

# Probabilistic reasoning of context aware systems using decision-making patterns

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**Abstract:** Computer performance has improved. Fine adjustment of system parameters for individuals has become possible. For personalized tasks, technologies of Kansei/Affective engineering and Service engineering are effective. In our daily life, we are not performing much decision-making by a logical standard. Therefore, in addition to a logical semantic relation, the emotion and Kansei/Affective, an illogical semantic relation, is also expressed by ontology. A system that offers service as an application of context awareness has been developed. A system of this type is expected to expand along with ubiquitous computing. This report describes a system that provides more than one service related to food and health considering context.

**Keywords:** *Probabilistic reasoning, Context aware system, Food and health care*

## 1. Introduction

Although human life is increasingly becoming materially rich, humans are increasingly confronting various mental stresses. In a stressful society, we are performing various tasks in the quest to achieve a rich and healthy life. Many works related to support systems have been reported. One of them is a system of food and health using IT. On a network, diverse information is accessible, but it is not easy to acquire information related to oneself appropriately because of the wide range of knowledge available about food and health. Regarding knowledge and the rules, general and the individual rules are intermingled. Therefore, it is not easy to choose suitable knowledge for oneself from the huge quantity of knowledge that is available.

Although many items related to food and health are available, we consider effective systems for a certain specific individual. Because a computer agent that serves a specific individual knows a user's condition, the agent can provide suitable advice according to a situation. In this work, contents necessary for development of such a system are considered. We are studying the state of an agent system that supports the optimal information offered for an individual from the idea of context awareness in a time of ubiquitous computing, service engineering, and Kansei engineering. Although food and health are regarded as short term phenomena, interactions of food poisoning, food allergy, and interactions between food and medicines can cause long-term problems for people. As a long-term phenomenon, dietary therapy for improvement of the physical condition can be considered. In this report of our study, we introduce decision support application subsystems related to food and health and try to integrate these subsystems as a whole system.

## 2. Check system for necessary nutrition

A system that confirms whether daily meals supply the suitable nutrients would be convenient. This subsystem

was constructed to calculate the ingestion of a required nutrient automatically [1]. The subsystem was extended and several knowledge functions were added such as 1) the physiological function of nutrient, 2) the medicinal action of nutrients, 3) foods containing a high degree of nutrients, 4) lack of particular nutrient, and 5) an excess intake of some nutrient. In the system, the nutrient is balanced using the 4 group mark method, in which 80 kcal of food energy correspond to one point. After acquiring the minimum points by 2 and 3 groups, the necessary remaining calories are adjusted by the fourth group. In Figure 1, the bottom rows show the intake of the four groups: the green cylinder represents standard necessary points. The red cylinder shows the actual intake points. Users can check whether a nutritional balance is achieved or not according to the interface shown in Figure 1.

When deciding the target amount of nutritional intake, individual calories and nutrition change according to age, sex, activity strength, and health conditions. Therefore, user information of these areas must be registered a priori. In this study, the nutritional intake is evaluated considering both user information and user activity strength based on "The Sixth Revision of Japanese Recommended Dietary Allowance" [2]. The system calculates user nutritional intake based on "The Fifth Revision of Japan Food Consumption Tables" [16]. Users understand what kind of nutrition is lacking or overflow through the chart. The chart can help control nutritional intake for users with the Web application. Moreover, because insufficient and excessive consumption are related to gender and age, the explanation contents should be selected according to the individual user.

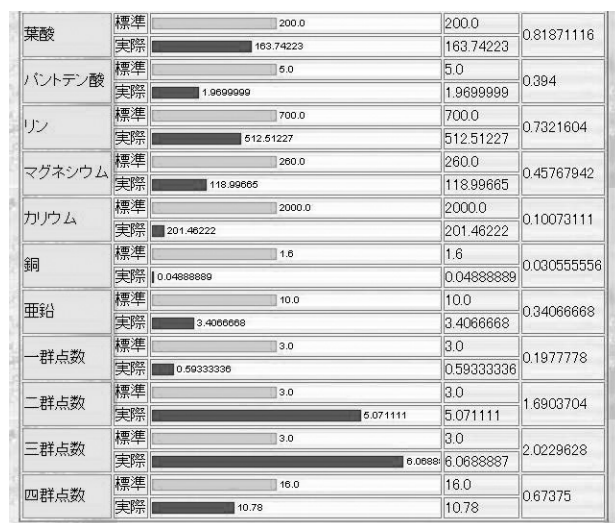


Fig. 1 Actual nutrition contrast to standard level.

### 3. Causal relation of dietary cures: Yakuzen subsystem

According to the concept of Kikei, food has five tastes. Each affects specific internal organs in the body. The Yakuzen effect of oriental medicine is a view that five spirits in a food affects internal organs, and it warms, or cools. Although Yakuzen is an effective means in cases where appetite is lost in summer time or because the heart is not strong, it is necessary to investigate the degree to which science is related to Yakuzen. Investigated from the viewpoint of an association rule, strong and weak relations exist, in general (Table 1). It is also expected that individuals will differ.

Foods of 156 kinds were selected for this study. The association between Kikei and internal organs was investigated. Using the Apriori algorithm, the result is presented in Table 2. As a criterion of associated rules,

support and confidence evaluation are not always appropriate. To evaluate the extracted association rules properly, chi-square tests were performed in addition to support and confidence [4]. Table 3 shows the results. These values differ among individuals. At the moment, this subsystem is used as a supplementary system.

Table 1. Kikei associating food tastes with organs

Taste	Sweet	Sour	Spicy	Salty	Bitter
Organ	Spleen	Liver	Lung	Kidney	Heart
Effects	Stress Reduction Weakness Improve- ment Pain	Hyper- hidrosis Diarrhea Frequent Urination	Poor Circula- tion Depre- ssion	Consti- pation Anemis	Consti- pation Appetite Digestio n
Foods	Grains Fruit	Apricot Plum	Ginger Garlic Onion Pepper	Kelp Laver Prawn	Bitter gourd Lettuce

Table 2. Extracted association rules of KIKEI with food characteristics

Lhs	Rhs	Support	Confi- dence	Lhs. supp	Lift
Neutral	Small intestine	0.027	0.067	0.385	0.945
Cold	Heart	0.051	0.296	0.173	2.719
Neutral	Heart	0.026	0.067	0.385	0.612
Cold	Lang Intestine	0.026	0.148	0.173	1.520
Cold	Lung	0.032	0.185	0.173	0.602
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Cold	Stomach	0.090	0.538	0.167	0.947
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Neutral	Stomach	0.179	0.467	0.285	0.945
Neutral	Spleen	0.186	0.483	0.385	0.992

Table 3. Chi-square test results

Associated item	Chi-square test value	Significance
Salty: kidney	23.458	Yes
Sour: liver	39.861	Yes
Bitter: heart	5.045	Yes
Sweet: spleen	660.061	Yes
Hot: lung	3.156	No
Sweet: stomach	638.625	Yes
Faint: kidney	9.572	Yes

#### 4. Food Poisoning and Allergy subsystem

Food poisoning and food allergies are short-term reactions. Although prevention can solve the latter problem to some degree, the former case is not so simple. Something can be found to be ‘bad’ according to its smell or color, but for other foods, the characteristics are indistinguishable. For food poisoning, the best way is to contact a

hospital immediately when observing a vital reaction. However, various factors are related to allergies. Not only food hypersensitivity, allergies related to cedar pollen are also common. Research into masks as filters has also been conducted [5]. The context awareness system will be changed if the concentration of the pollen in air could be measured with a convenient device. Moreover, some people show a strong reaction to chemical substances in newly constructed buildings: the so-called sick building syndrome. A computer agent can issue a warning immediately if a system measures a specific chemical substance to a user, but it is not easy to measure the contents of meals one by one. If ontology of the recipe progresses, coding of the meal contents can also be achieved.

While research progresses about food allergy and the mechanism of symptoms, prevention methods are proposed. Guidelines are reported from academic societies. Moreover, charts of the contents of allergens contained in food are published. With an allergy patient in a family, food preparation is a remarkable load. Because items related to allergies have a wide scope, we are dealing with ontology of a part of food allergy and querying of it. Numerous ontologies are built in “The Open Biological and Biomedical Ontologies” [6]. An ontology for food allergies is created for six foods, such as eggs, as allergens. Valarakos et al. reported how to manage allergy ontology through machine learning [7]. Solovieva et al. performed ontology of allergy-related knowledge using semantic web technology [8].

Because allergies can be debilitating or fatal, the diagnosis of a medical specialist is required without performing amateur diagnosis. However, because the management after diagnosis is left to an individual, performing all checks personally imposes a huge burden. After diagnosis is made by a doctor, it is not easy to maintain or update the information individually. Therefore, an ontology system is restricted to personal allergies specified by a physician at a hospital.

## **5. Interaction of Medicine and Food**

For those with a certain medicine prescribed from a doctor, it is necessary to be careful with some foods because some foods can diminish the strength of medicines and/or weaken the medicinal effect they have on a patient. Even if a patient receives a cautionary message at the time of the first diagnosis, it is possible for the patient to forget it. Therefore, it is convenient if a method of investigation simply exists. Moreover, when medicine is used for someone in the family, it is helpful to have knowledge for appropriate meal preparation.

Furanocoumarin (naringin) is contained in grapefruit. If taken during a period when a person is also being medicated for angina, hypertension, or bronchial asthma, then grapefruit can strengthen the effects of a medicine to the degree that it can influence sleepiness, cause liver problems, and engender other health problems. The same action can occur also with Hassaku oranges, shaddocks, and *Sweetie* citrus fruits. However, no interaction occurs with medicine in an orange or a mandarin orange. Moreover, many unsaturated fatty acids are contained in avocados, the so-called butter of the forest. It is said that absorption in intestines of warfarin potassium blocks blood coagulation. The interaction of such medicines and foods can greatly affect people.

## **6. Conclusion**

The benefits of describing knowledge to ontologies include the ease of information processing by the computer agent and the sharable property of knowledge. Decision-making is also included in information processing. The view of fluctuation is also examined by selection of dishes that accumulate the selections in which preferences are reflected, stimulating change so that one pattern of the same dish will not occur, while maintaining required nutrients.

System complexity differs according to the functions of food, which dish is chosen to match a season by what frequency, or whether it is a system for an individual person, or takes liking of family composition and a constituent into consideration for the which range, or taking economic restrictions into consideration by material selection.

Although automated, such personal extraction from maintenance and that of ontology for realizing food selection for an economic problem and stress alleviation etc. from the menu can not prevent short-term accidents, such as nutrient management, long-term healthy management by Yakuzen, and allergy, but liking nor weariness comes, and customizing, is the system now restricted in part. The system is rich in possibilities for improvement and individualization (Fig. 2).

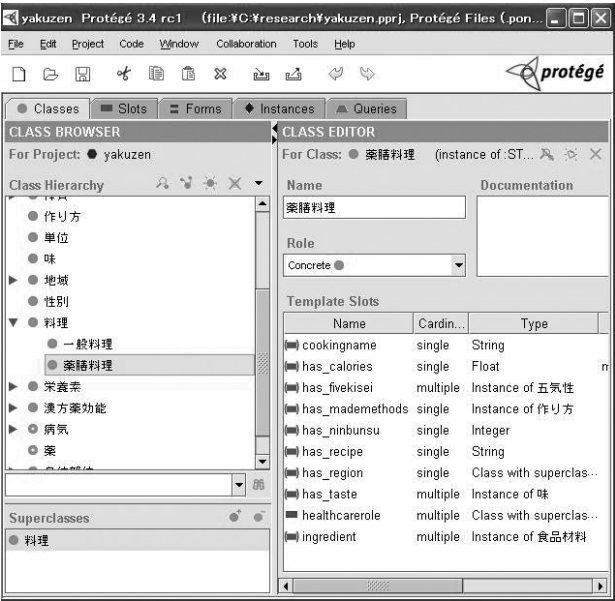


Fig. 2. Food ontology.

However, many issues must be resolved. The system described above comprises personal information. The more it becomes a system that is adaptable to the individual, the more closely it is related to personal information. Therefore, the effects of information leakage are important. Many studies have been undertaken to resolve such problems. As in our city hospital medical networks, non-direct physical connect must be avoided. Therefore, usual situation networks are disconnected and necessary networks are connected, imparting some inconvenience. Even in such cases, several connector devices are desirable. Research of a computer agent that can accommodate connector devices is therefore important.

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