A Study on the Construction of Intelligent Distribution Management System for Efficient Distribution of Agricultural Products

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***Abstract*- Electronic Commerce has been rapidly applied to various commercial transactions as an effective product distribution management method. But, agricultural products have different features from other ordinary commercial products. Those features make it difficult to apply agricultural products to the Electronic Commerce system. This paper proposes an Intelligent Agricultural Products Distribution Management System to solve problems prompted by those commercial features of agricultural products. This system forecasts the demands through purchase pattern analysis from the aspects of customers and analyzes the supply situations of producers and distributors from the aspects of suppliers. Then, this system automatically provides customers and suppliers with the needed information based on the forecasted demands and the supply situations. This system informs producers and distributors the appropriate production amount and distribution period according to the forecasted demand amounts while informing customers the current supply situations as well as the proper purchasing period and place. By providing customers and suppliers with those kinds of information, this system balances the demands and supplies and manages the efficient distribution system of agricultural products.**

Ⅰ. Introduction

Development of internet makes conventional commercial activities free from the boundary of time and space. This kind of commercial activity is called Electronic Commerce. Development of Electronic Commerce draws tremendous interest from every nation and is progressively conducted as a key strategy for survival in this unlimited competitive business environment[1].

GVU(Graphics, Visualization & Usability) center conducted a survey on purchasing experience through Electronic Commerce with 645 users. The result says that most products they purchased are processed products or manufactured products while the portion of agricultural products is very low [2]. The reasons for those results are related to two obstacle factors classified into quality and supply problems as followings.

First, quality features of agricultural products pose several problems. Even though there are some differences between types or kinds of each agricultural products, the quality of those products get deteriorated and finally lost their commercial value after a certain time as time passes after shipping. In Electronic Commerce, if goods are shipped after an order was placed to provide better quality, it will take a significant time to respond to the needs of customers. Also, for a quick response to the needs of customer, if goods are prepared and stored, the quality of goods will be deteriorated and customer will purchase the deteriorated goods according to the purchasing time.

Second, it is related to supply matters. Agricultural products are relied on natural conditions and amount of those products cannot be controlled manually. Because of this, it takes so many hours to adjust unstable supply or to reproduce the needed products. To solve those problems and to make an efficient distribution system of agricultural products, several studies are needed.

This paper proposes the Intelligent Agricultural Products Distribution Management System(IAPDMS) of agricultural products to solve those problems. First, this system forecasts future demands of customers by extracting purchasing pattern through data mining from customer transaction data. Second, this system analyzes supply amount and price of agricultural products at the trading market of producers and distributors by regions and periods. Last, this system adjusts supply amount and period fit to the forecasted demand based on the analyzed data on demand forecasting and supply situations to make it possible to balance between demands and supplies and to manage efficient distribution system for agricultural products.

Ⅱ. The structure of the IAPDMS

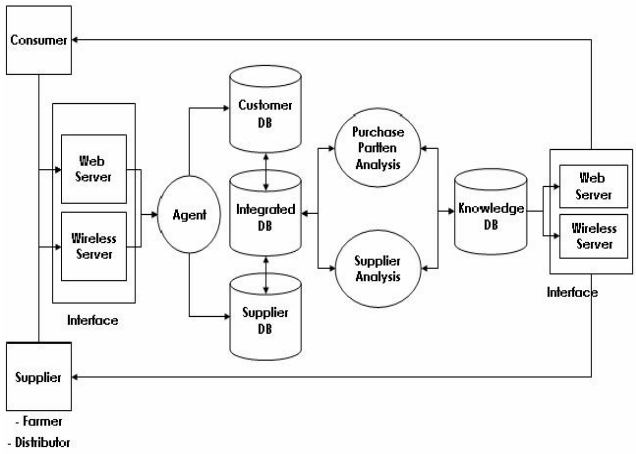

Fig.1 Intelligent Agricultural Products Distribution Management System

The structure of the IAPDMS proposed by this paper is shown in Fig. 1. This is composed by two analysis modules regarding the production of agricultural products and related parties to distribution of agricultural products, such as customer, farmer, and workers for agricultural market and agricultural industries. These two analysis modules divide into purchase pattern analysis module on the customer's side and supply analysis module on the supplier's side.

The purchase pattern analysis module on the customer's side is focusing on the forecasting of customer's purchase and demand. It analyzes customer's agricultural product transaction data by utilizing data mining method.

The supply analysis module on the supplier's side is focusing on the analysis of supply situations. It analyzes using CBR (Case Based Reasoning)[5-7].

Ⅲ. Composition module of IAPDMS

A. Purchase pattern analysis module

1) The outline of purchase pattern analysis module

Purchase pattern analysis module analyzes combining transaction data, market data, production data and consumer data. First of all, the purchase pattern analysis is conducted through data mining based on the transaction data which include consumer price, purchase quantity, customer information and transaction history. At this time, the analysis of purchase pattern analysis is conducted by following order.

<Step 1> By using market information by region from market data, customer is categorized by market. And it is analyzed to understand the characteristics and purchase pattern.

<Step 2> By grouping and analyzing customers whose same particular propensity using customer data, the purchase pattern is assured by customer group which has same propensity.

<Step 3> By grouping agricultural products according to their characteristics using item information of production data, customers' purchase pattern on such products is acknowledged.

Through these purchase pattern analysis, the demand by item as well as the forecasting about the demand of customer in each regional market can be forecasted.

2) The process of purchase pattern analysis

The process of analysis for data mining method, which is for the purchase pattern analysis proposed by this study, is accompanied by data mining method using Fuzzy Structure Modeling(FSM) as well as general data mining method. The reason why the data mining method using FSM was proposed is because of the quality characteristics of agricultural products. Conventional data mining method needs large amount of data to secure accuracy. However, the quality of agricultural is lowered as time goes by, so the quality characteristics of agricultural products require analysis on the information in the short term. Therefore, it is hard to secure enough data, if the conventional data mining method is used.

FSM method, proposed by Tazaki, et al., is to recognize the structure of the system which combined multi-dimensional value. The structuralization of system extract and sort factors which deem to form such objective system by reasonable method. The extracted factors from the relationship of context becomes hierarchy. The subordinate relationship of factors between class or in class is determined, and then it is shown as a graph[8].

This study regards the purchase pattern of customers as one system as seen in Fig. 2, and it analyzes the before-after relationship of products which constitute the system as hierarchy.

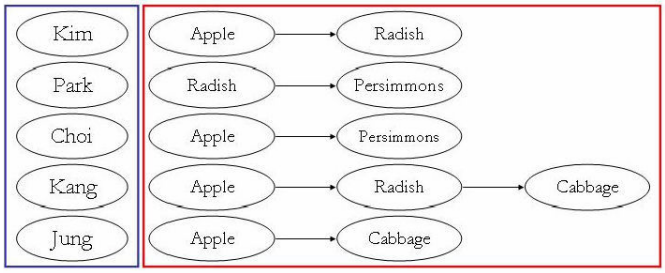

Fig. 2 Definition of Fuzzy Environment for Customer Action Analysis

a. Data cleaning and transformation

Before data mining, it is needed to eliminate and arrange unnecessary data for the purpose of the analysis. In this study, the transaction data is formed to conform the purpose of purchase pattern analysis beforehand. And to bring in FSM, fuzzy subordination matrix is constructed using equation (1) proposed by this paper.

$$A_{ij} = (j_t) / ((i_t) + (j_t)) \quad (1)$$

i : The number of customers who purchase product i

j : The number of customers who purchase product j

t : Certain period of analysis subject

That is, fuzzy subordination matrix can be obtained by dividing the number of customers who purchase product j for certain period of analysis subject by the total number of the customers who purchase product i and j for the certain period.

b. Clustering

Clustering performs the function which extract the association between the products and customers. From the result of clustering, each clustering represents the association of customer vs. purchased products. Therefore, because the group of products categorized by same cluster have similar customers,

such event like joint marketing can be conducted. In this study, Self Organizing Map(SOM)[9-11] is used for the method of clustering.

c. Association rules analysis and sequence pattern analysis

Association rules analysis analyzes the static association of certain periods between products. In this study, fuzzy subordination matrix was constituted from data cleaning and transformation not using correlation which had been used by traditional association rules analysis. And it analyzed the purchase pattern using FSM method.

The result of this association rules analysis can be used for various purposes such as inventory management, that is, controlling inventories between products related to the distribution of agricultural products or product management, that is, recommending related products to same type of customers who purchased a product.

The order of relationship analysis using FSM is as following.

<Step 1> The purchased products is extracted by customer as shown in Table 1.

<Step 2> Fuzzy subordinate matrix is made by extracted transaction information and equation (1) is shown in Table 2.

Table 1 Purchase data of customers

Customer	Purchased products
Kim	(Apple, Radish)
Park	(Radish, Persimmons)
Choi	(Apple, Persimmons)
Lee	(Apple, Radish, Cabbage)
Soh	(Apple, Cabbage)

Table 2 Fuzzy subordination matrix

	Apple	Radish	Persimmons	Cabbage
Apple	1	3/7	1/3	1/3
Radish	4/7	1	2/5	2/5
Persimmons	2/3	3/5	1	1/2
Cabbage	2/3	3/5	1/2	1

Table 3 Result of FSM analysis (p=0.55, λ=-0.5)

Level	Item	Give influence	Take influence
Top	Apple	None	Persimmons
Intermediate	Persimmons	None	None
Bottom	Cabbage	Apple Persimmons	None
Independent	Radish	None	None

The fuzzy subordinate matrix of Table 2 is analyzed by FSM method. Table 3 and 4 can be obtained as the results of analysis.

Table 4 Result of FSM analysis (p=0.55, λ=0.5)

Level	Item	Give influence	Take influence
Top	Apple	None	Persimmons Cabbage
Intermediate	Persimmons	None	None
Bottom level	Cabbage	None	None
Independent	Radish	None	None

p is threshold value, real number given on the semi-interval (0,1]. λ is fuzzy structural parameter which is given as $-1 < \lambda < \infty$.

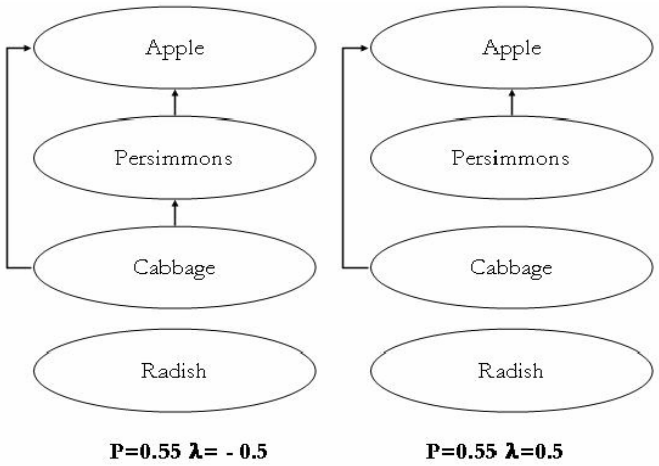

Fig. 3 Structure of customer purchase pattern in FSM analysis

The structure of customer purchase pattern is shown in Fig. 3. This shows how purchasing one product affects which products' purchase next. In Fig. 3, we are known that the pattern of customer who purchase cabbage or persimmons purchase apple. It is same the result of conventional data mining method. Also, in the conventional method, sequence pattern analysis had to be conducted separately. But if FSM method is used, association rules analysis and sequence pattern analysis can be conducted simultaneously.

In this paper, time t of association rules analysis was connected consecutively to analyze the flow as a whole. As the concept of dynamic time is added to the basic before-after relations of purchasing products appeared in association rules analysis, the needed time for the purchasing can be extracted.

d. Demand forecasting

The demand will be forecasted through the purchase pattern of the same type customers. The reason why this forecasting is important is because this is the most important information to

manage product and inventory, which is getting important as Electronic Commerce users are increasing.

B. Supply analysis module

While the purchase pattern analysis module is the analysis about the forecasting of demand, the supply analysis module is the analysis about the supply such as, how much it is produced and supplied. In this paper, the supply analysis is conducted by clustering agricultural products and cost sensitivity analysis.

1) Clustering agricultural products

The clustering agricultural products for supply analysis has to consider the characteristics of the agricultural products. Clustering agricultural products means clustering kind of using production data by region. In here, SOM was used for the clustering method. By clustering production data which includes producer, production item, production status, production quantity, the regional production quantity is determined.

2) Cost sensitivity analysis

Cost sensitivity analysis uses data of agricultural markets by distribution stages. In this data, sales year and date, time, name, price and producer are included. The trend graph for price and transaction quantity by each items can be drawn. Also, by using each price trend graph and transaction quantity trend graph, the change of transaction quantity versus price can be found. If this price trend graph or transaction quantity graph are used, the decision making, which control short-term production volume, can be supported. The producer is possible to decrease the supply where the price is falling upon the 'demand-supply theory', and increase supply where the price is climbing. Therefore, controlling the supply time and quantity becomes possible.

C. Knowledge database

Conventional agricultural products distribution management system, which only collects information regarding supply, can balance short-term demand and supply by distributing supply quantity by region and times. But because it doesn't have any information about the demand of customers, it is difficult to solve long-term and original problem by controlling supply quantities according to demand. This paper connected the forecasting of demand volume on the customer's side to the analysis of supply volume on the supplier's side.

As the forecasting of demand on the customer's side connects, the IAPDMS proposed by this paper can suggest recommendation of product item or production schedule using CBR based on the customer database and supply data base.

Knowledge database of Fig. 1 is the core of the CBR.

The information produced by the result of analysis of purchase pattern and supply from the IAPDMS proposed by this paper, can present the recommendation of product item and production schedule to support production while comparing it with similar cases accumulated in the knowledge data base.

This knowledge database recommends the product item by region and producers based on the forecasted demand and supply quantities after it check oversupplied item and undersupplied item and information to support production. Also this recommendation information is stored in the knowledge data base, and will be used for a similar case.

Ⅳ. Conclusion

As new type of commercial activities such as Electronic Commerce have been developed, the distribution method of products is more diverse and effective. However, the distribution of the agricultural products are not getting effective and the size of transaction is smaller than other products relatively thanks to its characteristics.

In this paper, to realize the effective distribution, the IAPDMS was proposed to solve the problem of quality and supply, which are two obstacles interrupt smooth distribution of agricultural products.

This system is constituted by two modules; first, on the customer's side, it is possible to forecast the demand through purchase pattern analysis module about the customer. And on the supplier's side, there is supply analysis module which analyzes the production and supply of agricultural products based on the information about the producer, distributor and production companies of agricultural products. In this paper, the model for the IAPDMS was proposed to realize effective distribution management through the forecasting for customer's demand and supply analysis of supplier.

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