COMP3141

Software System Design and Implementation

Property Based Testing Practice

Curtis Millar
CSE, UNSW (and Data61)

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Exercise 1

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2. **Moving Objects**: implement `movePictureObject`

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2. **Moving Objects**: implement `movePictureObject`
3. **Generating a Picture**: generate pictures of circles using `simpleCirclePic`

Property Based Testing

Key idea: Generate random input values, and test properties by running them.

Example (QuickCheck Property)

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prop_reverseApp xs ys =
    reverse (xs ++ ys) == reverse ys ++ reverse xs
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Haskell's *QuickCheck* is the first library ever invented for property-based testing. The concept has since been ported to Erlang, Scheme, Common Lisp, Perl, Python, Ruby, Java, Scala, F#, OCaml, Standard ML, C and C++.

Mersenne Prime Example

Example (Stereotypical Task)

- The n^{th} Mersenne number $M_n = 2^{n-1}$.
- M_2, M_3, M_5 and M_7 are all prime numbers.
- **Conjecture:** $\forall n.prime(n) \implies prime(2^n - 1)$

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It took humanity about two thousand years to do the same.

Semigroup and Monoid Properties

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QuickCheck Properties

```
-- Semigroup laws
prop_listAssociative xs yz zs = ((xs ++ ys) ++ zs) == (xs ++ (ys ++ zs))

-- Monoid laws
prop_listLeftIdentity xs = xs == [] ++ xs
prop_listRightIdentity xs = xs == xs ++ []
```

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Let's see how long it takes QuickCheck.

QuickCheck Property

```
prop_reverseInvolution xs = reverse (reverse xs) == xs
```

Ransom Note Example

Example (Demo Task)

Given a magazine (in `String` form), is it possible to create a ransom message (in `String` form) from characters in the magazine.


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2. Create an efficient implementation
3. Test the implementation

In Haskell.

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1. Horizontal flip
2. Vertical flip
3. Rotate 180 degrees

Example (Demo Task).

Implement the above for a single `Path`. (You might want to try and implement these for other `PictureObject` constructors or for an entire `Image` as self-practice.) In Haskell.

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- If software is incorrect, a proof attempt might simply become stuck: we do not always get constructive negative feedback.
- Proofs can be labour and time intensive ($$$), or require highly specialised knowledge ($$$).

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We lose some assurance, but gain some convenience ($$$).

Verification versus Validation

> *"Testing shows the presence, but not the absence of bugs."*
> – Dijkstra (1969)

Testing is essential but is insufficient for safety-critical applications.

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3. This week's quiz is also up, it's due next Friday (in 9 days).

Consultations

Tomorrow, 9am to 11am, on Blackboard Collaborate
Link on course website.

Be ready to share your screen with REPL (`ghci` or `stack repl`) and editor set up.