Neural Controller for Business Yield Management

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In the business and operational research field there is a class of perishable inventory control problems called 'yield management'. Examples are floating pricing strategies in air ticket reservation and hotel room booking. Due to the complex nature of yield management, there are few analytical models available for practical application. This paper presents a neural network approach to solving yield management problems. Using modified back propagation neural networks, a threshold band in the high-dimensional yield management space is generated based on historical data and/or management expertise. When the actual inventory level is outside the threshold band, prices should be adjusted to lead the inventory level back to the threshold band. The interval of the threshold band indicates the stability of the business system.

Keywords: Business yield management; Curve fitting; Neural control; Operational research

1. Introduction

Yield management is not a new idea in the business and operational research field, but it has not been applied effectively in practice [1]. Recent developments in information technology provide increasingly sophisticated measures in data collection and manipulation. Research is seeking to determine how information technology can facilitate yield management [2].

The concept of yield management is illustrated using an example of hotel booking as follows. A typical booking record of a hotel on a particular day can be depicted as in Fig. 1(a). Normally, the number of bookings is negatively related to the days before arrival. Due to a variety of reasons, the curves of room bookings can be different from day to day, as shown in Fig. 1(b). Normal curves of room bookings form a band, called a threshold band. When the curve representing actual bookings on a particular day is outside the band, prices should be adjusted. In Fig. 1(c), where actual bookings fall below the threshold band near the middle of the graph, the manager is advised to open discount rates to encourage more reservations. On the other hand, where the future bookings exceed the upper-level of the threshold band, the manager could increase the price and still reserve rooms for desperate customers.

Yield management techniques are applicable to those industries including airline tickets reservations [3], health care [4] and others, where inventory assets are perishable [5]. Despite its potential to business, yield management has not been intensively investigated. Traditionally, yield management is studied in the operational research community. Mathematical programming and statistical techniques are applied to find optimal pricing strategies in this school. There are several obstacles to analytical solutions of yield management. First, to solve a system-wide yield management problem would require a large number of decision variables which would make analytical modelling difficult [3]. Intuitively, the threshold band (Fig. 1(b)) is a complicated zone in the high-dimensional decision space with numerous decision variables being involved such as tour season, customer group size, competitor's policy, the firms' pricing scheme and other factors. Secondly, analytical models often rely on assumptions about probability distributions to
find 'optimal' solutions. However, some theoretical assumptions about probability distributions can never be verified (see discussions in [5]). In light of this, researchers and practitioners are seeking new supports from information technology for yield management. This paper proposes a neural controller model for yield management. For convenience, we shall use hotel room booking as a problem background for discussion. Nevertheless, the model proposed here is generally applicable to all types of yield management.

2. Controller Model for Yield Management

Suppose there is a set of data. Each data point represents a room reservation record under a certain circumstance. The variables which influence the number of reservations could be:

- days before arrival
- price
- tour season
- competitor's price,

and so on.

An interesting point is worth noting. In yield management one can easily find the monotonic relationship between the dependent variable (number of reservation) and these independent variables based on common sense. In fact, monotonicity is a generic characteristic which commonly exists in managerial functions, as discussed in [6]. In our case, for instance, other thing being equal, the closer to the arrival time, the nearer to the tour season, and the lower the price, the more reservations that would be made. The dependent variable and independent variables constitute a high-dimensional space. Suppose the available data are plotted in the space. A band with a monotonic trend will be obtained, as illustrated in Fig. 2(a). Note that in Fig. 2(a) X represents a vector of n independent variables, $X = (x_1, x_2 \ldots x_n)$, and the band is a solid in $(n+1)$-dimensional space.

Hotel room reservations involve uncertainty. The higher the uncertainty involved, the wider the interval band would be. Some data points, which represent unusual observations are considered as outliers (see Fig. 2(a)). For practical purposes, one would like to find a band which contains the most, say 90%, normal observations. To find a monotonic band to contain the noisy raw observations, but without making any statistical assumptions, heuristics must be applied. The fundamental idea, which is based on Gestalt psychology, is to find the monotonic trend by finding streamlines for the data. To do so, we first find the subset of data points which would constitute two frontiers (upper and