Probabilistic Programming And Bayesian Inference

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Markov-Chain Monte-Carlo Simulation (MCMC)
+ Program Analysis Techniques

Bayesian Inference based on ⬅ model

Data

Player 1 Beats Player 2
Player 1 Beats Player 3
Player 1 Beats Player 4
Player 4 Beats Player 2
Player 4 Beats Player 3
Player 5 Beats Player 1
⋮

Skill

Player 5: 80
Player 1: 70
Player 4: 60
Player 2: 30
Player 3: 30
⋮

Easy to design a good model

Probabilistic Programming Language

Pearl's Burglar Alarm Example

```
bool earthquake, burglary, alarm, phoneWorking, maryWakes, called;

earthquake = Bernoulli(0.0001);
burglary = Bernoulli(0.001);
alarm = earthquake || burglary;
if (earthquake) { phoneWorking = Bernoulli(0.7); }
else            { phoneWorking = Bernoulli(0.99); }
if (alarm) {
    if (earthquake)  { maryWakes = Bernoulli(0.8); }
    else             { maryWakes = Bernoulli(0.6); }
} else               { maryWakes = Bernoulli(0.2); }
called = maryWakes && alarm && phoneWorking;
observe(called);
return burglary;
```

Bayes' rule

$$P(A|B) = \frac{P(B|A) \times P(A)}{P(B)} \propto P(B|A) \times P(A)$$