CMPT 473
Software Quality Assurance

# Input Space Partitioning

Nick Sumner - Fall 2014
With material from Patrick Lam, Jeff Offutt

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- Testing involves running software and comparing observed behavior against expected behavior
  - Select an input, look at the output

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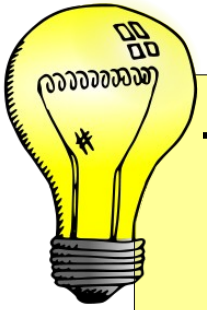
  - Select an input, look at the output
- Problem: The *input domain* is infinite or pragmatically infinite.

```
for test in allPossibleInputs:
    run_program(test)
```

# Recall

- Testing involves running software and comparing observed behavior against expected behavior
  - Select an input, look at the output
- Problem: The *input domain* is infinite or pragmatically infinite.
- Testing is about selecting a finite subset of inputs that can help measure quality

# Input Space Partitioning



Take the direct approach:
Focus on the input!

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  - Divide (*partition*) the set of possible inputs into equivalence classes

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e.g. `abs(x)`

Input Domain: ..., -3, -2, -1, 0, 1, 2, 3, ...

How many tests if done exhaustively?

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Partitions: ..., -3, -2, -1, 0, 1, 2, 3, ...

What might reasonable partitions be?

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How many tests for the partitions?

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Impressive! How do we do it?

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What might the inputs be?

# Input Space Partitioning

1) Identify the component

- Whole program
- Module
- Class
- Function

2) Identify the inputs

- Function/method parameters
- File contents
- Global variables
- Object state
- User provided inputs

# Input Space Partitioning

3) Develop an *Input Domain Model*

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What does that even mean?

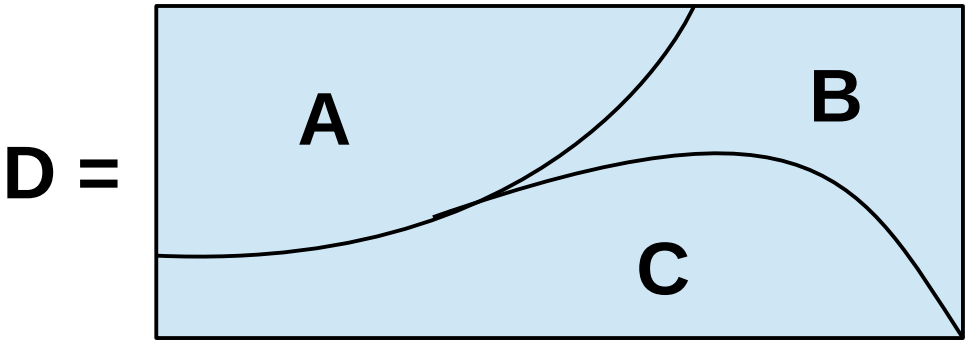
# Input Space Partitioning

3) Develop an *Input Domain Model*

- A way of *describing* the possible inputs
- Partitioned by characteristics

# Partitioned Input Domain

- ***Partition*** the domain D *on characteristics*



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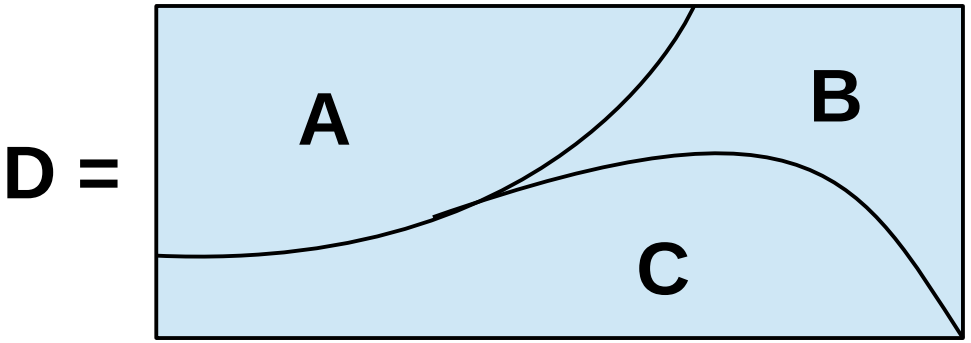
What are ***characteristics***?



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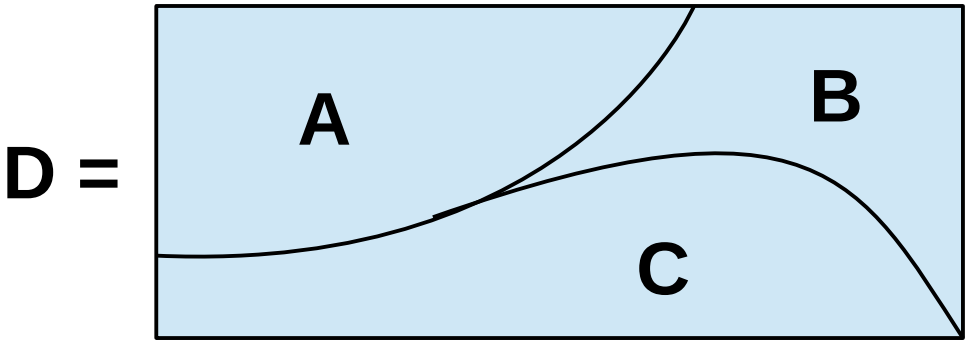
  - Disjoint: $A \cap B \cap C = \varnothing$
  - Cover: $A \cup B \cup C = D$



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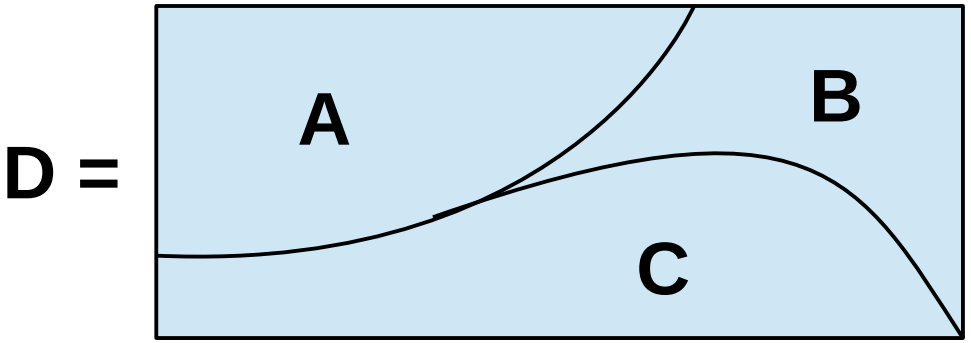


What do these criteria intuitively provide?

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Might there be more? Fewer?

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We're hiding some details in this last step.
It's not quite right yet.

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- How?
  - Identify ***characteristics*** of the possible inputs (from requirements, types, etc.)
  - Partition into ***blocks*** based on each characteristic
  - Create tests by ***selecting values*** for each block
- Characteristics:
  - List s is sorted ascending
  - X is null
  - String length
  - ...

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classifyParallelogram(p1)
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- It is easy to create overlapping partitions.
  - Care and design required to avoid it.

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Why do disjoint partitions matter?

# Process (Reiterated)

3 step process (for now):

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   - Must identify ***everything***

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3) Model the input domain

   - Identify characteristics
   - Partition the input domain
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   - Must identify ***everything***

Domain knowledge, tactics, and creativity apply here.

3) Model the input domain

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# Approaches to Input Modeling

We still haven't talked about ***how*** to model input!

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  - Derived from expected input/output by spec.

# Approaches to Input Modeling

2 Main approaches:

1) Interface based
   - Guided directly by identified parameters & domains
   - Simple
   - Automatable

2) Functionality/Requirements based
   - Derived from expected input/output by spec.
   - Requires more design & more thought
   - May be better (smaller, goal oriented, …)

# Interface Based Modeling

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How does this apply to our triangle classifier?

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How might this apply to our triangle classifier?

# Finding Typical Characteristics

What might typical characteristics be?

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What might typical characteristics be?

- Preconditions
- Postconditions

} Invariants

- Relationships to special values
- Relationships between variables

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Thought experiment:
What do boundary values as a selection approach indicate?

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- Consider our triangle classifier
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| Characteristic | b1 | b2 | b3 |
|---|---|---|---|
| Side 1 <?> 0 | Side 1 > 0 | Side 1 = 0 | Side 1 < 0 |
| Side 2 <?> 0 | Side 2 > 0 | Side 2 = 0 | Side 2 < 0 |
| Side 3 <?>0 | Side 3 > 0 | Side 3 = 0 | Side 3 < 0 |

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How many tests does this create?

What will this test well?
What won't this test well?

# Refining the Example

- We can subdivide partitions to cover more behavior

| Characteristic | b1 | b2 | b3 | b4 |
|---|---|---|---|---|
| Value of side 1 | Side 1 > 1 | Side 1 = 1 | Side 1 = 0 | Side 1 < 0 |
| Value of side 2 | Side 2 > 1 | Side 2 = 1 | Side 2 = 0 | Side 2 < 0 |
| Value of side 3 | Side 3 > 1 | Side 3 = 1 | Side 3 = 0 | Side 3 < 0 |

{Side n > 0} → {Side n = 1},{ Side n > 1}

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What does it test well? Not well?

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  - What might our characteristics & partitions be?
  - Are there alternatives?
  - Why might you use them?

# A Classic Example

- Start with a component / specification:

| | |
|---|---|
| **Command** | FIND |
| **Syntax** | FIND <pattern> <file> |
| **Function** | The FIND command is used to locate one or more instances of a given pattern in a text file. All lines in the file that contain the pattern are written to standard output. A line containing the pattern is written only once, regardless of the number of times the pattern occurs on it.<br><br>The pattern is any sequence of characters whose length does not exceed the maximum length of a line in the file. To include a blank in the pattern, the entire pattern must be enclosed in quotes (''). To include a quotation mark in the pattern, two quotes in a row ("") must be used. |

# A Classic Example

- Step 1: Analyze the specification
  - What is the component?
  - What are the parameters?
  - What are the characteristics?

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```
Characteristics:
  Pattern
  Input file
  Pattern Size
  Quoting
  Embedded Quotes
  File Name
Environment / System Characteristics:
  # of pattern occurrences in file
  # of occurrences on a particular line:
```

# A Classic Example

- Step 2: Partition the Input Space
  - Guided by intelligence and intuition
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```
Parameters:
  Pattern Size:
    Empty
    Single character
    Many characters
    Longer than any line in the file
  Quoting:
...
```

# A Classic Example

- Familiar Idea:
  - Select one region per characteristic at a time
  - Combine into test *frames* (test case plans)
  - e.g. …

# A Classic Example

- Familiar Idea:
  - Select one block per characteristic at a time
  - Combine into test *frames* (test case plans)
  - e.g.

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Pattern size : empty
Quoting : pattern is quoted
Embedded blanks : several embedded blanks
Embedded quotes : no embedded quotes
File name : good file name
Number of occurrences of pattern in file : none
Pattern occurrences on target line : one
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# A Classic Example

- Step 3: Identify ***constraints*** among the characteristics & blocks

```
Pattern Size:
  Empty                                  [Property Empty]
  Single character                       [Property NonEmpty]
  Many characters                        [Property NonEmpty]
  Longer than any line in the file       [Property NonEmpty]
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# A Classic Example

- Step 3: Identify ***constraints*** among the categories

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  Many characters                        [Property NonEmpty]
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Quoting:
  Pattern is quoted                      [Property Quoted]
  Pattern is not quoted                  [If NonEmpty]
  Pattern is improperly quoted           [If NonEmpty]
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What should this do to the number of tests?
To the quality of tests?

# A Classic Example

- Step 4
  - Create tests by selecting values that satisfy the selected blocks for each frame
  - Eliminate tests that cover redundant scenarios

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  - Create tests by selecting values that satisfy the selected blocks for each frame
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Why might scenarios be redundant?

# A Classic Example

- Step 5:
  - Take your generated test cases and automate them

# Your Assignment

- Posted tonight/tomorrow morning.
- You will be applying the C-P method to a file parsing function of an open source project.