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# Exploratory Automated Testing

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## About Doug Hoffman

I am a management consultant in testing/QA strategy and tactics. I help transform organizations. Effective software testing requires a special skillset and mindset. The problems and solutions are unique and specific to every set of relevant factors; the context. Over several decades in the business I have learned a great deal about software testing and automation in a large range of contexts from big government and commercial companies to Silicon Valley startups; from hardware and microcode to full blown applications. I enjoy sharing what I've learned with interested people.

### Current employment

- President of Software Quality Methods, LLC. (SQM)
- Management consultant in strategic and tactical planning for software quality

### Education

- B.A. in Computer Science
- MS in Electrical Engineering, (Digital Design and Information Science)
- MBA

### Professional

- Board of Directors and Past President, Association for Software Testing
- Past Chair, Silicon Valley Section, American Society for Quality (ASQ)
- Founding Member and current Chair, Santa Clara Valley Software Quality Association (SSQA)
- Certified in Software Quality Engineering (ASQ-CSQE)
- Certified Quality Manager (ASQ-CMQ/OE)
- Participant in the Los Altos Workshops on Software Testing and many others

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## Automation For This Discussion

Get the computer to do one or more of:

- Test data generation
- Setting-up or capturing pre-conditions
- Controlling test execution
- Selecting/generating inputs
- Running the test exercise
- Outcome monitoring
- Verdict determination:
  - Expected outcome generation
  - Actual outcome monitoring and/or capture
  - Outcome evaluation

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## Most Automated Tests Today

- Are based on the functions of a test tool
- Automate a manual tester's actions
- Are a specific set of test activities (script)
- Work only at the UI or API level
- Do program checking at specified points in the script
- Are used to repeat and speed up manual testing

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## The Regression Test Approach

- Identify potential problems and tests necessary to expose them
- Identify and prioritize important risks
- Standardize documentation and procedures
- Design and create tests that are repeatable
- Rerun the tests often

*Regression testing targets specific potential errors and repeatedly (and only) checks for those errors*

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## Questions We Should Ask About Testing and Automation

- Should we limit our thinking to what a tool does?
- Should we focus automation on things we can do manually and then script?
- Should we limit ourselves to UIs and APIs?
- Are we checking everything that's important?
- Do speedy manual tests find more or different bugs than manually running tests?
- Can inefficient or approximate tests be valuable?
- Must tests do the same things every time?

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## Exploratory Test Automation

- Does something new every time (except...)
- Does things a manual tester cannot do
- Gets ‘behind the scenes’ or “under the covers”
- May use massive numbers of iterations
- May use multiple parallel oracles

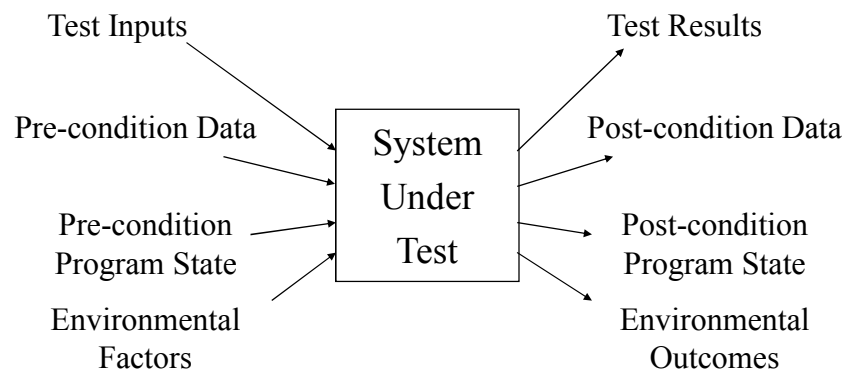
*Exploratory test automation can find bugs we never imagined and couldn't find any other way*

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## A Test Execution Model



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## Some Implications of the Model

- We don't control all inputs
- We can't verify everything
- Multiple domains are involved
- We don't even know all the factors
- The test exercise is the easy part

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## The Oracle Is Key For Test Automation:

- The principle or mechanism for telling whether the SUT behavior appears OK or if further investigation is warranted
- Addresses the question “is this unexpected behavior?”
- It's a basic part of every test execution

**Our ability to automate testing is  
fundamentally constrained by our  
ability to create and use oracles.**

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## Types of Test Oracles

- None
- Independent implementation
- Consistency
  - Saved master
  - Function equivalence
- Self-Verifying
- Model based
- Constraint based
- Probabilistic
- Property based
- Computational
- Diagnostic
- Hand-crafted
- Human

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## High Volume Random Tests

- Principle idea
  - High-volume testing using varied stimulus
  - Results checking based on individual results or population's statistical characteristics
- Fundamental goal is to have a huge number of iterations
  - The individual tests may not be not all that powerful or compelling
  - Stimulus is varied for each step
  - Individual results may not be checked for correctness (e.g., heuristics or population statistics)
  - The power of the approach lies in the large number of tests

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## Randomness and Tests

- Random number generators
  - Pseudo-Random numbers
  - Generating random seeds
  - Repeatable by entering seed value
- Randomized input values
- Randomized data generation

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## Repeatable Random Series

```
# RUBY code
MAX_SEED = 1_000_000_000
def initial_RNG_seed(myseed)
  if (myseed == nil) # Check if seed is provided
    # Create a random number to seed RNG
    puts "(no seed passed in, so generate one)"
    myseed = srand()
    myseed = rand(MAX_SEED)
  end
  # print the seed so that we know the seed used
  puts "myseed is #{myseed.to_s}\n"
  foo2 = srand (myseed) # initialize the RNG
  foo = rand()          # generate the [first] random number
  return foo
end
```

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## Random Series Output Example

```
puts ("First run: #{initial_RNG_seed(nil)} \n \n")
puts ("Second run: #{initial_RNG_seed(400)} \n \n")
puts ("Third run: #{initial_RNG_seed(nil)} \n")
→
(no seed passed in, so generate one)
myseed is 144288918
First run: 0.3705579466087263

myseed is 400
Second run: 0.6687289088341747

(no seed passed in, so generate one)
myseed is 108495905
Third run: 0.09838898989988143
```

[RandSeed](#)

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## Running Randomly Selected Regression Tests

```
# Ruby
threads = []
list = []
list = Dir.entries("./executables")
list3 = list.reject { |s| s =~ /^\.\/ }
TestCount = list3.length
for y in (1..10)
  name = list3[rand(TestCount)]
  threads << Thread.new(name) do |x|
    print "running \n"
    print x.to_s
  end
  # use ruby for running all types of scripts and programs
  system ('ruby ./executables/' + x)
end
threads.each {|thr| thr.join}
end
puts ""
puts "Exiting"
#puts rand(TestCount)
#puts list3[rand(TestCount)]
```

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## Well-Formed Input

```
#RUBY program that generates simple arithmetic phrases
def eq_gen
  jubilee = 1 + rand(8) # 8 choices for the 4 defined cases
  case jubilee
    when 1
      "(" << eq_gen() << ")" + "(" << eq_gen() << ")"
    when 2
      "(" << eq_gen() << ")" - "(" << eq_gen() << ")"
    when 3
      "(" << eq_gen() << ")" * "(" << eq_gen() << ")"
    when 4
      "(" << eq_gen() << ")" / "(" << eq_gen() << ")"
    else # generate number half the time
      rand(100).to_s
    end
  end
end
```

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## Example of Well-Formed Input

```
puts eq_gen.to_s
puts eq_gen.to_s
puts eq_gen.to_s
puts eq_gen.to_s
```

→

```
(77) - ((62) / (6))
```

```
((10) - (40)) + (67)
```

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```
(62) - ((96) * (((77) - (72)) - ((7) * ((47) - (91)))) /
((34) + (((70) - (18)) + (4))))
```

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## Low Volume Exploratory Tests

- Principle idea
  - One-at-a-time testing using varied inputs
  - Use automation to make exploration easier
- Fundamental goal is to enable exploration
  - Variations on a theme (modification of existing tests)
  - Quick-and-dirty generation of tests/data/comparisons
  - Checking in the background
    - Memory leak detection
    - File modification
    - Etc.

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## Examples of Exploratory Automation

- Random events (Cem Kaner's "Telenova" example)
- "Dumb monkeys" (Noel Nyman)
- "Sandboxed" random regression tests (Kaner/Hoffman)
- Single and multi-threaded database locking (Hoffman)
- Statistical packet profiles for data link testing (Hoffman)
- Random machine instruction generation (Hoffman)
- Database unbalanced splitting (Hoffman)
- Database load/unload dropouts (Hoffman)
- Database forward/backward link consistency (Hoffman)
- Device front panel state machine long walks (Hoffman)
- Periodic database unload/check (Hoffman)
- 1/3 or 3x timing difference heuristic in test harness (Oracle)

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## Advantages of Exploratory Automation

- Does things a manual tester cannot do
- Does something new every time
- May use massive numbers of iterations
- May feed inputs directly to SUT
- Oracles may check internal information
- May have multiple parallel oracles
- Supplements baseline tests
- Can uncover obscure bugs
- Can uncover bugs impossible to find manually

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## Disadvantages of Exploratory Automation

- May not be repeatable
- Difficulty capturing program and system information for diagnosis
- May have multiple parallel oracles
- Coordination of autonomous oracles with the test
- Does not provide rigorous coverage
- Can uncover bugs that can't be fixed

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## Summary

- Exploratory Automated Testing uses tests that get the computer to look for unexpected conditions
- Varies what the test does
- Opposite of regression tests
- Test oracles are fundamental in testing, especially in exploratory automated testing

