There’s Something About Bayes
Effective Probabilistic Programming for the Rest of Us

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Programs are doing (probabilistic) inference, even if they don’t realise it.

drawing conclusions from evidence

GeoCoordinate Loc = GPS.GetLocation();
if (GPS.Distance(Loc, Home) < 200) evidence
OpenGarageDoor(); conclusion

bool HasBeard = BeardRecognizer(Photo);
if (HasBeard) conclusion evidence
Avatar.AddBeard();
Programs are doing **(probabilistic) inference**, even if they don’t realise it. Programs are doing **(probabilistic) inference**, even if they don’t realise it.

```c
GeoCoordinate Loc = GPS.GetLocation();
if (GPS.Distance(Loc, Home) < 200)
    OpenGarageDoor();
```

...but the user is on a road

```c
bool HasBeard = BeardRecognizer(Photo);
if (HasBeard)
    Avatar.AddBeard();
```
Programs are doing **(probabilistic) inference**, even if they don’t realise it.

```
GeoCoordinate Loc = GPS.GetLocation();
if (GPS.Distance(Loc, Home) < 200) OpenGarageDoor();
```

...but the user is on a road

```
bool HasBeard = BeardRecognizer(Photo);
if (HasBeard) Avatar.AddBeard();
```

...but the user is male
The Reverend Thomas Bayes

\[ \Pr[H|E] = \frac{\Pr[E|H]\Pr[H]}{\Pr[E]} \]

These inference programs already have a Bayesian interpretation.

[Bornholt et al, ASPLOS’14; Sampson et al, PLDI’14]
GeoCoordinate GPSLoc = GPS.GetLocation();
if (GPS.Distance(Loc, Home) < 200)
    OpenGarageDoor();
GeoCoordinate GPSLoc = GPS.GetLocation();
U<GeoCoordinate> Loc = Bayes(GPSLoc, GPS.GetMapPrior());
if (GPS.Distance(Loc, Home) < 200)
    OpenGarageDoor();
GeoCoordinate GPSLoc = GPS.GetLocation();
U<GeoCoordinate> Loc = Bayes(GPSLoc, GPS.GetMapPrior());
if (GPS.Distance(Loc, Home) < 200)
  OpenGarageDoor();

U<bool> HasBeard = BeardRecognizer(Photo);
if (HasBeard)
  Avatar.AddBeard();
GeoCoordinate GPSLoc = GPS.GetLocation();
U<GeoCoordinate> Loc = Bayes(GPSLoc, GPS.GetMapPrior());
if (GPS.Distance(Loc, Home) < 200)
    OpenGarageDoor();

U<bool> HasBeard = BeardRecognizer(Photo);
double BeardProbability = IsMale ? 0.2 : 0.01;
HasBeard = Bayes(HasBeard, Bernoulli(BeardProbability));
if (HasBeard)
    Avatar.AddBeard();
```csharp
GeoCoordinate GPSLoc = GPS.GetLocation();
U<GeoCoordinate> Loc = Bayes(GPSLoc, GPS.GetMapPrior());
if (GPS.Distance(Loc, Home) < 200)
    OpenGarageDoor();
```

---

Rejection sampling  
Infer.NET

```csharp
Variable<GeoCoordinate> Location
    = GPS.GetMapPrior();
Variable<GeoCoordinate> GPSLoc
    = GPS.GetLocationDist(Location);
GPSLoc.ObservedValue = GPS.GetLocation();
var ie = new InferenceEngine();
var NewLocation = ie.Infer(Location);
```
Your PC ran into a problem and needs to restart. We're just collecting some error info, and then we'll restart for you. (0% complete)

If you'd like to know more, you can search online later for this error: HAL_INITIALIZATION_FAILED
GeoCoordinate GPSLoc = GPS.GetLocation();
U<GeoCoordinate> Loc = Bayes(GPSLoc, GPS.GetMapPrior());
if (GPS.Distance(Loc, Home) < 200)
  OpenGarageDoor();
Not everyone can make the same compromises as current probabilistic programming languages.

- R2: probabilistic program slicing [Hur et al, PLDI’14], program analysis [Chaganty et al, AISTATS’13]
- Approximate Bayesian computation (ABC)/Likelihood-free MCMC
- Likelihood weighting/importance sampling + sequential hypothesis testing (Wald)

Probabilistic programming is great, but please… think of the rest of us!