

프로그램으로 기술된 확률 모델의 결과로부터 원인 추론하기

허충길

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@Rosaec Workshop

확률 모델의 결과로부터 원인 추론하기

확률 모델과 추론의 예제들

- 필기 인식 (Handwriting Recognition)

허충길

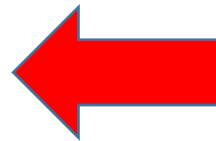
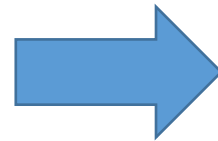
- 음성 인식 (Speech Recognition)
- 노이즈 감소 (Noise Reduction)

- 실력 알아내기 (Skill Inference)

Running Example: 실력 알아내기 (Skill Inference)

Skill

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



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
⋮

➤ Probabilistic Graphical Models

➤ Probabilistic Programs

```
p1 = s1 + random(Gaussian(0,beta));  
p2 = s2 + random(Gaussian(0,beta));  
if (p1 > p2 + epsilon) then r = 1;           // p1 wins  
else if (p1 < p2 - epsilon) then r = -1;      // p2 wins  
else r = 0;                                   // draws
```

추론하는 원리들

➤ Frequentist Inference

- Maximum Likelihood Estimation (MLE)
- Maximum a Posteriori (MAP)

➤ Bayesian Inference

예제: 실력 알아내기

Posterior 계산 공식 (Bayes' rule)

$$P(s|r) \stackrel{\text{ㄴㄹ}}{=} \frac{P(r|s) \times P(s)}{P(r)} \propto P(r|s) \times P(s)$$

Posterior 계산 방법

➤ Deterministic Approximate Methods

- Expectation Propagation
- Variational Message Passing

➤ Simulation-based Methods

- Importance Sampling
- Markov-Chain Monte Carlo Simulation (MCMC)

우리의 특별한 무기

- Program 분석을 이용해 성능 올리기
 - Program Splitting:
for efficient MCMC
 - Weakest Precondition:
for reducing rejection rate
 - Program Slice:
for eliminating unnecessary computation
 - 앞으로 훨씬 더 많은 아이디어들이 나올 것이라
예상 (이를 위해 연구 중)

예제: 실력 알아내기 (TrueSkill Model)

```
s[0] = random(Gaussian(mp[0],sp[0]));
s[1] = random(Gaussian(mp[1],sp[1]));
s[2] = random(Gaussian(mp[2],sp[2]));
v[0] = random(Gaussian(0,beta));
v[1] = random(Gaussian(0,beta));
v[2] = random(Gaussian(0,beta));
p[0] = s[0] + v[0];
p[1] = s[1] + v[1];
p[2] = s[2] + v[2];
if (p[0] > p[1] + epsilon) then r = 1;           // p[0] wins
else if (p[0] < p[1] - epsilon) then r = -1;    // p[1] wins
else r = 0;                                     // draws
observe (r == 1);
return (mp,sp);
```

Bayesian Inference Systems for Probabilistic Programs

➤ Infer.net

- Probabilistic C#
- Microsoft Research Cambridge
- EP(Expectation Propagation),
VMP(Variational Message Passing) 사용

➤ Church

- Probabilistic Scheme
- MIT, Stanford
- MCMC(Markov-Chain Monte Carlo) 사용

➤ R2

- Probabilistic C#
- Microsoft Research India (and SNU)
- MCMC + Program Analysis/Verification Technique 사용