Knowledge Assisted Pricing Advisor for Large-scale Retailers: KAPA

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[Abstract]

It is very difficult for the large-scale retailers, who deal with tens of thousands of items, to price all the items dynamically reflecting all the constraints and policies. In spite of its importance, the prices are determined by human experts because the process of setting the prices of all the items is not established yet. To solve this problem, we adopt a mixed model that combines three typical pricing models: cost-plus model, competition-oriented model, and demand-oriented model. Since each model can be converted to a set of constraints in point and interval forms, solving the pricing problem with the three groups of models requires an algorithm which can solve the problems with weighted constraints of intervals and points. So we have devised an algorithm named "Point Determination Algorithm". From the rules that represents the models, the constraints are extracted to be solvable by the Point Determination Algorithm. A prototype KAPA (Knowledge Assisted Pricing Advisor) is developed with this idea using the expert system environment UNIK - a tool developed by KAIST. According to the experiment with 76 items in comparison with 53 human pricing experts, we confirmed that the KAPA can perform highly consistent with human experts. This implies KAPA system is applicable to pricing millions of items dynamically.

1. Introduction

As the market becomes worldwide and quality of merchandise becomes equalized all over the world, price becomes more important variable of retailer's marketing strategy. WWW (World Wide Web) and Electronic Commerce made price more important variable. Moreover, WWW made it easy for retailers to get competitors' prices and for customers to search prices of many retailers with low search cost.

In marketing area, traditional research on the retail pricing problem was mainly focused on the formulation of mathematical programming models for optimal pricing. But practically it was not helpful for retailers. [Yoo 1991] Especially pricing problem of retailers who handle a large number of merchandise is more difficult to solve, because of the number of decisions to make

Retail managers usually set their prices by cost-plus pricing. But today as competition becomes more intensive, competition-oriented pricing becomes more important for retailers. And with the widely adoption of POS (Point Of Sales) terminals, retailers began to use demand-oriented pricing. Thus retailers need combined pricing method that can synthesize the 3 methods with changing environment.

A pricing method or a constraint produces an interval or a point on the line that represent prices on it. So interval-based price representation is necessary. Then, combined pricing method becomes a synthesizing scheme to select a point from a set of intervals and points.

A method to deal with the intervals and points to lead to a neat conclusion is temporal reasoning. Temporal reasoning tasks are formulated as constraint satisfaction problems, where the variables are temporal objects such as points and intervals. [Allen 1983] Temporal reasoning has been developed independently with pricing. But as we regard pricing problem as to select a point in the price line under the constraints of intervals and points, temporal reasoning can be used as a reasoning algorithm for combined pricing method. But temporal reasoning cannot give us solutions to pricing problems. With temporal reasoning, we can find only an interval that satisfies the largest number of constraints. But

pricing problem requires a point, an interval whose length is zero. So we need additional inference method to select a point from the interval. Let us consider following two examples of temporal reasoning problem and pricing problem.

Problem-1: I should attend the meeting begins at 5 p.m. and ends at 6 p.m. And I should go to the concert at 6 p.m. It takes 30 minutes from office to opera house.

Problem-2: A supermarket manager wants to set the price of "Choice coffee 227g bottle." Its cost is 5242 won. Average markup rate of instant coffee is 33.2. So to follow the markup of the category, he should set price at 6980 won. By market research he found that competitor-1 set their price at 6300 won (20.2 percent markup rate). An expert suggested that he should set price at the competitor-1 level, at 6300 won.

In the above two cases of real world, an ordinary man makes the decision instantly and unconsciously by his preference. A man would go to the concert or attend the meeting according to his preference and his situation. If he thinks that he should satisfy his wife in this week, then he would go to the concert and will quit his office before 5:30 p.m. Likewise, the supermarket manager would price "*Choice coffee 227g bottle*" at initial markup or at the competitor level according to his objective and financial status. If he want to maintain higher price image than the competitor, he would set the price at the initial markup. If he want to expel the competitor from the market, he would set price below 6300. In the above two examples, the factor that determines the time point or the price point is the weights that people give to the constraints or reference points by their situation and preference.

2. Combined Pricing Method

There are 3 distinct methods of setting retail prices: cost-plus method, competitor-oriented method, and demand-oriented method. [Michael Levy et al. 1995] In this section we briefly explain the three methods with a case and represent it on the price line. The case is an extension of problem-2 in section1. The information about the item, category, class, and department of 'bottled Choice coffee 227g' is stored in item knowledge base as Figure1.

Cost-plus method is the most widely used method for retailers. Using the cost-plus method, the retail price is determined by adding an initial markup to the cost of the merchandise. But practically, in supermarket chain initial markup is determined by the inherited average initial markup of its own category.

{{ **ITEM-1854299**
IS-A : ITEM
DESCRIPTION : Choice coffee bottle 227g
COST : 5242
INITIAL-PRICE : 6980
MARKUP-RATE : 19.8
PRICE : 6280
CATEGORY-OF : 070202 }}
{{ **CATEGORY-070202**
IS-A: CATEGORY
DESCRIPTION: instant coffee
CLASS-OF: 0702
INITIAL-MARKUP-RATE : 33.2 }}
{{ **CLASS-0702**
IS-A: CLASS
DESCRIPTION: coffee
DEPARTMENT-OF: 07
INITIAL-MARKUP-RATE : 30 }}
{{ **DEPARTMENT-07**
IS-A: DEPARTMENT
DESCRIPTION: processed foods
MD-GROUP-OF: 07
INITIAL-MARKUP-RATE : 20 }}

Fig..1. Item knowledge base

If we show the constraints made from cost-plus method on the price line, it is represented as Figure2.

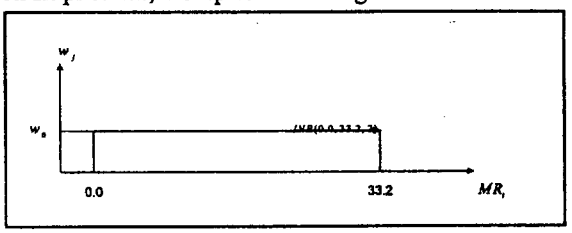


Fig..2. Cost-plus method represented on the price line

With competition-oriented pricing we use competitor' price as a reference or guideline of our price. Most retailers set their pricing strategy considering competitors' price image and their own price images.

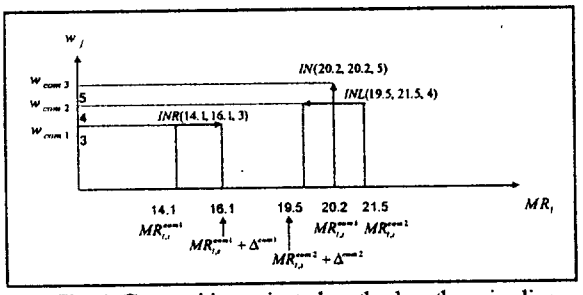
For an example, let us extend problem-2 with 3 competitors. The objective price image of 3 competitors are stored in the knowledge base as Figure3.

If we show the constraints made from competition-oriented method on the price line, it is represented as Figure4

In spite of mathematical demand-oriented method, we introduce the qualitative demand-oriented method using experts' knowledge. When we use qualitative demand-oriented method, we do not use price response function and price elasticity data. But we use the sense of experts to decide direction of price change.

{{ COMPETITOR-1
IS-A : COMPETITOR
COMPETITOR-OF: STORE-1
DESCRIPTION : RETAILER-A
PRICE-IMAGE : lower }}
{{ COMPETITOR-2
IS-A : COMPETITOR
COMPETITOR-OF: STORE-1
DESCRIPTION : RETAILER-B
PRICE-IMAGE : higher }}
{{ COMPETITOR-3
IS-A : COMPETITOR
COMPETITOR-OF: STORE-1
DESCRIPTION : RETAILER-C
PRICE-IMAGE : same}}

Fig..3. Competitors in knowledge base



.Fig..4. Competition-oriented method on the price line

Experts have sense or insight of whether to markdown or to add markup. Retail managers can guess the direction of price change for the improvement of profit or sales objectives. In store, usually retail managers use qualitative demand-oriented method with change of display space of the item.

If we represent the constraints made from qualitative demand-oriented method on the price line, it is depicted as Figure5. And, if we represent the constraints made from 3 pricing methods and other reference points on the price line, it is depicted as Figure6.

To set the price of an item, we should select a point that has the largest influence to be the price of next period. The span of influence is represented as the length of interval, and the strength of influence is represented as the height of interval. To build a combined pricing method, we should propose an algorithm to resolve the conflict sets.

3. The Structure of KAPA

Architecture of KAPA In the previous section we have

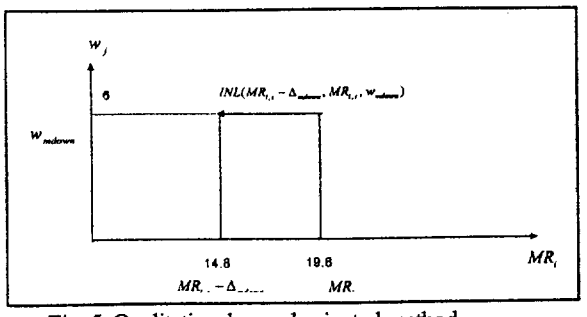


Fig. 5. Qualitative demand-oriented method

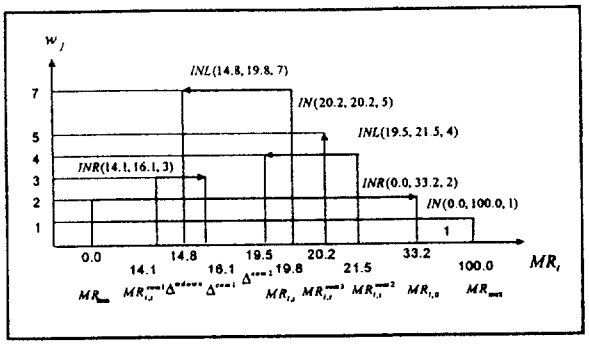


Fig. 6. Conflicts set on the price line

proposed a concept of combined pricing method. To realize the proposed concept, we have developed UNIK-KAPA(Knowledge-Assisted Pricing Advisor). The architecture of UNIK-KAPA is as Fig. 7.

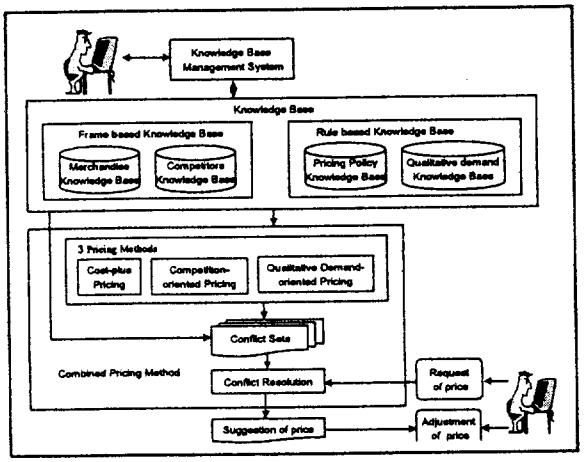


Fig.7. The architecture of UNIK-KAPA

Knowledge base management system In the knowledge base, there are two kinds of knowledge, general knowledge and firm-specific knowledge. General knowledge is the knowledge of general market of the industry. The firm-specific knowledge is the knowledge about the market that a firm is confronted. The sources of general knowledge are published materials, such as books and journals. The sources of firm-specific knowledge are market research and data analysis of the firm. The examples of firm-specific

knowledge are competitors' prices and pricing policy of the firm.

Point Determination Algorithm The criterion for an optimal point we adopted is the highest weight from the interval of highest accumulated weight. We named the reasoning algorithm as "Point Determination Algorithm. "

The overview of pricing process we have devised is as follows. The first phase is initialization phase. This phase is done when the system is introduced to the retail store. In this phase, we set the basic coefficients of the system, such as weights, differences from competitors, the size of price change, and global maximum and minimum. In the second phase, we apply pricing methods and rules to make conflicts set. From the second phase, the reasoning process is applied item by item. In the third phase, we find the most overlapping intersection from the intervals to resolve the conflicts. In the fourth phase, we find the appropriate point with highest weight from the candidate intersection.

4. Validation of the System

We wanted to show the conformity of the system with 53 experts who have experience from 1 year to 15 years. Their average experience was 6 years. As a measure of validation, we measure the hit ratio of KAPA system with the experts' answers. In 69 cases out of 76 test cases, KAPA gave the same price with the mode of experts' answers.

5. Conclusion

Contributions In this paper we have proposed a knowledge-based system architecture for retail pricing. In the development of KAPA we have proposed a concept of combined pricing method for retail pricing. And we have proposed a knowledge representation scheme for retail pricing. As a reasoning algorithm for combined pricing method, we have proposed the point determination algorithm. And we have shown that the algorithm can do pricing as experts do by questionnaire.

Further research directions Further research directions are as follows. First, machine learning from analysis of POS database will help data mining in retail industry. Machine learning can produce knowledge such as condition of price change, direction of price change, and size of price change. Second the combined pricing method can be applied to other industry in price competition. Third, the point determination algorithm can be applied to other problems of temporal reasoning, if the constraints car. have weights.

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