Mutation Testing

What / Why / How

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What is mutation testing?

White box

Introduce Mutations to program code

Mutant output should vary from original output

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Introduce Mutations to program code

Mutant output should vary from original output

Check effectiveness of test cases

Good test cases fail on mutated code

What is a mutation?

LOW LEVEL
CODE MODIFICATIONS

Value Mutations		
Change values / constants occurring in the programm Small ⟶ Large vs. Large ⟶ Small		

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What is a mutation?

LOW LEVEL
CODE MODIFICATIONS

Value Mutations	Decision Mutations	Statement Mutations
Change values / constants occurring in the programm Small → Large vs. Large → Small	Typically mutations to logical operators: AND, OR, XOR, NOT etc. or arithmetic operators: (+)→ (-) (*) → (**) (+)→(i++)	Removing or replacing lines / statements in code

Value Mutation

Original Code

```
def square():
    return pow(a, 2)
```

Mutated Code

```
def square():
    return pow(a, 20000)
```

Decision Mutation

Original Code

```
def subtract(self, a, b):
        return a - b
```

Mutated Code

```
def subtract(self, a, b):
        return a / b
```

Statement Mutation

Original Code

```
def some_logic(self, a, b):
    if (a > b):
        r = 15
    else:
        r = 10
```

Mutated Code

```
def some_logic(self, a, b):
    if (a > b):
        S = 15
    else:
        S = 10
```

mutmut - python mutation tester

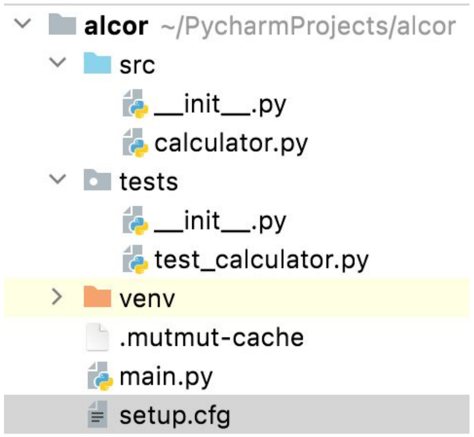
Hands on experience

```python
class Calculator:

    def add(self, a, b):
        return a + b

    def subtract(self, a, b):
        return a - b

    def multiply(self, a, b):
        return a * b

    def divide(self, a, b):
        if b == 0:
            raise ArithmeticError()
        return a / b

    def square(self, a):
        return pow(a, 2)

    def some_logic(self, a, b):
        if a > b:
            return 15
        else:
            return 10
```

```python
class TestCalculator(TestCase):
    calculator = Calculator()

    def test_add(self):
        result = self.calculator.add(1, 2)
        self.assertEquals(3, result)

    def test_subtract(self):
        result = self.calculator.subtract(1, 2)
        self.assertEquals(-1, result)

    def test_multiply(self):
        result = self.calculator.multiply(1, 2)
        self.assertEquals(2, result)

    def test_divide(self):
        result = self.calculator.divide(1, 1)
        self.assertEquals(1, result)

    def test_square(self):
        result = self.calculator.square(5)
        self.assertEquals(25, result)

    def test_some_logic(self):
        result = self.calculator.some_logic(6, 5)
        self.assertEquals(15, result)
```

mutmut - python mutation tester

Project setup



```
alcor ~/PycharmProjects/alcor
  src
    __init__.py
    calculator.py
  tests
    __init__.py
    test_calculator.py
  venv
  .mutmut-cache
  main.py
  setup.cfg
```

1. Install package

```
% pip3 install mutmut
```

2. Configure - setup.cfg

```
[mutmut]
paths_to_mutate=src/
backup=False
tests_dir=tests/
```

mutmut - python mutation tester

Running mutation tests

```
% mutmut run

Legend for output:
🎉 Killed mutants.   The goal is for everything to end up in this bucket.
⏰ Timeout.          Test suite took 10 times as long as the baseline so were killed.
🤔 Suspicious.       Tests took a long time, but not long enough to be fatal.
🙁 Survived.         This means your tests need to be expanded.
🔇 Skipped.          Skipped.

1. Using cached time for baseline tests, to run baseline again delete the cache file

2. Checking mutants
⠸ 11/11  🎉 10  ⏰ 0  🤔 0  🙁 1  🔇 0
```

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```

```
% mutmut show src/calculator.py

 Survived 🙁 (1)

 ---- src/calculator.py (1) ----

 # mutant 43
 --- src/calculator.py
 +++ src/calculator.py
 @@ -19,7 +19,7 @@
          return pow(a, exp)

      def some_logic(self, a, b):
 -        if a > b:
 +        if a >= b:
              return 15
          else:
              return 10
```

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```

```
class TestCalculator(TestCase):
    calculator = Calculator()


    def test_some_logic(self):
        result = self.calculator.some_logic(4, 5)
        self.assertEquals(10, result)
```

```
% mutmut show src/calculator.py

 Survived 🙁 (1)

 ---- src/calculator.py (1) ----

 # mutant 43
 --- src/calculator.py
 +++ src/calculator.py
 @@ -19,7 +19,7 @@
          return pow(a, exp)

     def some_logic(self, a, b):
 -        if a > b:
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          else:
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```

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Test improvements

```
% mutmut run

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1. Using cached time for baseline tests, to run baseline again delete the cache file

2. Checking mutants
⠋ 11/11  🎉 10  ⏰ 0  🤔 0  🙁 0  🔇 0
```

```
class TestCalculator (TestCase):
    calculator = Calculator()


    def test some logic (self):
        result = self.calculator.some _logic( 4, 5)
        self.assertEquals( 10, result)

    def test some logic2 (self):
        result = self.calculator.some _logic( 5, 5)
        self.assertEquals( 10, result)
```

Pros & Cons

+ Brings attention to new types of errors
+ Increases coverage of tested application / code
+ Introduces edge cases testing

- Can be resources and time consuming
- Not suited for black box testing
- Setup + automation required

Thanks / Q&A

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Sources:

1. https://www.javatpoint.com/mutation-testing
2. https://mutmut.readthedocs.io/en/latest/index.html#example-mutations
3. https://techbeacon.com/app-dev-testing/mutation-testing-how-test-your-tests