Order Production – Constructing a Framework for Prediction of Parts Demand

This case outlines how Bayesian network technology can be applied to the task of parts demand prediction in relation to production. The case considers the application of Bayesian networks to predict the demand for parts when items, articles, or elements are produced based on customer requests rather than production in series. The problem domain used here is order based production of cars, but could be any other product produced on the basis of customer requests. The ability to efficiently predict the demand for parts is, for instance, useful for reducing storage, can lead to faster response and shorter production time.

What's the Catch?

A Bayesian network model can be used to calculate the probability of an item to be produced will have a certain configuration, e.g. the model can be used to compute the probability that a car will be red, have a sun roof, a 2:2 liter engine, etc.. Depending on the configuration of the car a certain amount of parts of different types have to be used for the construction of the car. Thus, the expected demand on a specific part can be computed based on the probability distribution on different car configurations and the number of cars to be produced. The model can also help investigate the impacts of special marketing efforts, changing the technical constraints of the production, and so on.

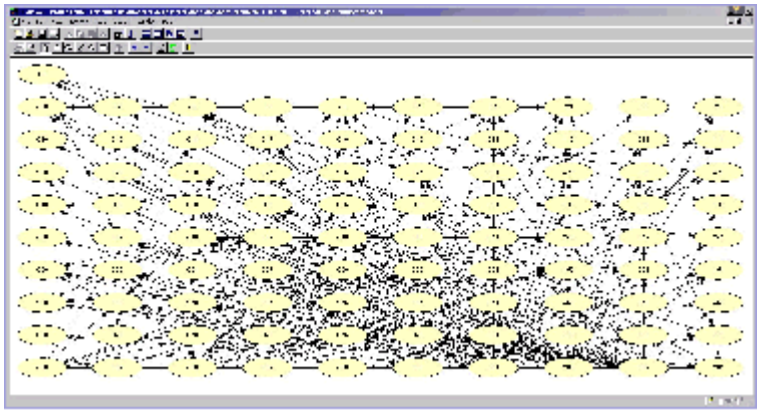
The Basic Idea

The basic idea is that the customer has a number of choices or options available when buying an item. These choices determine the configuration of the item to be produced for the specific customer. These choices could be built-in points or configuration points of the item, i.e. the item is partly specified from the manufacturer and a complete specification of the item is determined from the choices made by the customer. Even though the customer has a number of options available when choosing the configuration of the item she or he is buying, the choice of configuration is not completely free. The production of an item such as a car or a computer is often constrained by either technical constraints or rules, legislation, marketing efforts, or similar. For instance, all cars sold on the Danish market has to have the property that the head and tail lights are turned on when the car is started or all boats of length more than 30 feet has to have special life saving equipment. The choice of the customer with respect to each configuration point is free under these constraints.

Use of Historical Data

The past production of items is assumed to be recorded in a database. The database will consists of a complete configuration of each item produced in the past. The items produced in the past have been constructed under a set of constraints which may be different from the constraints which have to be satisfied in the future.

Construction of the Bayesian Network Model



A Bayesian network model can be constructed either manually, semiautomatic, or fully automatic. The construction of a Bayesian network model consists of two parts. One part is the qualitative part which describes dependence and independence relations of the problem domain. The technical and the marketing rules describe dependence relations which are due to legislation, production facility limitations, marketing efforts, etc. The historical data reflects the technical and marketing constraints at the time of production, but also the preferences of the customer, e.g. cars with large engines often have a large stereo and are often red or black of color. The other part of the construction phase is the quantitative part which describes the strengths of the dependence relations. The quantitative part is estimated from the historical data under the constraints of the technical and marketing rules.

The Quality of the Model

A number of different measures for measuring the quality of the Bayesian network model constructed exist. These measures can be used to determine how well the model predicts the data. Furthermore, there exist methods such as sensitivity analysis for analysis of how sensitive the predictions made by the model are to the model specification. This is very useful for focusing the attention of manual or semiautomatic model construction.

Use of the Developed Model

Once the model has been constructed from the historical data and the constraints, the model is used to predict the demand for parts efficiently. The prediction of parts demand could, for instance, be based on the production of a predetermined number of items over the next time period. The production period is the period where a predetermine set of items is to be produced and where the Bayesian network model is assumed to be fixed. The Bayesian network model is a representation of the average item build. The number of parts required for the production depends on the number of items to be produced, the configurations of the items, and the number of parts used for each particular configuration. From this the predicted number of parts of a partial kind to be used in the future production can be estimated.

Update of Model

During the production period the technical constrains, the marketing effort, or even the legislation may be changed. The changes can take different forms. For instance, the marketing division of a company may decide to do a special effort in order to gain market shares in a particular country in the middle of a production period. This implies that the model has to be revised such that the special marketing effort is incorporated into the predictions made by the model. Revision of a Bayesian network model can be performed efficiently. A Bayesian network can also be adapted to the local settings in which the model is used. For instance, the predictions made by the model can be adjusted each time an item is produced or solved. The model will be adjusted such that the configuration of the item produced or sold becomes more likely in future predictions. An example of a situation where it is necessary to update the model is when the set of options available with respect to a specific built-in point is extended. If suddenly a new color is available or a new type of a particular part is introduced during a production period, then the model has to be updated to make reasonable predictions in the future

Documentation

A Bayesian network model can be documented in a number of different ways. Due to the intuitive nature of a Bayesian network, the documentation of a Bayesian network is often an integrated part of the model specification. This ensures that the documentation is consistent with the model. The intuitive nature of a Bayesian network can also be exploited to generate explanations of the reasoning or predictions performed by the model. In relation to the prediction of part demands, this is valuable when validating and testing the predications made by the model.

Scientific Articles

Gebhardt, J., Detmer, H., and Madsen A. L., (2003), Prediction Parts Demand in the Automotive Industry --- An Application of Probabilistic Graphical Models, Proceedings of the first Bayesian Application Modeling Workshop.