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Integration of User Profiles and Real-time Context Information Reflecting Time-based Changes for the Recommendation System

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Abstract

Under ubiquitous environment, recommendation system is using the collaborative filtering methods by quantifying context information, but insufficient context information can cause inaccurate recommendation result. In order to solve such problems, the researcher used context information and user's profile. But service history information in users' profiles can have the problems of being influenced by change of the user's taste or fashion as time passes by. In addition, context information and user's profile can't be properly inter-locked according to situation, which can cause inaccurate predictability.

In this paper, in case a user's taste or fashion is changed as time passes by, the researcher didn't apply bundled-up value to the user's profile but applied different weight according to change of time. And the researcher could solve the problem that context information and a user's profile can't be properly inter-locked according to situation by applying different weight to the result gained by means of collaborative filtering and then by unifying it. In such ways, the researcher could improve predictability.

Key Words : Ubiquitous, Recommendation System, Context, Collaborative Filtering, User Profile

1. Introduction

Under ubiquitous environment, amount of context information is increased due to use of various sensor networks and context information is continuously and rapidly generated[1]. Furthermore, in order to use frequently changing context information, unification and classification of context information became to be necessary. Mobile equipment provides users with services of filtered context information in various ways. But even though much context information exists, there are cases when context information being proper for service recommendation is insufficient. Providing users with proper services by means of a collaborative filtering using profile information where real-time context information acquired and history information of users are saved can solve such problems[2]. But a user's profile can be much influenced by change of user's taste or fashion as time goes by. In addition, there are problems that context information and users' profiles can't be properly inter-locked according to situation.

In this paper, in case a user's taste or fashion is changed as time passes by, the researcher used different weight when applying the user's profile. And the researcher could solve the problem that context information and users' profiles can't be properly inter-locked according to situation by applying different weight to the result gained by means of collaborative filtering and then by unifying it. In such ways, the researcher could improve predictability.

As composition of this paper, in chapter 2, the researcher deals with relevant researches, in chapter 3, service recommendation system considering change of time, in chapter 4, contents of experiment and evaluation, and in chapter 5, conclusion.

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2. Related Works

2.1 Collaborative Filtering

Collaborative filtering is a method to recommend highly-preferred items by finding neighbors showing much similarity to a service requester who wants to know evaluation value for a certain item among enormous amount of information[3]. But collaborative filtering has also problems as follows:

First, as to the problem of evaluation at the initial step, there are problems that items not required by the user are not recommended to the user[4]. Second, as to the problem of scarcity, the number of items among enormous information domains far exceeds the number that can be assimilated by individual users. Thus, the matrix including evaluation of all items for all users shows very scattered distribution[5]. In order to solve the above problems, evaluation information of the data being accumulated for a certain period of time is necessary, so the researcher could solve the problem by using real-time contexts. Third, as to the problem of scalability, because algorism of the most adjacent neighbors that is mainly used in the fields of collaborative filtering uses calculation time in

proportion to the number of users and items, under the environment having millions of numbers of users and items, such calculation time can be fatal[5]. Thus for solution o f such problems, SVD[6], etc. are used.

As methods to measure similarity in the course of collaborative filtering, there are Pearson correlation coefficient, adjust cosine similarity and etc. In addition, as methods to select neighbors with high similarity, there are Thresolding method[7] of estimating by selecting only neighbors with higher value of similarity than determined standard, and Best n-neighborhood method[8] of estimating by using n-neighbors with high similarity to the service requester.

2.2 Context Awareness

In spite of various definition of context, it means information about the circumstances around a user. According to the fields of use, context can be classified into a user's circumstance, physical environment, computing system conditions, history of a user's computing conditions, state of usable resources, and other unclassified circumstances[9]. And the course of acquiring such context is called as Context Awareness Technology.

Methods of expressing information generally at a context information system are various. The model based on key-value has the simplest structure for expressing context information, which is easy to manage and can have questions using the value being expressed as context[10]. The model based on the object is using object-oriented technologies such as Encapsulation, Inheritance, Reusability in order to solve problems of dynamic circumstances under ubiquitous computing environment[11]. The model based on ontology is an easy method to describe correlation of information and express partial context information. In a model based on hierarchical context ontology, it is possible to make lower hierarchical ontology using upper hierarchical ontology[12]. The model based on mark-up expresses attribute, tech and contents as hierarchical structures. Contents of mark-up tech are expressed circularly by means of other mark-up tech. One of its demerits is that it is not easy to define the complex relationship of hierarchically-structured information[13]. The model based on logic expresses context using rules, facts and expressions. It is possible to infer facts or expressions through rules[14]. The model based on a graphic expresses information using graphics[15].

As context recognition service middle ways, there are SOCAM[16], Context-Toolkit[17], and CoBrA[18], etc.

SOCAM uses context models based on ontology and is driven at OSGI. It has independent service structure and uses OWL-based ontology. Merits of SOCAM are that it is easy to infer context and share knowledge, and is independent to platform by means of use of Java, and it is possible to have system security.

Structurally, GATECH's Context Toolkit uses a sensor and an intermediate mediator between the sensor and application service, which manages context, in order to solve subordinate problems between them.

Being developed by Chen, CoBrA provides users with services where intellectual space is sunk into physical space. Each agent of Context Acquisition Component, Broker Behavior, Knowledge, and Inference Engine can be web information used by users over web and information of mobile equipment used.

2.3 Users' Profiles

It is methods of acquiring information by means of asking questions to users. It is possible to provide users with proper services using matters of their interest or things they are actually using. Users' profiles can be classified into static profile and dynamic one[19].

2.4 Quantification

Because context information acquired at real-time can't receive information of users' evaluation, it is difficult to be used for the recommendation system such as collaborative filtering. Therefore, indication of such context information by means of numerical value is called as quantification[2].

3. Service Recommendation System in Consideration of Change of Time

Among real-time context information collected through the sensor, only necessary context information is classified at the context recognition and unification module and then moved to the next step. And to it, different weight is allocated in consideration of changeable taste of users and fashion according to time. In the relative quantification step, collaborative filtering is made using quantified context information on the basis of users so that context information would be used for operation and thereby proper services are recommended to users.

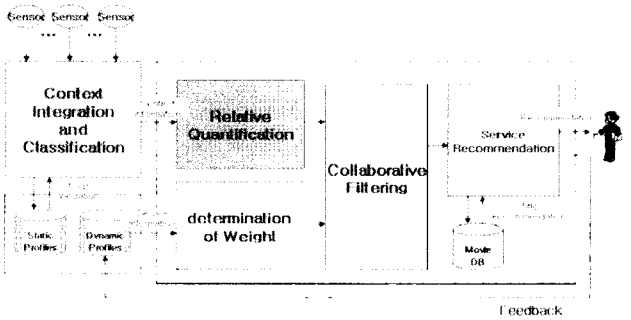

Fig. 1. System Flowchart

Fig. 1 shows a course recommending proper services to users using context information and users' profiles. And its order is as follows:

① Among real-time context information, only contexts

necessary for context recognition and module step are classified.

② In the relative quantification step, unified context information is indicated as numerical value after relative quantification on the basis of users so that it would be used for collaborative filtering.

③ In the step to determine weight, different weight is applied on the basis of present and serviced period using users' profiles.

④ In the collaborative filtering step, real-time context information and users' profile are collaboratively filtered respectively.

⑤ In the service recommendation step, the result gained after collaborative filtering is unified by according different ratio of weight and thereby proper services are recommended to users.

3.1 Context Awareness and Integration

In case of difficulty in receiving accurate services using information a user has, other users' real-time context information is necessary. In the step of context recognition and unification, recognition and classification work is done in order to use users' context information acquired in real-time from various devices.

In the context recognition step, information is acquired through outside sensors; users are recognized by means of users' profiles DB; and relationship with neighbors is grasped by confirmation of group names through telephone number lists and an address book.

Table 1. Context Information for Service

Type	Content
ID	Mobile Phone Number
Age	Age of User
Place	Service Place
Companions	Lover, Friend, Family ...
Sex	M/F
Time	Service Time
Genre	Genre
Subject	Movie Subject

In the context unification step, unnecessary context information is filtered. In addition, in order to solve insufficient context information, other users' context information is collected using Pure P2P. Among collected information, only necessary one is used and the rest one is not used. In the system in this paper, it is applied to the service for recommending movies. Context information used for movie recommendation service is as Table 1.

Users' telephone numbers are used as ID's but it is not possible for the service requester to identify the source of information.

3.2 Relative Quantification

In the relative quantification step, the researcher used relative methods of making classification on the basis of service receivers' ages. By means of existing methods, ages are classified by the teens, the 20s, the 30s and etc. But in case a user is 29 years old, the person behaves with sense of people from late 20s to early 30s, but (s)he is classified as the 20s on the basis of the existing methods, which shows some problems. In order to solve such problems, we can use more accurate classification method by means of 10 units' classification methods on the basis of a user's age. Table 2 shows the existing and relative classification methods in case a user is 29 years old.

Table 2. Existing Method and Relative Method

A. Existing Method

Index	Classification of Age	Count of Number
1	~ 10	19
2	20 ~ 29	52
3	30 ~ 39	45
4	40 ~ 49	26
5	50 ~ 59	6
6	60 ~	2

B. Relative Method

Index	Classification of Age	Count of Number
1	~ 14	8
2	15 ~ 24	49
3	25 ~ 34	61
4	35 ~ 44	23
5	45 ~ 54	6
6	55 ~	3

High value is allocated to those with same age as the user and low value to those who shows bigger age difference. According to types of companions, companions are also evaluated by means of comparison with the user. Movie watching time is also evaluated in the same way as the above.

3.3 Application of Weight in Consideration of Change of Time

In order to use service history information among information in users' profiles, it is necessary to save context information and service items used for service. By saving value for context information that was applied in the quantification step, we don't

have to have quantification step the next time.

In order to use users' feedback information, we have know serviced situation and items. But even though previously serviced situations are the same as that of the present time in all aspects, a user's taste can be changed, so different weight must be applied in consideration of change of time.

In order to solve the problem caused by change of a user's taste as time passes by, different weight is applied to a user's profile according to time.

For example, if information of movies a user saw 2 years ago is saved in the user's profile, we can use such information for this system. But if the user's taste is changed during 2 years, inaccurate result can be made. Thus, among feedback information in the user's profile, for 50%'s information that has been serviced recently, weight is applied as the following table. As to change of time, different weight is applied per every 6 month period.

Table 3. Rate of Weight in Consideration of Change of Time

Time	Rate of Weight
2 year ~	10%
~ 2 year	20%
~ 1.5 year	30%
~ 1 year	40%
~ 0.5 year	50%

A user's profile and applied weight become object for input in the course of collaborative filtering.

3.4 Application at Collaborative Filtering

Collaborative filtering is applied to context information being indicated as numerical value for proper service for users and service information in users' profiles. To calculate similarity, Pearson correlation coefficient is used and it is applied to Formula (1).

$$C_{x,y}=\frac{\sum_{a=1}^{n}(r_{x,a}-\overline{r_x})(r_{y,a}-\overline{r_y})}{\sqrt{\sum_{a=1}^{n}(r_{x,a}-\overline{r_x})^2}\sqrt{\sum_{a=1}^{n}(r_{y,a}-\overline{r_y})^2}} \quad (1)$$

$C_{x,y}$ is value of similarity between context information x and context information y. r_x is evaluation average for overall context information of user x. $r_{x,a}$ is evaluation value for context information a by the user x and n is the total number of context information. As methods to determine the number of neighbors, best n-neighborhood method is used and only 50%'s neighbors with high similarity are selected. Predictive value obtained as the result of using such neighbors is as Formula (2).

$$P_{x,b}=\overline{r_x}+\frac{\sum_{y=1}^{n}(C_{x,y})(r_{y,b}-\overline{r_y})}{\sum_{y=1}^{n}C_{x,y}} \quad (2)$$

$P_{x,b}$ indicates predictive value for the user x's preference to context b. Predicted high rank values move to the service recommendation step.

3.5 Service Recommendation

Determining the value calculated using context information as CI and value calculated using users' profiles as PI, the researcher obtained the value as the Figure (3).

$$F = CI * (1-k) + PI * k \quad (3)$$

In Formula (3), k indicates the rate of weight that applies Table 4. If ratio of weight is high, information in users' profiles is used more and if it is low, real-time context information is used more.

High value of F means that there is high probability of information desired by the user. Information recommended to users is saved again by making present context information and service items feedback to the dynamic profile of users.

n case of insufficient real-time context information, regardless of its amount, the researcher unified it by applying weight, and could solve the problem that real-time context information and users' profiles can't be properly inter-locked according to situation.

4. Evaluation

In this paper, the researcher designed experiments using MS at Pentium IV, 2.8Ghz, 512MB.

Scenario for context information filtering of users is as follows.

> Mr. Hong, Gil Dong arrived at a multiplex movie theater with his girl friend. Because he doesn't have any information about movies and couldn't search for data over the internet, he can't determine which movie he has to see. It is not easy to receive recommendation of any movie from his neighbors, so he wants to receive a recommendation service of a proper movie for him with a mobile using information of other users.

Using the P2P mobile agent, Mr. Hong, Gil Dong receives recommendation of information that is not under influence of users' privacy protection.

If type, age and genre of context information such as "\0112003000 \30 \movie \lover \M \200709091700 \Action \love" are formed, "0112003000" indicates a user's ID and "30" indicates his age. And "movie" indicates serviced place,

"love" a companion. In addition, "M" indicates a male and "200709091700" date and time. And "Action" indicates genre, and "Love" service item.

By means of a survey, the researcher investigated the total 509 persons (315 males and 194 females) to know relationship. Context information used for the service includes age, companion, time and sex, etc. As to age, the researcher observed age by means of a relative method of distinguishing the service requester and other users through comparison between them; in case of companions, the researcher investigated relationship through telephone numbers of groups registered in a mobile phone directory. And the researcher could confirm that according to movie watching time, watching person's taste is changed and difference in the taste of watching movies showed much difference not by means of sex but by companions and watching time. The value of preference used after the quantification step is indicated as 1, 2, 3, 4, or 5. 1 indicates the least preference and 5 indicates the highest preference.

As methods of evaluation in this paper, MAE is used. Formula (4) indicates difference of predictive value between actual users and predicted users. r_i is actual preference and v_i is predicted preference; N is the total frequency of prediction.

$$|E| = \frac{\sum |r_i - v_i|}{N} \tag{4}$$

Table 4 indicates MAE as the result of increasing the frequency of evaluation by using Formula. (3).

Table 4. MAE according to the frequency of evaluation at the nth time

nth time	MAE		
	CF_UC	CF_UCI	CF_TUCI
10	0.191	0.183	0.182
20	0.186	0.182	0.180
30	0.184	0.179	0.177
40	0.183	0.176	0.173
50	0.183	0.175	0.173
60	0.184	0.177	0.174
70	0.183	0.176	0.173
80	0.185	0.176	0.174

By testing the system proposed in this paper, the researcher did an experiment on the method not applying users' profiles and context information (CF_UC), the result applying unified profile and context information (CF_UCI) and the result applying unified users' profiles and context information considering changes according to time (CF_TUCI). As the result of an experiment, the researcher could know that CF_TUCI method is excellent.

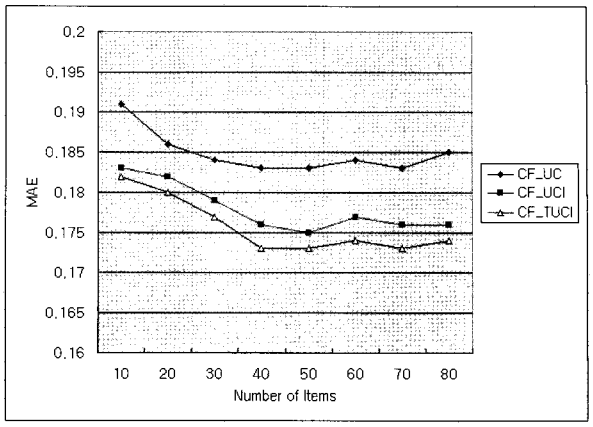

Fig. 2. Comparison of Functions According to Number of Users

5. Conclusion

Amount of context information is becoming increased more and more as information is input by various input sensors. But in spite of increase in context information, actually usable context information can be insufficient. In order to complement this problem, in this study, the researcher used the method of integrating user profiles and real-time context information on the basis of the fact that taste of users is changed according to time. In addition, in order to solve the problem that integration of context information and user profiles can' t be properly inter-locked according to situation, the researcher used respective collaborative filtering. As to filtered results, the researcher assigned high weight to the results of user profiles if the results are recent data, and low weight to not recent data as the result of calculating the service evaluation period of user profiles. Using such method, the researcher could improve the problem.

The system proposed in this paper showed more excellency of 4.9% in average than the method not unifying users' profiles and context information.

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