Artificial Intelligence

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Learning Outcomes of Lecture 07

- Understand the concept of deep learning
- Understand the rationale of deep belief networks and realize the advantages of deep learning
- Master the design of recurrent neural networks and realize the advantage of long short-term memory
- Master the design of convolutional neural networks and realize the characters of multilayer data abstraction
- Master the design of generative adversarial nets and realize its application in computational creativity

Probability and Uncertainty

- Uncertainty
  - The state involves in incomplete information
  - where it is impossible to exactly describe outcome
- Probability is a branch of mathematics
  - Deals with calculating the likelihood of a given event
  - which is expressed as a number between 1 and 0
  - An event with a probability of 1 can be considered a certainty
  - An event with a probability of 0 can be considered an impossibility
- Bayesian networks
  - Good at uncertainty
  - Good at find the reason behind the evidence

Bayesian Theorem

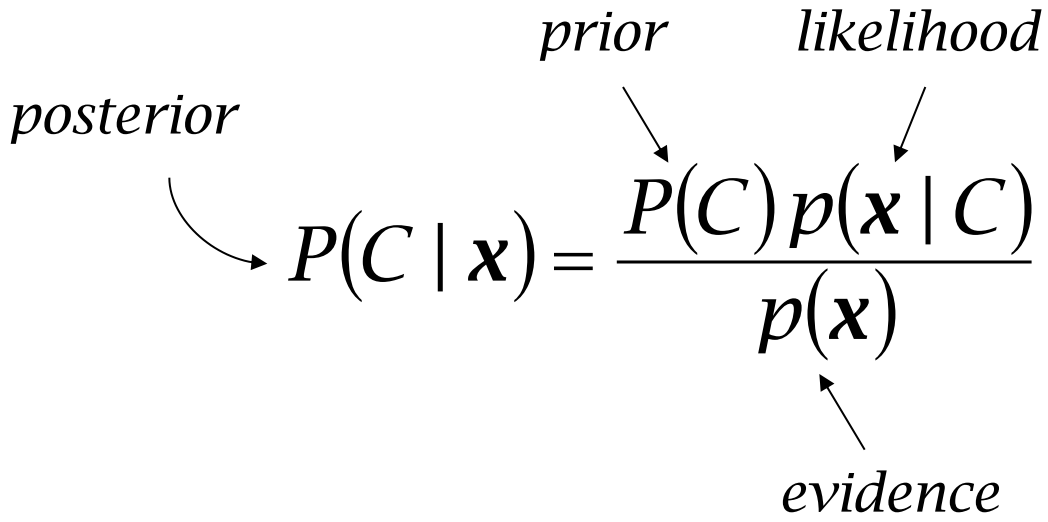
- Unconditional probabilities
  - Priors
- Conditional probabilities
  - Posteriors

$$P(A|B) = \frac{P(A \cap B)}{P(B)}. \qquad P(B|A) = \frac{P(A \cap B)}{P(A)}.$$

$$P(A|B)\,P(B) = P(A \cap B) = P(B|A)\,P(A).$$

$$P(A|B) = \frac{P(B|A)\,P(A)}{P(B)}.$$

Bayes' Rule



$$P(C=0)+P(C=1)=1$$

$$p(\boldsymbol{x})=p(\boldsymbol{x} \mid C=1)P(C=1)+p(\boldsymbol{x} \mid C=0)P(C=0)$$

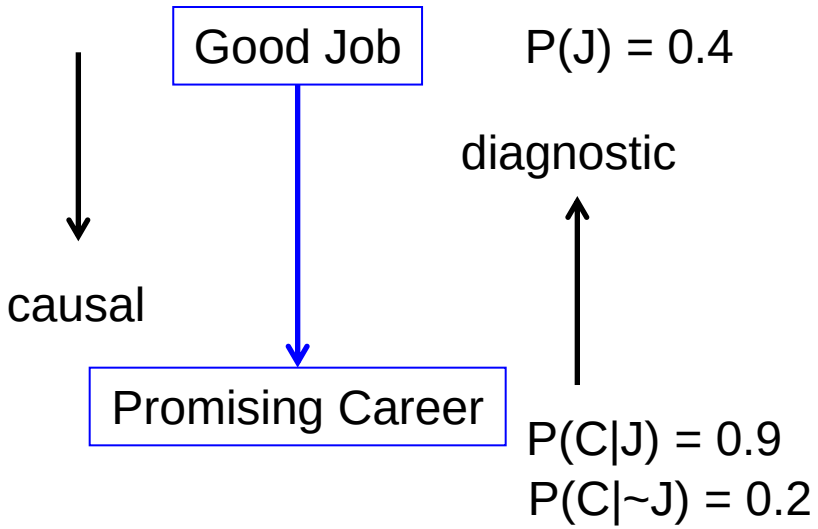
$$p(C=0 \mid \boldsymbol{x})+P(C=1 \mid \boldsymbol{x})=1$$

Problem

- 40% students can get a good job when they appear as freshman in job market
  - 90% students have promising career path if the first job is good
  - 20% students have promising career path even if the first job is not good

Diagnostic Inference

- Diagnostic inference
  - Knowing promising career,
  - What is the probability that the good first job is the cause?



$$P(J \mid C) = \frac{P(C \mid J) * P(J)}{P(C)}$$

$$= \frac{0.9 * 0.4}{P(C \mid J) * P(J) + P(C \mid \sim J) * P(\sim J)}$$

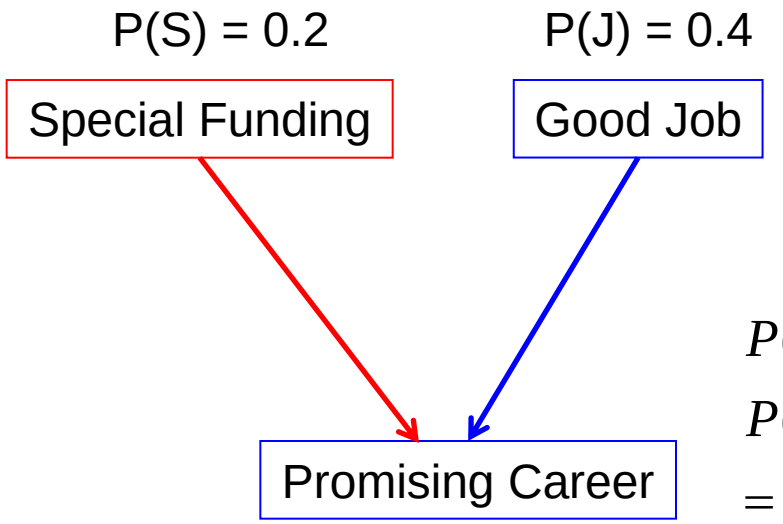
$$= \frac{0.36}{0.36 + 0.2 * (1 - 0.4)}$$

$$= 0.75$$

Problem

- 40% students can get a good job when they appear as freshman in job market
  - 90% students have promising career path if the first job is good
  - 20% students have promising career path even if the first job is not good
- Government has 20% probability to set special funding for young person to startup
  - With both good job and special funding, 95% students have promising career path
  - Without good job and special funding, 10% students have promising career path
  - With good job and no special funding, 90% students have promising career path
  - Without good job but have special funding support, 90% students have promising career path

Causal vs Diagnostic Inference



P(C|J,S) = 0.95

P(C|J,~S) = 0.9

P(C|~J,S) = 0.9

P(C|~J,~S) = 0.1

- Causal inference
  - Knowing special funding,
  - What is the probability leading to promising career?

$$P(C \mid S) =$$

$$P(C \mid S, J)P(J \mid S) + P(C \mid S, \sim J)P(\sim J \mid S)$$

$$= 0.95 * P(J) + 0.9 * P(\sim J)$$

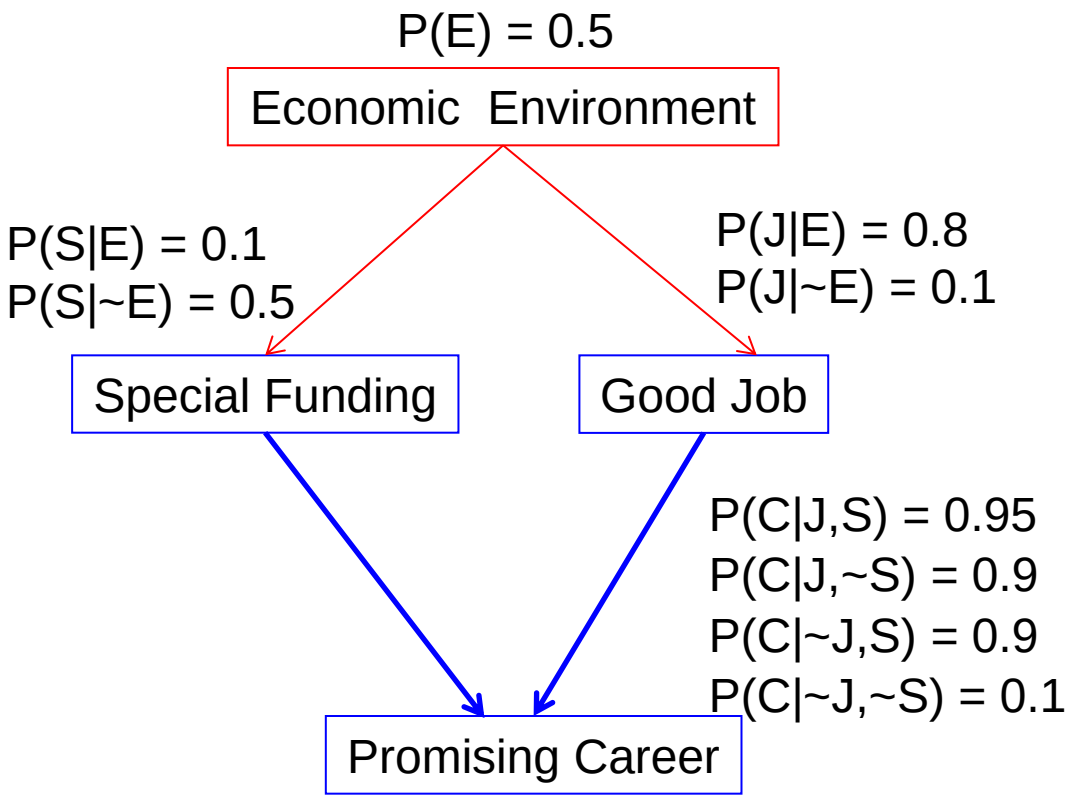
$$= 0.95 * 0.4 + 0.9 * 0.6$$

$$= 0.92$$

Problem

- When the economic condition is good
  - 80% students can get a good job
  - Otherwise, 10% can get a good job
- When the economic condition is good
  - Government has 10% probability to set special funding for young person to startup
  - Otherwise 50% probability to set special funding for young person to startup
- The probability of good economic condition is 50%
- What is the probability of promising path when the economic environment is good
  - What is the probability of the economic environment is good when we observe the promising career path

Bayesian Networks



Causal inference

$P(C|E) = 0.76$

Diagnostic inference

$P(E|C) = 0.58$