Hazel: Semantic Foundations for Interactive Programming Tools

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IBM PL Day 2016

Q: What do programmers interact with?

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```
fun summary_stats(m : matrix<float>) =
  { mean   = stats.mean(m, ColumnWise),
    std    = stats.std(m,
    median =
```

syntactically malformed program text

Syntactic error recovery heuristics

```
fun summary_stats(m : matrix<float>) =
  { mean   = stats.mean(m, ColumnWise),
    std    = stats.std(m, □),
    median = □
  }
```

syntactically malformed program text → term with holes

[Kats et al., OOPSLA 2009]

Syntactic structure editors

```
fun summary_stats(m : matrix<float>) =
  { mean   = stats.mean(m, ColumnWise),
    std    = stats.std(m, ▢),
    median = ▢
  }
```

~~syntactically malformed program text~~ → term with holes

[Teitelbaum and Reps, Comm. ACM 1981; many others]

Q: How to **reason statically** about terms with holes?

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fun summary_stats(m : matrix<float>) =
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    median = ▢
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What **type** of expression is expected here?

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What **type** is synthesized for the function as a whole?

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[Omar et al., POPL 2017]

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matrix<float> →
  { mean   : vec<float>,
    std    : vec<float>,
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  }
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What **type** of expression is expected here? `(RowWise + ColumnWise)`

```
matrix<float> →
  { mean   : vec<float>,
    std    : vec<float>,
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A: A **static semantics** for terms with holes.

[Omar et al., POPL 2017]

Q: How to **reason statically** about terms with type errors?

What **type** is synthesized for the function as a whole?

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fun summary_stats(m : matrix<float>) =
  { mean   = stats.mean(m, ColumnWise),
    std    = stats.std(m, “oops”),
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A: A **static semantics** for terms with holes.

[Omar et al., POPL 2017]

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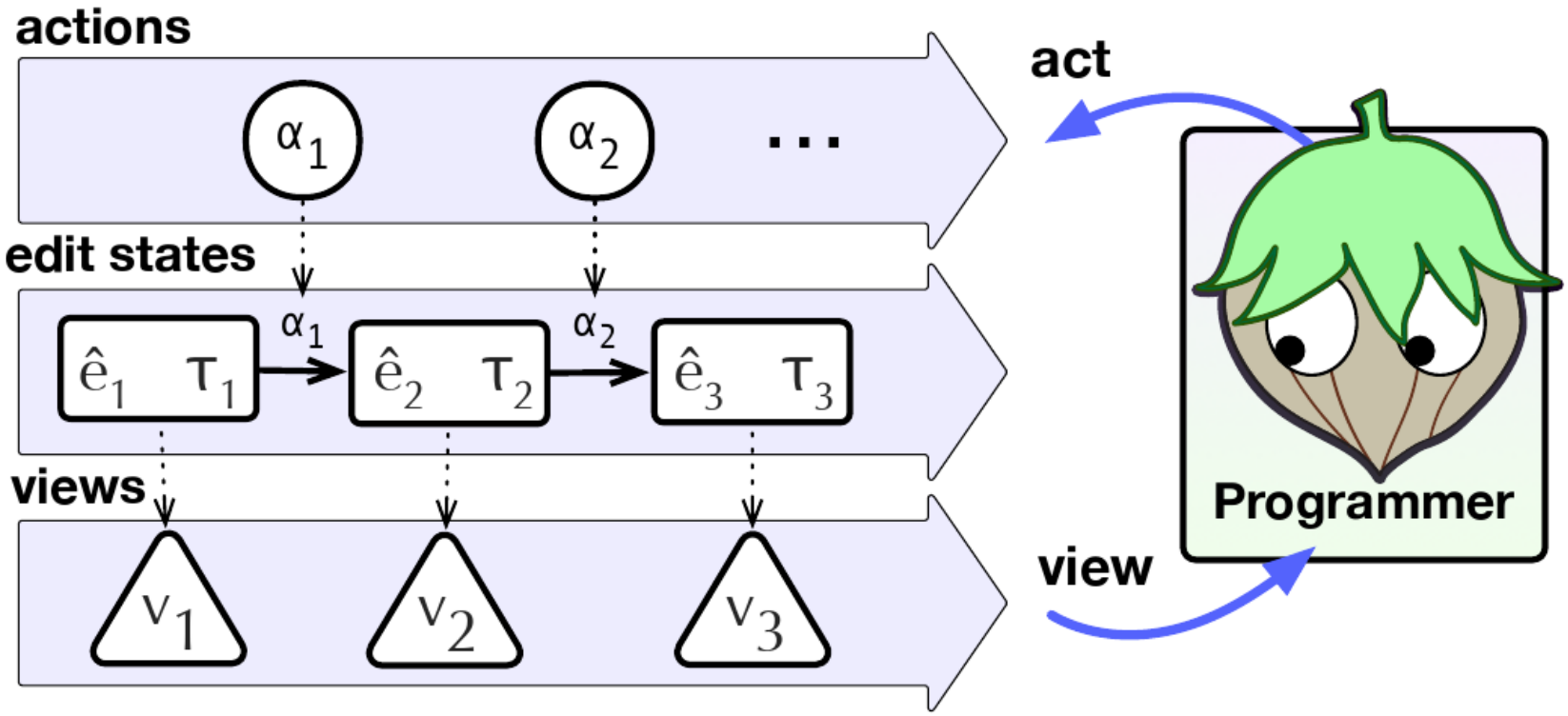
[Omar et al., POPL 2017]

A **static semantics** for lambda terms with holes

$$\begin{array}{llll} \text{HTyp} & \dot{\tau} & ::= & (\dot{\tau} \to \dot{\tau}) \mid \texttt{num} \mid \text{⦇⦈} \\ \text{HExp} & \dot{e} & ::= & x \mid (\lambda x.\dot{e}) \mid \dot{e}(\dot{e}) \mid \underline{n} \mid (\dot{e} + \dot{e}) \mid \dot{e} : \dot{\tau} \mid \text{⦇⦈} \mid \text{⦇}\dot{e}\text{⦈} \end{array}$$

[Omar et al., POPL 2017]

A typed edit action semantics



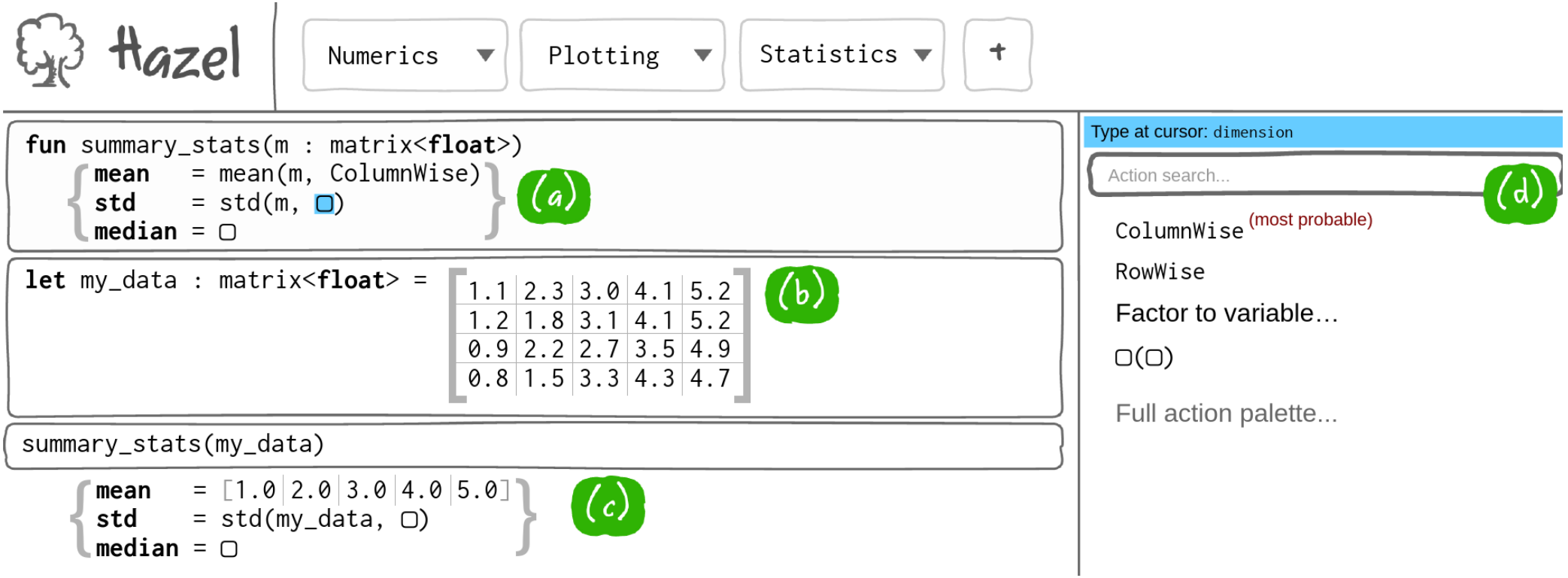
[Omar et al., POPL 2017]

Demo

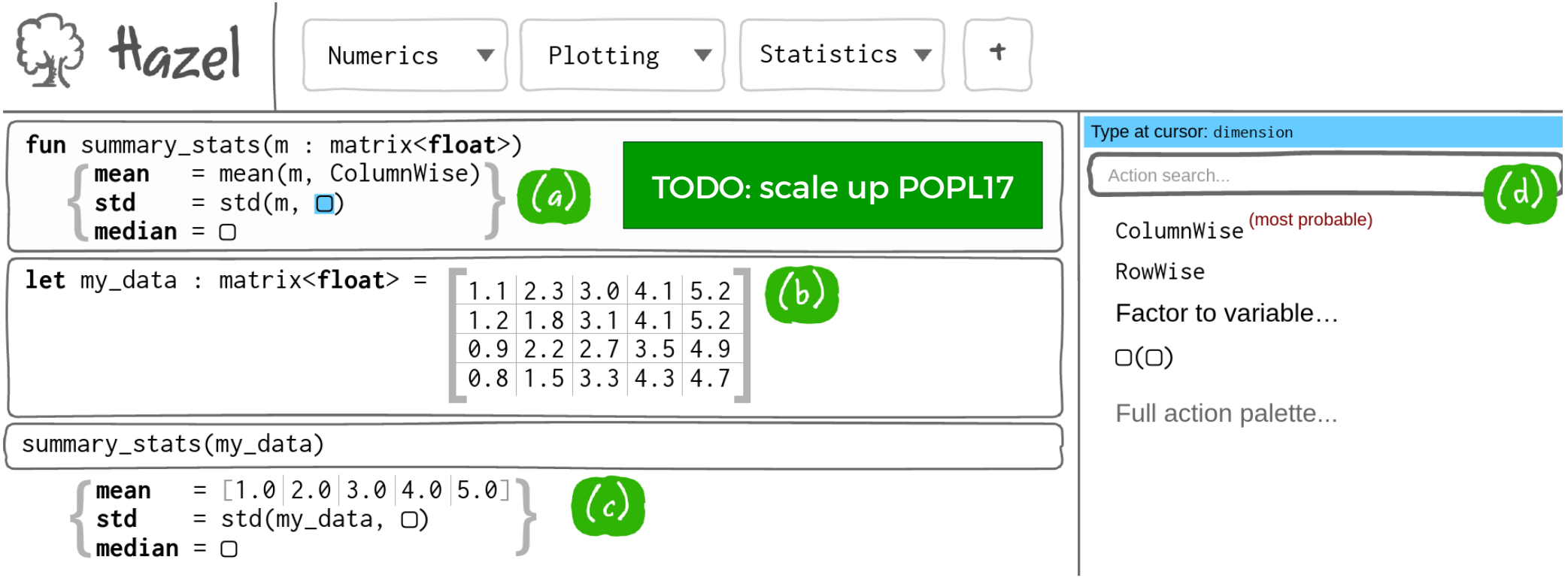
See http://hazelgrove.github.io/

[Omar et al., POPL 2017]

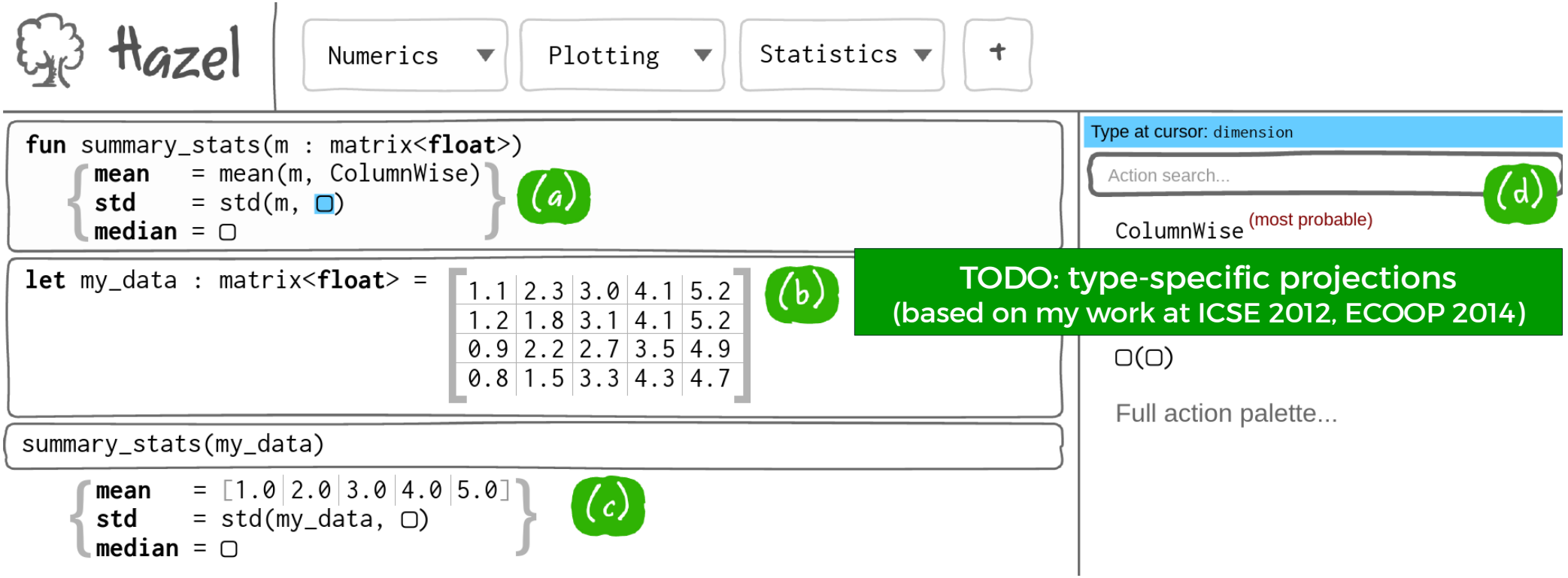
From Hazelnut to Hazel



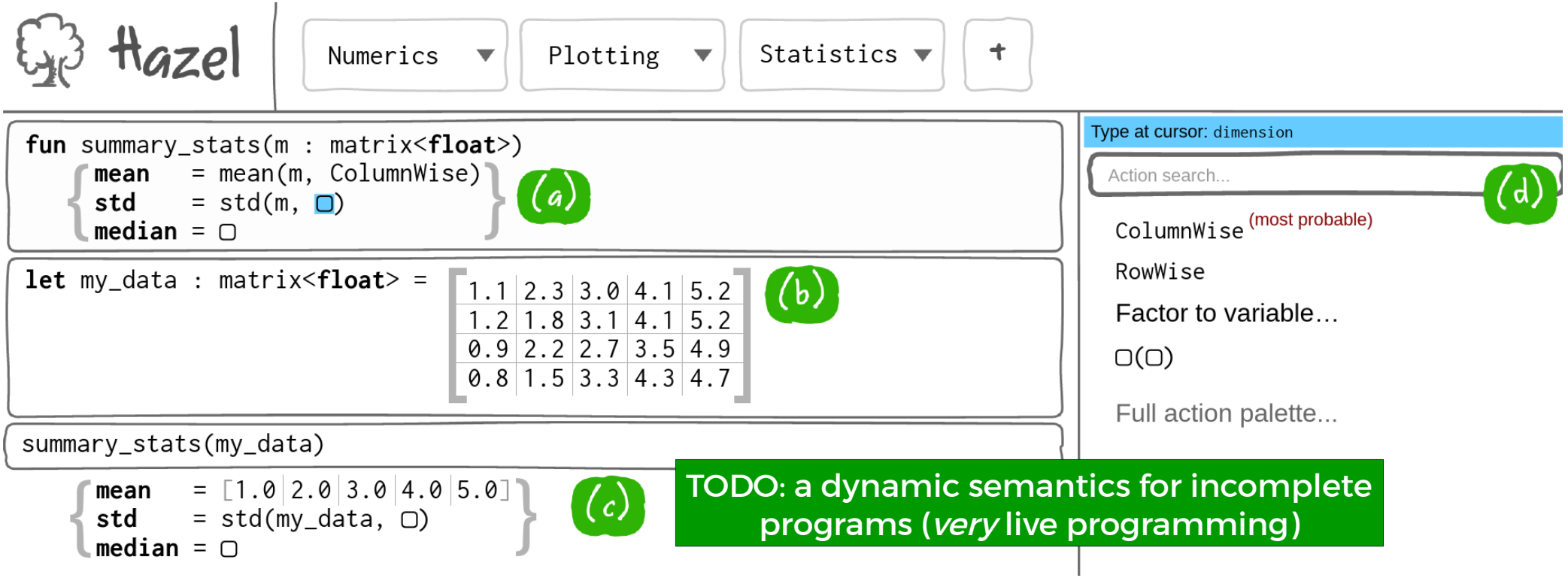
From Hazelnut to Hazel



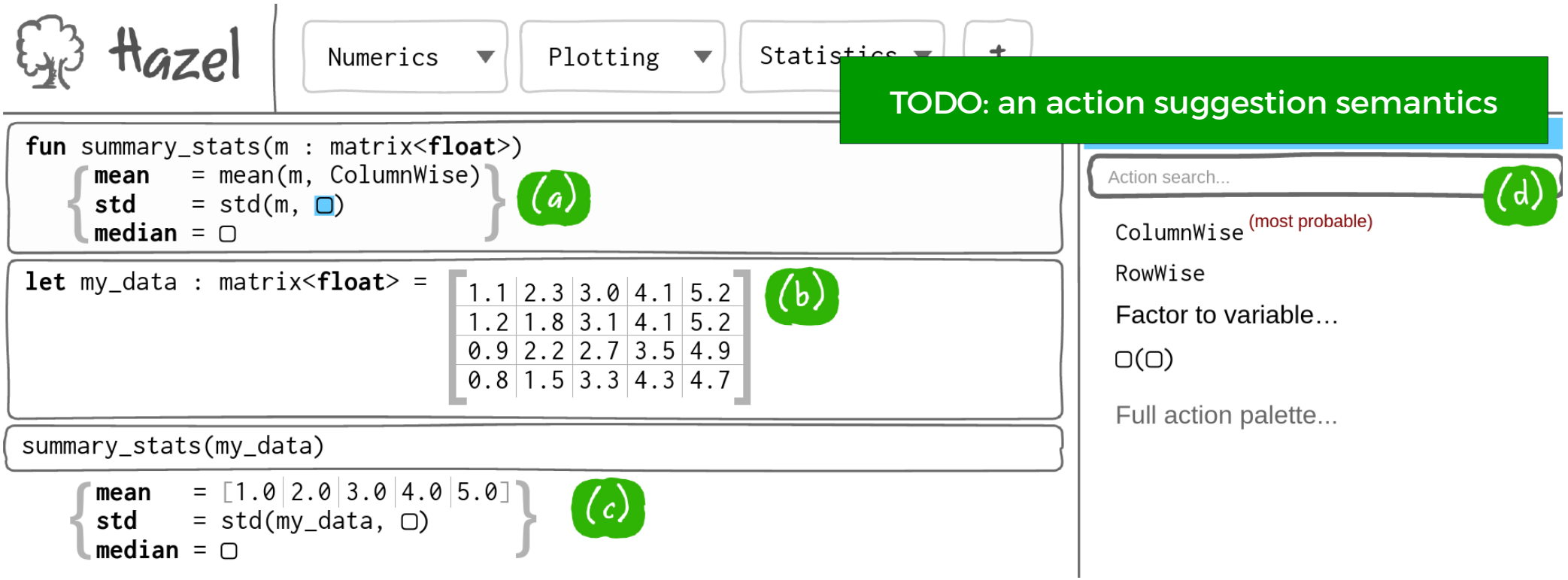
From Hazelnut to Hazel



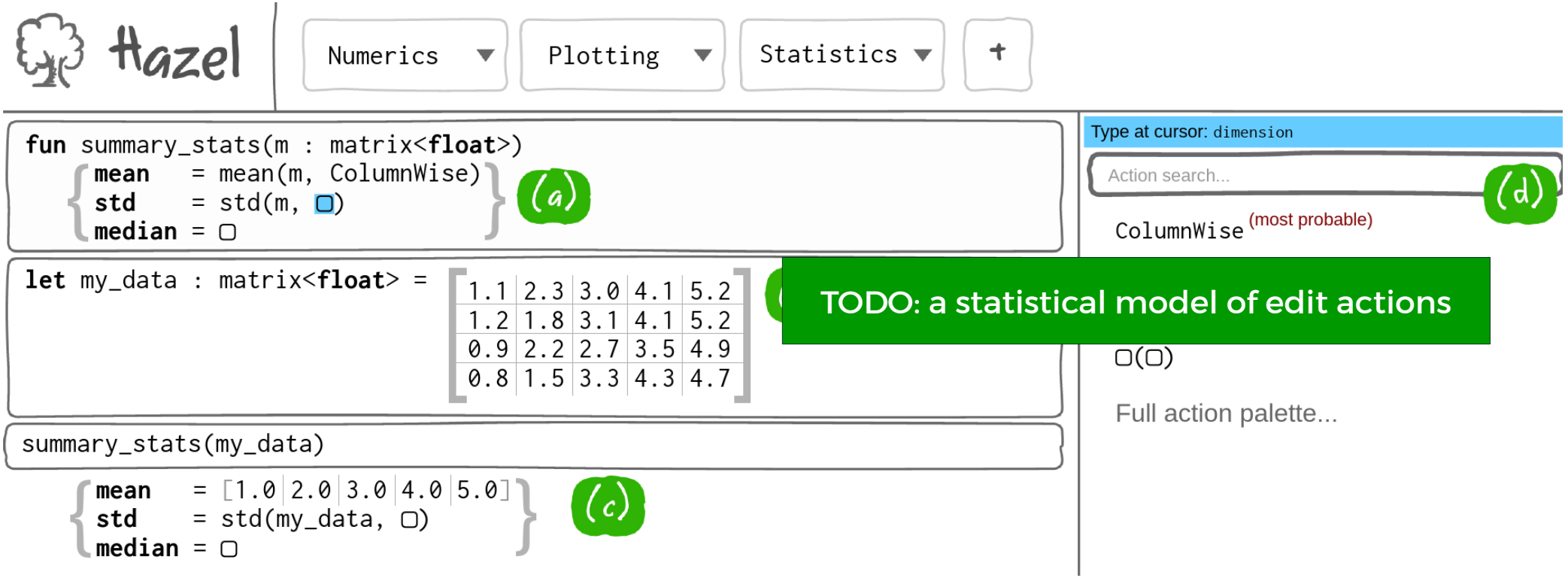
From Hazelnut to Hazel



From Hazelnut to Hazel



From Hazelnut to Hazel



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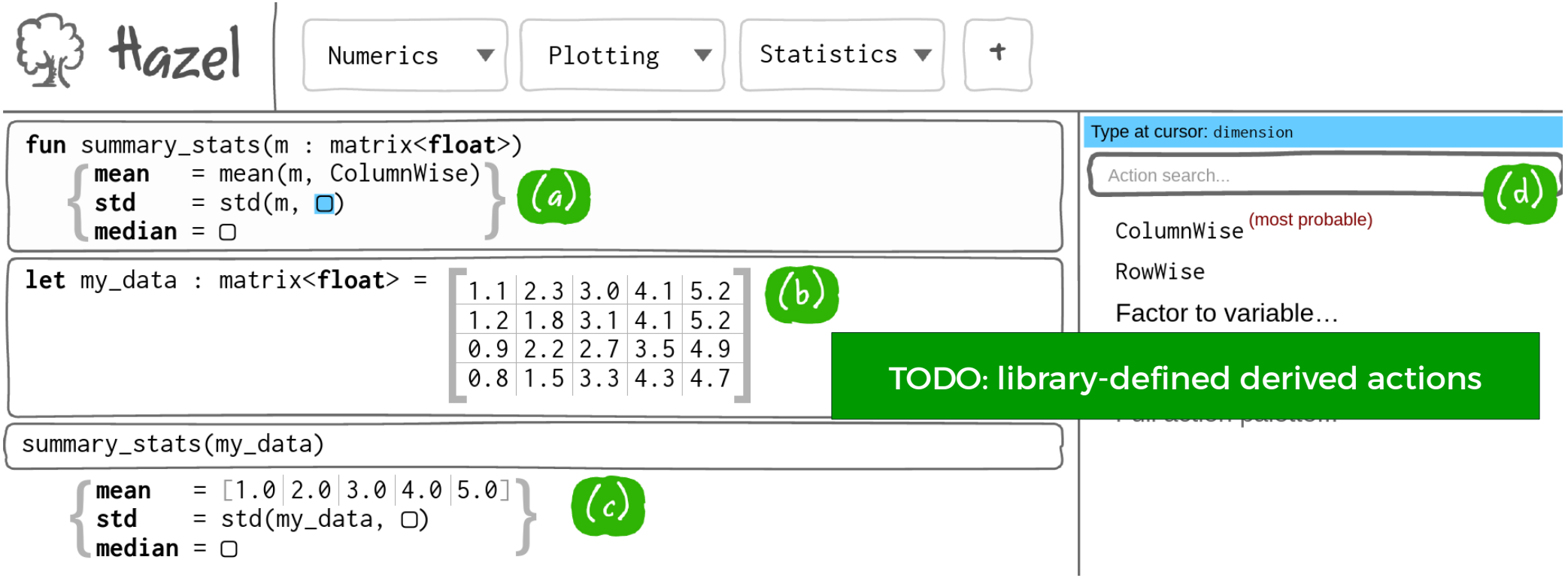

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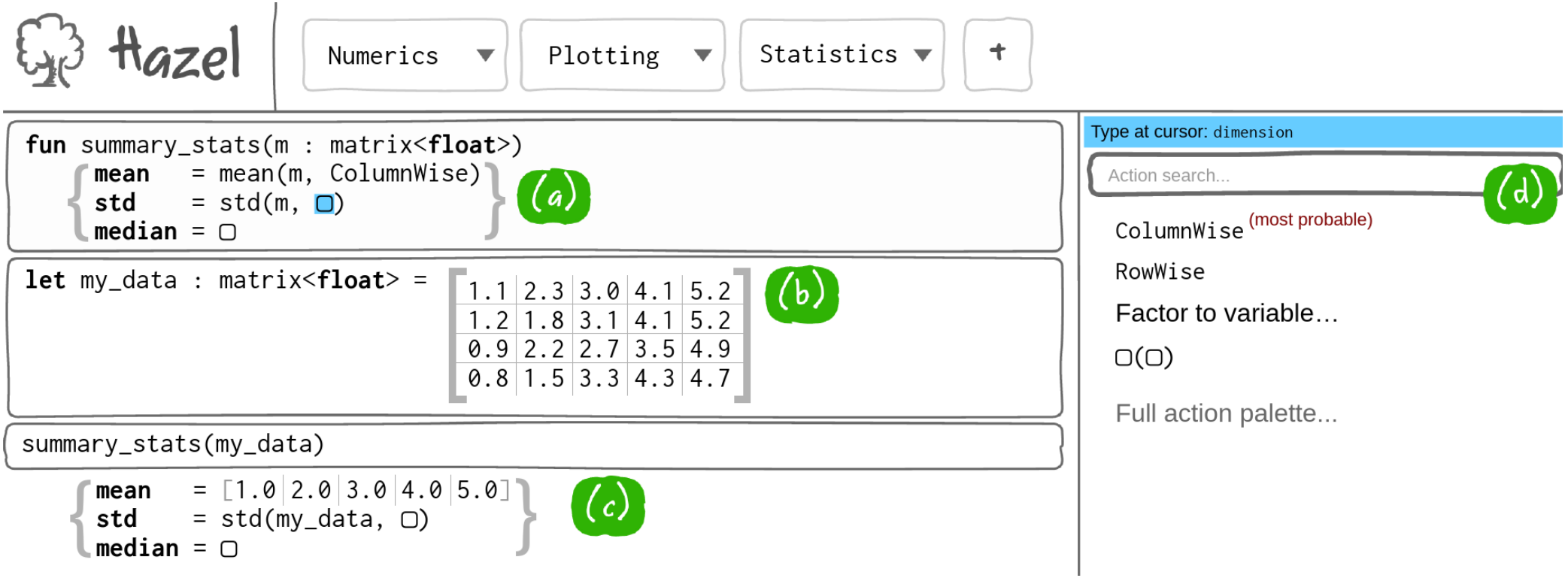

Joint work with Ian Voysey (CMU), Matt Hammer (CU Boulder), Michael Hilton (Oregon State), Claire Le Goues (CMU), Jonathan Aldrich (CMU), Josh Sunshine (CMU).

Interested? Contact me! http://hazelgrove.github.io/