

Property Testing with derived idempotents

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Introduction to Property Testing

Isomorphisms: Ideal Property Testing Candidates

Idempotents: Making Property Testing Practical

Application: Deriving Idempotents for Property Testing

Live Coding: Property Testing FizzBuzz

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What is Property Testing?

$$\exists \implies \forall$$

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Unit tests on cartoon steroids.

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Take from the source:

QuickCheck

Hypothesis

JSVerify

Property Testing - A closer look at the examples

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How do you make meaningful assertions without re-implementing the code under test?

Property Testing - A closer look at the examples

You don't know what your inputs are.

Your properties are meant to hold over a broad set of inputs, they must be general.

How do you make meaningful assertions without re-implementing the code under test?

Revisit:

QuickCheck

Hypothesis

JSVerify

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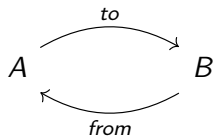
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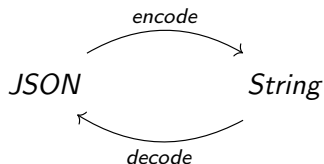
Isomorphism Defined



$$from(to(A)) = from \circ to = 1_A$$

$$to(from(B)) = to \circ from = 1_B$$

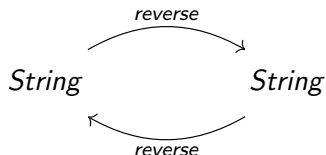
Isomorphism Example: encode \Longleftrightarrow decode



$$\text{decode}(\text{encode}(\text{JSON})) = \text{decode} \circ \text{encode} = 1_{\text{JSON}}$$

$$\text{encode}(\text{decode}(\text{String})) = \text{encode} \circ \text{decode} = 1_{\text{String}}$$

Isomorphism Example: reverse \Longleftrightarrow reverse



$$\text{reverse}(\text{reverse}(\text{String})) = \text{reverse} \circ \text{reverse} = 1_{\text{String}}$$

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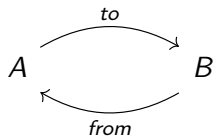
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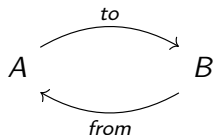
Live Coding: Property Testing FizzBuzz

Idempotent Defined



$$to(\text{from}(B)) = to \circ from = 1_B$$

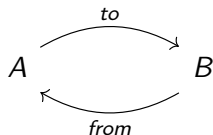
Idempotent Defined



$$to(from(B)) = to \circ from = 1_B$$

$$from(to(from(to(A)))) =$$

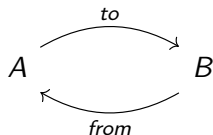
Idempotent Defined



$$to(from(B)) = to \circ from = 1_B$$

$$from(to(from(to(A)))) = \\ from \circ to \circ from \circ to =$$

Idempotent Defined



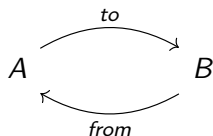
$$to(from(B)) = to \circ from = 1_B$$

$$from(to(from(to(A)))) =$$

$$from \circ to \circ from \circ to =$$

$$from \circ (to \circ from) \circ to =$$

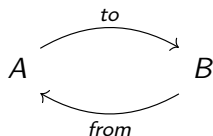
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$$to(from(B)) = to \circ from = 1_B$$

$$\begin{aligned} from(to(from(to(A)))) &= \\ from \circ to \circ from \circ to &= \\ from \circ (to \circ from) \circ to &= \\ from \circ 1_B \circ to &= \end{aligned}$$

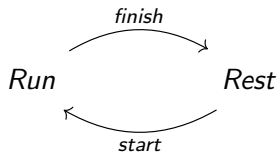
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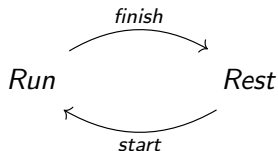
$$\begin{aligned} & from(to(from(to(A)))) = \\ & from \circ to \circ from \circ to = \\ & from \circ (to \circ from) \circ to = \\ & from \circ 1_B \circ to = \\ & from \circ to \end{aligned}$$

Idempotent Example: $\text{Run} \hookrightarrow \text{Rest}$



$$\text{start}(\text{finish}(\text{Run})) = \text{start} \circ \text{finish} = 1_{\text{Run}}$$

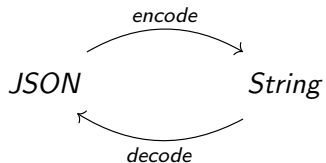
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$$\text{start}(\text{finish}(\text{Run})) = \text{start} \circ \text{finish} = 1_{\text{Run}}$$

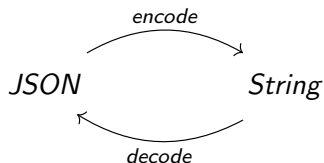
$$\begin{aligned} \text{finish}(\text{start}(\text{finish}(\text{start}(\text{Rest})))) &= \\ \text{finish} \circ \text{start} \circ \text{finish} \circ \text{start} &= \\ \text{finish} \circ (\text{start} \circ \text{finish}) \circ \text{start} &= \\ \text{finish} \circ (1_{\text{Run}}) \circ \text{start} &= \\ \text{finish} \circ \text{start} \end{aligned}$$

Idempotent Example: $\text{JSON} \hookrightarrow \text{String}$



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Making Properties Easy

We know that properties are easy and effective when we have an isomorphism.

```
from hypothesis import given
from hypothesis.strategies import text
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```
@given(text())
def test_decode_inverts_encode(s):
    assert decode(encode(s)) == s
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What about when we don't have an isomorphism?

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What about when we don't have an isomorphism?

Can we *find* an isomorphism?

Finding an isomorphism

FizzBuzz does not belong to an isomorphism.

```
from typing import List
def fizzbuzz(nums: List[int]) -> List[str]:
    res: List[str] = []
    for num in nums:
        s = ""
        if num % 3:
            s += "Fizz"
        if num % 5:
            s += "Buzz"
        if s == "":
            s = str(num)
        res.append(s)
    return res
```

Finding an isomorphism

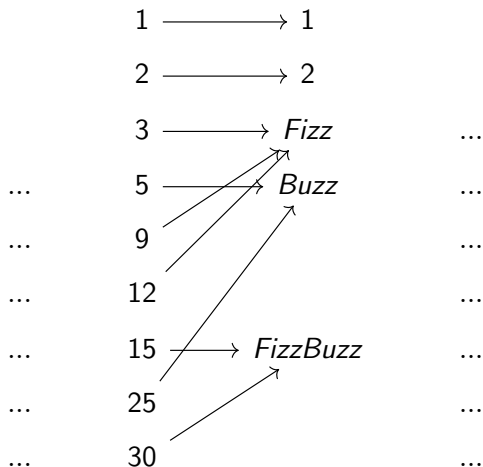
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What is the closest isomorphism we can find?

It helps to take a different perspective.

FizzBuzz as a Set Function



We cannot have an isomorphism because inputs *collapse* onto outputs.

This prevents construction of an inverse.

FizzBuzz as a Set Function, Partitioned Domain

$$\{1\} \longrightarrow 1$$

$$\{2\} \longrightarrow 2$$

$$\{3, 6, 9, 12, \dots\} \longrightarrow \textit{Fizz}$$

$$\{4\} \longrightarrow 4$$

$$\{5, 10, 20, 25, \dots\} \longrightarrow \textit{Buzz}$$

$$\{7\} \longrightarrow 7 \quad \dots$$

$$\dots \quad \{15, 30, \dots\} \longrightarrow \textit{FizzBuzz}$$

$$\{16\} \longrightarrow 16$$

We have an isomorphism, can we fix the input type?

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$$\{16\} \longrightarrow 16$$

We have an isomorphism, can we fix the input type?

With an idempotent.

FizzBuzz⁻¹ as a Set Function, Idempotent

We just pick one value from each input set.

1 ← 1

2 ← 2

3 ← *Fizz*

4 ← 4

5 ← *Buzz*

7 ← 7 ...

... 15 ← *FizzBuzz*

16 ← 16

This can be pre-composed with FizzBuzz to create an identity on the output set.

This means we have an idempotent on the input set.

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