Live Functional Programming with Typed Holes

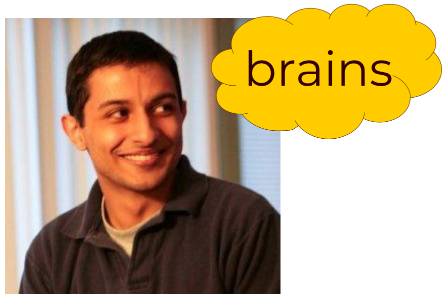
Cyrus Omar

Future of Programming Lab (FP Lab)

University of Michigan

@neurocy

http://fplab.mplse.org/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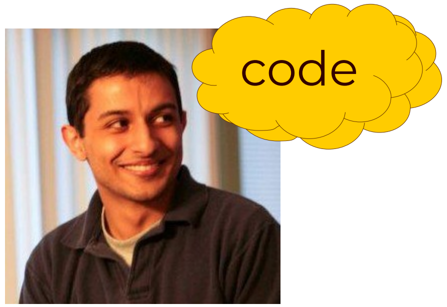
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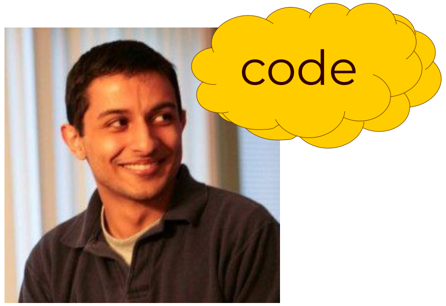

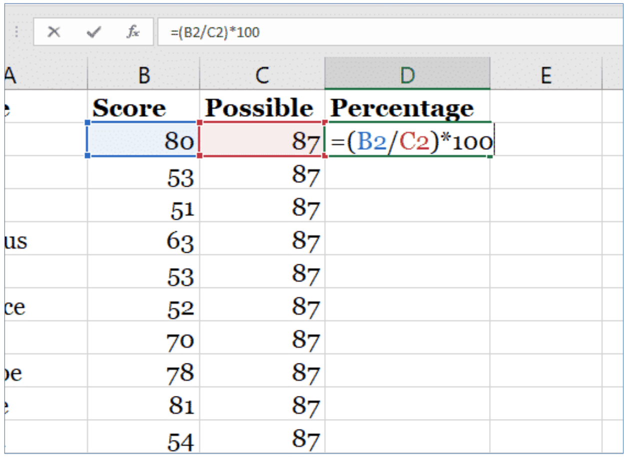
=(B2/C2)*100

A	B	C	D	E
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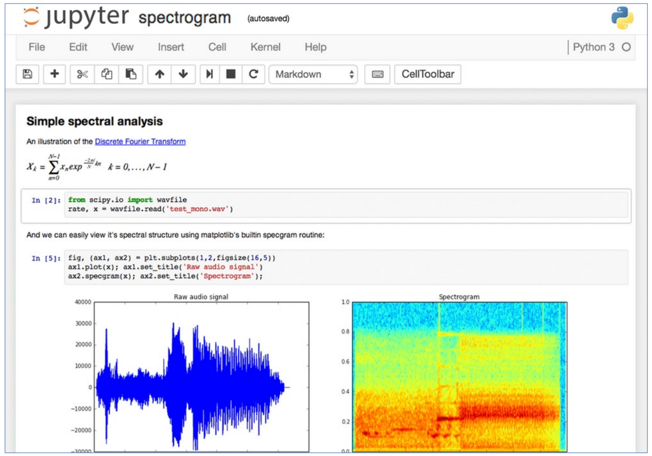
jupyter spectrogram (autosaved)
File Edit View Insert Cell Kernel Help
Python 3
Markdown
CellToolbar

Simple spectral analysis

An illustration of the Discrete Fourier Transform

$$X_k = \sum_{n=0}^{N-1} x_n exp^{\frac{-2\pi i}{N}kn} \quad k = 0, \dots, N-1$$

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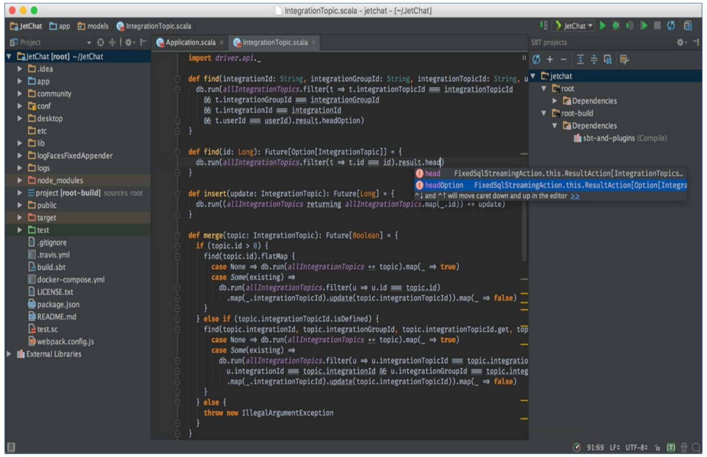

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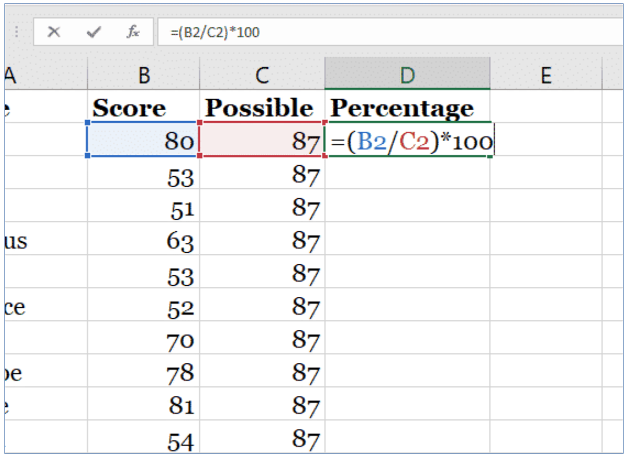
End-User Environments

Professional End-User Environments

Professional Environments



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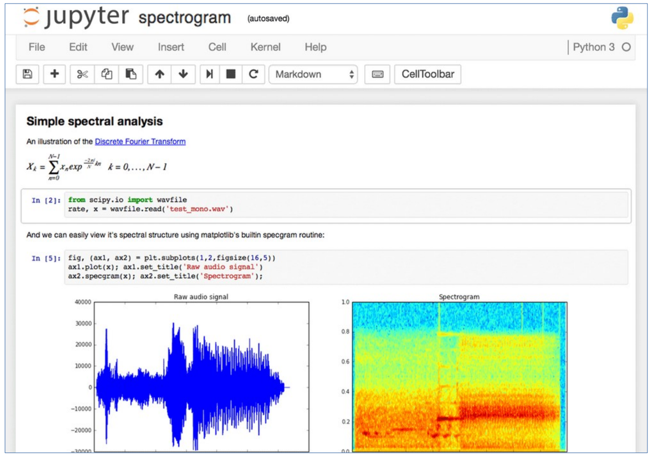

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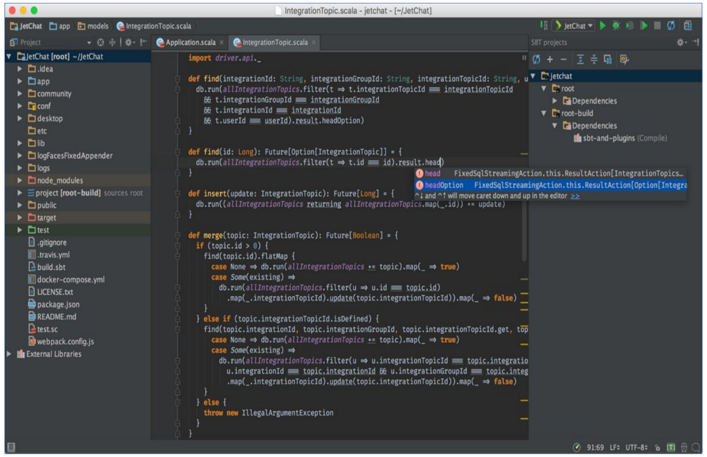

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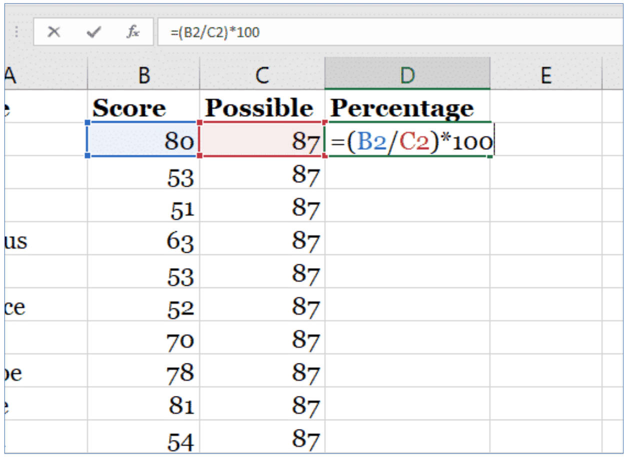

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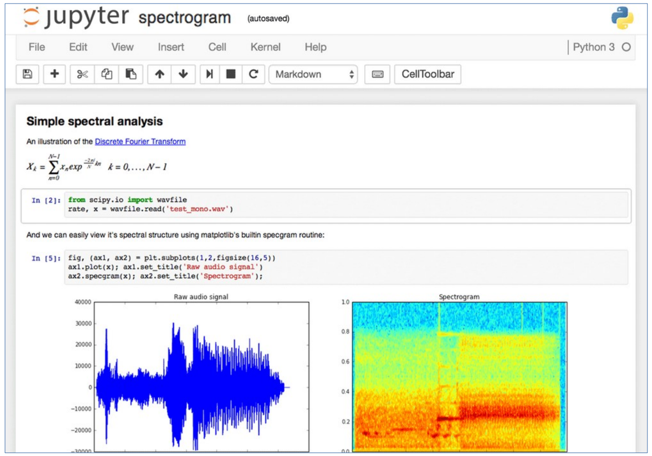

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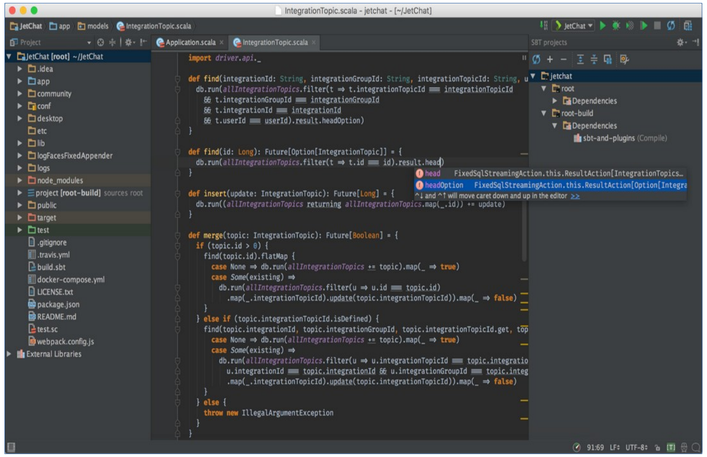

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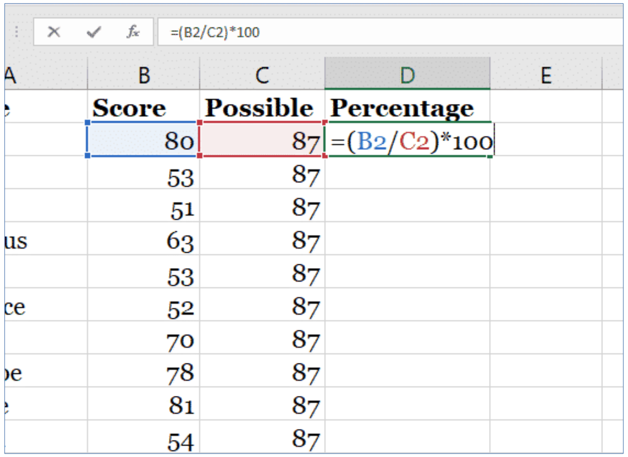

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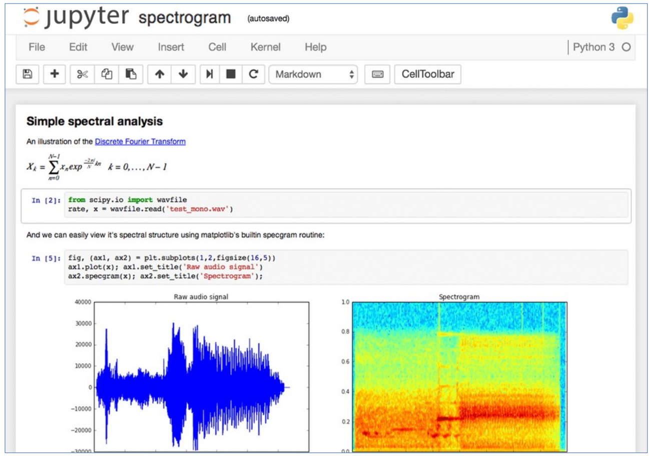

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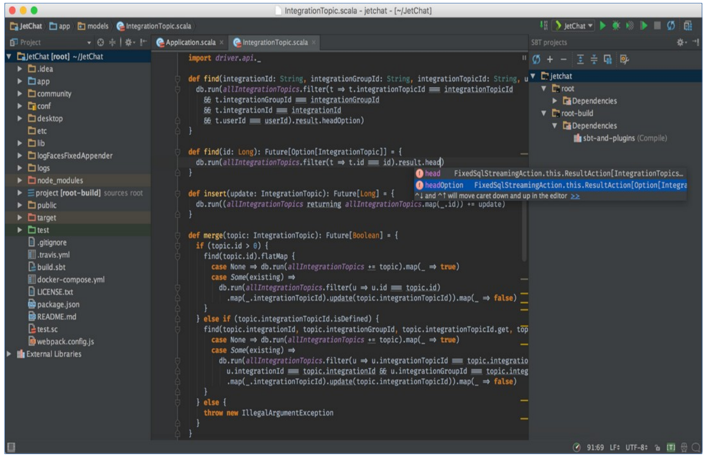

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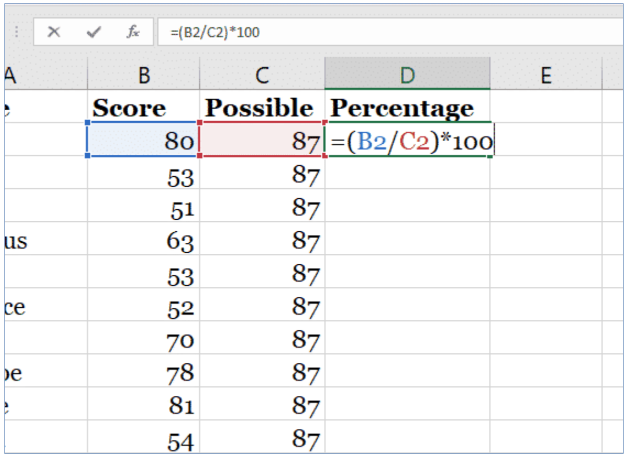

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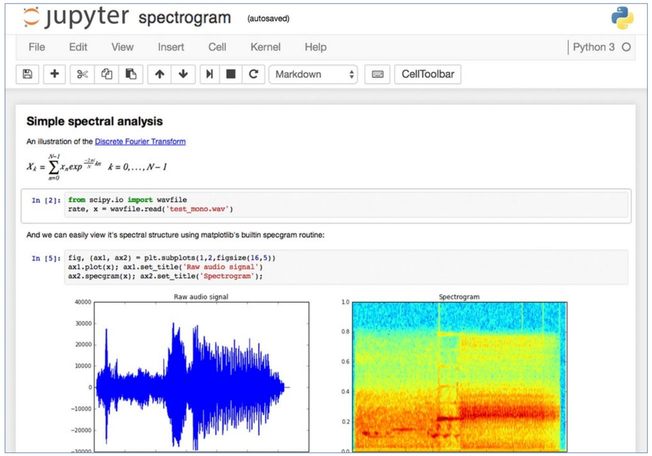
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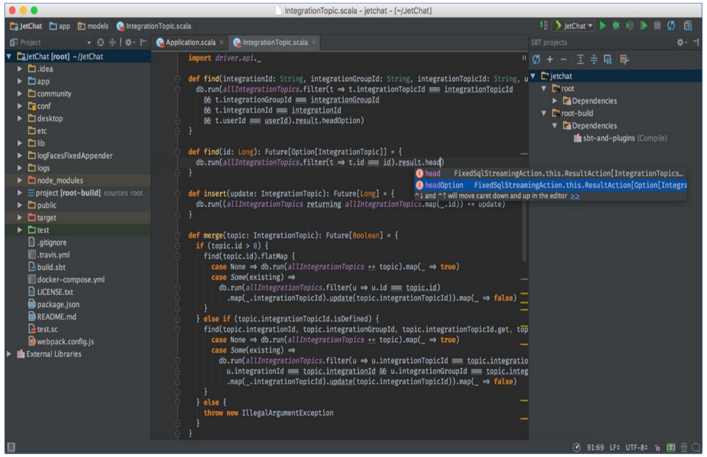

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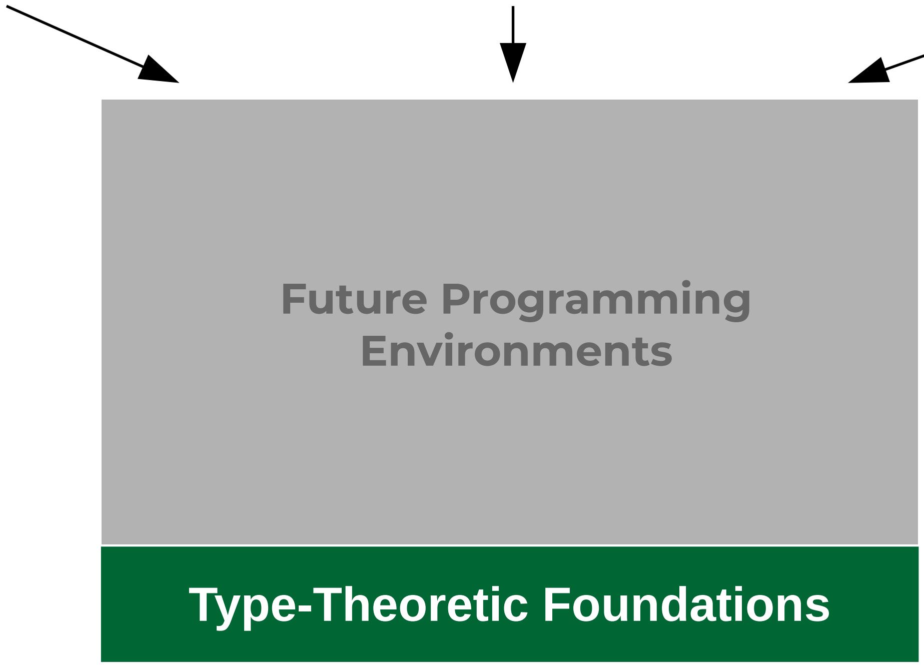

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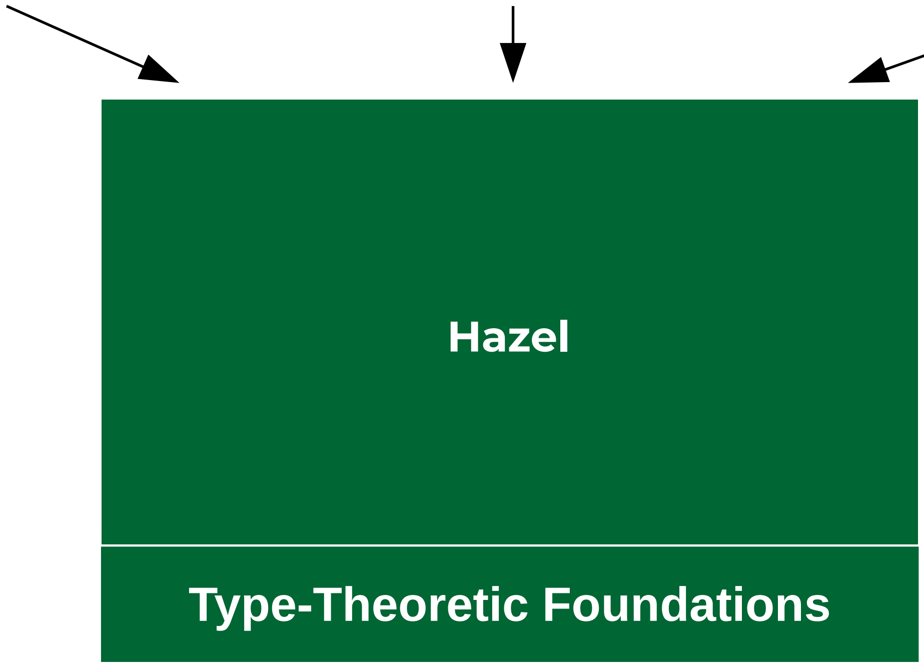

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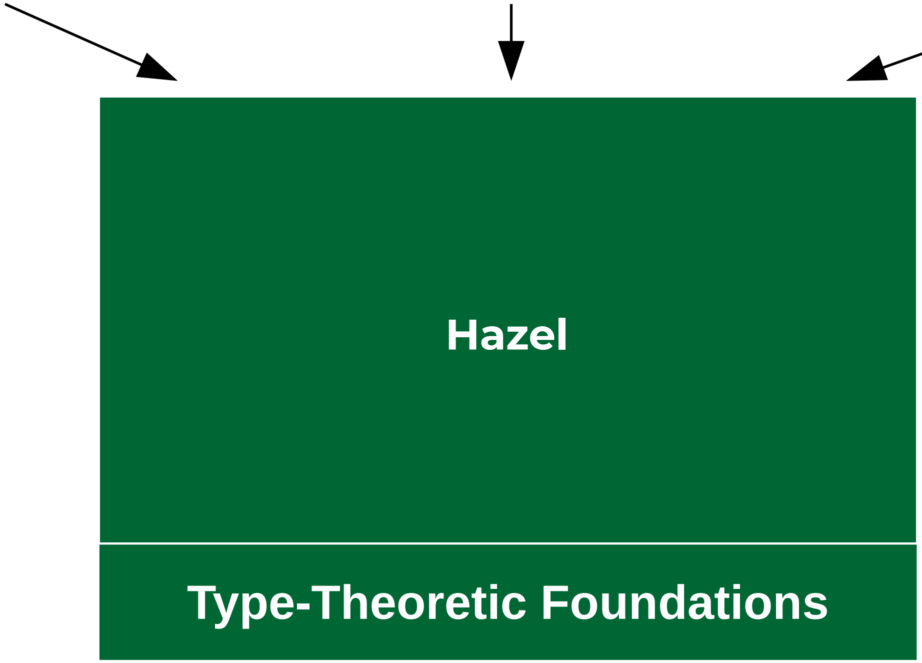

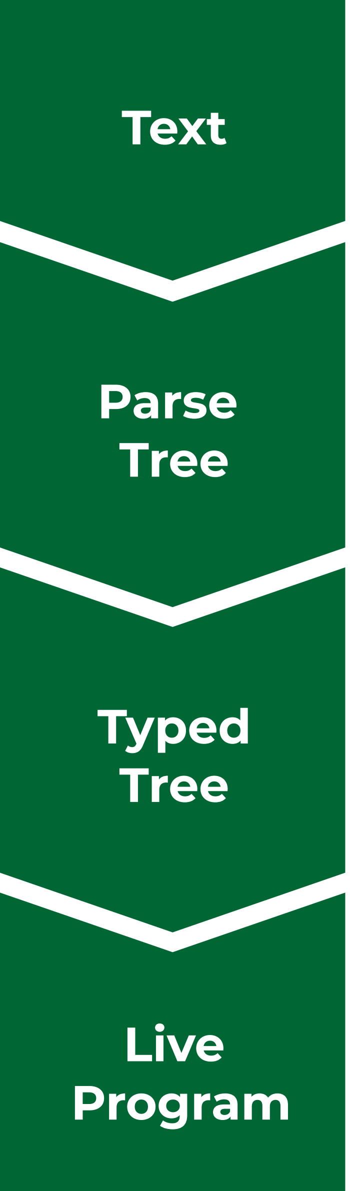

The **gap problem**.

Text

Parse Tree

Typed Tree

Live Program

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Text

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Live Program

è""55pooooodffffffffffffffffff
fffffffffffffffffffffffffff'fd""'ddd

Hazel **solves** the gap problem using **typed holes**.

Every editor state in Hazel is semantically meaningful.
(It has a type, it has a result, and it can be transformed as a tree.)

[Omar et al., POPL 2017] & [Omar et al., POPL 2019]

Demo: Live Programming with Typed Holes in Hazel

See hazel.org

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Ongoing Work: Hazel Assistant

Let’s use types + examples + live evaluation + edit action history + statistics to fill holes (i.e. synthesis within program sketches).

Ongoing Work: Hazel Assistant

Let’s use **types** + **examples** + live evaluation + edit action history + statistics to fill one hole.

[Osera and Zdancewic, PLDI 2015]

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Let's use **types** + **examples** + **live evaluation** + edit action history + statistics to fill holes (i.e. synthesis within program sketches).

[Lubin, Collins, Omar, and Chugh, *Program Sketching with Live Bidirectional Evaluation*, ICFP 2020] + https://uchicago-pl.github.io/smyth/

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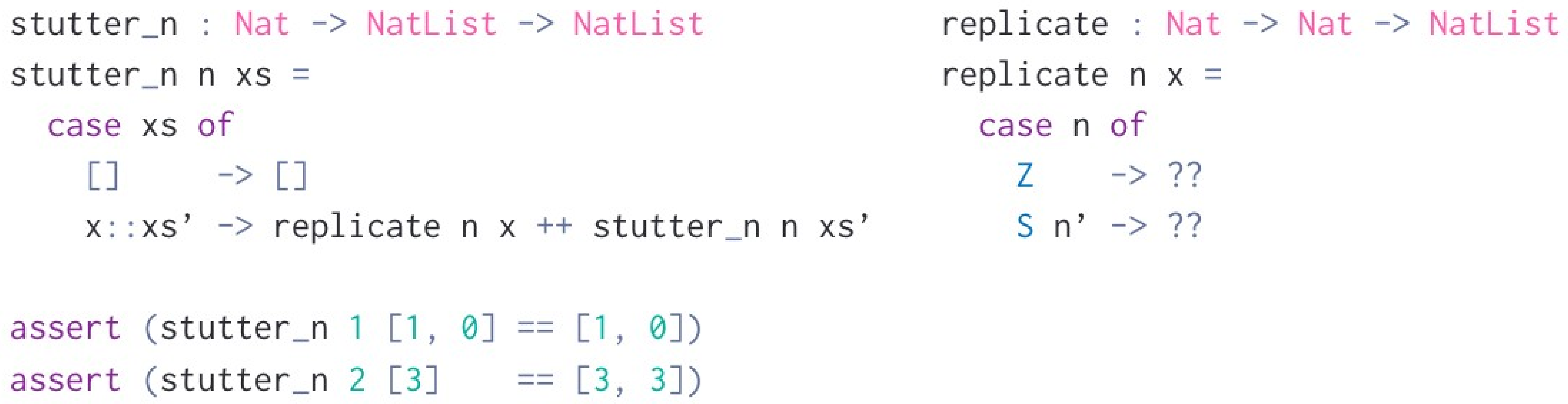

```
stutter_n : Nat -> NatList -> NatList
stutter_n n xs =
  case xs of
    []     -> []
    x::xs' -> replicate n x ++ stutter_n n xs'

assert (stutter_n 1 [1, 0] == [1, 0])
assert (stutter_n 2 [3]    == [3, 3])
```

```
replicate : Nat -> Nat -> NatList
replicate n x =
  case n of
    Z    -> ??
    S n' -> ??
```

Fig. 1. A program sketch in Smyth to "stutter" each element of a list n times. The desired solutions for the holes in `replicate` are `[]` for the `Z` branch and `x :: replicate n' x` for the `S` branch.

[Lubin, Collins, Omar, and Chugh, ICFP 2020]

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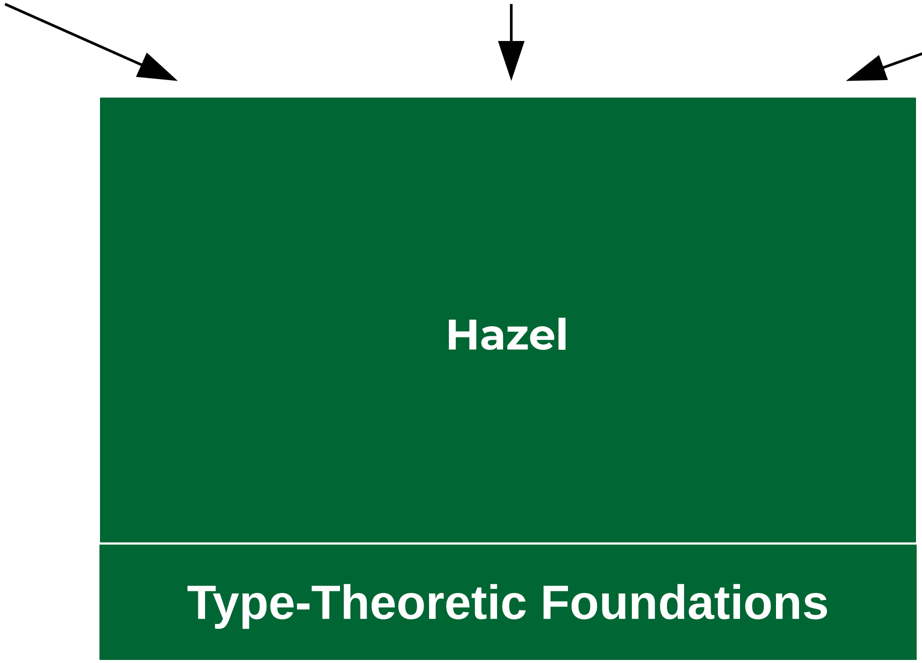
- Static Typing
- Collaboration Facilities
- Automation


Hazel
Type-Theoretic Foundations