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A proposal of support system for product development in pickles on *Kansei* engineering

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1. Introduction

In background, recent advanced information technologies are focused on techniques for retrieving useful business information from accumulated previous many data. Though, some researches for product developments in the food industry, particularly in pickles trade, have often depended on intuitions, and are not also sufficiently great to utilize such data and previous experiences. Especially, as the sense of taste is often a vague concept, it is difficult to extract such product features as popularity and sales trends in the evaluation of food. Therefore, we focus on data processing on *kansei* engineering to build a new support system for product development and its evaluation processing of pickles commodities.
From these viepoints, this paper examines a new product approach based on various emotional data of human being, such as on *kansei* engineering, to improve the traditional processing on intuition and previous experiences for product development in the food industry. This approach uses a neural network, which is composed of data trains from the actual products ranked for large sales or poor sales. At first, each input data for neural network is transformed into a numerical value from product data which mean taste, appearance, slicing and the other 6 items based on market research in advance(Endo, 2005, 2005, 2006). The output data are also classified into 3 items corresponding to sales figures based on the total sales of all products. Next, the neural network is trained using the data group for learning. Thereafter, the data group for verification is also evaluated using the trained neutral network, and the probability of appropriate evaluation is examined. Each group has 150 product data in this experiment. In the experiment, all previous product data are randomly classified into

the data group for learning or for verification respectively. And, the system reliance is examined on the extent of coincidence between the results yielded by the system and the current impressions of the goods according to 50 subject members' market assessment. The statistical test methods (Asai, 2004), such as Wilcoxon test, show there is little difference in the results between sales rank obtained by using the system and goods image by user impression. These results mean that the higher the sales ranks to products assigned by the system, the better the user impressions to goods on the purchase of pickles. As the results, this system is useful for developing and evaluating tool of goods for large sales trends. Based on these results, This paper says that our prototype system is available to the new support system for product development, and it is expected to be applied to product development toward a new direction in the food industry in the future.

2. Review of pickle industry and business environment in Japan

Pickling has a long history in Japanese cuisine. It has been applied to *takuan* (radish) for a side dish in meal sets or bowl foods, *umeboshi* (plum) filling in rice balls, and *gari* (pickled ginger) on the side in sushi and other foods. Up to now, pickles are a traditional food for which indicators for assessing market success remain to be vague. Therefore, it will have to re-analyze its data on customers' tastes and actions, attract new customers, identify the direction for its products, and predict the next successful products.This report describes an attempt to create a new product development system that provides quantitative and simple assessments of products. Moreover, it is also one purpose this system employs a database of consumers' *kansei*.

3. Objective of research

This report makes some observations of the pickle industry and attempts to construct a quantitative and simple support system for evaluating the developing products and evaluating their marketability. One of the features of this system is that it was specifically designed for analysis of product development based on evaluations by human tastes and *kansei*. After this system was completed, the results were compared with those from surveys of consumers' impressions and subjective observations of products for comparison to verify whether the system is effective. The creation of this system has created an opportunity to review legacy data and to establish an index for understanding consumers' tastes. This system is expected to contribute to product development in the near future.

4. Proposal of support system for product development

4.1 Design of the assessment system

A new product development support system was constructed using a neural network (NN) as the basis for analysis(Kitahara, 2003). NNs are often able to extract meaningful information out of large volumes of data. The product data in the NN training signal that provided NN teaching was a collection of varied information about products developed in the past. The input items were spicing, price and product type, and there were two output items: the market share of the product and ranking (A, B or C). A three-layer NN with learning by back propagation was employed in order to carry out the analysis as simply and efficiently as possible.

4.2 Selection of input items

In the opening of this research, we tried to investigate the classifications of input data that would be needed to create a new product evaluation system based on *kansei*.

The data would chiefly be provided by surveys of young people, who will become the next generation of pickle consumers. The survey was designed to assist producers in developing products and addressed the 14 factors that young consumers are believed to consider when they select items in the market. The survey asked respondents to mark the factors "Primary," "Secondary" or "Tertiary"; the analyst scored each response as 3, 2 and 1 points, respectively. The survey population was mainly university students and there were 177 respondents of both sexes. These results were used, along with elements added by the developers, to select appropriate categories for input into the NN. Other data items that have been recorded during product development as key to marketability were added to the final selection of inputs. Table I provides the list of selected classifications in input items.

Table I: Input Items

<table>
<tr><th>Category</th><th>Input items</th><th>Score type</th></tr>
<tr><td>Customer</td><td>Store</td><td>Categorical values</td></tr>
<tr><td>Ingredients</td><td>Ingredient</td><td>Categorical values</td></tr>
<tr><td rowspan="2">Ingredient amount</td><td>Solid weight</td><td rowspan="2">Continuous values</td></tr>
<tr><td>Fluid weight</td></tr>
<tr><td rowspan="2">Processing method</td><td>Slicing type</td><td rowspan="2">Categorical values</td></tr>
<tr><td>Size</td></tr>
<tr><td rowspan="2">Additives</td><td>Preservatives</td><td rowspan="2">Categorical values</td></tr>
<tr><td>Dyes</td></tr>
<tr><td rowspan="3">Spicing</td><td>Saltiness</td><td rowspan="3">Continuous values</td></tr>
<tr><td>Acidity</td></tr>
<tr><td>Sweetness</td></tr>
<tr><td>Price</td><td>Mean price</td><td>Continuous values</td></tr>
<tr><td>Amount shipped</td><td>Amount shipped</td><td>Continuous values</td></tr>
</table>

4.3 Selection of output items

Many our sales data for already existing products were used to determine the output items from the NN in this system. The sales share of each product was extracted from the data and each product was classified into rank A, B or C according to the size of its market share. This system was used to determine what elements of each of the low-ranking products needed to be improved and the extent of its role in the increase in profits was estimated.

4.4 Normalizing data

The input data used in this evaluation system were digitized for entry into the NN. For the input items of the categories of Customer, Ingredients, Processing method and Additives, input data was created by assigning specific values to each choice as a category value. The continuous values employed to describe the Ingredient amount, Amount shipped, Additives, and Seasoning were digitized to allow comparison of the ranges of the different categories. Equation (1) is the conversion method that uses the minimum and maximum observed values for each item.

$$P = \frac{Q - R_{\min}}{R_{\max} - R_{\min} + 1} \quad \ldots (1)$$

Here, P is the input datum and Q is the input item. Generally, Rmax and Rmin are the maximum and minimum for calculations within the range of values observed. Then, the input data for a NN must have values in the range [0,1], and no weighting was applied to the values in different categories during the digitization in the initial stage. Weighting is varied automatically during learning in the back-propagation learning algorithm.

5. Prototype system for assessment

5.1 Definition and classification of data

As defined in Section 4 above, the 13 digitized groups of input item data for each product were defined as a single input data set. The data set input as the teaching signal in the NN was defined as the training data set. The training data set for each product incorporated a single input data set and the sales ranking of A, B or C for the product. The input data set for execution in the trained network was defined as the validation data set. No sales ranking data were included in the validation data set. Data were prepared for a total of 300 products; 150 of these were training data sets and 150 were validation data sets. The sets were randomly assigned to one group or the other.

5.2 Learning by the neural network

The number of hidden layers in the NN was found by adding the total number of input features to the total number of output features and dividing by two. The output layer showed three responses (in the range [0,1]) corresponding to the product ranking (A, B or C). The response with the highest value was the assessed ranking. The convergence conditions for this NN were a maximum of 20,000 training iterations and a minimum-square error of 0.01. The learning rate η and momentum constant α were varied by the appropriate amounts as found empirically. The PC on which the operation was performed had a 2.6 GHz Pentium 4 CPU and 512 MB of memory and ran on Windows. The training data sets were entered with the product rankings into the NN for each of the 150 randomly chosen products and training was initiated.

5.3 Verification of the effectiveness of the neural network

Once the training of the NN was complete, the validation data sets for the remaining 150 products were loaded and the product rankings were output. Table II shows the output results of the products for comparison with their actual rankings. The gray portions of the table indicate the probability of a correct assessment.

5.4 Observations

The mean rate for correct prediction of product ranking was 80%. This system can be described as providing estimates with a high degree of accuracy. However, there was a somewhat high fraction of rank A products which had been underestimated as rank B. This can be explained as follows. The product rank, which was the output, was defined by the sales market share. If the high-selling products account for a large fraction of the total sales, it then follows that the number of high-selling products is lower than the number of other products. It appears that the NN was not allowed to perform enough learning. Future analyses must have higher numbers of training data sets; also, the sales shares, which are the basis for the output items, must be re-analyzed in order to improve the precision of the assessment.

Table II: Verification Results by Ranking

		Output results		
		A	B	C
Actual product ranking	A	76%	22%	2%
	B	15%	79%	6%
	C	6%	9%	85%

6. Market survey from the *Kansei* viewpoint

6.1 Survey of impressions of the product

It is essential to survey consumers to find the basis on which they decide to buy any given actual product in order to assess that product. Therefore, the authors polled consumers to obtain their *kansei*-based views of actual products. The subjects were shown samples of 24 products with the price tags attached and asked to choose which products (multiple products) they wanted to buy and which ones they did not want to buy. They were then asked to write down at least five reasons for their selections. The subjects were 24 men and women in their twenties and thirties.

6.2 Setting the assessment terminology

The written responses as to why the subjects wanted or did not want to buy the products allowed the authors to classify the reasons into personal likes/dislikes, taste, price, volume, appearance, packaging, and convenience. The fact that the reasons were classifiable meant that it was possible to limit the elements used for assessing the products during the selection. Therefore, the factors most frequently mentioned in the responses were picked out and a list of assessment terminology was selected. This list was used in all further analyses. These terms can be considered as critical factors when assessing products. The selected terminology is shown in Table III.

Table III: Terminology for Assessment

Like	—	Dislike
Looks good	—	Looks unappetizing
Expensive	—	Inexpensive
Plenty of volume	—	Skimpy volume
Looks tough	—	Looks tender
Attractive	—	Unattractive
Good design	—	Bad design
Looks easy to eat	—	Looks difficult to eat

7. Experiments in support system for product development

This system employed past data for training, so it was appropriate to carry out further investigation of its applicability for product development. Some product samples developed with this system were assessed with the system; then, consumers were polled for their impressions of the products. The results of this system were compared with those of a conventional consumer poll, and the effectiveness of this system was verified.

7.1 Product assessment using this assessment system

In contrast to the data used to create this system (Section 5), six newly developed samples were prepared for assessment with this system. The samples were pickled ginger and plums. Figure (1) is a photograph of the newly developed products and Table IV provides the assessment results. This system placed samples 1 and 4 in rank A, 2 and 5 in rank B, and 3 and 6 in rank C.

Figure (1): Photograph of Product Samples
Above, from left : Samples 1-3
Below, from left : Samples 4-6

Table IV: Results of Assessment with the System

	Ranking according to assessment system		
	A	B	C
Product samples	No.1	No.2	No.3
	No.4	No.5	No.6

7.2 Product assessment from the *Kansei* viewpoint

The new product samples described in Section 7.1 were assessed with the terminology given in Section 6 and the consumers' impressions of them were analyzed by the semantic differential (SD) test. The effectiveness of the system was verified by comparing the results of the above survey with those gathered using this system. Price tags were attached to the samples for the experiment, as shown in Fig. (1). Fifty males and females in their twenties and thirties were employed as subjects. A maximum of three people were polled at the same time. They were shown one sample of each product in a random pattern in order to avoid biases in the order of display. The survey form showed seven stages of reaction to the product, allowing the subjects to give their responses such as "Extremely," "Fairly" or "A little" for each response term, or "Neutral". The subjects circled the level of response for each term to show their impressions.Figure (2) shows an example sheet of the responses.

7.3 Results of written survey

Values of –3 to +3 were assigned to the seven levels to digitize the responses given on the survey forms and mean values were found for each response classification describing the products. The products were of differing ranks. The Wilcoxon signed rank test was used to compare between ranks. Table V shows the differences in impressions between the ranks that were indicated by the test, but only the assessment terminology for which the subjects indicated strong differences in their choice of terminology are shown. The figures in parentheses show the statistical significance of

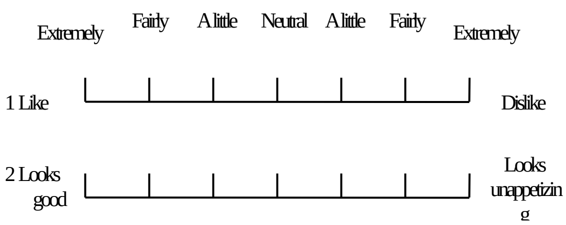

Figure (2): Example of the Survey form

the difference. In this survey, it was decided to exclude scores given for "Expensive," "Plenty of volume" and "Looks tough," as the assessment of these factors seemed likely to vary too greatly with the sample. In the comparison between rank A and rank B items, the rank A items scored more highly on the factors of "Attractive" and

"Good design." Rank A items stood out more sharply in the A/B/C comparison; they scored higher on every one of the factors. Rank B items significantly outscored rank C items for the factors of "Looks good," "Attractive" and "Good design."

Table V: Results of Wilcoxon Signed Rank Test (Significance)

		Comparison between ranks		
		A/B	A/C	B/D
Assessment terminology	Like		A(1%)	
	Looks good		A(1%)	B(1%)
	Attractive	A(5%)	A(1%)	B(1%)
	Good design	A(1%)	A(1%)	B(1%)
	Looks easy to eat	B(1%)	A(1%)	

7.4 Considerations

It was shown in this system that the higher the rank of the item, the better impression it made on the consumer. These results indicate that the predictions of this assessment system match with consumers' *kansei* in terms of their desire to buy the products. Therefore, it appears that it is possible to use this system as an indicator for ranking products. Also, as shown in Figure (3), when a product has been predicted to show low sales, the product parameters can be changed and the system can be re-used in another cycle of assessments. This system seems to have much potential to contribute to the development of products with high sales, and will help makers wean themselves from dependence on experience and intuition in product development.

8. Conclusion

This report describes an attempt to create a neural network-based product development support system for the pickle industry, whose producers have depended on experience and intuition for developing new products. A new development method employing a database was investigated for its effectiveness as an indicator of product marketability.

First, an assessment system based on an NN was designed and its reliability was verified in analyses of many data. An experiment examined the extent to which the rankings predicted by this system matched with the actual historical rankings of products according to previous market research data, and the results verified that the system was effective. Next, a market survey of consumers was carried out and an

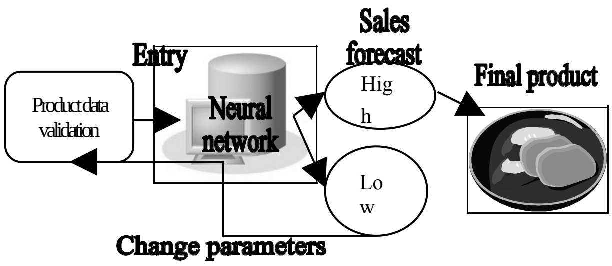

Figure (3): Product Development Support System

original system of assessment terminology was selected to be used in creating a new product assessment and analysis system. The results provided by the product assessment by this system were compared with the results of a subjective evaluation by consumers using the same assessment system. This showed that the higher the ranking for a product by this system, the more the consumers were interested in buying it. This indicates a strong relation of *kansei* assessments by consumers with the product development support system proposed in this study; thus this system was shown to be very effective. This means that this system can be expected to provide quantitative and speedy estimates of sales. In conclusion, our prototype system is available to the new support system for product development toward a new direction in the pickles industry in the future by improving the traditional processing on intuition and previous experiences for product development in the food industry.

Remaining challenges include more improving the precision for evaluations with increased numbers of data groups for learning in neutral network. Another essential issue is to survey the actual course of sales of products developed under the guidance of this system. The authors look forward to seeing this system contribute to the creation of successful products that satisfy customers.

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