A Proposal of a Model using Kansei Evaluation integrated with Fuzzy Rules and Self-Organizing Map for Evaluation of Bio-Food Products

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Abstract. Agricultural product intelligence is a new way for biotechnology that can be made multiple food products with a variety of characteristics, enhanced flavor and nutritional quality of foods. To evaluate food products of bio-food products for improvement of the food quality in global bio-food markets, cross-cultural customer behaviors are mostly influenced with healthy food in global markets. In this study, we propose a new approach using *Kansei* Evaluation integrated with fuzzy rules and Self-Organizing Map (SOM) model, together with customers and expert sensibilities and preferences for selection of the appropriate alternatives (bio-food and food technology), matched with mass customer and expert group behaviors. To confirm the model's performance, the proposed approach has been tested in experiments for the validated model and applied in several domains in Asian countries.

Keywords: Kansei Evaluation, Food Biotechnology, Bio-food Evaluation, fuzzy rules, Self-Organizing Maps

1 Introduction

The potential food biotechnology is a key biotechnology engineering to produce good bio-food, attractive marketing, or healthy nutrition in daily life. Food biotechnology has been widely produced healthy foods in daily life [1]. Food biotechnology is one of the ways quickly producing fresh foods and improving quality. Researchers need to determine if each potential new food product will be a useful, beneficial and safe development. Customers and consumers would be expected good food products as well as quality foods. In conventional methods [1] [2] [5] [6], most approaches have been investigated bio-food evaluation of good features based on food factory standards. However, the weaken points of

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these approaches using group customer/expert sensibilities and preferences are not aggregated concurrently that affects to evaluate a bio-food quality in terms of customer feedbacks. In food biology evaluation, Kansei evaluation makes it possible to quantify expert and customer perception, sensation, cognition, sentiment, and impression about food quality [3]. In Kansei Evaluation, we have determined adjective pairs called Kansei words in pairs: Synonym - Antonym, Synonym - Not Synonym. For instance, the pairs of adjectives "good - bad"and "satisfied- not satisfied"are Kansei words. Emotions are part of human behavior in certain sensibilities that affect human final decisions [3]. Collaborative Decision Making (CDM) can be defined as a decision problem with the selection of alternatives, using CDM obtains dynamic decision solutions talking into account these preferences. Self-Organizing Maps (SOMs) were invented by Kohonen as a computational method for the visualization of high-dimensional data [4]. The study in this paper is to solve the existing problems in a dynamic evaluation of the appropriate alternatives (bio-food, food technology and food product) in dynamic markets. The aim of proposed approach is to evaluate alternatives (bio-food, food technology and food products), using Collaborative Decision Making (CDM), together with expert sensibilities and emotions. The advantages of the proposed approach are presented in this paper by dealing with multi-cultural customers in market dynamics as follows: 1) qualitative factors with uncertainty in dynamic market conditions, consisting of expert preferences are considered through the model; 2) the framework is used to quantify expert's sensibilities and emotions using collaborative decision making decisions. To confirm the model's performance, the proposed system has been validated by experimental results for the demonstration of this study.

2 Kansei Evaluation in quantification of human sensibility and behavior

2.1 *Kansei* word matrix construction

In the preliminary experiment, the surveys were done by 30 customers including local, international students and experts from Hanoi Fresh Vegetable and Fruit Institute with export companies for the markets. There were 5 experts and 25 customers who participated in the surveys for selection of 14 adjectives as pairs of *Kansei* words in total of 16 *Kansei* words influenced to these criteria. In the final data collection, we have selected 14 *Kansei* words of the most relevant words with redundance of 02 *Kansei* words using Factor Analysis that are influenced to these criteria for evaluation of biology-food products, as shown in Table 1.

A *Kansei* matrix is constructed using *Kansei* words for the steps as follows:

1. Collect customer surveys in the preliminary experiment using Semantic Differential (SD) method with a five-point scale definition (0: *oppose*, 0.25: *almost oppose*, 0.5: *have no preference*, 0.75: *almost agree*, 1: *agree*).
2. Consider the most appropriate *Kansei* words in the bio-food market belonging to *Kansei* criteria evaluation.

3. Structure *Kansei* words using Factor Analysis to identify conditional factor loadings and commonalities in the model.
4. Select the most appropriate *Kansei* words and construct a *Kansei* matrix from the average of *Kansei* weights.
5. Update *Kansei* weights to the *Kansei* matrix in a Database.

Table 1. Pairs of *Kansei* words for *Kansei* evaluation

No	Positive word	Negative word	Factor	Criteria Evaluation
1	Good	Not good	Product name	Product Information
2	Pleasant	Unpleasant	Bio-food product	
3	Famous	Not famous	Brand name	
4	Flavor	Not flavor	Customer satisfactory	
5	Cheap	Expensive	Bio-food Price	
6	Satisfactory	Not satisfactory	Product quality	Product quality
7	Low	High	Customer satisfactory	
8	Acceptable	Not acceptable	International standard	
9	Satisfactory	Unsatisfactory	Customer behavior	
10	Global	Local	International market	Markets
11	Stable	Changing	Asian market	
12	Standing	Falling	Government market	
13	Liked	Disliked	Asian culture	Culture
14	Preferable	Not preferable	Vietnamese culture	

2.2 *Kansei* matrix evaluation

Let $X^S = \{X_1^S, X_2^S, ..., X_m^S\}$ be a set of *Kansei* words that use to evaluate bio-food products, where m is the number of *Kansei* words. In order to quantify customer's sensibilities in evaluating bio-food products, we have refined for the most important *Kansei* words in X^S to evaluate a bio-food product with respect to criteria in stock market S.

Let $W_m^S = \{W_m^-, W_m^+\}$ be opposite pairs of *Kansei* words with respect to X_m^S. Let P customers collect their preferences by surveys. To evaluate bio-food product C_j^S, its *Kansei* weight w_{ij}^t represents by the *i-th Kansei* word of the *j-th* bio-food product evaluated by the *t-th* expert. Hence, the average weight of *i-th Kanse*i word is evaluated by P customers, as given by Eq.(1).

$$k_{ij}^S = \frac{1}{P} \sum_{t=1}^{P} w_{ij}^t \qquad (1)$$

$K^S_{n\times m} = (k^S_{ij})_{(n\times m)}$ is a *Kansei* matrix construction, where n and m is the number of bio-food products and *Kansei* words respectively. Table 2 illustrates a sample of the *Kansei* matrix consisting of alternatives in *Kansei* evaluation.

Table 2. The *Kansei* score matrix in an evaluation

ID No	X^S_1	X^S_2	**...**	X^S_{16}	**Bio-food product**
1	k_{11}	k_{12}	**...**	k_{1m}	P_1
...	**...**	**...**	**...**	**...**	**...**
n	k_{n1}	k_{n2}	**...**	k_{nm}	P_n

3 Proposed approach

3.1 Human emotions in decision making

Human emotions in decision making can be presented as an integration of logical rules, quantitative knowledge and reasoning evidence. Figure 1 shows the quantification of expert sensibilities and emotions.

In common sense human reasoning, linguistic expressions represent rules for expert decision situations. To quantify emotions and sensibilities in reasoning of expert in dynamic market environments, we use fuzzy rules as illustrations of an example as follows:
Rule 1: IF Japanese people prefer an organic apple juice with its red color AND satisfaction with its fresh fruit THEN The system marks positive emotion status liked++
Rule 2: IF Chinese people do not like an organic apple juice AND Chinese markets have many fresh apples with these low prices THEN The system marks negative emotion status disliked- -
Note that emotion expert status represents in the subset disliked- -, disliked-, neutral, satisfied+, satisfied++, as described human reasoning emotion decisions.

Common Sense Human Reasoning can be presented as an integration of fuzzy rules, quantitative knowledge and reasoning evidence. Linguistic expressions can be used to represent rules for expert decision situations. To quantify the Common Sense Human Reasoning of expert e_i in dynamic market environments, we use the following logical rules as **Rule *i*** can be expressed by Eq.(1):

IF ***Condition*** **1** AND...AND ***Condition m***
THEN ***Actions***

Note that expert decision status is represented in a five step scale {invest++, invest+, neutral, risk-, risk- -}

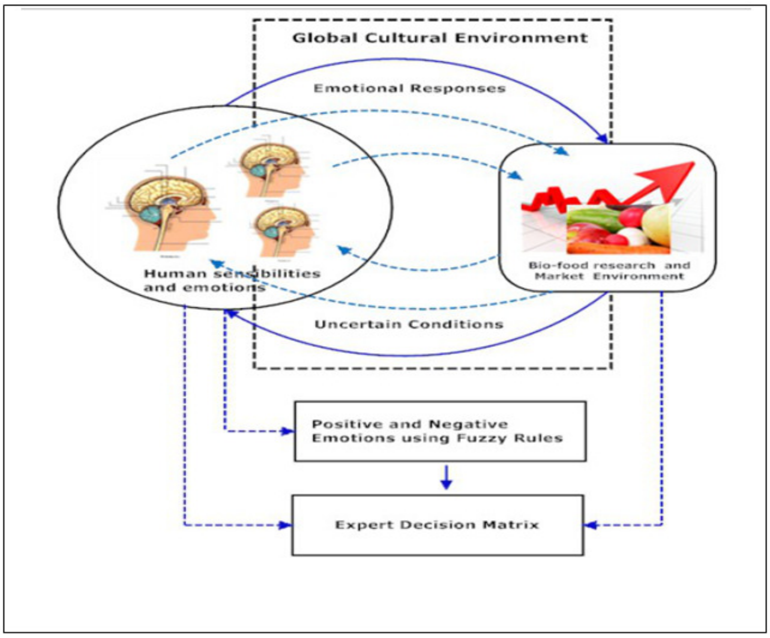

Fig. 1. An Overview of Human emotions in decision making

4 Steps in the Proposed Model

The proposed model aims to explain how we evaluate bio-food products in terms of expert preferences and customer behaviors. This uses uncertainty of quantitative and qualitative factor weights, together with the quantification of customer sensibilities in bio-food products environments. These weights can be transformed through the framework, representing in interval values [0,1]. Mechanisms of data process in the proposed model are divided into four steps as follows:

Step 1. Kansei Evaluation to quantify expert sensibilities and preferences. Pairs of adjectives called Kansei words are collected from bio-food markets. Based on the experts' experiences, Semantic Differentials (SD) method is applied to refine pairwised Kansei words. All refined-adjective words use to evaluate alternatives based on expert preferences. In Kansei evaluation, expert sensibilities and emotions are quantified in weights, representing in an internal value [0,1] with factor weights and stored data sets in a Database.

Step 2. Collaborative Decision Making using sensibilities and preferences in Bio-food Evaluation. Experts surveys are collected that divided into several groups. Each group of experts makes surveys and provides its preferences using collaborative decision making.

Step 3. SOM visualization by updating weights of Kansei data sets together with expert sensibilities and emotions. Kansei bio-food evaluation matrix, as discussed in Section 2.2 is divided into two sub matrices. Kansei Bio-food matrix and Kansei decision matrix are the same as bio-food alternatives, indicators and Kansei words. The Expert decision matrix using collaborative decision making of expert groups by calculating weights. These matrices are visualized by SOM to aggregate customer/expert preferences.

Step 4. Selection of alternatives matching with customer/ expert preferences. The outcomes of the systems are shown in the best bio-food products, matched with customer/expert preferences using collaborative decision making. To select the quantity of bio-foods, we apply logical fuzzy rules to consider the bio-food results by dealing with group customer/expert decisions as follows:

Step 4.1 Calculation of decision maker preference distances with updating *Kansei* bio-food matrix. In order to aggregate all decision maker preferences, the decision maker preference distance $d^S_{e_i \to e_j}$ between two vectors $D^S_{e_i}$ and $D^S_{e_j}$ represents by decision maker preferences, in food market S as defined by Euclidean distance given by Eq.(2).

$$d^S_{e_i \to e_j} = \parallel D^S_{e_i} - D^S_{e_j} \parallel \tag{2}$$

Step 4.2. Calculating weights of decision maker preference distances. To select bio-food products $p^S_t|(t = 1, ..., c)$ in food market S, the decision maker preference distance $d^S_{e_i \to e_j}$ is represented by m^t_{ij} calculated from the *Kansei* product attribute distance v^t_{ij} evaluated by decision maker e^S_i of his/her group at iteration t and the *Kansei* bio-food weight w^t_{ij} of the decision maker group. The weight of m^t_{ij} is expressed by Eq.(3).

$$m^t_{ij} = \parallel \frac{1}{P} \sum_{j=1}^{k} w^t_{ij} - v^t_{ij} \parallel \tag{3}$$

where (i = 1,...,q, j = 1,...,k) and p is the number of decision makers in each group.

Step 4.3. Updating *Kansei* bio-food weights. A Decision matrix $A^S_{q \times k}$ is updated by its weights given by Eq.(4). After that, the Decision matrix $A^S_{q \times k}$ is joined with *Kansei* bio-food matrix $M^S_{n \times p}$ and its weights are updated to $M^S_{n \times p}$.

$$m^{t+1}_{ij} = m^t_{ij} + \beta^S_j (\parallel \frac{1}{P} \sum_{j=1}^{m} w^t_{ij} - v^t_{ij} \parallel) \tag{4}$$

where β^S_j is a set of decision maker preferences as defined in a five-point scale (0: *oppose*, 0.25: *almost oppose*, 0.5: *have no preference*, 0.75: *almost agree*, 1: *agree*)

To select c bio-food product $(p_1^S, p_2^S, ..., p_c^S)$, the similar steps are repeated between Step 4.1 and Step 4.3 until c decision maker groups with updated weights to the Decision matrix completely.

5 Results and Discussions

The proposed model has been employed several domains of Asian markets for demonstration of the proposed approach. In data collection, web-based application is designed to allow any authorized user via the Intranet / Internet connection. Figure 2 shows an example of results for the illustration of collaborative decision making of expert and customer groups for evaluation of bio-food products on the Asian markets.

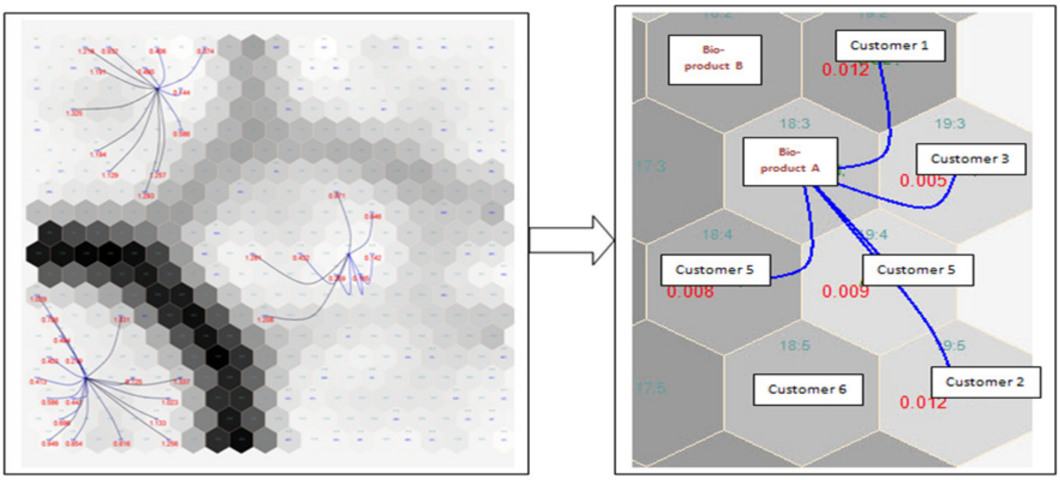

Fig. 2. The results of customer satisfaction with bio products on maps in detail

The proposed model is used to evaluate dynamic solutions of bio-food technology, based on collaborative expert preferences and customer behaviors. The simulation results showed that customer behaviors, together with expert preferences matched with bio-food products. Decision makers can dynamically evaluate bio-food properties on map results as well as optimal decisions. Compared to conventional methods in evaluating bio-food products, most approaches have been used statistic methods in evaluation, the proposed model has been figured out dynamic evaluation in quantification of customer sensibility and behaviour. The new approach using Kansei evaluation is to quantify human sensibilities and emotions about bio-food quality in market and bio-food research environments. This approach is also illustrated with a case study of experimental results to validate the model. In future works, the proposed approach is extended to evaluate multiple food products in daily life.

6 Conclusion

The proposed approach has been applied in evaluation of bio-food products, based on collaborative expert preferences and customer behaviors. The simulation results showed that customer behaviors, together with expert preferences matched with bio-food products. Decision makers can dynamically evaluate bio-food properties on map results as well as optimal decisions. The new approach using Kansei evaluation is to quantify expert sensibilities and emotions about bio-food quality in market and bio-food research environments. This approach is also illustrated with a case study of experimental results to validate the model. In future works, the proposed approach is extended to evaluate multiple food products in daily life.

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