Visual Question Answering with Graph Matching and Reasoning

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Abstract

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1. Reasoning

1.1. Inference Graph

In this section, we briefly introduce the construction of inference graph to infer the hidden attributes. The inference graph is constructed using Bayesian network described by a pair $\mathfrak{B} =< \mathcal{G}, \Theta_{\mathcal{G}} >$. Specifically, the notation $\mathcal{G}$ is a directed acyclic graph, of which the i-th vertex corresponds to a random variable X_i, and the connected edge in $\mathcal{G}$ between two vertexes indicates the dependency. The second item $\Theta_{\mathcal{G}}$ is a set of parameters used to quantify the dependencies of $\mathcal{G}$. We use the notation $\theta_{X_i|\text{Pa}(X_i)} = P_{\mathfrak{B}}(X_i|\text{Pa}(X_i))$ to denote the parameter of X_i, of which Pa(X_i) is the attributes of the parents of X_i. The joint probability distribution of Bayesian network is given by:

$$P_{\mathfrak{B}}(X_1, \cdots, X_n) = \prod_{i=1}^{n} P_{\mathfrak{B}}(X_i|\text{Pa}(X_i)) = \prod_{i=1}^{n} \theta_{X_i|\text{Pa}(X_i)} \tag{1}$$

The role of Bayesian network is to predict the object class when given the attributes $\{X_i\}_{i=1}^{n}$ as input. In the sense of probability, the object class is also a variable. Let $Y = X_0$ be the class variable, the network now has one extra vertex Y. According to the Bayesian rule, the network can be rewritten as:

$$\begin{aligned} P_{\mathfrak{B}}(Y|X) &= \frac{P_{\mathfrak{B}}(Y) P_{\mathfrak{B}}(X|Y)}{P_{\mathfrak{B}}(X)} \\ &= \frac{\theta_{Y|\text{Pa}(X_0)} \prod_{i=1}^{n} \theta_{X_i|Y,\text{Pa}(X_i)}}{\sum_{y' \in \mathcal{Y}} \theta_{y'|\text{Pa}(X_0)} \prod_{i=1}^{n} \theta_{X_i|y',\text{Pa}(X_i)}} \end{aligned} \tag{2}$$

where $\mathcal{Y}$ is the set of class.

In the context of Naïve Bayes, the significance of $P_{\mathfrak{B}}(Y|X)$ is stressed by taking the class variables as the root, and all attributes are conditionally independent when making the class as a condition. As a consequence, the calculation can be simplified as:

$$P_{\mathfrak{B}}(Y|X) = c \cdot \theta_Y \prod_{i=1}^{n} \theta_{X_i|Y} \tag{3}$$

where c is constant: $c = \sum_{y' \in \mathcal{Y}} \theta_{y'} \prod_{i=1}^{n} \theta_{X_i|y'}$.

References