A First Analysis of Qualitative Influences and Synergies

Jesús Cerquides[1], Ramon López de Màntaras

Artificial Intelligence Research Institute, IIIA
Spanish Council for Scientific Research, CSIC
08193, Bellaterra, Barcelona, Spain
{cerquide,mantaras}@iiia.csic.es

Introduction[2]

Comprehensibility is a key characteristic for learning algorithms results to be useful in Knowledge Discovery in Databases tasks.

Bayesian reasoning has been usually criticized as hard to explain and understand, but achieves high performance rates with simple constructs, as happens for instance with the Naive-Bayes classifier.

Our approach can be viewed as a refinement of qualitative probabilistic networks in order to allow them to do the work probabilistic networks do, or as a way of showing that, slightly modified, Elsaesser's explanations can be used for reasoning and prediction, achieving results similar to Bayesian reasoning, while keeping intact their interpretability.

Influences and synergies revisited

Neufeld states a *favours* b if $Prob(b|a) > Prob(b)$ that is if $\frac{Prob(b|a)}{Prob(b)} > 1$. This quotient was also used by Elsaesser in his work trying to explain bayesian reasoning, to denote the shift in belief that a produces in b. We will define influence of a in b as:

$$Influence(a,b) = \frac{Prob(b|a)}{Prob(b)} \quad (1)$$

We note that:

$$Influence(a,b) = Influence(b,a) \quad (2)$$

We make use of the absolute order of magnitude model to discretize influences in order to gain in comprehensibility (Figure 1). Synergies can be seen as the difference in influence between two facts that happen together with respect to these two facts happening separately. We can give the following expression for synergies of two variables:

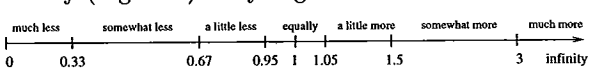

Figure 1: Influence discretization scale

$$Synergy(\{a_1,a_2\},b) = \frac{Influence(a_1 \cap a_2, b)}{Influence(a_1,b) * Influence(a_2,b)} \quad (3)$$

We can discretize synergies as we do with influences.

[1]Jesús Cerquides research is supported by a doctoral scholarship of the CIRIT (Generalitat de Catalunya).

[2]All the references can be found in (Cerquides & López de Màntaras 1998)

An application of qualitative influences and synergies: The Qualitative Bayesian Classifier

Qualitative influences and synergies can be used for reasoning and concretely for classification tasks, allowing high classification rates and having a good self-explanation hability. We have used them to get a qualitative version of a well known classification method, the Naive-Bayes classifier.

Assuming E_j's are independent, Naive-Bayes can be expressed as:

$$P(C=i|\mathbf{E}=\mathbf{e}) = P(C=i) * \prod_{j=1}^{N} Influence(E_j = e_j, C=i) \quad (4)$$

We can apply this rule with qualitative influences and analyze the difference between applying the Naive-Bayes classifier where shifts in belief grade continuously from 0 to 1 and our qualitative influences framework, where shifts only can have the seven values shown in Figure 1

Similarly we have created an approximation of the Second Order Bayesian classifier. In this case we have to avoid applying two synergy corrections over the same variable. Thus we apply the synergies in decreasing size order (from large ones to small ones).

Empirical results

We have tested the two classifiers against CN2, ID3, IBL and Naive-Bayes over 14 UCI datasets. The results of the first order classifier are slightly worse than the quantitative version (Naive-Bayes), but surprisingly 4 out of 14 times the qualitative version outperforms the quantitative one. The results of the second order one are as good as those from ID3, CN2 or IBL, and better than the Naive-Bayes ones.

Conclusions

We have introduced qualitative influences and synergies based on the absolute orders of magnitude model. We have shown that their accuracy results are good and they greatly improve the comprehensibility of probabilistic reasoning. These two facts make us believe that they can be useful within a KDD system.

References

Cerquides, J., and López de Màntaras, R. 1998. Qualitative Influences and Synergies: A Step Forward in Explaining Probabilistic Reasoning. Technical report, IIIA-98-04.