A Multi-Agent Framework for Decision Support and Implicit Knowledge Transfer

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1. IMPLICIT CULTURE FRAMEWORK

Groups, or *communities* of people have knowledge specific to the environment in which they act, and independently of changes, the behavior of community members must be preserved. For example, the process of software release should not depend on the people currently working in the company [10]. Alternatively, groups of agents can benefit from using the knowledge of other groups. For example, PhD students would like to use the knowledge of their tutors about the state-of-the-art in the research field. All above highlights the importance of knowledge transfer and the problem is exacerbated by the fact that the knowledge which is subject to transfer is often implicit (i.e. highly personalized) and is hardly representable explicitly by means of information bases. To transfer this knowledge to new community members or to make it available for another community is a challenging problem. For example, Mimnagh and Murphy [8] report on the importance of implicit knowledge transfer from senior doctors to junior ones in the healthcare domain.

The thesis will deal with the problem of knowledge transfer between two communities of human or artificial agents acting in similar environments. We suppose that the agents of the first community have knowledge specific to the environment and this knowledge could be useful for the agents of the second community. The propagation of the knowledge present in the first community to the members of the second community can be necessary due to the reasons such as preserving pre-defined or emergent behavior of the community; facilitating decision making process for new agents; reusing knowledge of agents that were in similar environmental conditions before.

We propose to use Implicit Culture (IC) [4] as a framework for computer-human, or, more generally, computer-agent interactions, that supports, preserves, and encourages desired behavior of the members of communities according to the extracted knowledge. IC combines multi-agent systems (MAS) and learning techniques (data mining or machine learning) to facilitate the transfer of implicit knowledge and to assist in decision making process. The essentials of the IC ideas can be summarized as follows: information systems are used to observe behavior of one group of agents (with respect to their activities); then interesting and/or useful patterns (theory) about the behavior of the group are discovered (e.g. causes and effects of certain actions); finally, the patterns are applied to another group. The control and observations over environment are exerted by Systems for Implicit Culture Support (SICSs). A SICS consists of the three modules: the *observer* that records agents' actions, the *inductive module* that applies data mining techniques to induce a theory about these actions, and the *composer* that is responsible for modifications of the environment to encourage actions consistent with the theory (desired behavior patterns). The composer uses the information saved by the observer and the theory produced by the inductive module.

IC is defined as the relation between two groups of agents such that the agents belonging to a group behave consistently with the "culture" of the agents belonging to another one [4]. IC takes its name from the idea of learning hidden laws of the community behavior, its "culture", non-obvious sequences of actions which execution can involve the use of implicit knowledge. The application of the patterns of behaviors to the second group is also done implicitly, since agents of the second group do not need to know anything about the first group and its behavior.

Although IC was applied in different domains like web search, supporting work of biologists in their labs[1], it still lacks sound semantic and is poorly tested. The contribution of our research is twofold. We will provide a formal framework for the problem of implicit knowledge transfer and validate the framework in a number of applications. The results of validation will be thoroughly analyzed and the framework will be refined, if necessary.

2. VALIDATION OF THE FRAMEWORK

To validate the IC framework we will use the following application scenarios.

Scientific publications search. The first scenario is a system that facilitates scientific publications search [2]. The architecture of the system is distributed and includes several multi-agent platforms. Each platform represents an organizational community of users with similar research interests. Alternatively, virtual communities of cloned experts can be created to facilitate the search of the papers relevant to a specific topic. Users interact with their personal agents (equipped with SICS) which cooperate and produce the transfer of knowledge about relevant publications from experts to beginners.

Web service discovery. In the second scenario we are going to apply the framework to web service discovery. Due to a big number of web services available it is increasingly problematic to search for a service that best fits the needs of a user or of another web service. To find services that satisfy specified functional and non-functional requirements,

[1] See http://dit.unitn.it/∼implicit for a complete list of references

the system will exploit others' previous experience in using web services.

Recommendation system. Finally, we will use the framework in a recommendation system for web search [3]. The system differs from the existing tools because it is intended for communities with specific common interests (e.g. PhD students of the same department, or members of the same project team) and helps to find links relevant to their specific interests. The results can be used to support decisions regarding the classification of web documents.

These application scenarios have been chosen due to several reasons. Firstly, we are dissatisfied with the current state of affairs in these areas: many valuable hours are wasted in searching something (e.g. a relevant link or article) which is already known by others. Secondly, the scenarios allow testing the IC framework in several domains which are different in terms of agents, actions and objects which constitute the environment. However, the task of search or resource discovery is common for all these applications, which makes it possible to have a general framework as a result.

3. RELATED WORK

To the best of our knowledge, there does not exist any similar architecture or project in the literature. However, it is related to the following research fields: knowledge management, MAS and information agents, recommendation systems in general and collaborative filtering in particular.

Recommendation systems. Agents, particularly those endowed with learning techniques, are widely used in recommendation systems as personal assistants which help their users to find desired items [1]. The most close to our ideas is I-SPY metasearch engine [5] that tries to guess the implicit context of the query and re-ranks search results by taking into account previous searches of similar users. The system tends to capture preferences of the users and adapts to the emergent communities.

A problem of providing interesting recommendations can be formalized in terms of the IC framework: it is necessary to transfer knowledge about interesting items from those who possess this knowledge to interested users.

Collaborative filtering. Collaborative filtering(CF) [9] is one of the most popular techniques in the field of recommendation systems nowadays. The main idea of CF is that comparing users' ratings of items it is possible to recommend to the user previously unseen (but seen by similar users) items. One of the probably best-known applications of CF is Amazon.com [7], where it is used for product recommendations. IC is claimed to be more general than CF [4] since it filters not only ratings, but executed actions in general, with "rate" being only a particular example of the action.

Information agents. The application fields chosen for testing the framework (see Section 2) make our proposal close to the research on information agents. Information agents have access to information sources and use the information from these sources to answer queries posed by users and other information agents. There are a number of information sources that can be used, and such a huge information source like the Internet attracts probably most attention. Among early papers on agents dealing with information available on the Internet we should mention personal assistant agents which accompany users searching the Web, try to guess users' needs and suggest interesting web sites. For a survey on information agents we refer the reader to [6] and to CIA workshop series.

4. RESEARCH CONTRIBUTION

The expected outcomes of the research are as follows:

Implicit Culture framework. A formal IC framework will be defined. In formalization we will focus on the concepts of agents, actions, objects, scenes and situations. The framework will deal with the problems of decision support and implicit knowledge transfer expressed in terms of choosing actions by agents in different situations. The framework will support designers of systems which preserve desired behavior in a community of human/artificial agents acting in dynamic environment. It will be tested, validated and evaluated in several application scenarios.

Scientific contribution. The framework will contribute to the area of MAS (in particularly, learning, information and intelligent agents), and to other areas of Computer Science (through the developed applications).

A case tool. The case tool for the development of SICSs will be created. It will include libraries implementing the IC framework, and libraries of learning techniques.

System prototypes. The prototypes of the systems mentioned in Section 2 will be developed and made available for common use. It will contribute to the application fields, namely recommendation systems, information retrieval, web services and digital libraries.

5. REFERENCES

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