Applying Cognitive Informatics to Improve Communication in Geographically Distributed Environments

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Abstract

When stakeholders are geographically distributed, elicitation process becomes more difficult and communication between all the participants presents new challenges for software engineering community. Considering characteristics of interpersonal communication and the virtual area where it is carried out, we aim at improving the quality of elicitation results by applying concepts from a new transdisciplinary science called Cognitive Informatics.

1. Motivation

Eliciting requirements is a process that involves the discovery of functional and non-functional requirements that software should attend, but, to be successful, this process must take into account the point of view from all the participants of the process [11]. It is estimated that 85 percent of defects in developed software originate in requirements, and can be classified into incorrect assumptions (49 percent), omitted requirements (29 percent), inconsistent requirements (13 percent), and ambiguities (5 percent) [13].

Failures during the elicitation process can be partially attributed to the difficulty of the development team in working on a cooperative-basis [11] but today there are some other points that have to be considered.

It is a fact that modern software organisations usually have their software development team geographically distributed. Costs of travelling and lack of local availability of quality technical staff are the most important factors that lead to these kind of virtual environments [8]. But when stakeholders are geographically distributed, distance between members is an important issue added to the traditional problems of requirement elicitation process [1,9]. According to the work in [3], eliciting requirements with geographically distributed stakeholders must face four major problems: inadequate communication, knowledge management, cultural diversity and time difference.

2. Related Research Areas

There are some areas of research that try to minimise the impact of these problems. One of them is the CSCW (Computer-Supported Cooperative Work), which is the area that takes into account human behaviour as well as the technical support people need to work as a group in a more productive way. Technical support is the software used for communication and collaboration in workgroups and it is called GroupWare.

Generally speaking, groupware is software for enabling communication between cooperating people working on a common task, and it may include different communication technologies, from simple plain-text chat to advanced videoconferencing [7], or the combination of more than one of them. To be more specific when talking about groupware, as we explained in [10], we will refer to every simple communication technology (email, chat, videoconferencing) as *groupware tools*, and to the systems that combine them as *groupware packages*.

Another approach to face the problems of a distributed requirements elicitation process, is the use of Cognitive Informatics (CI).

The scope of cognitive science emerged from the study of psychology and artificial intelligence, and covers a wide range of studies [2]:

- *Cognitive Psychology* is the study of the thinking mind and it is concerned with how we attend and gain information about the world. *Cognition* is defined as *knowledge acquisition*, and a cognitive model is essentially a metaphor on observation and the inferences drawn from that observation.
- *Cognitive Science* is defined as an intensely interdisciplinary study of cognition, perception, and action. *Cognition* is defined as *information processing*, which is understood as the rule-governed manipulation of data structures that are stored in a memory.
- *Neural Science* attempts to understand how neural nets process information. A fundamental part of this quest is how information is relevant to behaviour, and how this process is represented in the activity of neurons.

From the point of view of Informatics, we also found the following definitions in [2]:

- *Conventional informatics* treats information as a probabilistic measure of the variability of messages that can be received from a channel. It is focused on information transmission rather than information itself.
- *Contemporary Informatics* perceives information like aspects or attributes of natural world that can be abstracted, digitally represented, and mentally processed. From this point of view, information is regarded as an independent and essential entity in modelling the natural world.

Finally, *Cognitive informatics* is defined as an extension of contemporary informatics into the study of the brain and its information processing mechanisms. It is a transdisciplinary research area that encompasses informatics, computer science, software engineering, mathematics, cognition science, neurobiology, psychology and philosophy, as well as knowledge engineering. It focuses on the nature of information processing in the brain such as: information acquisition, representation, memory, retrieval, generation, and communication.

From Wang point of view [12], human beings are living in two worlds: one is the concrete or *physical* world, and the other is the abstract or *perceived* world. His world model, commonly known as the I-E-M model, indicates the relationship between matter (M) and energy (E) in the physical world, and information (I) in the latter. According to this model, information plays a vital role in connecting the physical and the abstract world, as Figure 1 shows.

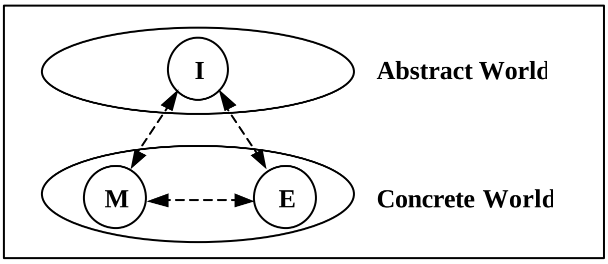

Figure 1: Relationships of the I-E-M Model

3. Distributed Elicitation Case Studies

In [3] the authors present a case study about a real multi-site organisation in which the product strategy is managed from US, the development groups are distributed in three Australian and one New Zealand locations, and customers are across five continents.
To cope with distance this company uses a mix of synchronous and asynchronous tools. To communicate across continents they perform a biweekly teleconferencing call and these formal meetings are complemented by phone calls and email between key stakeholders. Participants, also share a common repository of documents (graphics in Microsoft Powerpoint and Excel forms). Members in US are located across three locations, so they communicate by phone and email, while developers in Australia use phone and Internet technologies for weekly "requirement capture" sessions.

The authors collected data from inspecting documents, observed requirements meetings and performed semi-structured interviews with 24 stakeholders that played different roles into the company. Grounded theory techniques were used in comparative analysis of interview data within each stakeholder group and from different groups. As a conclusion, some of the points that stakeholders mark as problems – especially interesting for us – are the lack of informal ("corridor talk") or face-to-face communication and the difficulty to share drawings on a whiteboard during spontaneous discussions.

As another example, [8] reports the results of an exploratory empirical study about effectiveness of requirement engineering in a distributed setting. Forty-six students from different graduate Software Engineering courses played the role of customers or engineers in six separate groups. The participants that play the role of software engineers wrote a Software Requirements Specification (SRS) document using only the knowledge gained from remote collaboration with their customers. During the distributed requirement engineering project simulation, the participants never met face-to-face. They could just use a previously selected set of synchronous and asynchronous groupware tools: Centra Symposium to support real time virtual meetings; MOOsburg to facilitate file sharing and informal (chat) meetings, and email for file sharing and asynchronous discussions. Software engineers could just use a series of four planned virtual meetings, no more than 19 minutes each, with customers. MOOsburg and email use was not restricted. The elicitation techniques they were able to use were: question and answer methods, customer interviews, brainstorming, storyboards, prototyping, questionnaires, use cases and requirement management.
After the SRS documents were produced, a set of metrics was applied to assess document quality. Also artefacts produced during simulation (records of meetings, emails, documents) were monitored and examined.
They conclude that students that played the role of software engineers chose the techniques accordingly to previous experience and instruction in the course, and for instance Prototyping was not use at all. Questionnaires were used especially when engineers felt their customers had a high level of participation outside the virtual meetings. Data collected suggested that groups producing high quality SRS did not need to use email and asynchronous elicitation methods.

4. How can Cognitive Informatics be applied in Software Engineering?

The psychotherapeutic approach known as *Neuro-Linguistic Programming* (NLP), has been successfully used by the Sophist group in requirements elicitation. They have developed a set of rules for analysing requirements linguistically. This set of rules can be applied in different ways: 1) within interviews, 2) when writing requirements, and 3) for checking written requirements. The main aspects that these rules can help to avoid are deletions (under-specified process words), generalizations (use of universal quantors: all, each, never) and distortions (nominalizations) [6].

Another example are *Learning style models*, which classify people according to a set of behavioural characteristics, in order to improve the way people learn a given task. For example, the Felder-Silverman (F-S) Model [4,5], classifies people into four categories, each of them further decomposed into two subcategories as follows:

- *Sensing* (concrete, practical, oriented toward facts and procedures) or *Intuitive* (conceptual, innovative, oriented toward theories and meanings);
- *Visual* (visual representations of presented material – pictures, diagrams, flow charts) or *Verbal* (written and spoken explanations);
- *Active* (working by trying things out, working with others) or *Reflective* (thinking things through, working alone);
- *Sequential* (linear, orderly, learn in small incremental steps) or *Global* (holistic, systems thinkers, learn in large leaps).

As we have discussed in [10], in a distributed elicitation context it is possible to consider an analogy between stakeholders and roles (student-instructor) of learning models since during an elicitation process everybody must “learn” from others (for instance, developers must “learn” what a user wants the system to do).

Since people clearly have preferences in the way they take in and process information, we have analysed the characteristics of some groupware tools to find which one would be more suitable for people in each category of the F-S model. To do so we just have taken into account the visual-verbal and active-reflective categories. Table 1 shows a categorisation of groupware tools according to the F-S model. We have used the sign “++” to indicate those groupware tools more suitable for a given category. The sign “+” indicates a groupware tool is mild preferred by a stakeholder of that category. Finally, the sign “-“ suggests that a particular groupware tool is “not suitable” for that category. (For further details see [10]).

		Visual	**Verbal**	**Active**	**Reflective**
Asynchronous	E-mail	+	++	-	++
	Mailing Lists, Newsgroups	-	++	-	++
	Async. Shared Whiteboard	++	-	-	++
	Forums	-	++	-	++
Synchronous	Instant Messaging	+	++	++	-
	Sync. Shared Whiteboard	++	-	++	-
	Chat	-	++	++	-
	Video Conference	++	++	++	-

Table 1: Characterisation of groupware tools based on the F-S model

5. Conclusions and Future Work

Nowadays organisations have adopted a decentralised, team-based, distributed structure, whose members communicate and coordinate their work through groupware tools, which allow groups to develop distributed software-engineering activities. In this kind of scenario, research is needed for coping with problems due to distance between members.

Cognitive Informatics is a profound interdisciplinary research area that tackles the common root problems of modern informatics, computation, software engineering, artificial intelligence (AI), neural psychology, and cognitive science. One of the most interesting things found in cognitive informatics is that embodies many science and engineering disciplines, such as informatics, computing, software engineering, and cognitive sciences, sharing a common root problem: *how the natural intelligence processes information*.

Case studies show there is a real interest in software engineering community on finding a solution to improve quality during the elicitation process. Both case studies have very interesting conclusions each, but we think that a different conclusion could be reached if aspects relative to personal characteristics had been applied. For instance: Why students that wrote the highest quality SRS documents did not need to use email to communicate with their customers? May be because the personal characteristics of both (engineers and customers) were propitious for synchronous and visual tools, while those who needed email interaction needed also more time to think and prepare questions or answers, and synchronous communication was not the best for them; or may be because they needed "to see" the words written, and videoconferencing was not appropriate. On the other case, the need of using a whiteboard to draw during discussions indicates people with a strong preference for visual tools. Unfortunately we do not count with information about the classification of the stakeholders according to the learning style models.

We believe that an elicitation process in geographically distributed environments is a propitious field to apply techniques that come from the cognitive informatics research area. Our future work is oriented to analyse how to apply them and validate their use through empirical experiments.

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