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Recipe search engine inspired by ant colony's foraging

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Abstract: These days, concern with link between consumer electrical appliances and information devices has been growing such as the refrigerator which has a managing function of food ingredients. This environment is called 'Ubiquitous computing', 'Smart home appliance' which has possibility of further development. In this environment, we consider the system which suggests users some well-balanced recipes that can be cooked by the available ingredients. Especially, we focus on recipe search engine for limited state such as using only existing foods ingredients in the refrigerator. However, conventional keyword search does not suit this system. In this paper, we focus on the ant colony's foraging in order to make a new recipe search engine. We confirm the effectiveness of the proposed search engine by conducting simulations.

Keywords: ant colony's foraging, ubiquitous computing, smart home appliance, recipe search

1 Introduction

With progress of information network technology, our life style becomes remarkably convenient. Furthermore, according to link with mobile phone, consumer electrical appliances and many other information devices recently, we can get a lot of high quality services more and more. This environment is called 'Ubiquitous computing', 'Smart home appliance' which has possibility of further development [1].

Especially, the concern with link between consumer electrical appliances and information devices has been growing for these days. The refrigerator which has a managing function of food ingredients and a recipe search engine, also a built-in kitchen linked this are expected leading example of application.

Now, we propose the system which suggests users some well-balanced recipes that can be cooked by the available food ingredients in the refrigerator. However, conventional keyword search does not suit this system.

In this paper, we focus on the ant colony's foraging in order to make a new recipe search engine. Ant repeats simple actions – 'Lifting up', 'Carrying', 'Lifting down' and ant colony make food clusters. Ant colony makes food clusters at random, so it is different size and placed position. We consider ant's food as food ingredients in refrigerator, and food clusters as recipes. Then we can make a recipe search engine by represent ant colony's foraging on simulation. We confirm the effectiveness of the proposed search engine by conducting simulations.

2 Goal of the proposal system

We propose the system which suggests users some well-balanced recipes that can be cooked by the available food ingredients in the refrigerator. Therefore, new recipe search engine have to find various desirable combinations as recipes from existing foods ingredients in refrigerator.

Furthermore, In order to improve usefulness, the system makes general Japanese menu plans per serving.

3 Problem with conventional keyword recipe search engine

In conventional keyword search, users input some keywords such as name of dish or food ingredient to search engine, then it give them information about relative to keywords. Because of keyword search engine provide us information that only based on input keyword, and food ingredients are not unlimited, many search results containing a keyword are obtained.

On the other hand, we keep food ingredients in the refrigerator, and we consider using these every day. There are many kinds of combinations from existing food ingredients in the refrigerator. So we can make use of those combinations as recipes. In this case, conventional system can not make useful combinations from limited state such as only existing foods ingredients in refrigerator, because it depend on only keyword and does not consider foods ingredients in refrigerator.

Therefore, we need new concept for new recipe search engine and we focus on the ant colony's foraging. Using this ant's simple repeat action, the recipe search engine

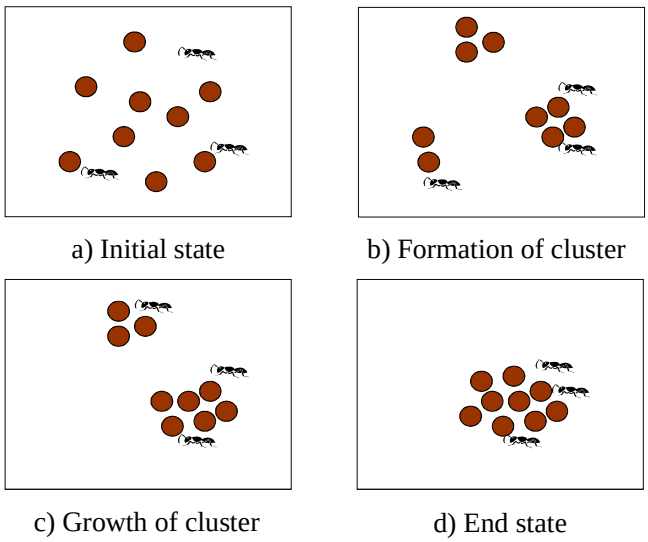
gives information to users even if user does not input keywords.

4 Ant colony's foraging

Ant colony does not have central controller, however ants can collect foods on the basis of local information. Using following Fig. 1, we explain this mechanism.

An ant moves at random on the environment where objects are scattered such as Fig. 1 a). When it finds an object, ant lifts up the object by a certain probability. An ant which has the object moves to other place. When it finds other objects, ant lifts down the object by a certain probability, and then a small cluster is made by these objects.

The probability is determined by the size of that cluster which placed somewhere. In certain place where are many objects, ant tends to lift down the object. Conversely, in certain place where are few objects, ant tends to lift up the object. Ant colony repeat simple actions – 'Lifting up', 'Carrying', 'Lifting down' and they make many small clusters. Smaller size cluster move to larger one by repeat of ant colony simple actions. As a result, clusters grow up and it becomes a few larger clusters [2].



a) Initial state b) Formation of cluster

c) Growth of cluster d) End state

Fig. 1. Ant colony's foraging

We apply this ant colony's foraging algorithm to recipe search engine, we consider ant's object as food ingredients in refrigerator, and clusters as recipes on simulation.

5 Proposal method

Ant colony's foraging is reproduced on virtual environment, and it uses for recipe search engine. Food ingredients in refrigerator correspond to ant's food and collected by ant colony's foraging algorithm to make recipe. When all required food ingredients are collected to make recipe, it shows as a recipe which can cook.

5.1 Environment of recipe search engine

As shown in Fig. 2, environment of recipe search engine is one-dimensional space with several cells in the shape of a straight line.

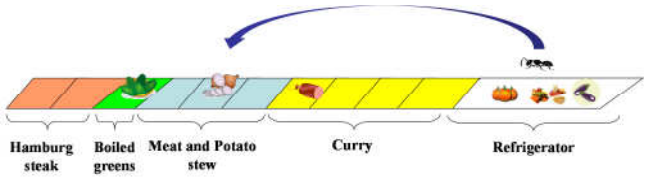


Fig. 2. Environment of recipe search engine

Recipes are assigned on a several cells. To make Recipe which is required a large number of food ingredients, takes more times for carry food ingredients and it is hard to be made up. Therefore, several recipe cells are proportional to the number of food ingredients and we consider that agent visits the recipe cell which is more required number of food ingredients. Food ingredients are arranged in the refrigerator cell at first and carry on the recipe cell by the agent which is reproduced ant colony's foraging. Agent moves at random such as jumping each cell. The recipe which all the required food ingredients are collected on an own cell is recognized as a recipe which can be cooked.

5.2. Recipe search engine inspired by ant colony's fo raging

The flowchart of recipe search engine inspired by ant colony's foraging is shown in Fig.3.

First, agent moves at random on the each cell. When it enters the cell which is existing food ingredient, agent lifts up the food ingredient by a certain probability. The probability of lifting up the food ingredient is shown in equation (1).

· Lifting up probability

$$P_i = 1 - \left\{ 0.999 \cdot \left(\frac{a_i}{n_i} \right) + 0.001 \right\} \quad (1)$$

i : Identification number of a recipe

n_i : Total number of food ingredients required for the i-th recipe

a_i : Number of food ingredients which placed current recipe cell

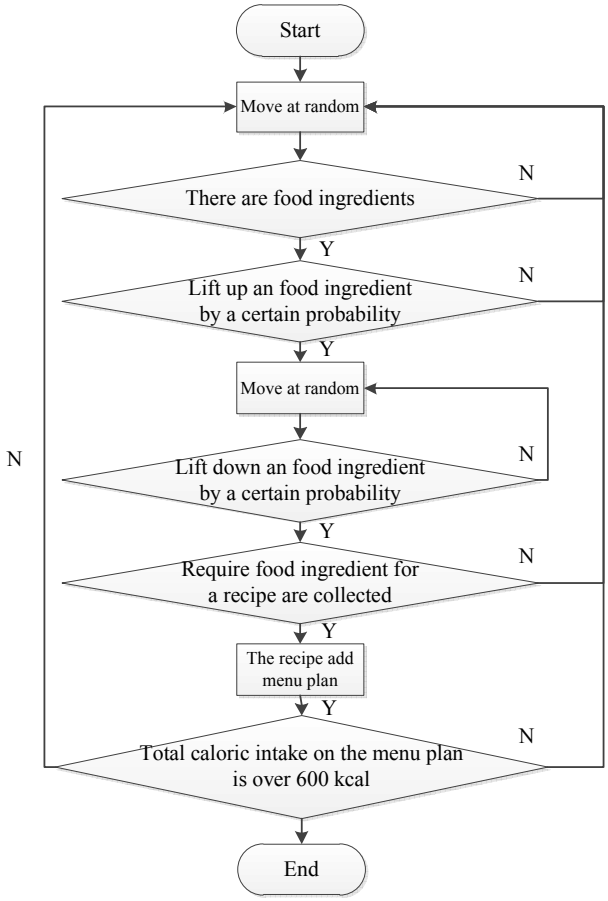


Fig. 3. Flowchart of ant colony's foraging

The agent which has the food ingredients moves at random on the each cell again. When it enters the cell which is existing food ingredient, agent lifts down the food ingredient by a certain probability. The probability that agent lifts down the food ingredient is shown in equation (2).

·Lifting Down probability

$$Q_i = 0.999 \cdot \left(\frac{a_i}{n_i} \right) + 0.001 \qquad (2)$$

When all required food ingredient for certain recipe are collected, it is recognized as a recipe which can be cooked, and the recipe adds menu plan. We consider that caloric intake set 600 kcal for serving, and when the total caloric intake on menu plan is over that value, recipe search is end.

6 Simulation

We simulate recipe search engine inspired by ant colony's foraging. The recipes used for the simulation are selected 80 kinds of recipes as shown in the following Table. 1[3].

Table 1. Recipes used for the simulation

Recipe No.	Name of Recipe
1	Beef curry
2	Chicken cream stew
3	Japanese-style pancake
4	Hashed beef with rice
5	Omelet rice
6	Spaghetti with meatballs
. . .	. . .
79	Hamburg steak
80	Pork cutlet

6.1 Simulation condition

To confirm the effectiveness of the proposed method, we conduct simulations with 3 different conditions written below.

a) General search: In order to verify the usefulness of the recipe search engine, we simulate it with the condition that a lot of food ingredients which is enough to search various recipes are in the refrigerator.
b) Search with condition that a lot of meat: We simulate recipe search engine with the condition that a lot of meat are in the refrigerator.
c) Search with condition that a lot of vegetables: We simulate recipe search engine with the condition that a lot of vegetables are in the refrigerator.

6.2 Simulation results

Each simulation results are shown below.

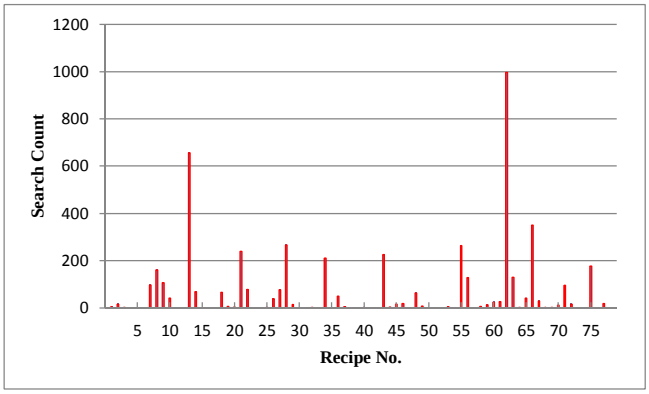


Fig. 4. The result of general search

The vertical axis of Fig. 4 shows each recipe search count and the horizontal axis show recipe number in Table. 1. As a result, various recipes were searched by search engine. Most searched 2 recipes are as below.

Table 2. Most searched 2 recipes

Recipe No.	Recipe Name	Food ingredient
13	Boiled spinach	Spinach
62	Salmon meuniere	Salmon

Least searched 2 recipes are as below.

Table 3. Most searched 2 recipes

Recipe No.	Recipe Name	Food ingredient
25	Sukiyaki	Beef, Mushroom Egg, Welsh onion
53	Green pepper steak	Beef, Green pepper Ginger, Welsh onion

Compare Table 3 with Table 4, we can figure out that recipes which is required lower number of food ingredients are well-searched than others. If users would like to get other recipes, they can get useful recipe information by re-search.

Table 4 - Table 6 show the examples of the searched menu plans for each condition.

Table 4. The result of condition a) – various food ingredients

Menu 1	Menu 2
Mackerel simmered in miso sauce	Potato gratin
Rice with bamboo shoot	Japanese hotchpotch
Boiled spinach	Boiled spinach
Chop suey	Scallop cream croquette

Table 5. The result of condition b) – A lot of meat

Menu 1	Menu 2
Hamburg steak	Chinese dumpling
Potato croquette	Cabbage roll
Fishcake soup	Fishcake soup
Omelet rice	Omelet rice

Table 6. The result of condition c) – A lot of vegetables

Menu 1	Menu 2
Rice with bamboo shoot	Rice with bamboo shoot
Boiled spinach	Spaghetti with tomato sauce
Scallop cream croquette	Japanese-style pancake (Okonomiyaki)
Potato gratin	Boiled spinach

Each table shows that recipes were searched according to food ingredients in the refrigerator. If users would like to get other menu plans, they can get useful menu plan information by re-search.

7 Conclusion

In this paper, we consider the recipe search engine inspired by ant colony's foraging for the refrigerator which has a managing function of food ingredients. In order to verify the usefulness of the proposed system, the proposed system was mounted on the personal computer and we have conducted several simulations by each condition.

As a result, various recipes were searched by new search engine, proposal system was realized.

Our future work is to take the nutritional information into consideration and to add learning mechanism to the search engine for adapting user's taste.

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