

TEAKS: Simulation of Human Performance at Work to Support Team Configuration

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ABSTRACT

The management of a complex engineering project is a difficult task that initially involves the division of the project into tasks; the selection of the right people; and the correct allocation of those tasks for the selected people. Team configuration process is typically performed by a manager based on his/her past experience and the available (though frequently scarce, uncertain and dynamic) information about the cognitive, personal and social characteristics of the potential team members. To support this decision-making process we propose TEAKS, a knowledge-based tool that given an initial team configuration and a set of tasks, simulates the most possible team performance. Its formal bases are Fuzzy Set Theory and Fuzzy Logic and it is implemented using Multi-Agent Systems technology in Java, JADE, JESS and FuzzyJESS. This tool was validated with an industrial project involving 23 team members and 23 tasks (ranging from task assignment to SAP administration, SQL programming and equipment connectivity).

Categories and Subject Descriptors

I.2.11 [Artificial Intelligence]: Distributed Artificial Intelligence – coherence and coordination, multiagent systems.

General Terms

Management, Performance, Experimentation, Human Factors.

Keywords

Agents and cognitive models, agent-based simulation and modelling, applications of autonomous agents and multi-agent systems, artificial social systems.

1. INTRODUCTION

When a new complex project starts, a project manager is put in charge of partitioning this project into tasks and selecting the people who will perform them. The success of a project is greatly

due to the personal responsibility of each member, but also to an adequate communication, collaboration and co-operation between them [2]. In addition to social factors, the emotional state of a person plays a critical role in rational decision-making, perception, human interaction, and human intelligence [11]. The computational simulation of human intelligent behaviour has been one of the main research topics in Artificial Intelligence, and therefore, some of these techniques can be employed to simulate social human behaviour as well, particularly human social interaction and behaviour in a team. In this paper we present TEAKS (TEAM Knowledge-based Structuring), a fuzzy agent-based tool that can be used to simulate team-working performance.

2. RELATED WORK

The simulation of human behaviour has been one of the most interesting areas of research and application since early 70's [6]. More recently, the computational simulation of work groups to predict group performance has started to emerge. For instance, each worker can be modelled as a self-running process that controls a worker entity through data and rules embedded in each process as is proposed in [1].

Given the characteristics of the Multi-Agent Systems [13], they can be seen as a very useful tool for modelling human behaviour and in particular social behaviour. The agent-based approach enhanced the potentialities of computer simulation as a tool for theorising about social scientific issues, since it facilitates the modelling of artificial societies of autonomous intelligent agents [5]. In [10] an agent-based model to represent human behaviour is presented where the agents can be characterised by a set of attributes and their behaviour can be described by a set of simple decision heuristics. Additionally, in [12] an application-independent agent architecture called PECS (Physics, Emotion, Cognition, Social Status) to simulate human behaviour within groups is proposed.

Fuzzy logic can also be considered to represent some human characteristics. In [7] a fuzzy emotional agent for decision-making in a mobile robot is described. Another interesting work is presented in [9] where fuzzy agents with dynamic personalities are proposed. Our TEAKS model is based on fuzzy agents; fuzzy parameters represent human characteristics and fuzzy rules model

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the human performance within a work team. The agent architecture is based on the PECS model.

3. TEAKS PARAMETERS TO SIMULATE HUMAN PERFORMANCE

To simulate the human behaviour at work, those relevant human characteristics that affect a person performance at work should be identified. In this research we have decided to incorporate the following characteristics to our team members: personality trends, a set of basic emotions, social characteristics and cognitive capabilities.

3.1 Personality Trends

There are several studies that show the importance of the personality traits in the job performance [4]. We have taken into account the CLEAVER technique to identify behaviour styles in front of different work situations [3]. The CLEAVER technique is applied to the candidates through several psychometric questions. The result of this questionnaire is a numeric value between 1 and 99 for each of the following personality trend parameters (DISC): **Drive, Influence, Steadiness** and **Compliance**: capability to develop the work following establish rules or procedures.

3.2 Emotional State

Emotions have been proven to be an important factor at work place [8]. Given the importance of the emotions in the human work behaviour, the critical decision is to select the set of basic emotions to model them into the agents. From the extended psychology classification of the basic emotions, we select a little set of four basic emotions to model the agents' emotional state at work. Two of them are positive emotions and the other two have a negative influence over the people's performance: **Positive emotions**: *desire* and *interest* of the person to develop a specific task in a given moment. **Negative emotions**: *disgust* and *anxiety* generated by a given task in specific moment.

3.3 Social Characteristics

The characteristics of human relations in groups and teams (such as competence, trust, co-operation, among others) are the main topic of research in areas such as social psychology, social sciences and organisational behaviour. Modelling all these characteristics is out of the scope of this research, but nevertheless, we considered a small set of social characteristics: **introverted / extroverted**, and **prefers to work alone / in team**: when a person is working, he/she may prefers to work alone to develop a specific task(s) even though this person can be extroverted, and vice versa.

3.4 Cognitive Capabilities

Human cognitive capabilities involve several brain processes such as learning and memory among others. Modelling these brain processes and their interactions to generate an intelligent behaviour has been one of the main goals of Artificial Intelligence and it is, as well as human social characteristics, out of the scope of this research. The cognitive capabilities of a person were taken into account in our model by considering the person degree of expertise in a particular domain: **Project Manager**: a person in charge of managing the project and assigning tasks to the other

team-members. **Co-ordinator**: person in charge of specialised tasks, re-configuration of tasks and re-location of resources. **Specialist**: person in charge of complex and specialised tasks. **Technician**: Person who can deal with technical and no-specialised tasks. **Assistant**: Person in charge of not complex, routine and repetitive tasks. In addition of each person's role, every team-member has two other independent-role parameters to represent his/her cognitive capabilities: **experience level** and **creativity level**.

3.5 Performance Parameters

The resulting team members' performance is calculated by taking into account its internal characteristics, the interaction with its assigned task and the interaction with the rest of team-members. We have proposed six parameters to evaluate the expected final performance of each team member: **goals achievement**, **timeliness** and **quality** of the performed task, **team collaboration level**, **individual contribution level** and **required supervision level**. These six parameters had been taken from the existent formats used by project leaders of the Mexican Petroleum Institute (IMP), (the institution which provides us the case study described in section 7).

3.6 The Project

In the TEAKS model a project is represented by its division into tasks, every task is then represented by the following parameters: **number of participants** in the task, **estimated duration** (measured in days), **sequence** (two or more tasks could be executed sequentially or in parallel), **priority within the project**, **deadline**, **cost**, **quality**, **application domain**, **task description**, **level of difficulty** and **type** (required specialisation level).

4. TEAKS FUZZY AGENTS

The behaviour of a person, i.e. the simulation of his/her performance within the project individually and as a team-member, is generated by the combination of all the previously mentioned characteristics. It is difficult to accept that a numerical value could be used to measure the intensity of either human emotion, experience or creativity level. However, we frequently use qualitative attributes to describe properties of human moods, features and emotions. Following this fact, we propose that it is more natural and intuitive to associate qualitative values to the person's internal parameters.

4.1 Fuzzy Rules

Once the fuzzy sets for the agent and task parameters have been defined, the next step is to build the fuzzy rules that are required to simulate the agent behaviour. Fuzzy rules are used to update the values in the internal state of the agents and the agents' performance.

An example of the fuzzy rules used in this process is shown below (where T1 represents a task and A1 an agent):

IF T1 presents a *high_delay* AND A1 has a *driver* personality with *high_intensity* THEN

The *desire* emotion will have a *high_increase*

The *interest* emotion will have a *high_increase*

The *disgust* emotion wills *stay_equal*

The *anxiety* emotion will have a *low_increase*

5. TEAKS VALIDATION

TEAKS was implemented over the JADE Multi-Agent framework (see <http://jade.tilab.com/>). JESS (see <http://herzberg.ca.sandia.gov/jess/>) and FuzzyJESS (http://www.iit.nrc.ca/IR_public/fuzzy/fuzzyJToolkit2.html) rule engines were used to implement the fuzzy sets and the reasoning mechanism required to simulate the agent performance. TEAKS initial test and validation was performed at the Mexican Institute of Petroleum (IMP, www.imp.mx), a research and technological development centre. At the IMP, like in other organisations, the configuration of the project team is fundamental to success in large and complex projects.

An Information Technology project was selected for validation due to the availability of the project manager, the accessibility to confidential documents that evaluate the performance of some of the people involved in the project; and the recent finalisation of that project. In particular, this case study was a project on the development and implementation of a Geographical Information System (GIS) for internal use at the IMP. This project was divided into 23 tasks and assigned (coincidentally) to 23 team-members (1 project manager, 1 coordinator, 15 specialists and 6 technicians). The results generated by our simulation tool were compared with the evaluation reports provided by the project manager.

6. DISCUSSION

The people (and agents) performance is strongly affected by the values of the CLEAVER parameters. Low values for these parameters generate low values in most of the other evaluation parameters. On the other hand, high values of CLEAVER parameters and high values in the parameters related to the social characteristics give rise to a better performance. The difficult of the task parameter influences the team member behaviour. Agent 11 was in charge of 2 tasks (without team-mates in both tasks), and one of these tasks was of medium difficulty. The result of its behaviour for each of the six parameters was better for the *low difficulty task* than for the *medium difficulty task*.

It can be argued that most of the results depend on the rules configuration, despite that, in most cases, the simulation and the GIS/IMP project results were similar. Nevertheless, we must take into account the following:

- We could not access the information for all the team members involved in the project. Nevertheless, we had the opportunity to talk with the project manager and some of the people who worked in the project. Their comments were that, given the software limitations (absence of some of the policies of the institution, such as involvement of the client and manager services among others), the initial predictions can be considered useful and resemble a part of the reality.
- The project manager filled the evaluation documents where the results of the team-members performance are recorded. This evaluation is according to the project manager perception and, in many cases, he/she did not work directly with some of the team members.
- The personality type parameters for each agent were set according to the results of the application of the CLEAVER technique. Nevertheless, the values of parameters such as creativity and experience were configured according to the

perception and experience of one of the project co-ordinators regarding his/her interaction with the other team members.

- We have compared the results for only one project. As a result of these initial results, the managers of IMP have shown a huge interest in applying this model for more projects. Once the new information becomes available, we plan to use it for further comparisons and validation (IMP plans to finish this job in the next months).

Even with this set of encouraging results of the initial validation, more tests with other case studies are obviously needed to enhance TEAKS and improve its validation.

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