Programming the Internet of Uncertain <T>hings

James Bornholt University of Washington

Na Meng University of Texas at Austin

Todd Mytkowicz Microsoft Research

Kathryn S. McKinley Microsoft Research


Sainsbury's
BOLT

24 mph

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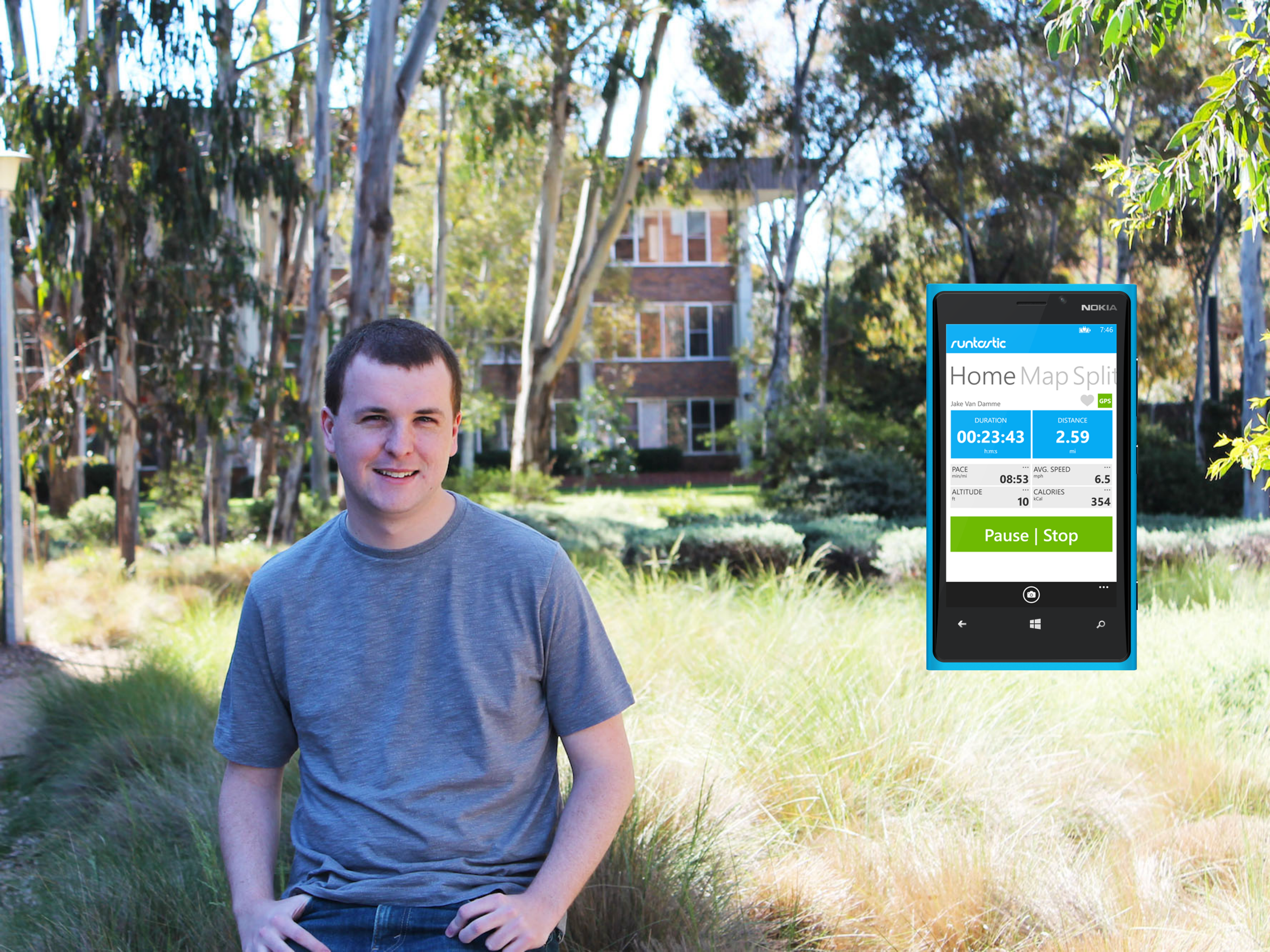
NOKIA
7:46
runtastic
Home Map Split
Jake Van Damme
GPS
DURATION
00:23:43
h:m:s
DISTANCE
2.59
mi
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mph
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ft
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CALORIES
kCal
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Pause | Stop


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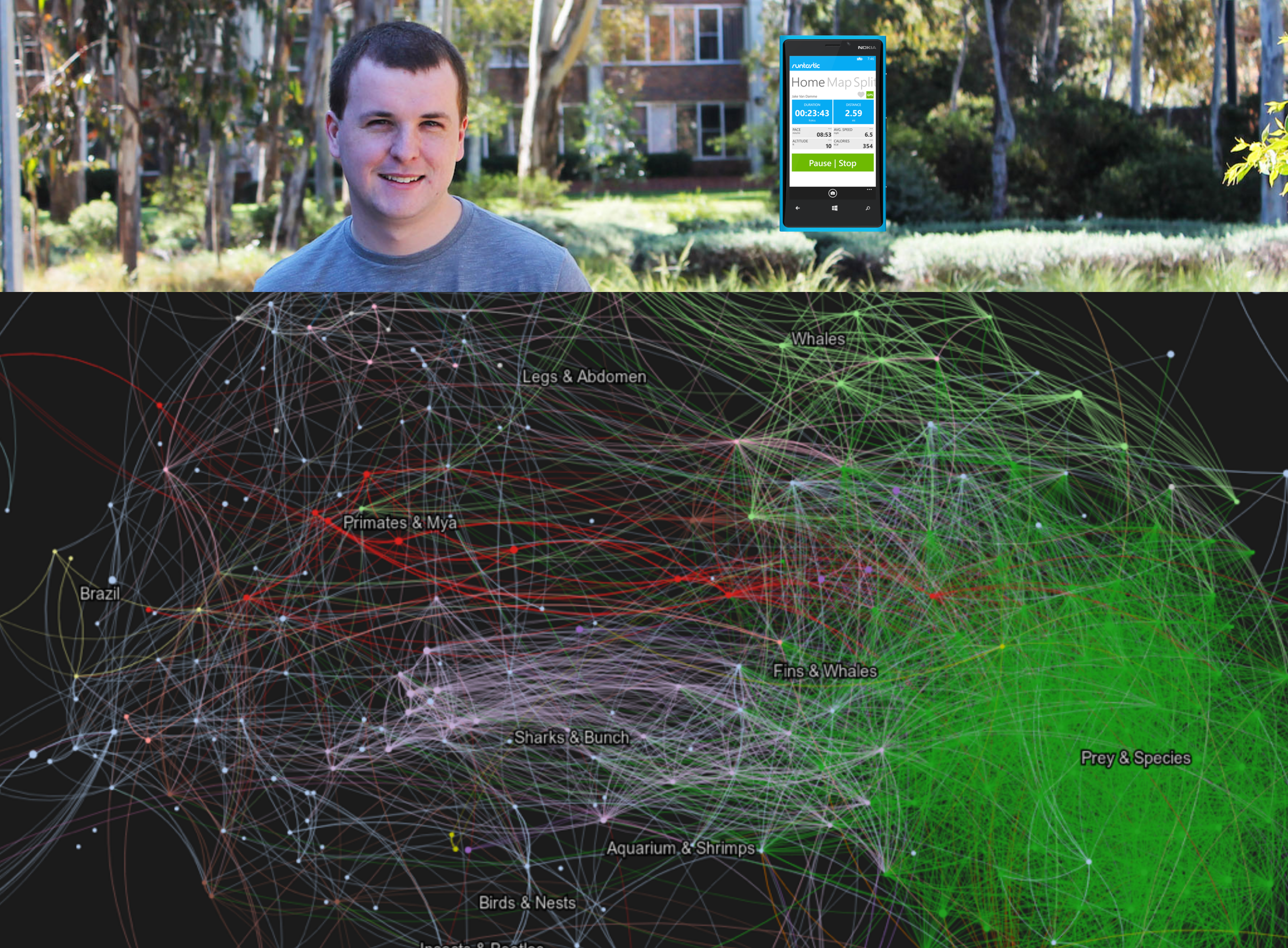
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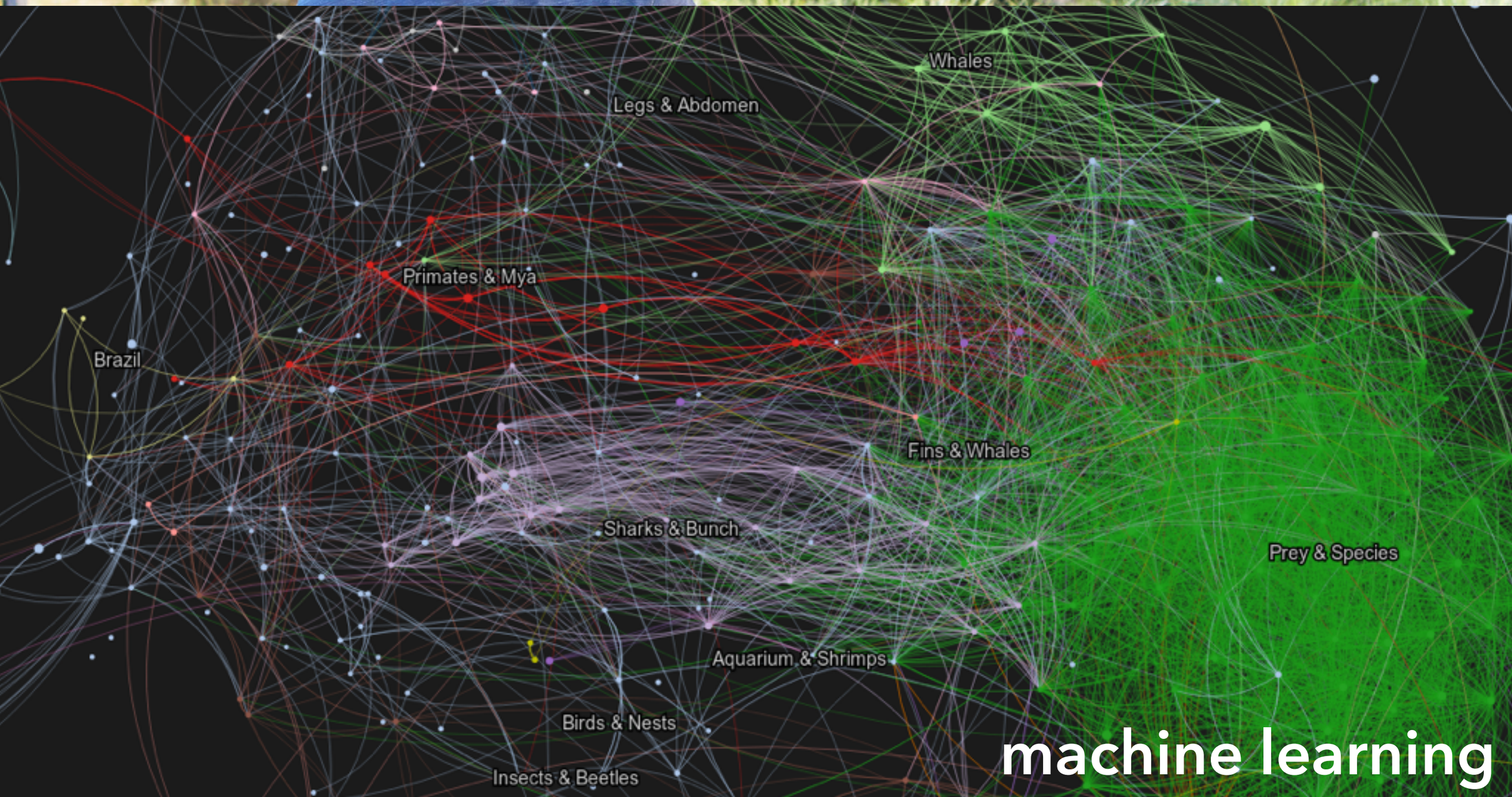
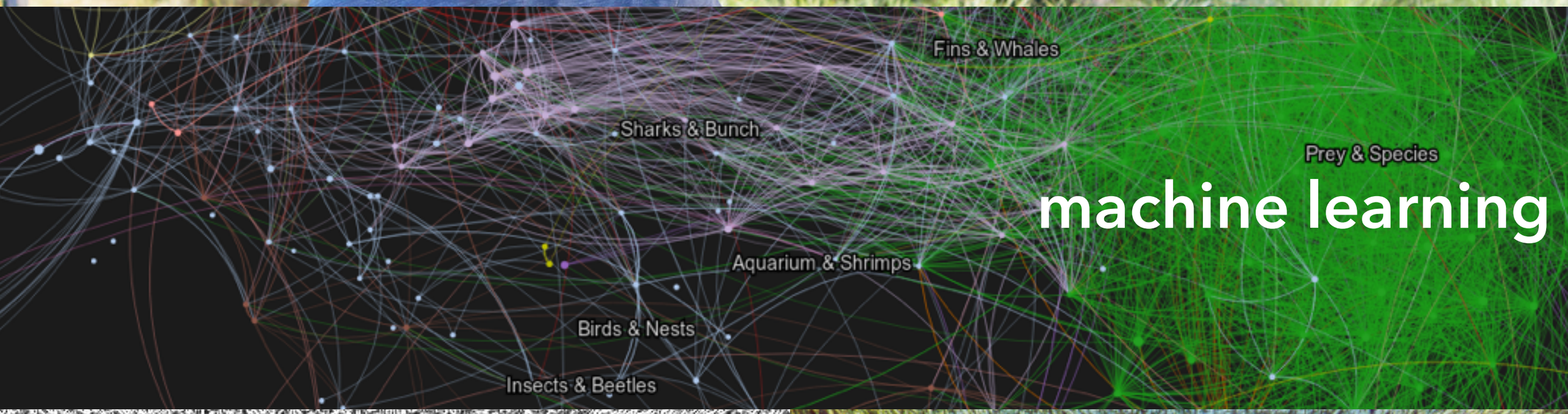
Whales
Legs & Abdomen
Primates & Mya
Brazil
Fins & Whales
Sharks & Bunch
Prey & Species
Aquarium & Shrimps
Birds & Nests
Insects & Beetles

sensors



machine learning

sensors



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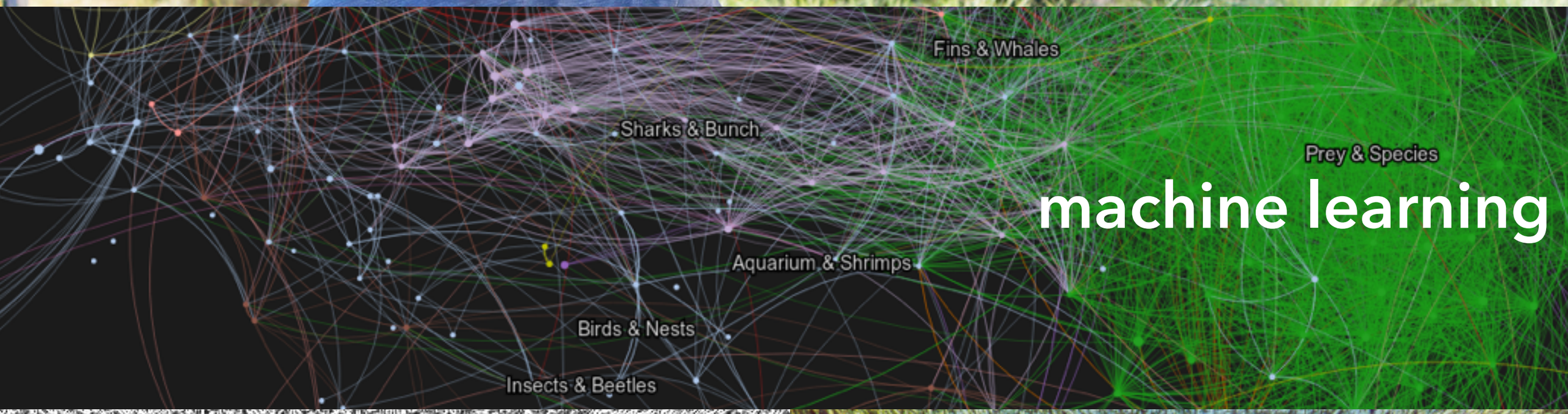

machine learning

approximate computing

Uncertain<*T*>

an abstraction for reasoning about noise [ASPLOS'14]

exploiting context

language constructs to make data more accurate

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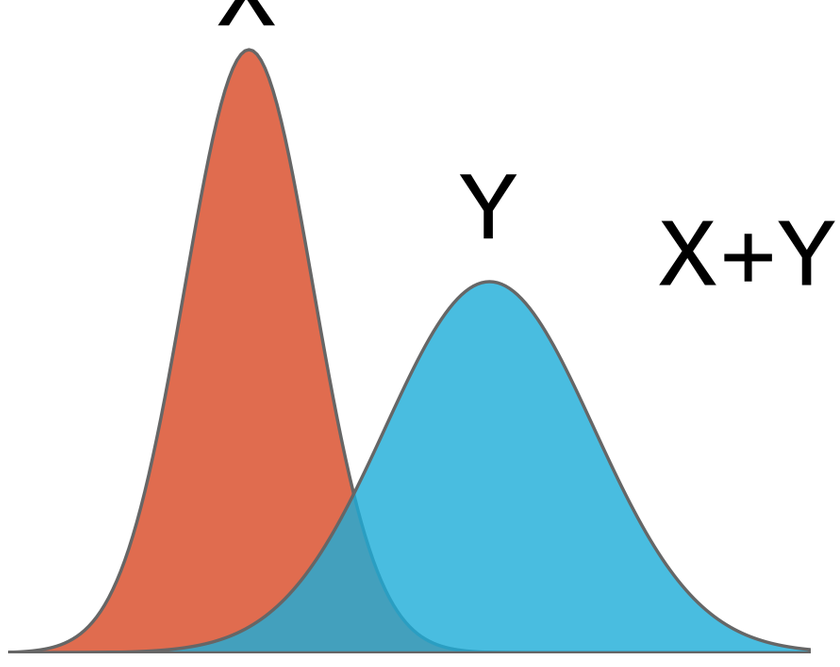
Semantics

Uncertain<T> encapsulates probability distributions and hides statistical complexity.

- Computing over random variables
- Deciding conditionals

Computations

Represent distributions by random samples



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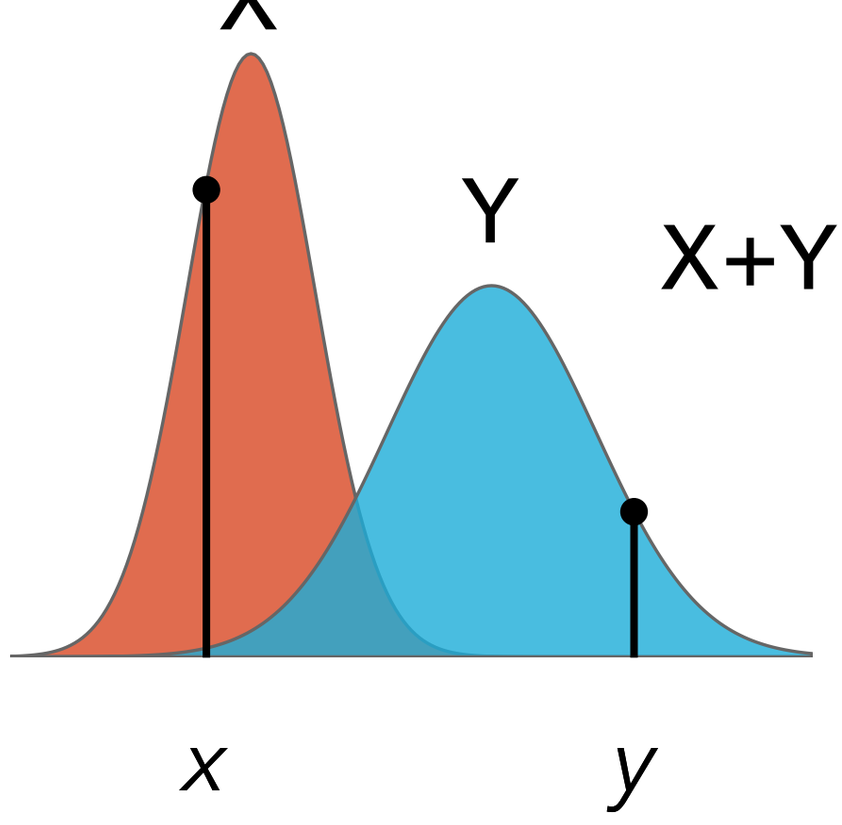

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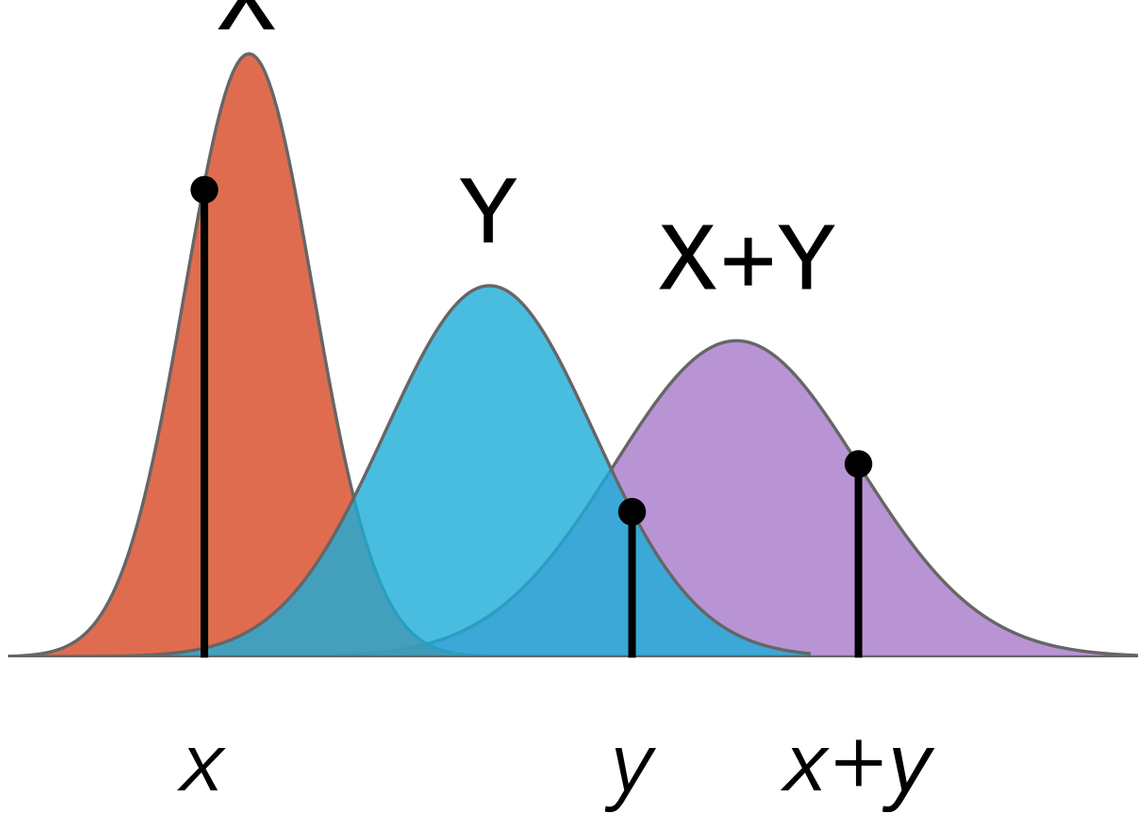

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Operators build a Bayesian network rather than evaluating immediately.

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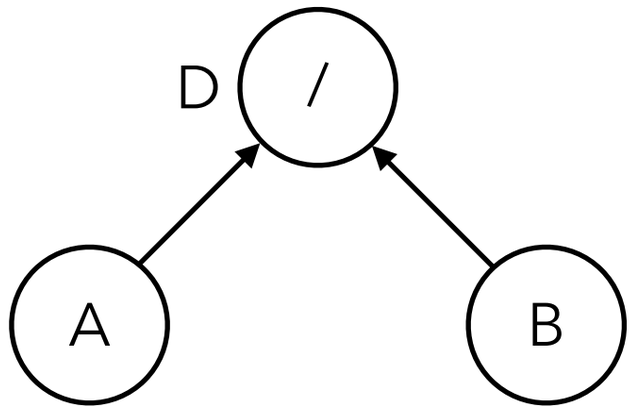

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D = A / B
E = D - C
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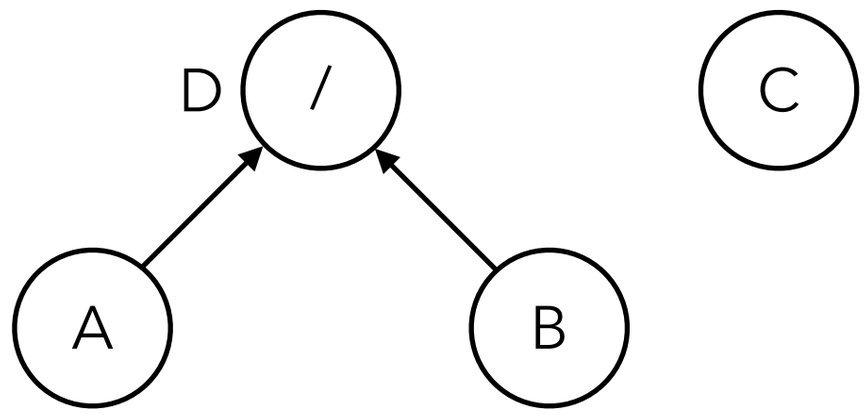

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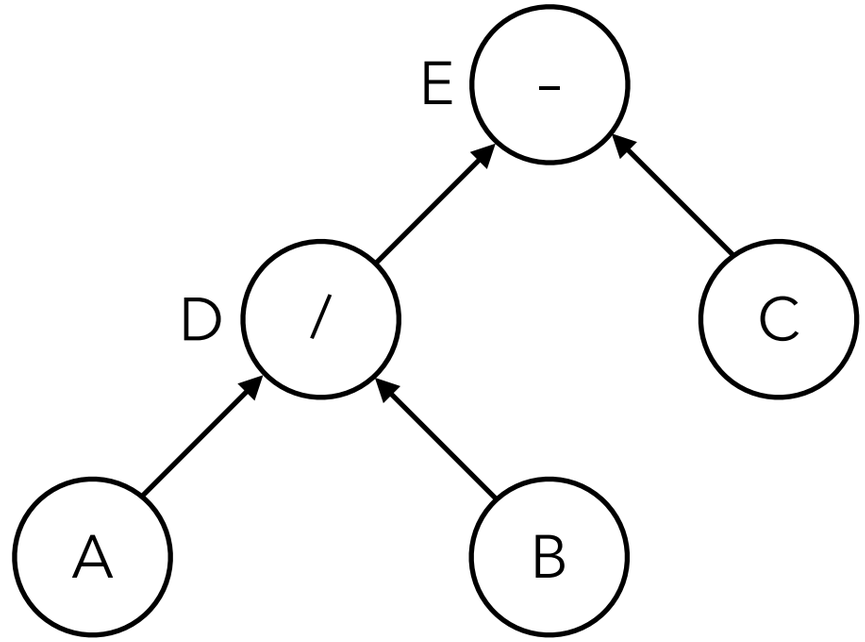

Deciding conditionals

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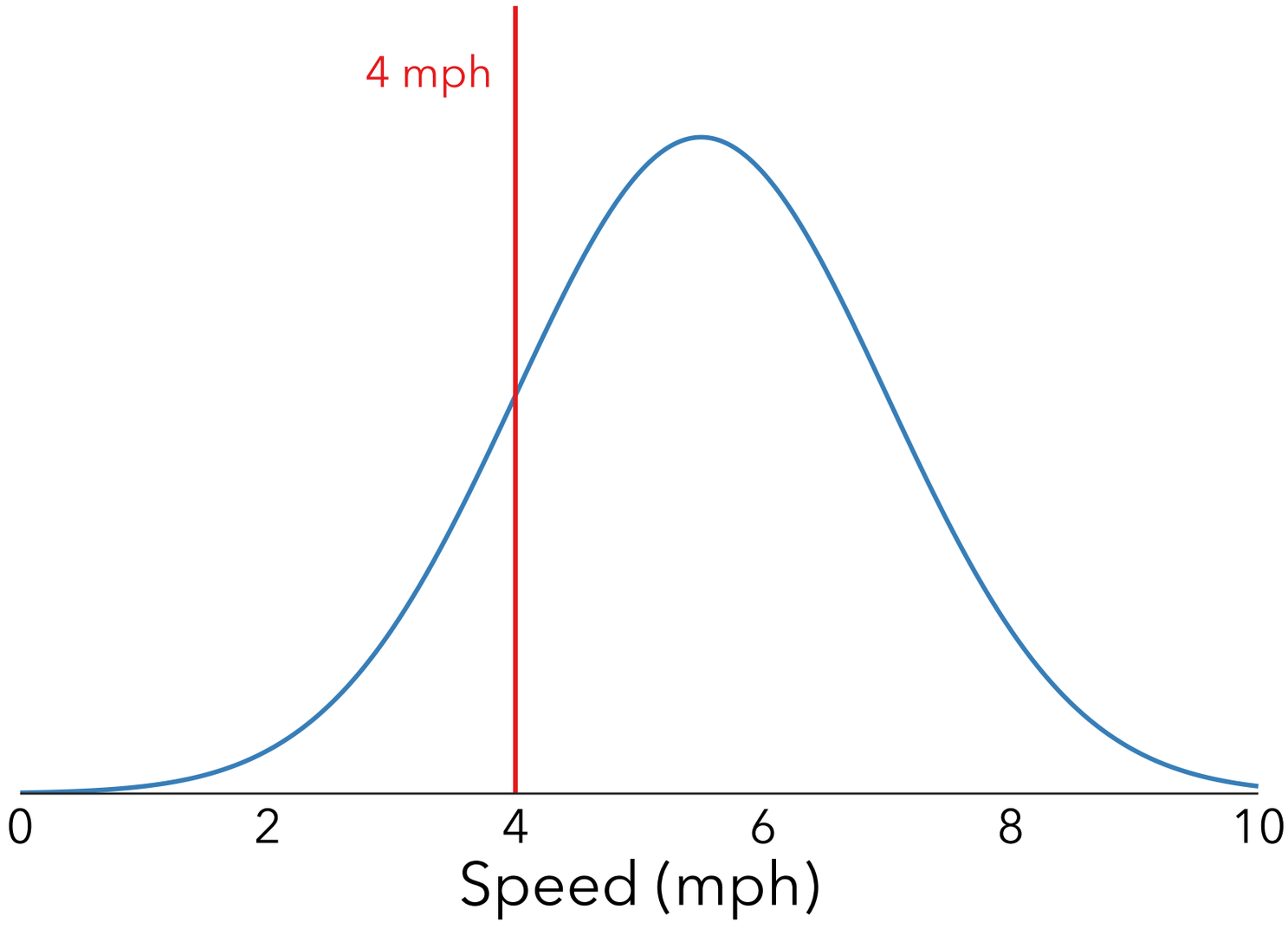

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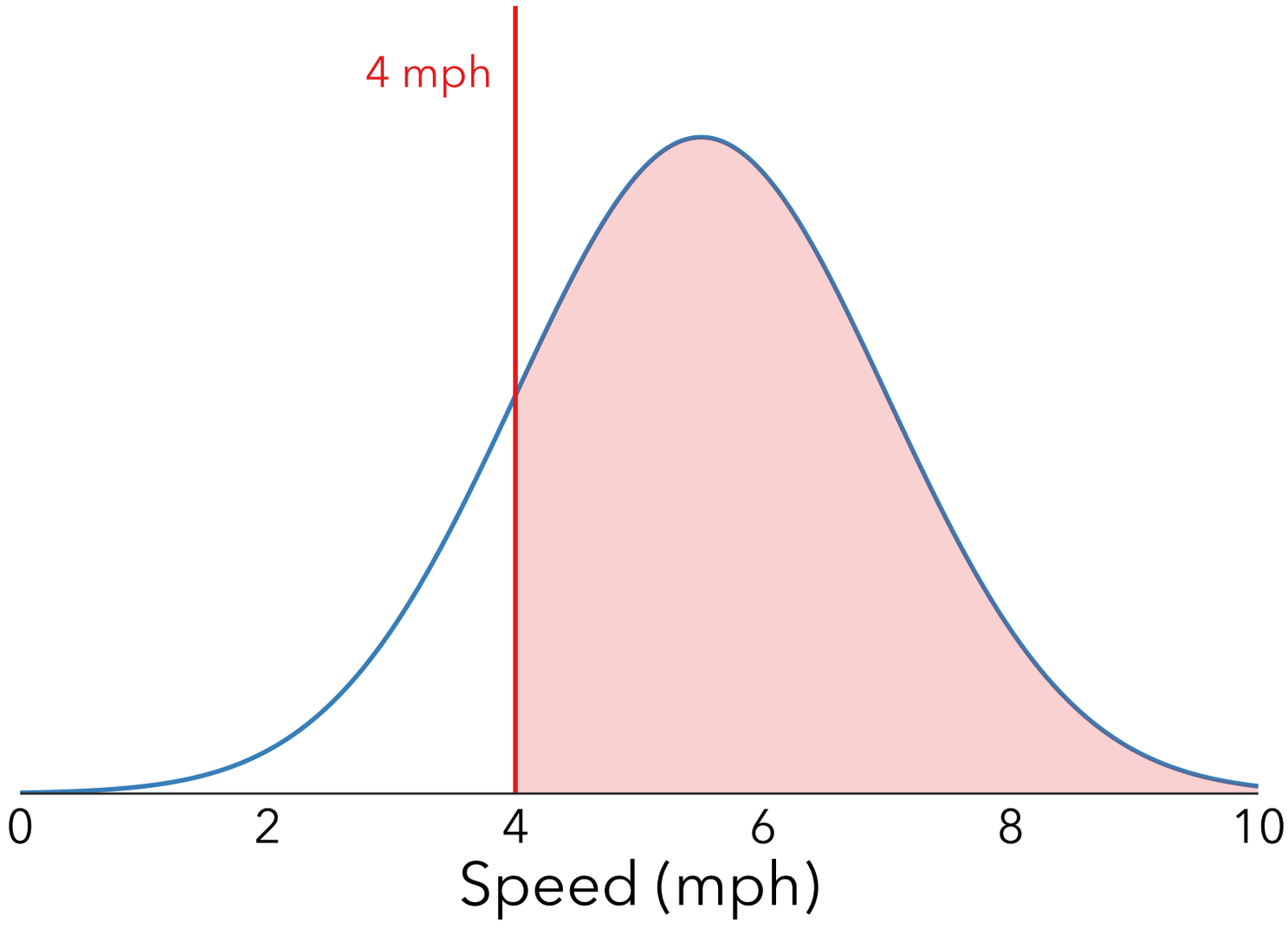

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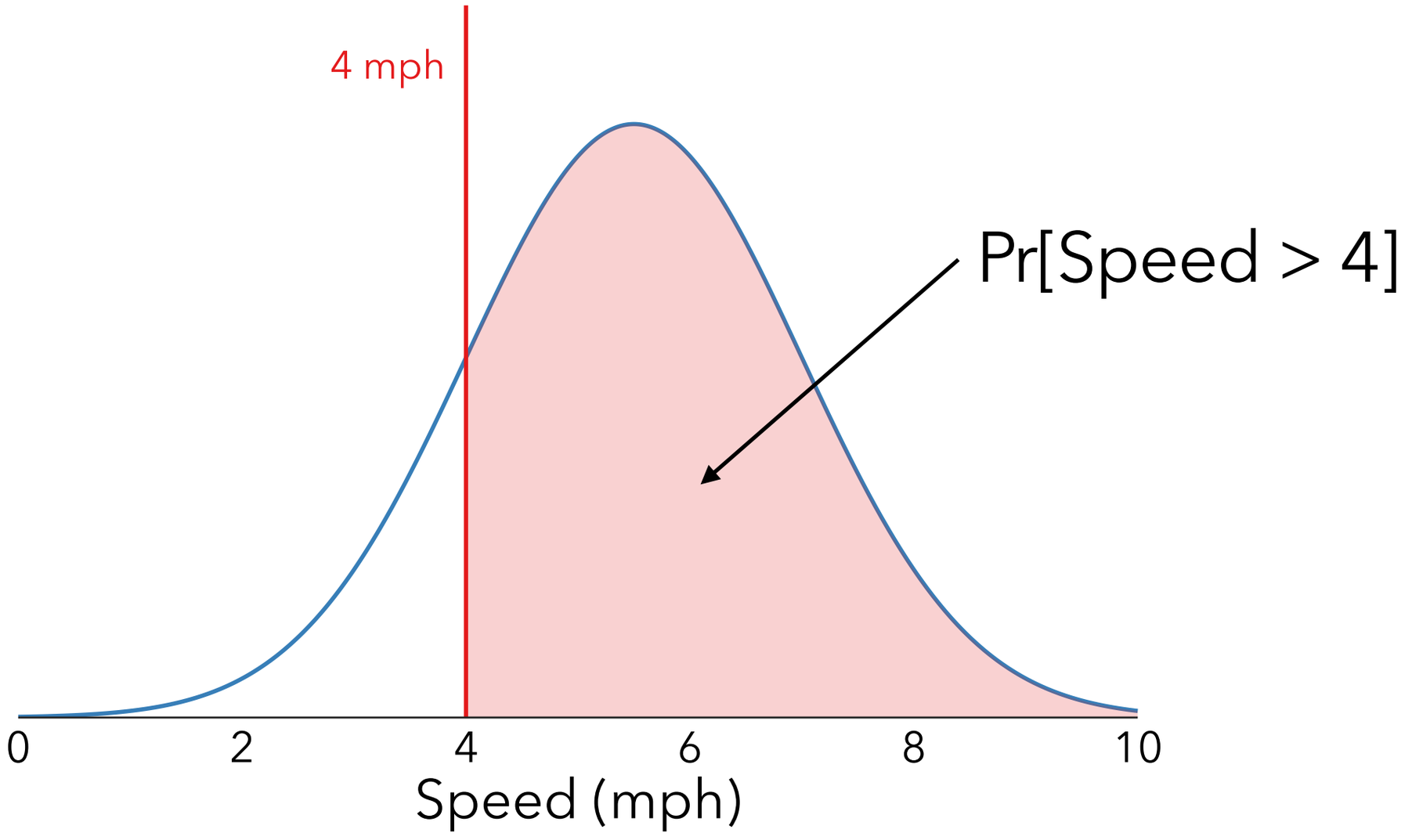

Deciding conditionals

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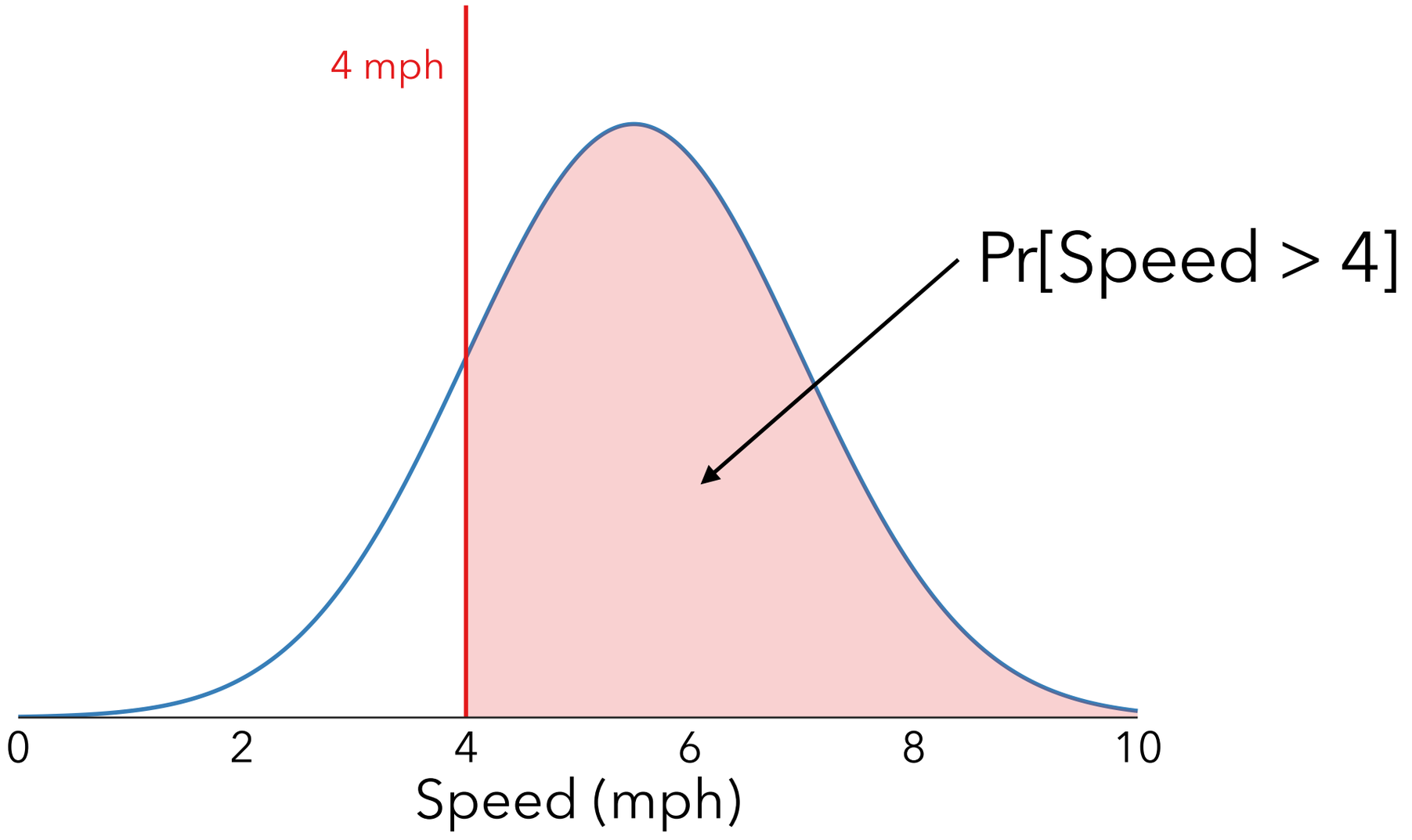
More likely than not that Speed > 4?



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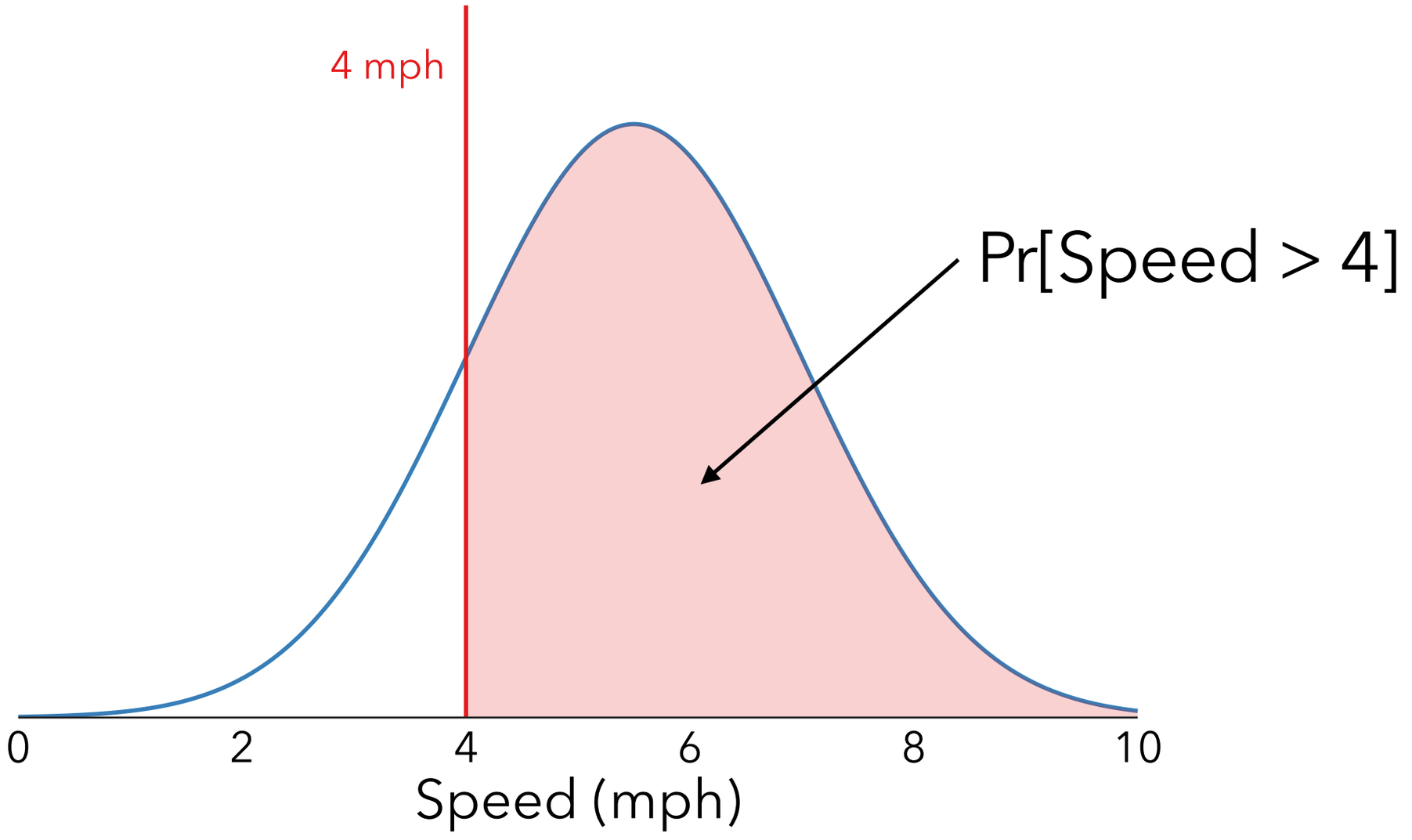

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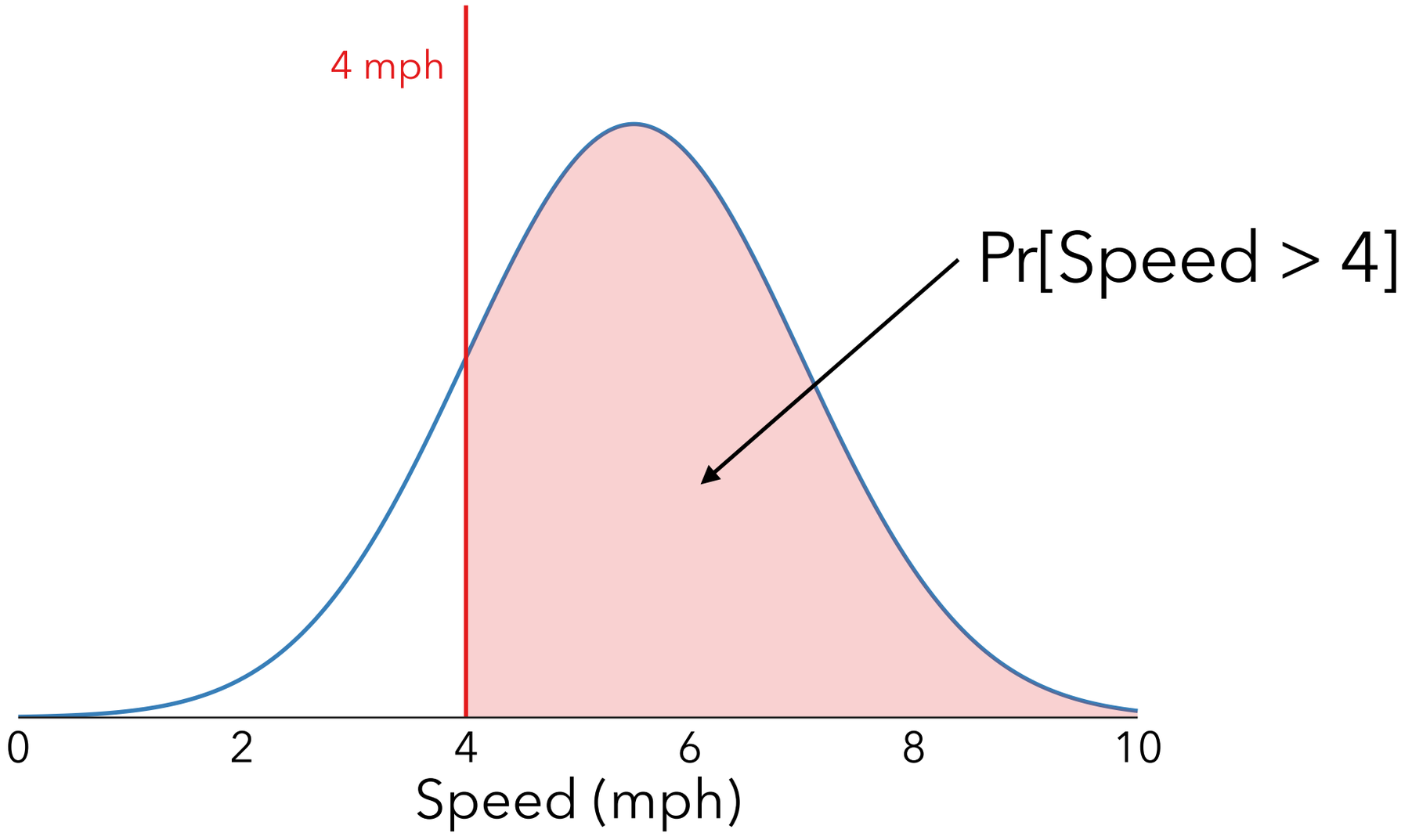
At least 90% likely that Speed > 4?



Identifying absurd data

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GeoCoordinate PrevLocn = Get();
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GeoCoordinate Location = Get();
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if (Speed > 4)  // 7 mph
    Alert("That's crazy!");
```

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50%: 4 times

90%: never

Uncertain<*T*>

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Uncertain<

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2013β


2013β


XBOX 360
KINECT


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if (RecognizeBeard(photo))
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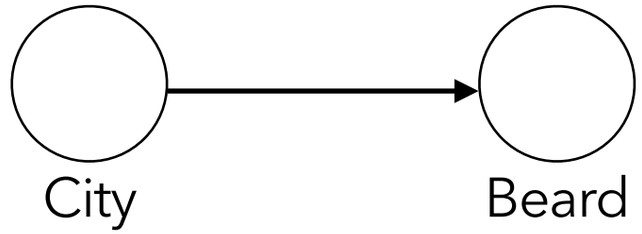
context

application-specific

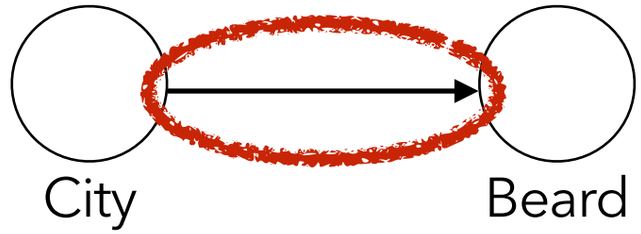
domain knowledge

Static context



- How does city influence beards?

Static context



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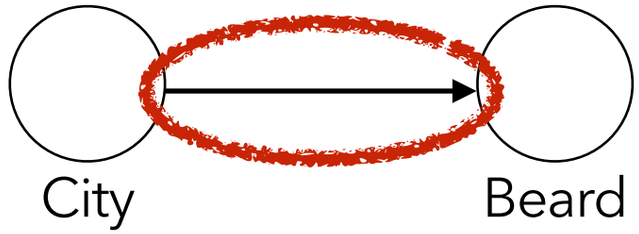

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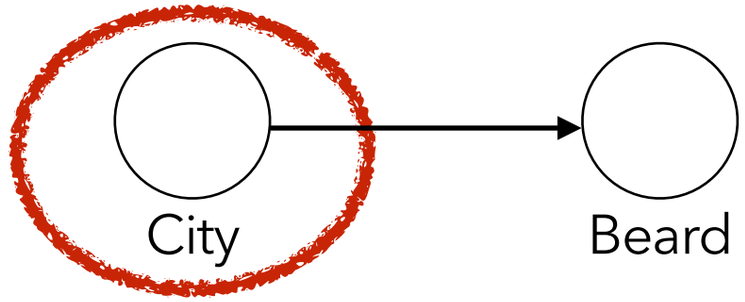

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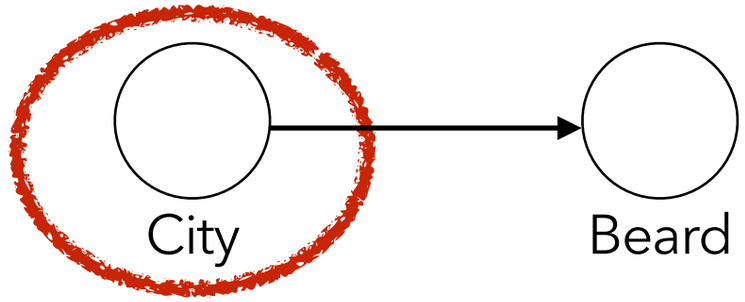

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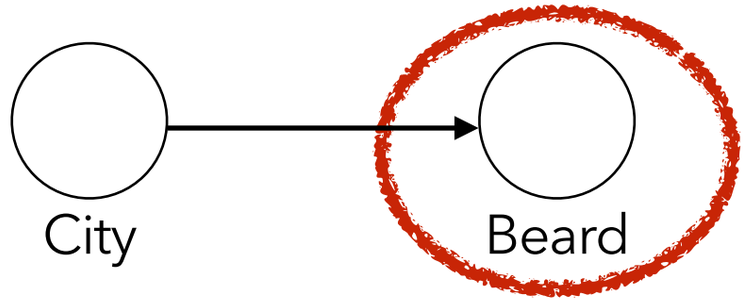

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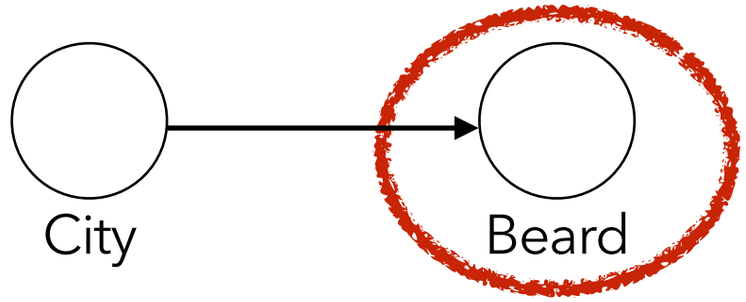

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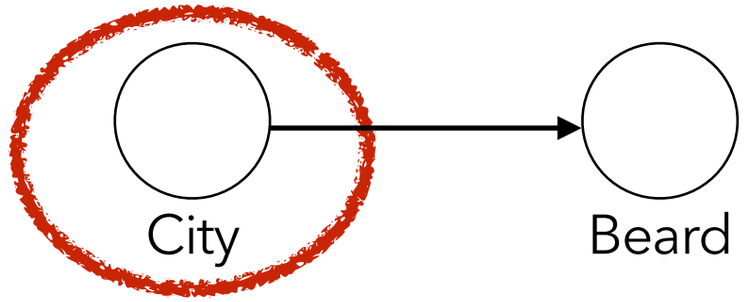

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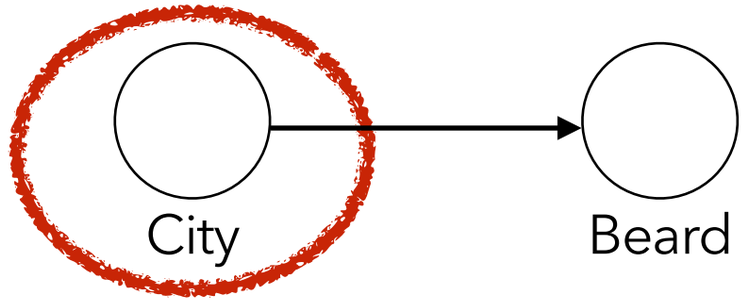

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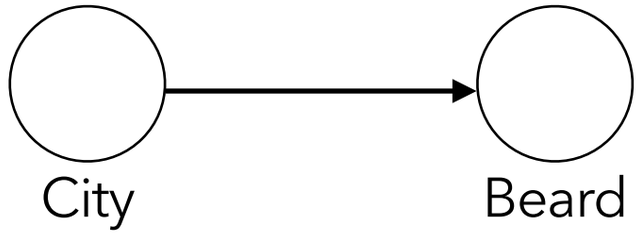

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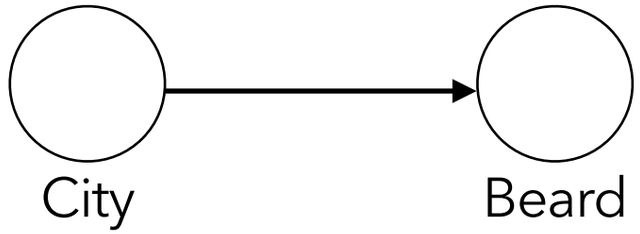

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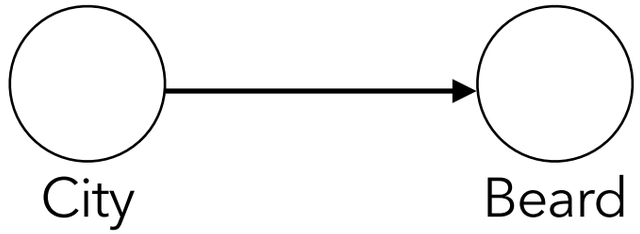

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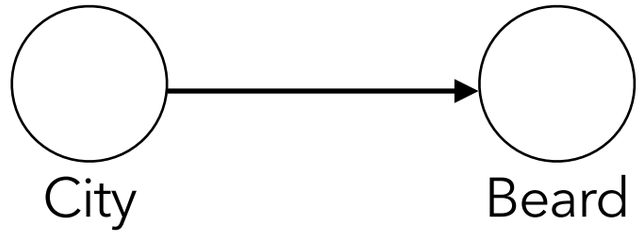

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if (newHasBeard.Pr(0.9))
    AddBeardToAvatar();
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Two new constructs

<|

Building probability distributions (conditional probability)

#

Composing context and estimates (Bayesian inference)

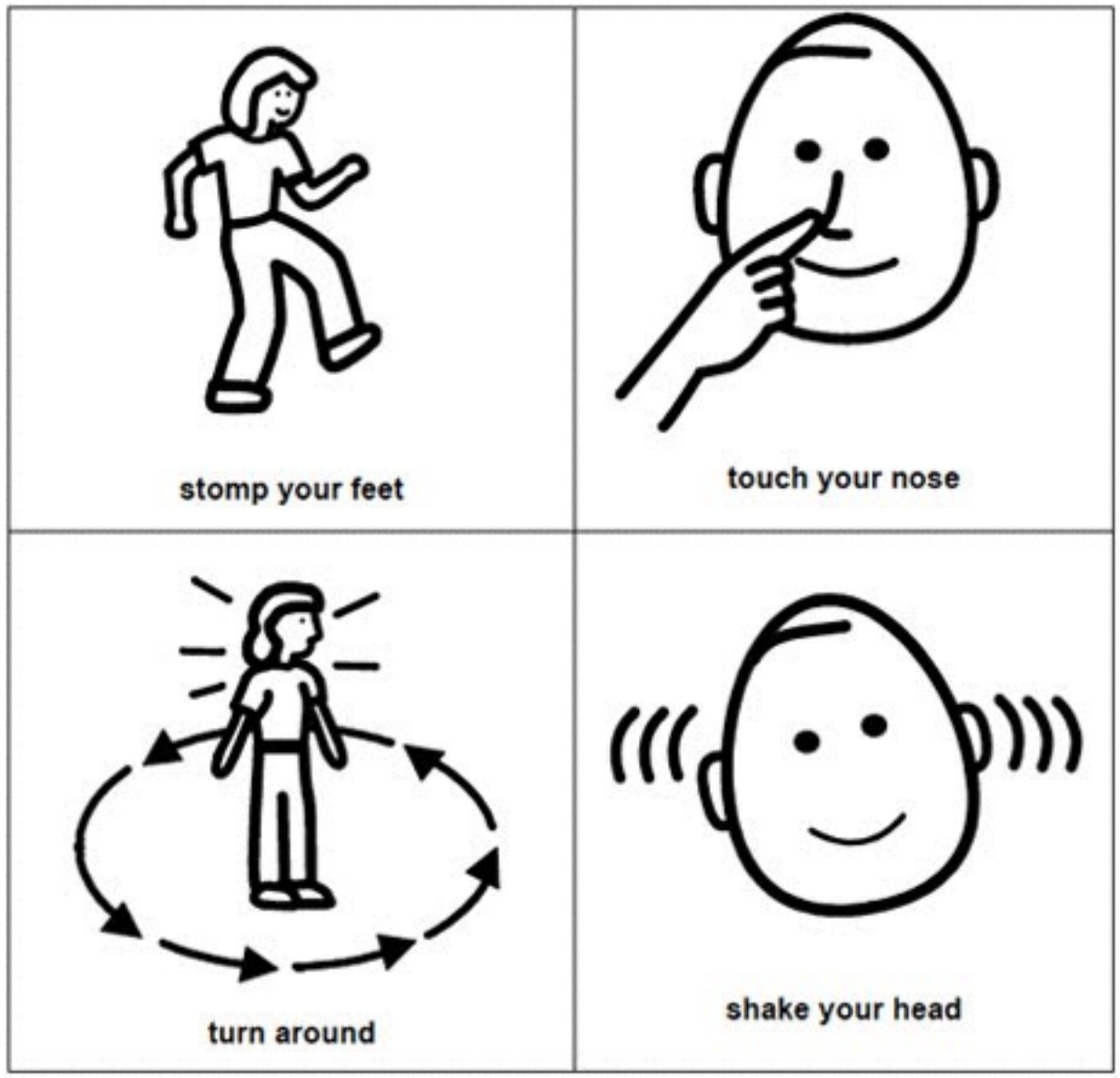
Implementation

- We designed a *sequential likelihood reweighting* algorithm to implement this abstraction
- But we'd like to compile down to probabilistic programming languages, which have better inference

figaro

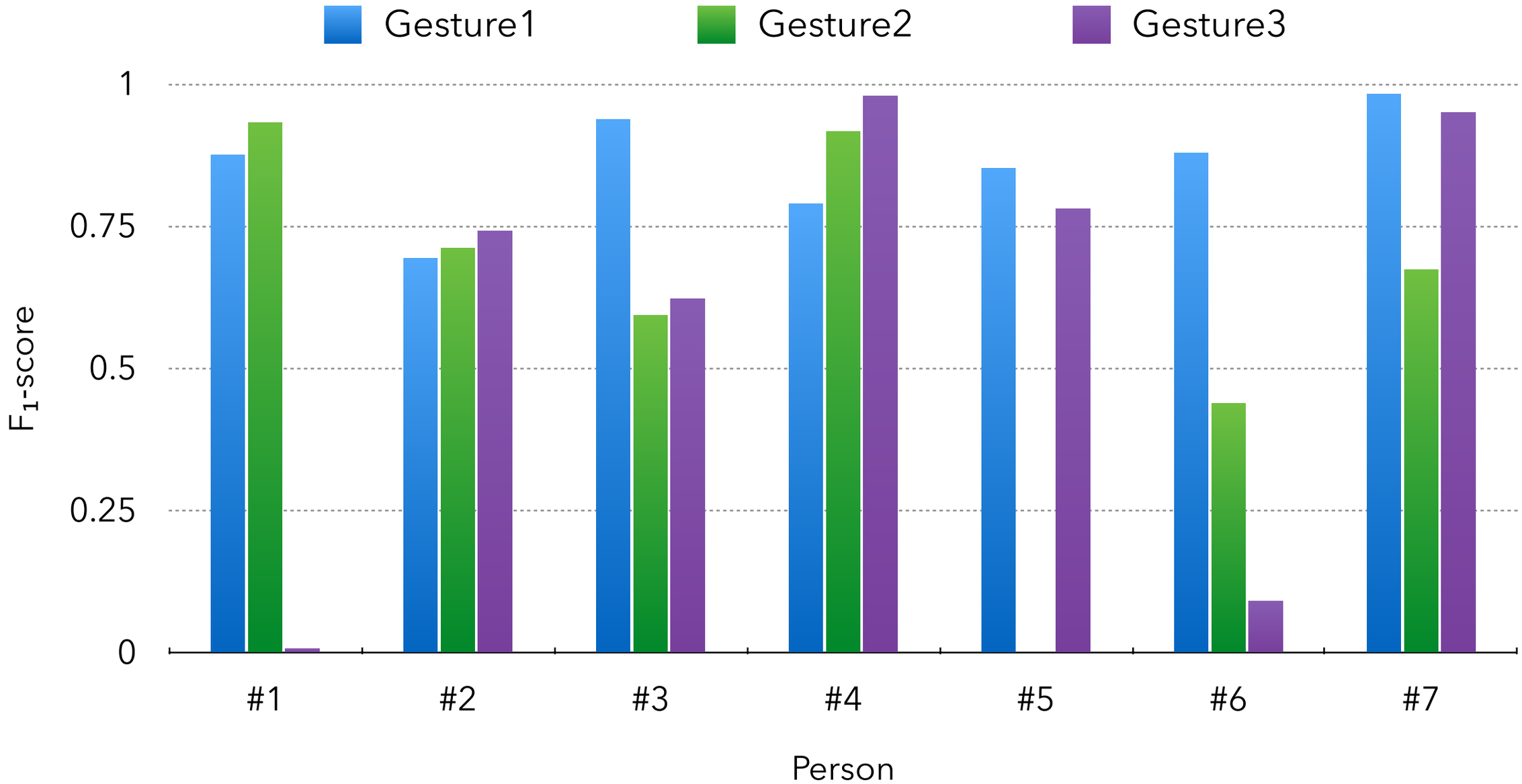
STAN

Simon Says



Simon Says

- Xbox Kinect gesture recognition API



Simon Says

Local model

- Specific to our user
- Need lots of examples to avoid noise

Simon Says

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Global (API) model

- Trained over many users
- Generalises well

Simon Says

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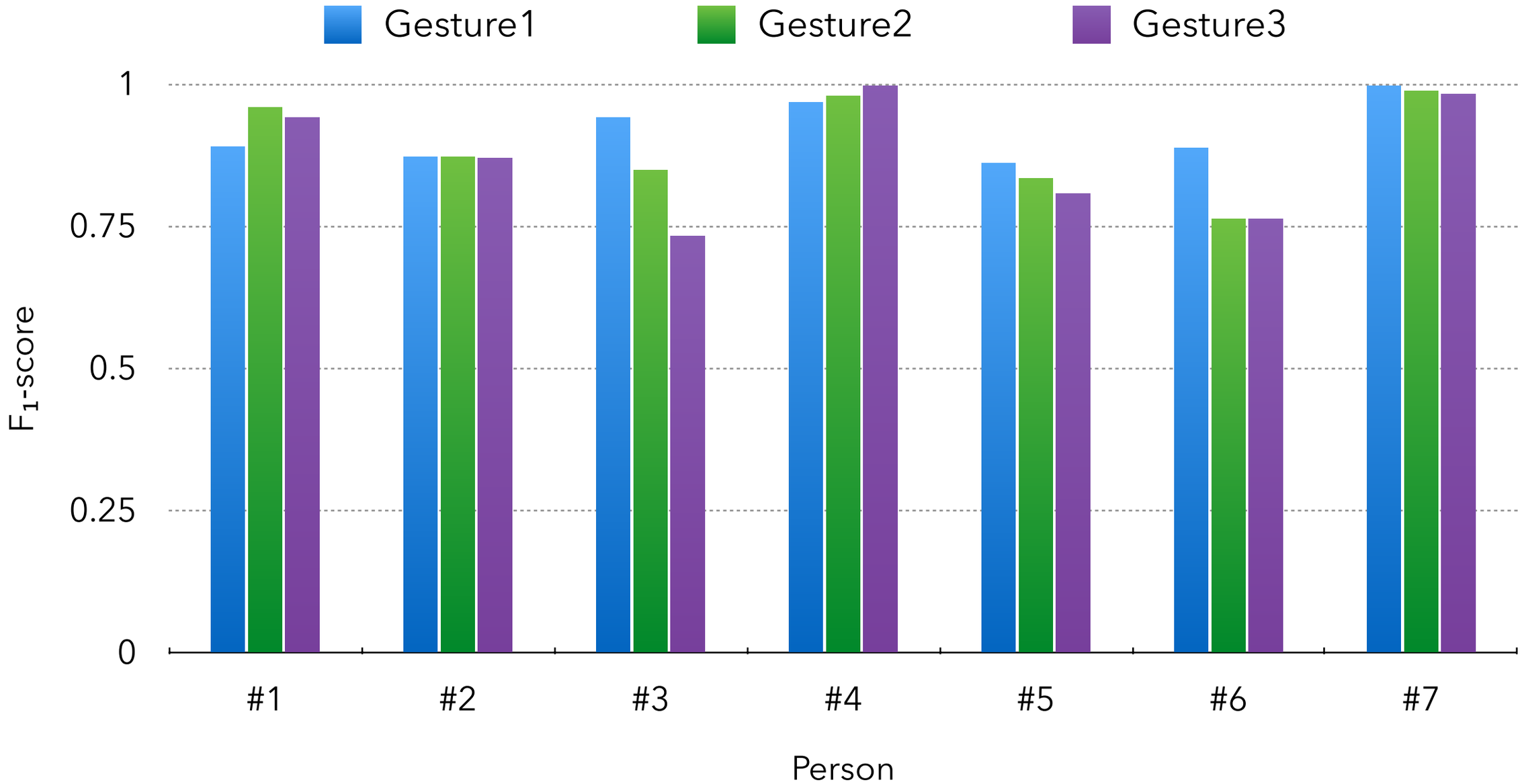
We’d like to keep both!

Simon Says

- Personalised gesture recognition model



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