Agent based multimedia interface using fuzzy logic

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Abstract

In this paper, a model and architecture of an Agent - based Multimedia User Interface will be presented. We introduce two types of agents: User Agents and Media Agents. As User Agents we propose a Browsing Agent responsible for preparing the presentation scenario and a Filtering-Scheduling Agent responsible for handling of the new items. Media Agents are used for different media manipulation. The internal structure of all agents is based on the Visual Widgets [11]. The first experiments show that the fuzzy set theory is a useful tool for modelling the Agents' activities.

1 Introduction

Theoretical issues and recommended techniques relevant to the design of Multimedia User Interface (MM UI) have been addressed in [8], [9], [13], [10]. Non-command interaction principles considering the nature of human senses, prediction of all possible reactions and demands of the final user are some of the proposed rules.

According to [8] these principles will allow target users to focus on the task, rather than on operating the computer. In [9] an Information Visualizer which explores a user interface paradigm is described. It supports applications that retrieve, store and manipulate large amounts of information. The value of MM interface is not just how it enhances the perception of information, but also how information can be expressed by the user [13]. Human performance

efficiency in virtual worlds and user characteristics are some of the issues that have been overviewed in [10].

An object oriented approach for designing MM UI provides more universal and adaptable interface tool kit [2], [3].

In [2] an interface that separates the UI logic from the application logic is established. A non-graphical element such as video widget that represents a UI component, rendered using video data, is described in [3].

The research prototype of ACE (Application Construction Environment) which is given in [4] consists of reusable and extendible software libraries for development of interactive graphical applications.

In order to provide more intelligent and interactive systems, different types of agents have been proposed [1], [5], [6], [7], [14]. In [1] the basic issues in modelling software agents in a computer-supported collaborative learning environment, have been presented. Two approaches in building software agents are described in [6]. The model of learning agents that customize knowledge resource retrievals for each user, is given in [7]. The architecture of the learning agent consists of a knowledge processing component and its local persistent memory. An intelligent media agent (IMA) developed for the purposes of the multimedia interactive television system was introduced in [14]. Each robot works with different media data and has different techniques for knowledge acquisition and filtering. In [5], the multimedia conference is modelled as a cooperative task in which agents representing users handle complex interactions with other cooperating agents and system resources. The architecture and the functions of the Agents used in the above studies are determined by the specific nature of the applications they are designed for.

In this paper, an agent-based Multimedia User Interface will be presented. The agent-based approach combined with the fuzzy set theory is suitable for defining personalized working environments where specific user demands and motivations can be treated in an appropriate way. We introduce several types of agents that consist of agents on different levels of granularity. Each function is performed by a group of agents of the same type with a distributed knowledge about that function.

2 Agent Based Multimedia User Interface

2.1 Architecture and Model of the Interface

Intelligent software agents are programs that are able to perform certain operations or make decisions on behalf of the end users. The software agents adapt to each user using the prior knowledge about the user's behavior, his/her wishes, motivations and desires. These characteristics are embedded in the user profiles that are necessary for building personalized working environments. An

important role of the software agents is to learn from the user's interactions and to change the content of the user profile.

Understanding the user's behavior is a very complex process. Since the cognitive factors that affect that process have not been properly analyzed, the fuzzy approach seems to be a possible solution to this methodological problem.

We have designed an agent-based multimedia user interface considering multimedia presentation applications. The internal architecture of our User Interface is presented on Fig.1. UI consists of a group of agents that use the information stored in the User Profile Database and the Media Database. The linkage with any application goes through an object called Application Linkage, which represents the application in the way that is suitable for the UI.

The user usually demands information to be ordered and presented in a specific way. For that purpose he/she uses the services of the Browsing Agent. The Browsing Agent consults fuzzy attributes in the User Profile Database and according to the information stored in the Media Database, activates a certain set of Media Agents. If the user wants to incorporate new multimedia information presented in the most suitable way, he/she uses the services of the Filtering-Scheduling Agent. The information in the User Profile Database and the Media Database are used to generate the most appropriate fuzzy attributes for that new multimedia material.

The internal structure of all agents is based on the structure called Visual Widget [11]. The cooperative work of the Visual Widget group represents an agent activity. Therefore, we might think about entire organization of our UI as an agent consisting of agents on different levels of granularity.

Each Media Agent is a set of Visual Widgets (VW), responsible for

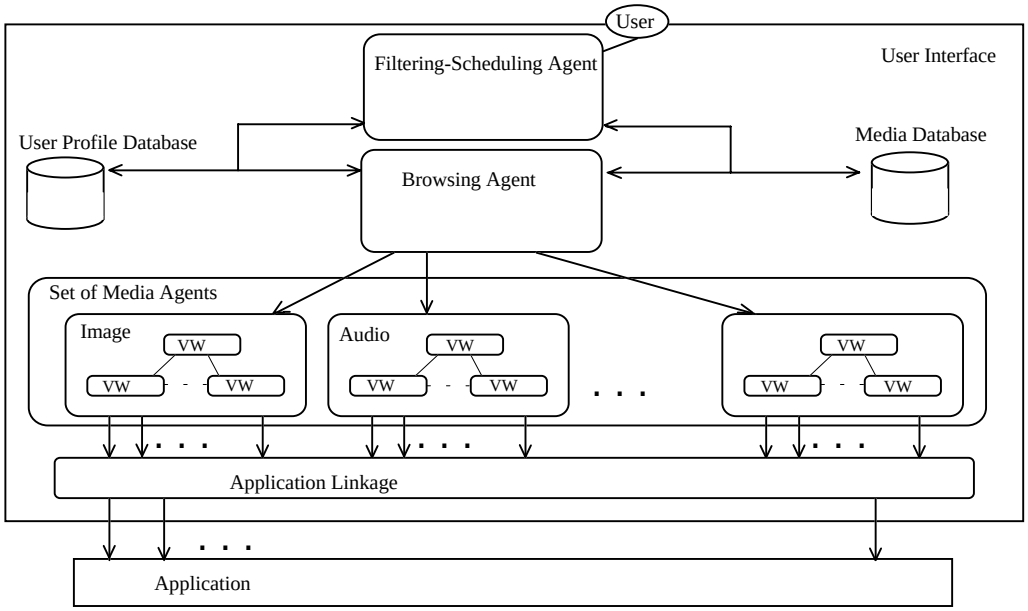

Figure 1. Architecture of the User Interface

manipulation of one media stream (video, audio, images, animation etc.).

The Media Database consists of all available media streams stored on a hard disk together with their identification and basic characteristics. The information in Media Database is represented by one relation using relational database (RDB) system support. In the relation, every item has an associated data presented in different media. The classifications of the media streams on different bases are also incorporated in the database.

The User Profile Database contains User Profiles for every known user. The description of the user specific demands, desires and motivations are converted in these personal profiles. The methods of a fuzzy set theory have proved useful to specify the attributes that can describe user's demands and motivations. The fuzzy attributes represented by ranges of values can help the system to distinguish between 'favorite', 'undesirable' or 'preferred' items. The User Profile contains the wishes and motivations for different media types as well as for different media streams. The ranges of values based on the fuzzy membership function, that describe user demands are specified for those media streams. The User Profile Database is organized as a RDB. The relations contain a set of scenarios, which are represented by a set of all possible paths. Each path contains selected presentation items scheduled in a certain way. The mechanism for automatic profile generation should be applied as well.

The Browsing Agent is created whenever a user is identified. The Browsing Agents provide more relaxed interaction between the user and computer. It consists of a set of Visual Widgets. The selected Visual Widgets reflect a specific user viewpoint and navigation through the application. Based on the knowledge in the User Profiles, the Browsing Agent is responsible for preparing the scenario of the presentation that includes the display appearance, chosen media types and their relations. The Browsing Agent also uses fuzzy membership values from the User Profiles to determine the most suitable presentation scenario. According to this scenario, certain Media Agents are activated. Different users may expect different results when performing the same action because they have different fuzzy membership values stored in their User Profiles.

Users must have the feeling of control while interacting with the software agents. So, the Browsing Agent chooses the best suitable scenario of the presentation, but the users are free to commit or change it. By monitoring the user actions, the system provides a feedback about the user satisfaction or changed needs. Statistics about user interactions in a given period of time are recorded, and an analysis of this information is used in the process of learning. So, the learning process controlled by the learning algorithm makes changes in the User Profiles when necessary. The learning algorithm is based on the fuzzy set theory. If the Browsing Agent can not make a decision, it can request assistance from the user. A list of selected items is given and a suggestion from the user is accepted. The Browsing Agent can also use the experience of other users from the same or similar situations that can be found in their User Profiles.

When a new item has to be incorporated in the User Profile Database, a Filtering-Scheduling Agent is activated. Its role is to set a fuzzy membership value to the new item according to the previous knowledge about the user's wishes. It should find the right place of the item in the scenario using previous user behavior.

2.2 A Prototype Implementation

We will illustrate our model by describing a prototype implementation of a museum presentation application, which can be described as navigation through a regular painting exhibition. We use two agents: Browsing Agent that is responsible for the navigation through the exponents (items), and Filtering-Scheduling Agent responsible for inserting new exponents. In this application only the "image" Media agent is activated.

Every painting in the exhibition has associated data about its author, category and other related information that can be found as textual or audio data. This information is stored in a Media Database. For example, painting1 may have associated audio and textual data. In the Media Database this will be described by Relation 1. The attribute in italics is a key attribute.

The kind of information displayed with each painting depends on the user desires stored in the User Profile Database as Relation 2. A similar relation can be used to describe a cultural context of the presentation. The cultural context represents the way in which different media can be combined and used in the process of communication with the user.

Relation1 (*PaintingID*, TextID, AudioID, VideoID)
Relation2 (*UserID*, *PaintingID*, TextValue, AudioValue, VideoValue)

Browsing through the paintings is provided with the assistance of a Browsing Agent. Categories are used to group paintings according to certain features. We have defined two categories: Author category and Period category. The first one is used to group paintings from the same author, and the second one is used to group paintings created in the same period. The Browsing Agent could predict some of the user actions in order to free him from unnecessary work. The result of the ”next action” depends on the user's wishes, which are stored in the User Profile database.

The Browsing scenario is presented by Relations 3 and 4 in the User Profile Database. The Relation 3 is used to describe the top list of the paintings for every user in each category. If there is more then one painting with the same value, all paintings can be presented to the user, or other User Profiles can be consulted. Once the painting is displayed, the corresponding presence variable responsible for that painting will mark that painting as not interesting for further browsing in that category.

The Relation 4 from the User Profile Database is used to store the information about the user wishes to change one category of browsing with another.

Relation3 (*UserID, PaintingID,* AuthorValue, PeriodValue)
Relation4 (*UserID, PaintingID, CategoryID,* AuthorValue, PeriodVlaue)

The Browsing Agent uses Relation 3 and presence variables history set to find the next painting that should be presented.

When a new painting has to be displayed, the Browsing Agent according to the corresponding fuzzy decision rule will give the name of the preferred painting. In our case, this rule can be understood as finding the maximum degree of the fuzzy membership.

If the user is not satisfied with that result, the fuzzy membership values and User Profile Database will be changed. The user has to cooperate with the Browsing Agent and gives the information whether he wants to look at the next picture in the same category, or at the picture in the next preferred category. Then fuzzy membership value of the painting in the correspond relation is changed according to the formula: new_value=old_value$^{1.75}$. This formula describes the fuzzy term “not so sure about”. Accordingly, when the user performs the same action again, a different link will be established.

If the user is satisfied with the agent choice, the fuzzy membership values of the recommended painting and category alter according to the formula: new_value=old_value$^{0.9}$. This formula describes the fuzzy term “more sure about”.

It is obvious that above discussed fuzzy terms can be modelled in many different ways, as well as that the fuzzy terms such as: “sure about”, “absolutely sure about”, “not sure about”, etc. could be expressed with similar formulas.

The change of a certain fuzzy membership value leads to a different value range (interval). The value intervals show the user’s interest for a given painting according to certain criteria. If the fuzzy membership value is decreased, it might belong to a lower interval that will classify the painting as less desirable and vice versa.

These changes globally result with a more interesting and focusing scenario. With time, the user will have the information he is really interested in. By choosing one particular link, the user will reject the information related to the other links as not interesting at that moment. However, if the user finds that some information has become interesting to him, the Browsing Agent will alter the presentation in the desired way by changing the fuzzy sets of the related categories. This is possible because the User Profile Database stores information about all possible browsing scenarios. The Browsing Agent picks the most preferable browsing scenario.

We found that the Fuzzy theory is very useful when we want to implement the fact that different users have different desires. For example, if



a) before update b) after update

Figure 2. Two possible presentation scenarios for three museum items in the case of the "same author" category.

user2 wants a different medium from a given user1 when some painting is presented, then the system will generate complementary values for user2 in respect to the values of user1. In a case of more complex differences we can define more sophisticated rules. The same approach should be used in Relation 3 and Relation 4. It is easy to define different User Profiles if we can describe differences between users with the human terms such as "opposite from", "not so sure about", and so on.

At the time the presentation starts, the user identifies himself to the system. Then he has to decide what will be his starting category of browsing. After that, an interactive presentation screen is presented as is shown on Fig 2.

When the user clicks with the mouse on the painting, the next painting is displayed. The user can accept or reject the Browser Agent's choice. In the case of rejection, Relation 3 or Relation 4 will be updated. This change will result in a different presentation order of the museum items. For example, if Relation 3 is updated, the presentation scenario shown on Fig 2a. will be changed to the presentation scenario shown on Fig 2b according to the previous fuzzy values.

The Filtering-Scheduling Agent is used when new paintings are inserted. It is responsible for generating data entries in the four previously discussed

relations. Relation 1 has to be updated manually. Relation 4 entries are generated with the assumption that the browsing category will remain the same. The fuzzy membership values for the new painting in Relation 3 are computed as a statistical function of the paintings with the same key words in each category. For example, a new Van Gogh's painting will have an average value of all Van Gogh's paintings in the "Author Value" field and average value of all impressionists' paintings in the "Period Value" field.

Entries in Relation 2 are generated according to the Relation 3 values. We assume that every painting should be presented in a similar way as other paintings in the same category. The Filtering-Scheduling Agent will look in the Relation 3 for the painting that has the most similar values with the values of the new painting. Then, in Relation2 the Filtering-Scheduling Agent will copy the corresponding values of the most similar painting as values for the new painting.

The Browsing Agent will change these initialization settings according to the user's wishes. The filtering process does not eliminate paintings that are not preferred by the user scenario. It only gives them low fuzzy membership values. In that way the Filtering-Scheduling Agent performs a combination of filtering and scheduling processes.

We tested the adaptability of our agent-based UI using the method similar to the method described in [12]. Adaptability is one of the main features of the agent based UI systems.Whenever the user refused the agent's choice, we compared the fuzzy membership value of the recommended painting with the fuzzy membership value of the painting selected by the user. For that purpose, we used the values stored in Relation 3 and Relation 4 of the typical User Profile. A typical user is a user with certain experience with the system.

The results obtained from the test are shown on the Figure 3. The Y axis represents the fuzzy membership values of the recommended painting, while the X axis represents the fuzzy membership values of the accepted painting. The empty points correspond to the Relation 3 values and the filled points correspond to the Relation 4 values.

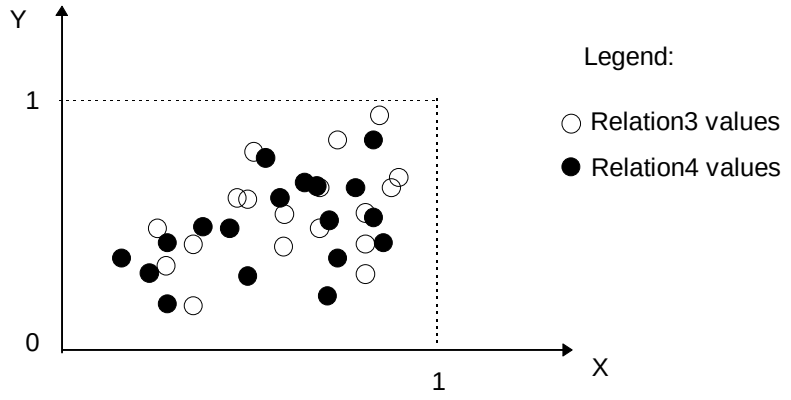

Figure 3. Graphical representation of the results from the adaptability test.

The differences between the above discussed values for a certain user profile decrease with time because our browsing process changes the fuzzy membership values of the "refused" and "selected" paintings. The fuzzy membership values of the "refused" paintings are decreased and vice versa.

3 Conclusion

In the paper, a model of an Agent - based Multimedia User Interface suitable for Object-Oriented applications has been described. We introduced two agents: Browsing Agent that is responsible for the navigation through the exponents (items), and Filtering-Scheduling Agent responsible for inserting new exponents into exhibition. The results obtained from the adaptability test showed that the differences between the fuzzy membership values of the recommended painting and accepted painting for a certain user profile decrease with time. The fuzzy membership values of the refused paintings are decreased and vice versa.

In future work, we plan to use a similar approach for comparing two paintings presented on the same interface screen. We will define Retrieval Agent that will be able to perform tasks such as: "Find me the most similar paintings to the one presented" using certain context (category). For that purpose, the Agent will use the fuzzy membership values from the same relations in order to find the best matches.

The interface has been implemented in C++. We plan to provide some experimental evidence about usability and acceptability of the interface as soon as more user's profiles will be included in the system.

Keywords: Multimedia User Interface, Intelligent Agent, Fuzzy Logic, User Profile

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