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The understanding about Bayesian Networks

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Colab Link	https://colab.research.google.com/drive/1gD7pD6Q66KsUvCYXdIbBuWJpbJzXktcx

1.Content

1.1 Introdution

This report will provide an introduction the paper "The Computional Complexity of Probabilistic Inference Using Bayesian Belief Networks" by Greory F. Cooper which proves the calculation of probabilistic inference using bayesian belief networks is an NP-hardness problem.

1.2 Bayesian Belief Network

Before we talk about that paper, we first need to introduce the Bayesian Belief Network, because that paper describes the Bayesian Belief Network shortly. Subsequently, we denote the Bayesian Belief Network as BN.

The BN has a little bit difference with other machine learning method. Its theory bases largely on the statistic and probabilistic knowledge. This algorithm will construct a graphic structure for probabilistic relationship between several events. By BN, we just need to consider the known dependencies rather than to build a fully-connected dependency matrix. Moreover, the representation of graphic strucure can be more intuitive, and we will discuss that later. The structure of the BN is a direct acyclic graph (DAG), and this will be related to the conditional independence

One of the reasons why we need BN is that there are some problems which cannot be calculated by Bayesian theory. The Bayesian theory can be presented as follow:

$$P(B|A) = \frac{P(A|B)*P(B)}{P(A)} \tag{1}$$

For instance, sometimes doctor need to diagnose a patient by other related factors. There is an example given by Neapolitan(2004). Suppose we know whether the patient smoke hold a direct impact to whether they have bronchits or whether they have lung cancer, and these two diseases have a direct influence to whether they experience fatigue. Furthermore, whether the patient have lung cancer has a direct effect to whether their chest X-ray is positive. Obviously, only Bayesian theorem, as shown in (1), cannot predict the result with this complex relationship structure. Furthermore, it is too abstract to understand the casual relationship between these variables based on the above description. However, if we use the BN to present the probabilistic relationship as shown as Figure 1.1, it will be clearer than the description.