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ORIGINAL ARTICLE

Research on life-cycle of user model in U-Business

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Abstract "U-Business" is a novel type business environment, which can provide various services via many mobile devices. In order to provide personalized service to different users, user model (UM) can play an important role in U-Business. UM reflects some characteristics of users to a certain degree, which is used widely in U-Business, like personalized recommendation, social computing, information retrieval services, and so on. Currently, there are more and more researchers who focus on the building and update of UM based on the activities of people. However, as too many UM appeared, the number of UM in cyber space is increasingly large, which takes a lot of space and cost. Furthermore, after some users disappear in the physic world, their models are still working in the cyber world. This case is not reasonable obviously, but few researches take care about it. Therefore, one of important issues, the death of UM should be taken into account in the whole life-cycle of user model. This paper proposes a specific user modeling method for the Cyber Individuals (Cyber-I) in U-Business. The essential difference between this UM and traditional ones is that it has a life, that is, birth, growth, and demise, like a life-cycle of Cyber-I. Specially, the significance of UM life ending and five states of UM death are described from an organic viewpoint. In addition, there is a framework of the whole life process of UM. Finally, the proposed idea is applied to the field of personalized service.

Keywords Cyber-I · User model · Life-cycle · Personalized services

Abbreviations

UM	User model
Cyber-I	Cyber individual
Rea-I	Real-individual

1 Introduction

1.1 Cyber-I

The issue of human nature has attracted a lot of attentions for some philosophers. For instance, Kant (1724–1804) believes that a rational person is a true sense of the people. Feuerbach (1804–1872) opposes to self-consciousness point of view that Kant holds, and he believes that man is a "sensitive" class lived animals… a natural essence. However, nowadays the activities in U-Business are always integration of online and offline business, and simultaneously how to research these activities in U-Business is significant for knowing users' intentions, which can help provide novel and abundant services based on various computing environment. Therefore, we can assume that there exists an implicit entity in U-Business to match people's action and idea as much as possible, which can be described a digital user in cyber space.

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Furthermore, the rapid research on cyber space is giving rise to unforeseen development. The cyber space is a hyper world, not a real world [1]. Recently, we have proposed that Cyber-I is some kind of self-digital clone of human in the real world [2], which is another self in the other world. Cyber-I has some characters, each of which is a symbolic user modeled by some profile [3]. It further promotes to enlarge the edge of Real-Individual (Rea-I) model, information processing, interactive digital information. In other words, Cyber-I evolves, like human is evolving. It also has the processes of birth, growth, and demise.

We believe that Cyber-I has three main parts: Cyber-I Mind, Cyber-I Pivot, and Cyber-I Spine, and Cyber-I has provided different service forms in various application fields [2]. In the future, the world's computer network will be combined by Real-I, Cyber-I, and their network connections. Once a Real-I's birth, Cyber-I that is affiliated to Real-I would have, Cyber-I Mind will grow, Cyber-I's wisdom is also gradually growing with the wisdom of the Real-I increasing. In the theoretical circumstances, Cyber-I Mind and Real-I Mind is equivalent. That is, the decision making and analytical thinking a Cyber-I has are as much as a Real-I owns.

1.2 User model

As is known, user preference plays an important role in text information retrieval and user modelling for personalized services [4]. We will only review user models–related papers. WebPlanner [5] were designed to satisfy users' needs by using structured domain-specific queries. With a representation of the user preference, UM may serve as input parameters for a filtering action operating on the available offer [6]. UM is evolving with learning from user behaviors' feedbacks. Based on the users' rating, "ProspectMiner" [7] is another retrieval system that can learn user's interests and preferences. As is the essence of the well-known collaborative recommender systems [8–10], items are recommended to a specific user based on his shared interests and similar users' interests which are collected through his own or others' historical actions. Our UM is also built with users' behaviors. In addition, in this paper we focus on studying UM from a new perspective for its life.

Taking into account both the mental process of Cyber-I Mind and services for Real-I, UM is one form of Cyber-I Mind to predict behavior activities. Like Cyber-I Mind, depending on state, thinking, and behavior of Real-I, UM also has birth, growth, and demise of three processes. Real-I can build his own Cyber-I Mind through UM. When a Real-I was born, it would produce a UM. UM lives by the ideas, knowledge, thinking, infrastructure data of Cyber-I Mind while Real-I interacts with environment in social application. Hence, the cognitive thinking and social behavior of people in the real world will be collected as core data for the Cyber-I Mind, which is the soul of Cyber-I mind, continue to influence the update process of UM.

After the UM is born, UM will begin growing, which has positive growth and negative growth. Positive growth can be defined that, as the expansion of UM data, the process of Cyber-I Mind's thinking and the results are consistent with the activities of the Real-I brain, even directly proportional. In contrast, negative growth refers that, as the growth of the data scale, the process of Cyber-I Mind and Real-I brains' activities are inconsistent, or even divergent. In essence, UM's growth is viewed as a self-learning and self-evolutionary model. In fact, rather than considering the positive growth, it could be a downward trend for life of UM. Furthermore, how a UM can stop evolving or growing? We present UM will continue evolving until it is into death.

In addition, if the number of available UM is large and is rapidly growing, the management of UM is becoming a cumbersome and fatiguing task for Cyber-I platform. We should subtract the outdated UM's influence and fulfill the need to adapt to the newest UM, while discarding the outdated UM. These problems could be alleviated if a UM has a life ending.

Actually, we believe that there will be sleep, death, and burial state for UM to a certain degree of growth, where UM is in a process toward extinction. This will last a period of time, named as death of UM. All the activities related to UM during this period are not very frequent. We believe that not only this idea of UM with life is promising but also that it could be further extended, such as knowing human, exploring virtual world. Hence, this state is an important characteristic of UM, because we have made application studies on some behavior and consciousness activities controlled by brain from the standpoint of organic firstly.

Death of UM has some states. For example, after sleep, if subjected to external stimuli, it will be awake again and far away from the edge of dying, and work again; or it will go dead if it is asleep for a long time. Mind, the UM core, has stopped updating and evolution. After death, the corresponding Cyber-I binding it had died, but the important data can also be used and shared by other Cyber-Is for a certain extent, as donation after the death of UM; the last state during the extinction procedure is burial, interment is UM's model structure is destroyed while cremation is UM's basic data information is destroyed.

As for a Real-I's decision making, a UM with life will generate the same think as much as possible. That is, the UM should have virtual behavior activities as a person has. This is the motivation for constructing UM based on users' behavior activities. Actually, the behavior activities of a

Real-I involve extensive aspects, such as web browsing, sending tweets, blogging, and so on. In many of them, however, the web browsing has the most extensive generality for all the Real-Is on the Internet. So in this paper, we consider users' web browsing historical records to simulate the beginning of UM's life, and justify the ending of UM's life via browsing historical variations.

The organization of the rest of this paper is as follows. In Sect. 2, with respect to user actions, the birth of UM is described. The growth of UM is analyzed in Sect. 3. In Sect. 4, the death of UM is defined. Section 5 gives a framework of UM's life-cycle and necessary complements. Section 6 gives an example based on UM and Sect. 7 concludes the paper.

2 Birth of user model in Cyber-I

To solve the problem of the birth of UM, we should be faced with three significant issues:

1. What is the method of representation and mechanism for UM?
2. How to get the behavior data as nutriment for UM?
3. How to give a birth to UM?

2.1 Presentation of user model

In this section, we first review some basic presentation methods for UM in cyber space, such as key words model, case model, the vector space model, ontology model, and so on.

Key words model is UM which express users' preferences and interests extracted from some web browsing historical lists with some traditional machine learning algorithms. Furthermore, key words could be given or assigned directly by users. However, sometimes multi-theme will be included in the same web content, which results in the phenomenon of synonymous words. Key words model would not well depict all interests of user owing to its disadvantages of word sense disambiguation.

According to the case user visited, UM is built by extracting the attributes of case, which reflects latest interests of user. But this method could not tell the differences of interests coming from different cases.

By extracting key words from web contents, the vector space is proposed to represent user's preferences with features and correlative feature values. Specifically, it provides a mechanism to represent the degree of user's preference for some subjects in terms of weight. Unfortunately, the vector space model does not always show user's real interests, which is induced without taking synonymy or near synonymy of words and context into consideration.

Ontology model is proposed for word sense disambiguation with special domain terms combining user's close interested contents. Accordingly, structured model is considered to represent user's interests. This method is mainly taking the semantic level structure into consideration, which solves the differences of distinct interests and the problem of synonymy. Now, many methods have been combined for interest study [11]. Hence, it is our wish that this study provides a new viewpoint through ontology model.

2.2 User behaviors collecting

The user's interest is mainly coming from domain ontology. In this paper, UM based on ontology is composed of user's general information and user's browsing historical behaviors, which could be used to extract some significant key words for forming the structure of domain ontology. A domain ontology concerned with computer is established according to Wikipedia computer science. The following is part of domain ontology user might be interested in, as shown in Fig. 1.

In this paper, we assume that if one is interested in some meaningful theme, he or she will implement necessary relevant behavior actions. In other words, we can analyze valid behaviors related to the subject through collecting the records of user's historical browsing contents [4]. Note that user's browsing contents and actions can be used to calculate the weight of different interests, provide that they can reveal the behavior of the user preference and show a widely used prospect for predicting the user's following actions.

As a complicated work for collecting user browsing historical behaviors, this article captures many actions in Microsoft Internet Explorer Browser, such as clicking of the mouse, sliding of roller, collecting, saving, copying, printing, and so on. For the clicking of the mouse, we

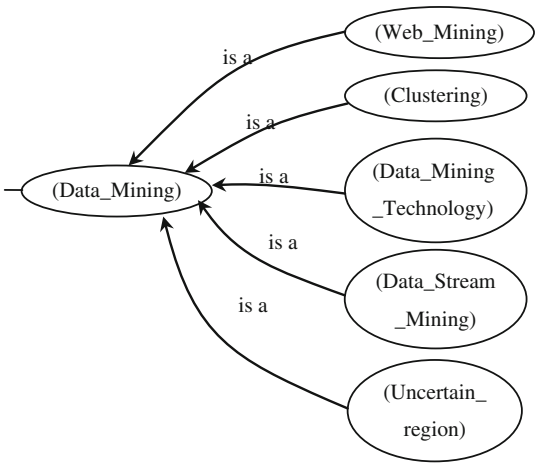

Fig. 1 Parts of domain ontology

divide five kinds of actions according to their actual purposes: opening a new page, activating an existing page, hiding an existing page, closing an existing page, and habitual click coming from left button or right button. With respect to a specific web page, if a user is interested in the content, he will have general operations, for example, opening, hiding, activating, hiding…, activating, and closing. Sometimes there will be multiple operations as activating and hiding.

When a user is more interested in it, he will linger many times and have a read, or do some actions similar as sliding of roller. Furthermore, if a user has a special interest in it, he will perform collecting, saving, copying, printing to satisfy his thirst for knowledge. However, if a user has a little interest in it, some simple operations will be conducted. Based on the above idea, we collect users' behavior habits for making research of implicit interests. Figure 2 is a chart of a user's behavior operations for a period.

In contrast to other approaches on collecting user's web browsing historical records, our approach makes use of user's actions in fine-grained level. In Fig. 2, the actions in details are significant to calculate the valid time of user browsing web pages, which is more accurate than direct time that is the balance of closing time and opening time. Based on this fine granular collecting, the presentation approach of UM can reflect different rates of preferences accurately for specific themes. Because the data collected have much noise, we need to find some effective pre-treatment methods to get available behavior sequences by analyzing data.

2.3 User interests extraction

User behavior sequence is a vector that contains the degree of valid browsing time, printing, saving, copying, and collecting. It provides an adequate grounding for the extraction of the user's interests, and can be a key enabler to deal with the subtleties of user preferences. The user behavior that represents user's interests covers two aspects: one is the theme content of Url users has visited, and the other is the specific operation for content. As we know, the interest extraction involves two methods that are contents and operations.

ID	Action	Url	Time	Userid
1739514	scroll	http://news.baidu.com/	2011-12-02 11:02:26	0
1739515	scroll	http://news.baidu.com/	2011-12-02 11:02:31	0
1739521	leftclick	http://news.baidu.com/	2011-12-02 11:03:08	0
1739522	leftclick	http://news.baidu.com/	2011-12-02 11:03:17	0
1739523	hidden	http://news.baidu.com/	2011-12-02 11:03:22	0
1739524	active	http://news.baidu.com/	2011-12-02 11:04:19	0
1739525	leftclick	http://news.baidu.com/	2011-12-02 11:04:24	0
1739526	hidden	http://news.baidu.com/	2011-12-02 11:04:28	0
1739527	active	http://news.baidu.com/	2011-12-02 11:12:09	0
1739528	scroll	http://news.baidu.com/	2011-12-02 11:12:22	0
1739529	leftclick	http://news.baidu.com/	2011-12-02 11:12:31	0
1739530	hidden	http://news.baidu.com/	2011-12-02 11:12:36	0

Fig. 2 Records of user behavior operations

Based on the domain ontology, for the Urls users have accessed, the text information extraction process is firstly handling the web pages and removing tags; secondly, save as no structured text and make the segmentation of words; thirdly, extract key words and compare them with domain ontology vocabulary; lastly, establish a tree of XML with user's interests. In addition, the key words revealing user's interests have the weight. The value of weight expresses the degree of interest for a node, as the word frequencies in the document. However, as an important research field, here we do not conduct it into deep study. Figure 3 shows that part of XML interest tree for a user interested in computer science.

The actions operations of user behavior sequence represent user's strong interest: one is the implicit interest which is depicted through the valid time and corresponding time rate, and the other is the dominant interest that can be described by some behavior activities, such as printing, saving, and so on. In most cases, there is an implicit interest for a user, that is, browsing time, and it will be enhanced for a certain degree only when the user has dominant behaviors. Note that the idea is different from the

```
<?xml version="1.0" encoding="UTF-8"?>
<Computer_Science value="0.35">
    <Theoretical_Computer_Science>
        <Theory_Of_Computation>
        </Theory_Of_Computation>
        <Databases_And_Information_Retrieval>
        </Databases_And_Information_Retrieval>
    </Theoretical_Computer_Science>
    <Applied_Computer_Science value="0.3">
        <Artificial_Intelligence value="0.4">
            <Data_Mining value="0.4">
                <Web_Mining value="0.5">
                </Web_Mining>
                <Clusteing value="0.3">
                </Clusteing>
                <Data_Mining_Technology value="0.3">
                </Data_Mining_Technology>
                <Data_Stream_Mining value="0.4">
                </Data_Stream_Mining>
                <Uncertain_Region value="0.5">
                </Uncertain_Region>
            </Data_Mining>
                    :
                    :
        </Artificial_Intelligence>
    </Applied_Computer_Science>
</Computer_Science>
```

Fig. 3 Part of XML interest tree for a user interested in computer science

traditional strategy, which is believed that both the implicit and dominant interests are independent.

According to the above idea, in this work, we study the feasibility of merging strategies based on the content and behaviors for the birth of UM in cyber space by combining multiple individual preferences. The proposed presentation method only depicts one character at a special angle, but it is more specific and creative in cyber space. In the future, we need to find other construction types for birth of UM, which is one of the basic questions for researching the Cyber-I.

3 Growth of user model in Cyber-I

With the birth of UM based on the semantic relation, we should seek to establish some mechanism about how can a Cyber-I sustain its life, and how we can measure its growth. After UM has its presentation and birth, it need to grow gradually, that is the updating and evolving of UM. In our work, the evolving has both the positive and negative growth, and the positive growth is that the interest degree of node on interest tree is positively correlated with time while the negative growth is the degree reduces with time.

According to the above strategy, the evolution of UM in cyber space will change as the preferences of a user drift in the real world. In fact, the interests of a user vary from gender, age, time, position, and so on. Therefore, the preferences we get through the behavior activities of user might transform as the circumstance factors change in different situations. Existing updating strategies of UM include forgetting and reenergizing mechanism, spreading activation model, which were proposed by Hermann Ebbinghaus [12] and Collins [13], respectively.

The traditional method makes use of updating and changing of single node for UM's evolution, without considering the other nodes' variations related with original node. Moreover, some methods about spreading activation model take unidirectional spreading of a node into consideration. Neurologists have believed that the transmission way that stimulation of excitement is on the nerve fibers is bilateral. In this paper, we realize the update of the node, depending on incremental updating methods based on two-way transmission mechanism, which is more close to the real model than some existing methods.

Similar to the features that electric potential transmits on the nerve fibers, the proposed transmission mechanism has three rules in UM's growth, that is, evolution.

1. The value of spreading has attenuation characteristics, and diminishes quickly with increasing distance.
2. The degree of interest enhances with stimulations increasing.
3. If there are many times stimulations, the degree of interest will be overlying.

Rule (1) can be expressed as the basic feature for UM's update process. That is, the memory is forgotten with time going by, so the degree of interests will reduce if it has not been stimulated for a long time. Taking into account both the transform of interests and augment of interests as well as the basic characteristics of UM, Rule (2) and Rule (3) consist of necessary updating strategy standards, which interpret the trigger of UM's growing and the way how to grow consistently. For example, if a UM with a high weight on some concept has not been stimulated by series of activities related to the concept, it will drop its attention on the concept, even the similar theme. Nevertheless, if the UM will be stimulated several times in a short time, the interest intensity on this concept is strengthened. The article has put forward a new standpoint for UM's growing, but the specific update function will be discussed in other papers.

4 Death of user model in Cyber-I

The person's death process in forensic medicine usually has three phases: dying phase, clinical death period, and dying in medical science. Similar to the death of a person, we assume that the UM's life will be shortened when its life-cycle has reached a certain degree or its growing power has decreased greatly. In other words, the life of UM has a stop process, namely death, which owns five aspects specifically: sleep, retirement, donation, interment, and cremation. With these ideas in mind, the following could be a reasonable interpretation for the concept of death of UM and its procedures.

4.1 Definition of death

4.1.1 Why?

The United States research statistics institutions have a survey that the adult users in America make a surf on the Internet for about 13 h every week by the year 2009 [14]. According to the investigation and our idea, the UM will grow every day. However, based on the basic rules in [1], which are each Cyber-I must obey: (1) All of a Cyber-I's rights belong to Real-I; so the Cyber-I as a digital clone of Real-I should be disappeared while a Real-I die. Meanwhile, as one form of Cyber-I, the corresponding UM must disappear, too. (2) A cyber-I and its Real-I are one-to-one correspondents, although the Cyber-I might have various forms and different facets, where the life-cycle of UM should end with the life-cycle of Real-I.

Once more, as an individual UM, the natural environments where it lives determine there is a close competition relationship with other UMs. As is well known, the resources are limited in real world, so the competition among people is pretty severe. It is not supposed to completely analogy from social competition relationship to that of UM in cyber space, but their competition and collaboration mechanisms for models reflect the relationship of individuals in social communities. Therefore, more and more UMs will complete finite resources in cyber space if we do not destroy some structures of UMs for a period of time. In addition, there will be a mass of UMs existing on the Internet, and at last the resources are badly scarce, all the UMs are disordered, all the links are into vicious circle, no UM can run robustly.

Furthermore, because there are too many relations of cooperation in cyber space, when a person dies, his or her UM and its virtual social relationships are still living. As a result, there will be a great chance for UM to be distorted, and it may be becoming some other virtual creature, which violates the last rule in [1]. At the worst, the Real-I may break the law and be punished for tampering other UMS deliberately, which will break the construction of harmonious society. So the death process of a UM should be researched for making a balance of relationship links in virtual society.

4.1.2 Conditions of death

Analogously to the death of a Real-I, the death of UM have five stages, which are related and sequential, respectively, and some particular state can transform into another state in special occasion. Firstly, when the life of UM is growing as negative way or starting appearing the new problem in the recession, it may go into sleep. The moment here can be viewed as a sign for the death of UM. At this point, if the stimulation has worked on the UM at a certain degree, it may rouse UM, meanwhile the UM will be awake again. However, if the UM has not received any stimulation from Real-I for a long time, it will step into retirement stage, namely stopping working state. It needs too much attention, once that the UM begins stepping into retirement state, it cannot be awakened, which states that the UM will not evolve or update again. However, at that moment, part of functions and organizations in the structure of UM can be used for donation. In other words, its structure and interests statistical law can be migrated to the other UMs, which have similar behaviors with it. After a while, the UM should be buried, that is, UM has an interment, and the data structure from behavior ought to be destroyed. The last state is cremation, which means the UM's life has stopped thoroughly, and the basic information stored in the Cyber-I platform has destroyed absolutely. The specific process in detail is shown in Fig. 4.

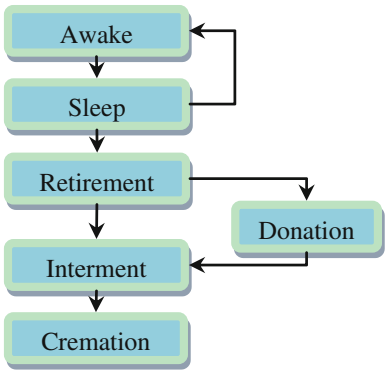

Fig. 4 The structure of death of UM

4.2 State of death

4.2.1 Sleep of user model

The sleep of UM is that the phenomenon happens, where the life activities of UM have stopped updating in a short time because of the impacts of changes from the external or internal environment. Of course, it needs some necessary conditions for stepping into sleep, or else the concept of death of UM is impossible. When a Real-I has not surfed on the Internet for a long time, or a Real-I has no interactions with the Cyber-I platform, it means that behavior data have not been collected to update the degree of UM's preferences for a short time. Once it occurs, it is a specific symbol that when the UM's life will begin declining. The evolution of interests will halt in a short time, and the speed of changing of interests is becoming lower and lower. Apart from that, there is another characteristic that is the dynamic relationships and dynamic interaction activities with other UMs will also stop. However, at this time, if UM is stimulated by Real-I's behavior, it will revive and be awake again.

4.2.2 Retirement of user model

As a Real-I passed away, the corresponding Cyber-I should stop all the work and functions, as a form of Cyber-I in cyber space, the UM should retire, too. Indeed, it means it will not work again and end its life, which is different from the retirement of Real-I, and it cannot be activated at this time. In addition, there are also some concrete typical characteristics in this state of death process. For example, the behavior data of UM are completely unable to update, and the evolution of preferences stop thoroughly. It will stop some dynamic interactions activities with other UMs, but keep a lot of static contacts, such as some virtual social relationships with other UMs. According to the idea, in our work, the retirement of UM is that Cyber-I has stopped some services for its own Real-I, but it can participate with other Real-Is' services.

4.2.3 Donation of user model

After these two phases, the UM has stepped into death. The following is that what the UM in death can do to help to serve corresponding Real-I or other Cyber-Is.

As described in the above, the UM has some static connections with other UMs, where it happens at the time after retirement. Hence, we can donate some useful structures to others, although the UM stop updating thoroughly. For instance, two UMs may have a coincident taste in sport, and the update strategy is generally consistent. Consequently, the opinions of UM that is dead could be highly valuable for the other one, and they even can be shared by many other similar UMs.

Here, the donation has three ways: the donation of UM's basic data information; the donation of UM's behavior data set; and the donation of data about how to evolve for interests. As we know, all of a Cyber-I's rights belong to Real-I. Consequently, all the kinds of rights are affiliated to Real-I of its own. Here, we believe that the donation of UM is a kind of transfer of property rights on the Cyber platform legally, according to a series of agreements between Cyber-I and Real-I. The representative characteristic is that the ownership of general information, behavior data, and data information about evolution of interests belong to Real-I, only the right of use transfers to others. Similar to the previous state, the static contacts are still keeping. As a result, this state is optional, which is dispensable, not necessary.

4.2.4 Interment of user model

The interment of UM is defined that some data information affiliated to Real-I is destroyed after donation. It also has some fundamental principles to access this state of death. When a Real-I has passed away, taking into account both sleep and retirement of UM, the UM can only be given an interment. The basic characteristics of UM at this moment can be described that the behavior data information and information about evolution of interests are destroyed, which are changeable, mainly reflect the users' interests, for example, a user's buying history. Meanwhile, Real-I will no longer have the rights. On the other hand, the static contacts with other UMs are also destroyed. From the whole life of UM, the thing destroyed at this stage is the user model based on the ontology coming from social behavior habits.

4.2.5 Cremation of user model

In this state, the valuable thing is scarce for UM. It only contains some general information registered. As last state of death for UM, the cremation is of great significance. After cremation, all the natural data are destroyed. Here, natural data are users' fundamental data, which are changeless, such as gender, blood type, identity, parents, and so on. Because of cremation, the UM disappears completely. The life-cycle of UM has terminated. The Real-I and whose UM will fade out of people's horizon, which may not play a direct manipulation or control on physical world and cyber space again.

Through all the five states, the life of UM ends. Generally speaking, as a digital representation of Cyber-I in cyber space, the UM is born based on extracting interests from the general information and behavior data collected. It combines the cognition of individual brain, through which the UM try to study and learn Real-I's ways of thinking and analyzing. Then, it updates and evolves continuously, makes it grow. Similar to a Real-I, it will die if suffered some troubles.

The death of UMs is significant, which can help people know and understand themselves further. By researching the recession phenomenon of UMs, we conclude the change trend of user's interests so as to discover some regular laws, which improve the quality of personalized services. Furthermore, we could build some virtual communities of UMs that have same or related interests via these important laws, which involve some interest update rate, update cycle, evolution model, and so on. In this case, a group of UMs could be managed effectively in unified platform.

5 Framework of UM with life

Figure 4 shows the whole process of life for a UM with a Real-I growing, which also goes through birth, growing, death as a natural person has.

The upper is the birth of UM related to preference combining behavior list and ontology. Like parents giving birth to a natural person, the birth of UM also needs external environment. Here, the behavior list is intrinsic data while the ontology is the best structure.

The middle represents the incremental growing of UM based on forgetting mechanism and spreading activation model. Like a person absorbing the nutrients gradually, the UM must derive the behavior data for its growth.

The lower is defined the end of life for UM, where the green is the symbol of life. When a person in real world is dying, his or her life activities stop slowly. The death of UM is gradual and orderly, which is similar to the natural person. However, sometimes the physiology organs of a person can be recycled for other special use, so the UM dead also has many valuable applications.

In Fig. 5, the color fading from inside to outside represents the life power is declining, namely, the number increasing indicates that the life of UM is dying slowly. The whole life of UM is similar to the life a person has, which is evolutional.

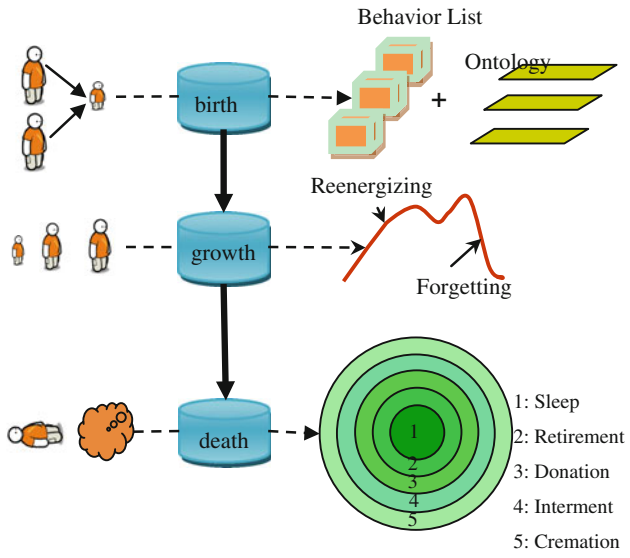

Fig. 5 The framework of UM with life

6 An example: UM-based personalized service

Along with information overload, service flooding, which is caused by services and connection explosions, has attracted more and more attentions in recent years. Sometimes people need to know what they want accurately or what is the best suitable for them. As a digital description form of Real-I, the UM can be utilized for personalized service.

A service platform based on UM was developed and some experiments were tested in this platform. For example, a man would like to keep a concern of sports for long time, and he only wants to pay attention to the news of sports from the web sites. The platform can create a UM for him according to his behavior history, and then collects the news of sports for him. His UM will grow up as his browsing actions, which will be recorded automatically in the platform. Some preferences in his UM will increase, some will decrease contrarily, and some of them will disappear, as shown in Fig. 6.

Certainly, if there is no any preference in his UM, the whole UM is going to enter the death period, like sleep, retirement, donation, interment, cremation. The experiments show that this mechanism of UM death works well.

Of course, an UM might be widely used in many fields, such as personalized search, personalized trip, personalized query, decision making, learning in cyber space [15–18]. The service based on UM can be open, friendly, and can make more and more contributions in cyber space. Besides, the hyper world in the future will also be holistically "intelligentized" to provide transparent and safe service as the development of technologies in web and ubiquitous intelligence [19, 20].

7 Conclusion and future work

In this paper, we have presented a user model with life in cyber space based on the web behavior activities in U-Business, and described the life-cycle of UM in U-Business detailedly.

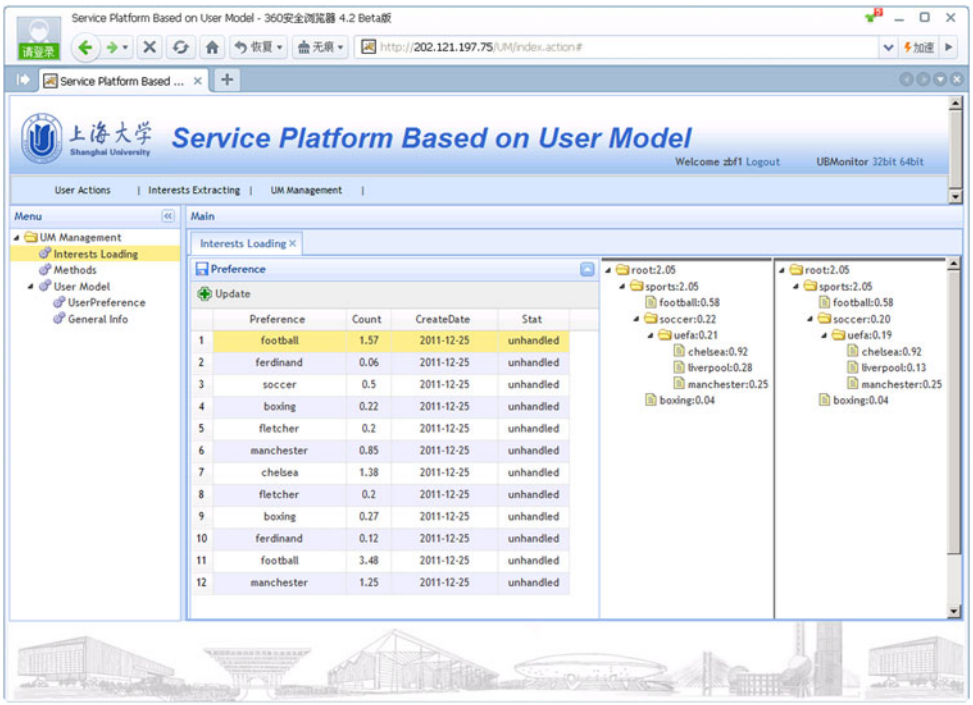

Fig. 6 Interface of service platform based on UM

Firstly, the birth of UM utilizes the user behavior data to extract user interest subject, which can reflect user's behavior preference to a great degree. This scheme based on the semantic relation is more powerful than the usual methods and techniques for computing the term frequency similarity, since it takes into consideration of the synonymous words very elegantly and specific behavior activities roundly.

Secondly, a spreading activation with a bidirectional bus is to model the way of UM growing, like a person absorbing necessary nutriments. Furthermore, it is partitioned into positive growing and negative growing, which is closely relevant to the behavior habits of browsing web.

Finally, the death of UM is proposed which keeps a balance of virtual ecological environment. Five states of UM death are depicted in details. The idea firstly describes the life of UM in an organic way, makes UM survive as a Real-I, and shows the UM life-cycle in cyber space. The idea of UM with life can be extended to other services supplied by Cyber-I on the Cyber-I platform.

We have provided the life-cycle of UM in U-Business in which the changing trend of users' interest appears. Note that the strong vitality of UM represents vigorous spreading of interest, which may happen for individual or communities, so it can be used successfully to recommendation based on interests. These pivotal moments in UM's life-cycle need to be further researched. Additionally, the law of life-cycle will reflect the duration of interest, which can detect the stability of interest for Real-I and perform optimization for personalized services.

As we know, the Cyber-I has many advantages for Real-I, but it also has some problems. For example, the creation of UM as a form of Cyber-I would require some privacy policies, which is quite challengeable [21]. The laws and regulations are needed to become sound in the cyber space, which could protect Real-I's personal information and enable the efficient use of UM informations shared and controlled by other Cyber-Is legally in U-Business. Besides, in order to investigate the robustness of evolving on predicting the accuracy of user interests for UM, there is still not an adequate way to evaluate the performance of UM.

However, how to make full use of the effective work of UM potentialities with life for Cyber-I in U-Business is a challenging issue. The UM with life will play an increasingly important role in the cyber space in the future, which can help people work, manage some trivial things, complete a variety of decision-thinking activities. In this scenario, the future extensive research will absorb more and more attentions. For instance, the state of living and how to make confirm of the begin time and finish time of dying for UM in U-Business are both worthy of further study and exploration in the electronic commercial field, which will accelerate the development of multi-business activities and produce some valuable research space.

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