficiency, extension, new regulations

Research Interests

1. What is the effort/cost of upgrades?
2. Test adequacy criteria for regression testing
3. What is the regression test effort/cost?
Cost Models

- Highly inaccurate and research in building these models is from a decade ago
- DATA DATA DATA – Machine learning techniques that considers program change sizes, organisational factors, developer experience, past project data.
- Combine them with precise static analysis