Intelligent Software Agent

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Abstract

As a part of Tangible Space Initiative Program, an Agent has been developed in order to make system react proactively understanding any needs of service to human users. The motivation, definition, and methodology of the Intelligent Software Agent are described and the implementation for the case of virtual tour is given and discussed.

Key words: Virtual Reality, Agent, Knowledge management, Context-awareness

1. Introduction

In most cyberspace user interface situation, the user must explicitly state what the system requires from the situation. In TSI, RCS with its TI and TA components can monitor the user situation and his surrounding environment and more "responsive" to the needs that may not be explicitly requested to the system. So, the responsiveness in RCS may depend on the context of many different activities such as education, shopping, maintenance of machineries, etc. In education, the responsiveness may be the tutor must adjustment to the student's understanding of the course material; the shopper may inquire different shopping list depending on the meal being prepared for the evening; in the maintenance of machinery, the mechanic may need to require maintenance record of different parts of the machinery from the manual depending on what subassembly of parts being attended by the mechanic. For enhancing the level of participation, human needs a proper amount of information appropriate for the situation at hand and likewise RCS. Furthermore, while, the information is provided to the human, it should be done in non-intrusive and pleasant manner.. An agent is proactively responding to the user's needs and providing the required information in a non-intrusive manner so that the user is not deterred from his/her main activity at hand.

The necessity and amount of information should depend on the local context – the situation and also the status of a human. The situation obtained through monitoring could be interpreted to query, a set of keywords for data retrieval. The pre-indexed list of the retrieved information is supplied proactively with no triggering. This process should not deter the human, but it could be intrusive since it is done autonomously by the system. Therefore, the whole process of information providing is to be observed. Especially, the reaction of the human who is being provided with the information is to be monitored. By using the result of monitoring, the manner of providing information is self-improved through the machine learning**.** The figure 1 shows the position of the agent in the context of TSI.

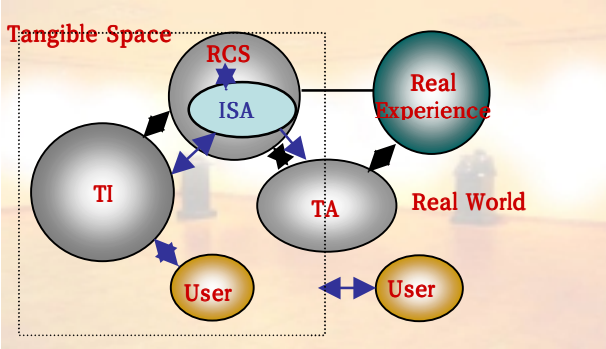

Fig.1 Components of Tangible Space

2. Definition of Intelligent Software Agent

In our definition, ISA (Intelligent Software Agent)

Provides human user in virtual or real world with information for decision making or service by intellectually searching and inferencing the context sensed from the virtual space and real world.

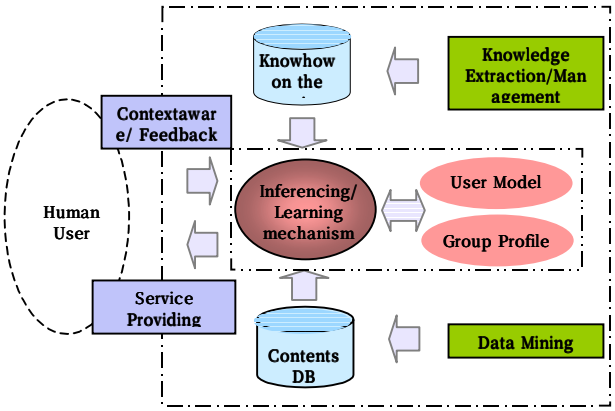

Fig.2. Function Architecture of the ISA

Figure 2 diagrams the function architecture of the Agent. It would replace tour guide in case of virtual experience of cultural asset, act as a tutor in e-education, and make everyday life more informative,

especially in ubiquitous environment. The agent interacts and monitors the human user in order to decide what kind of service required. The decision is based upon the knowledge and perceived context. In current application, the service means providing information proactively

3. Technological Issues in ISA

Awareness of context

Context implies various conditions to be taken into account during decision making for the selection of service. Some of contexts such as personal information are given by the users interactively. Location and intention of user are perceived by monitoring behavior of human user.

User Modeling

User preference is the key for selection of appropriate service or information. It needs to be modeled and kept renewed using several methods depending on the local function.. In case that the system users are anonymous, users are grouped considering similarity of their tendency on the service object. In the user group profile, the preference on the category of the service object is quantified and updated using reinforcement learning process.

Inference mechanism

The requirement for the service is inferred through processing the user preference, context and relevant knowledge. Corresponding service is searched and retrieved among available ones. Bayesian Network, fuzzy rules, difference chaining algorithm, and reinforcement learning algorithm can be considered for the purpose.

User driven adaptation

The appropriate service is retrieved and also adapted according to the reaction of the user. In case of the experience of virtual tour, the routing of the tour can be modified in real time based on the feedback taken during the tour. Multimedia information stored in DB is retrieved dynamically in real time. The information differentiated for the level of interest is queried intelligently before the provision.

4. The architecture of the intended system

In this work, the context-awareness architecture is expanded into an agent-based web service system to be used in real life like Figure 3. Agents are suitable for perceiving and processing changeable context in ubiquitous computing environment because of their properties such as autonomy, seamless communication, interaction, etc.

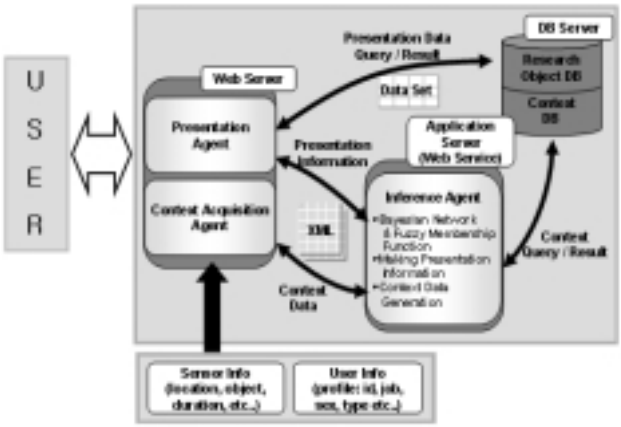

Fig.3 Agent based Context-Aware System

A. Context Acquisition Agent

Context acquisition agent is designed to perform monitoring the change of situation and acquires the context information like users' ID, location, and duration.

B. Inference Agent

Inference agent creates the suitable output type tailored for user with hybrid algorithm, which consists of fuzzy logic and Bayesian network, by the transmitted information from context acquisition agent and past user related data. The preference on the relevant information is inferred and renewed in real time using reinforcement learning.

C. Presentation Agent

Presentation Agent provides individualized contents based on data generated by inference agent. It can also interact with users through GUI and modify layout or color on screen.

5. Generation of adaptive story board

In case of virtual tour, ISA is expected to act as a professional tour guide whose first task is to decide routing appropriate for a user or a group of users. This is done based on the expert knowledge. As a way of inferencing method in the application, a new algorithm called 'difference chaining algorithm' has been studied. In the method, human knowledge is extracted through the interviews with experts. The human knowledge is classified and core indices to the classified knowledge are defined first. According to the defined core index, templates for knowledge extraction are determined. The function architecture for the implementation of the method is shown on Figure 4. During the interviews with human experts, the templates are filled with the acquired knowledge fragments. The core indices form the knowledge axes that have many dimensions according to the knowledge properties. The knowledge

axes become the basis for standardization of knowledge, by which the relations among the knowledge fragments are constructed.

The difference chaining algorithm is a user-driven adaptation mechanism where the user selection is compared with the recommendation of the system and the differences are used to set up a hypothesis that the user preferences have been shifted. After the cycle of refining the user preferences, the final description of the user tendency is obtained.

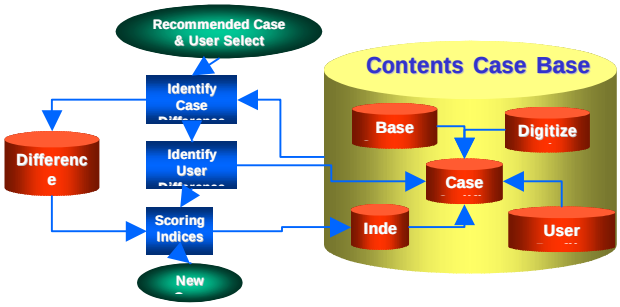

Fig.4 Difference chaining algorithm

6. Group profile using reinforcement learning

The preference of user group on a specific service cannot be completely modeled from the beginning. It is realistic that the model evolves as the system is accessed by many users and gets feedback for improvement. For the evolution of group profile, reinforcement learning is adapted. The reinforcement learning is a sort of unsupervised learning, which learning is not carried out by fixed data but by self experience autonomously. It is a learning method to maximize the reward given by environment through trial and error in dynamic environment. The reward value symbolized by Q is given to each status after an action as in the example shown at Figure 5.

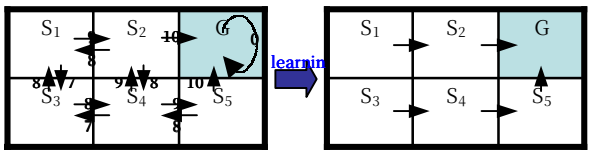

Fig.5 Reinforcement learning

The example is to learn the shortest way to reach the goal G in an environment composed of 6 grids. The reward to an action is stored as Q and arranged in a table. Initial Q is set to zero or arbitrary number. The arrow means possible action at each status. The reward value at the goal is propagated to every status according to update rule as expressed below until the optimal Q table is created as on the right hand side.

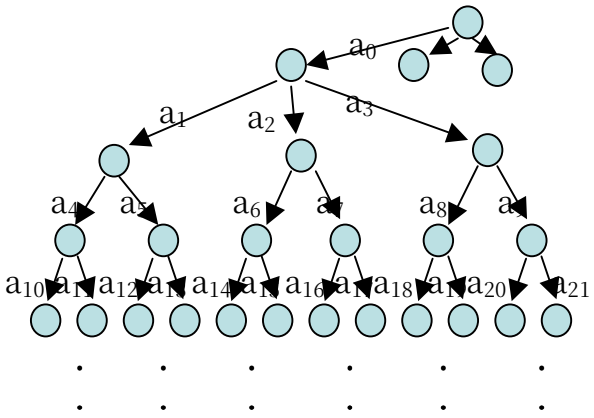

Fig.6 Hierarchy and Reward for Information to be served

In case that the service is provision of information and the information can be hierarchically structured as in Figure 6, the preference on a certain node can be expressed by the reward function Q(s, a) .

$$Q(s,a) \leftarrow r + \gamma \max Q(s', a')$$

s : current status
a : action taken at current status
Q(s,a) : reward after taking action at current status
s' : next status
a' : action taken at the next status
max Q (s', a') : maximum reward available at the next status
r ; immediate reward
γ ; discount factor

Q(s, a) is used for selection of the information in immediate lower level and kept modified according to the reaction from the information user. Different set of Q(s, a) is maintained for the different user group, which means profiling of preference of user groups. At the early stage of use, the recommendation would be not accurately satisfactory, but the system evolves as it is accessed repeatedly and the reward function is kept modified.

7. Case study

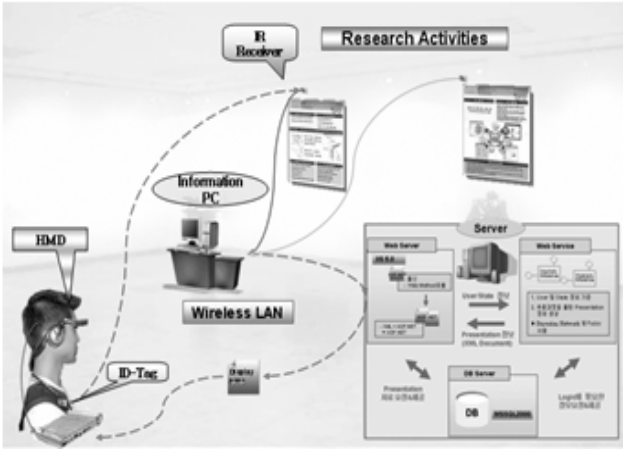

Fig. 7 The application case of the RGA

Visitors enter RGA-equipped laboratory to learn about the research activity. They input their profile such as age, sex, job through web page. Then they receive an ID-tag and a display device to see the detail introduction of the research activities.
The context acquisition agent collects visitors' location and duration in front of a work by interacting with the ID-tag. And they are mapped into pre-defined context massages format like Figure 8

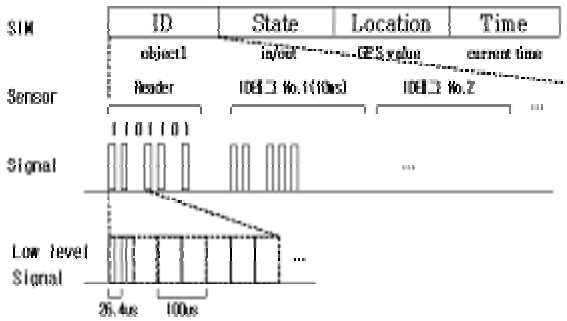

Fig. 8 Pre-defined context message form.

The personalized service type is decided in inference agent by using current context and users' information. Then the agent produces presentation node value as shown in Figure 9.

Example for generating Presentation node

Visitor: Personnel working in the field of rotorcraft
Visitors' age: 20 ~ 28 years old.
RGA object: Documents related to hummingbird

Fig. 9 Example of presentation node value

If users give some additional information like a change of menu, background color of the mobile device, presentation information is re-generated and re-mapped as Figure 10

Fig.10 Hash-table for context information.

Presentation agent makes various individualized displays as shown in Figure 11 that is tailored to corresponding information type from the hash table.

Fig.11 Personalized presentation by hybrid algorithm.

8. Conclusion

An Agent has been defined and implemented in order to make system react proactively understanding any needs of service to human users. Through this system, a new architecture for context aware service consisted of user preference model, inference mechanism, contents base, knowledge base, and presentation module is suggested. For those functional elements, appropriate algorithms and methodology such as difference chaining algorithm, Bayesian network, and reinforcement learning have been studied and exploited. The Agent is expected to play the role of intelligence kernel of many systems for making everyday life convenient and efficient.

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