

There's Something About Bayes

Effective Probabilistic Programming for the Rest of Us

James Bornholt

Todd Mytkowicz

Kathryn S. McKinley

Microsoft Research

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();
```

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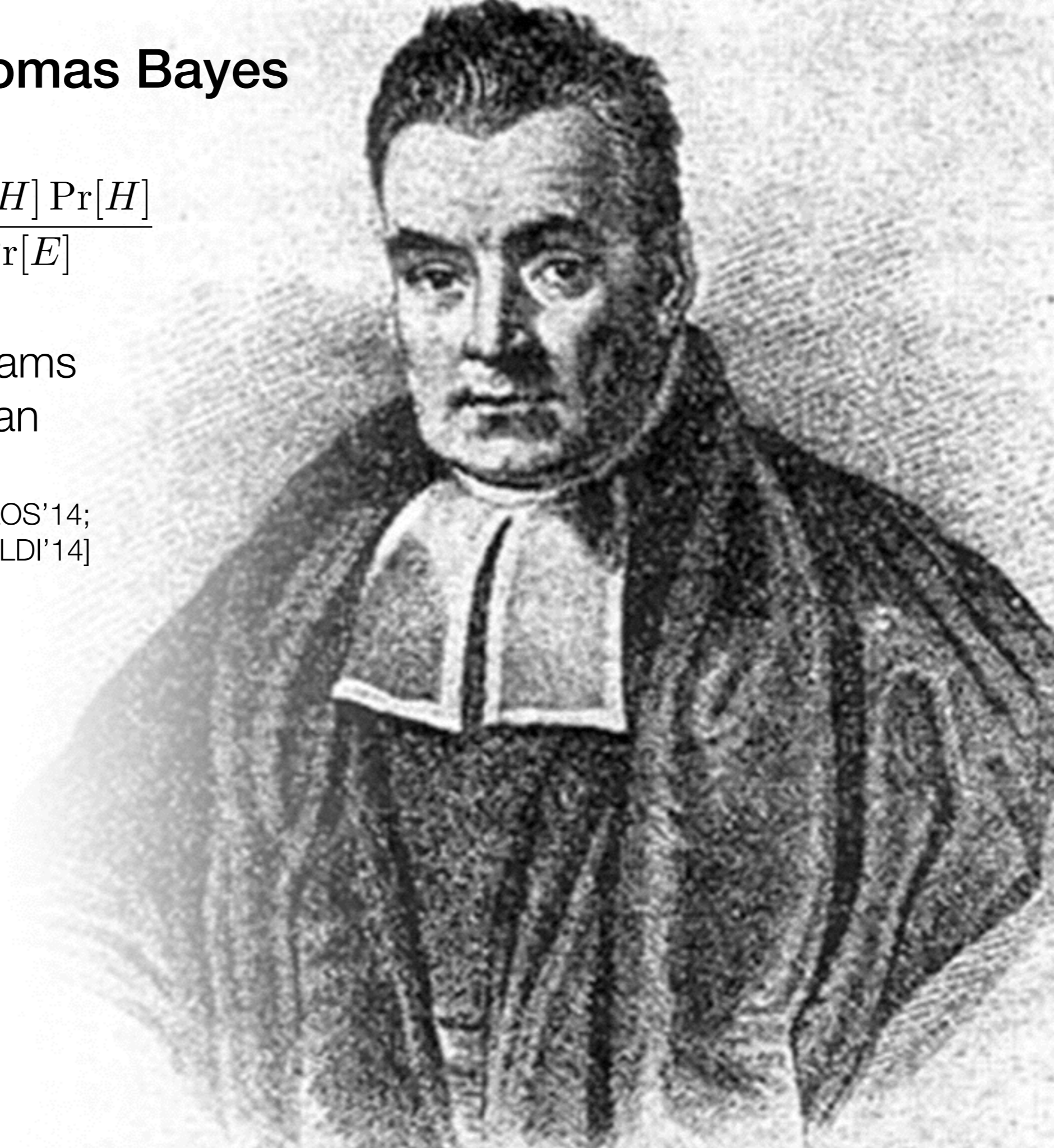
...but the user is male

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]



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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)  
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U<bool> HasBeard = BeardRecognizer(Photo);  
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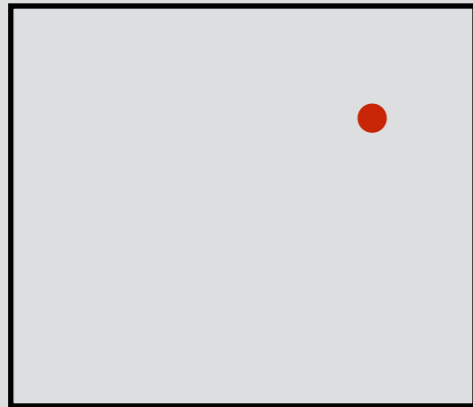


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U<GeoCoordinate> Loc = Bayes(GPSLoc, GPS.GetMapPrior());
if (GPS.Distance(Loc, Home) < 200)
    OpenGarageDoor();
```

```
U<bool> HasBeard = BeardRecognizer(Photo);
double BeardProbability = IsMale ? 0.2 : 0.01;
HasBeard = Bayes(HasBeard, Bernoulli(BeardProbability));
if (HasBeard)
    Avatar.AddBeard();
```

```
GeoCoordinate GPSLoc = GPS.GetLocation();
U<GeoCoordinate> Loc = Bayes(GPSLoc, GPS.GetMapPrior());
if (GPS.Distance(Loc, Home) < 200)
    OpenGarageDoor();
```

Rejection sampling



no constraints
poor performance

Infer.NET

```
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

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!