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Modeling and Using Context: Report on the First International and Interdisciplinary Conference CONTEXT-97

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Abstract

The first International and Interdisciplinary Conference on Modeling and Using Context (CONTEXT-97) held at Rio de Janeiro, Brazil on February 4-6, 1997. This article provides a summary of the presentations and discussions during the three days with a focus on context in applications. The notion of context is far from defined and is dependent in its interpretation on a cognitive science versus an engineering (or system building) point of view. However, the conference make it possible to identify new trends in the formalization of context at a theoretical level as well as in the use of context in real-world applications. Results presented at the conference are ascribed in the realm of the works on context over the past few years at specific workshops and symposia. The diversity of the attendees' origins (Artificial Intelligence, Linguistics, Philosophy, Psychology, etc.) demonstrates that there are different types of context, not a unique one. For instance, logicians model context at the level of the knowledge representation and the reasoning mechanisms while cognitive scientists consider context at the level of the interaction between two agents (i.e., two humans or a human and a machine). In the later case, there are now strong arguments proving that one can speak of context only in reference to its use (e.g., context of an item or of a problem solving exercise). Moreover, there are different types of context that are interdependent. This makes it possible to understand why despite the consensus on some context aspects, agreement on the notion of context is not yet achieved.

1. BACKGROUND

Advances in multi-disciplinary research show that 'knowledge' has a contextual component. However, even if its importance is acknowledged, this contextual component is rarely represented explicitly in available knowledge representation systems and not used in subsequent processing of knowledge. Thus, there is a gap between what is known and what is done. Acquisition, representation and exploitation of knowledge in context would be a major contribution in knowledge representation, knowledge acquisition, explanation, maintenance, documentation, learning, human-computer communication, pattern recognition, and validation or verification. A computational capability to understand, represent and reason about context will be very valuable for, and of immense benefit to, problems in many areas.

In formal approaches, several formalizations of context have been proposed to treat, for instance, preferences, presuppositions and beliefs as well as knowledge management and reasoning on knowledge in context. In Computational Linguistics,

context is a central notion both in understanding and generating text, and in managing discourses. In Artificial Intelligence, knowledge-based systems now are designed and developed to cooperate with users in performing a task. This shift in the expert-system paradigm towards that of intelligent assistant systems (e.g., see [Boy, 1991]) implies that a system must integrate such notions as cooperation, explanation and incremental knowledge acquisition. A real integration of these notions in a system relies heavily on making context explicit. Cognitive Scientists have long been debating the general meaning and significance of context in the environment and the interaction between a human and a computer system. Cognitive system engineering has always recognized that cognition does not exist without a context (e.g., see the situated cognition defended in [Clancey, 1991]). Context also plays an important role in other domains as decision support systems, human-computer interaction, intelligent tutoring systems, pattern recognition, logic programming, management, psychology, etc.

One acknowledges the importance of context, as evidenced by the numerous workshops, symposia and seminars on context held mainly since 1993. There also is a web page on context (information can be obtained at `http://cdps.umcs.maine.edu/Context`) containing a variety of information as a mailing list on context with 80 participants (in December 1996). The First International and Interdisciplinary Conference on Modeling and Using Context (CONTEXT-97) was held at the Federal University of Rio de Janeiro (Brazil) in February 1997. Its goal was to bring together about forty researchers from different communities working on the notion of context from different viewpoints and in a variety of disciplines to discuss the many issues surrounding context at the conference.

The use of context across domains implies that each researcher may benefit of others' experience. An exchange of ideas from different areas must provide some answers to questions that remain open or, at least, must permit to give a right formulation of problems, knowing that a well-formulated problem is half solved.

2. CONFERENCE ORGANIZATION

The scientific part of the conference was under the responsibility of the Chair person of the Programme Committee, Patrick Brézillon, and a Steering Committee, which was composed of Chandrasekaran B. (Ohio State Univ., USA), Clancey W. (IRL, USA), Giunchiglia F. (IRST, Italy), Hayes P. (Beckman Institute, USA), Lenat D. (MCC, USA), Sowa J. (Binghamton Univ., USA) and Steels L. (VUB, Belgium).

Participants were selected on the basis of submitted papers by three referees at least. Seventy-two papers were submitted and thirty-two retained. Papers came from about fifteen domains, mainly Artificial Intelligence and Linguistics, but interestingly from real-world applications in different areas. Globally, almost half of the papers address theoretical aspects of context and the other half the use of context in applications. The Proceedings of the conference are published by the Federal University of Rio de Janeiro, host of the conference. Abstracts of the papers are available from the web page cited in Section 1, and a selection of papers will be published soon in two special issues.

The interdisciplinary dimension of the conference was one of the reasons of the success of the conference. The domains represented at the conference were artificial intelligence, natural language processing, pattern recognition, decision making, communication, psychology, information processing systems, design of interfaces, databases, scientific discovery, intelligent assistant systems, multi-agent systems. Even with the difficulty faced by each participant in understanding presentations in a such large number of domains, each session was attended by about thirty participants.

3. GENERAL COMMENTS ON THE CONFERENCE

From a survey of the literature on the use of Knowledge-Based Systems (KBSs) in companies and administrations, Brezillon and Pomerol (1997) point out that the two important causes of failures in KBS use are the lack of consideration of the notions of interactivity and of context at all the steps of the KBS development from the phase of knowledge acquisition to the phase of implementation of KBSs in the working environment. The recent paradigm of intelligent assistant systems relies on notions of cooperation, incremental knowledge acquisition and explanation. These notions are intertwined through the notion of context. This conference provides some cues on the need to make context explicit in applications.

Roughly, accepted papers came mainly from three areas: logic, natural language processing and applications.

- In logic, there is a focus on the different ways to extend formally logic to account for context to deal with preferences, beliefs, presuppositions, etc. Part of these works concerns extensions of the **ist(c, p)** formula proposed by McCarthy [McCarthy, 1993]. (Someone even spoke of the Stanford School of context.) Interestingly, another part of the papers focused on the implementational means of mechanizing the reasoning. Many of these originate from Giunchiglia's group at IRST (Trente, Italy). In this area, most of the studies consider context in isolation, in an abstract way, at the level of the knowledge representation and the reasoning mechanisms on it.
- In natural language processing, papers concern factors that influence the generation or the understanding of texts. The main factors evoked are presuppositions, beliefs, argumentation, and discourse elements. Here, theoretical approaches to study context are applied on texts or discourses. Although several types of context are identified, most of the works focuses on one type of context, namely the linguistic context considered as the text around a word.
- In applications, the problem is to identify contexts from the domain knowledge, the task at hand and the interaction between the user and the system. The different context models proposed at the conference show that a definition of context is highly dependent of the domain. Thus, it may be difficult to reuse a context model across applications. However, contextual knowledge can be reused for different tasks in a same domain (e.g., monitoring, diagnosis, etc.). In applications, context is always referred to a given item: context of the interaction, context of the problem solving, context of the task at hand, etc. Often, the context of one item is considered at two levels, a global one and a local one. For instance, different contexts are identified according to the problem solving as a whole or to a given step of the problem solving. In the former case, there is one context that evolves dynamically as the problem is solved, when in the latter case a static context can be associated with each step of the problem solving.

As a first conclusion, one notes that logic has a top-down approach of context (from theory to application), while applications imply a bottom-up approach of context (from the application to a modeling of context). Linguistics has an intermediary position, dealing with a real-world application (text or discourse) with theoretical tools developed in logic.

However, if logic and natural language processing are relatively close (at least by the formal approaches), the problems treated in these domains appear quite different from problems in real-world applications. Clearly, there is a deep gap between the viewpoints of Engineering and Cognitive Science. The gap that had been identified in previous events (e.g., see [Brezillon and Abu-Hakima, 1995]) is stressed in this conference. It is due to the interdisciplinary dimension of the conference. However, if every one acknowledges the gap, clearly each one wants to know what is done in the other side of the gap to benefit of the results obtained rather than to attempt to fill the gap.

4. SPECIFIC POINTS

4.a. Introduction

Context is considered in a number of domains, some ones being rather far from computer science as psychology and geology. This section presents examples in two domains, namely Logic and Natural Language, and in applications. A summary is given at the end of each subsection. A general discussion follows in the next section.

4.b. Context in Logic

Two aspects of context are particularly discussed in logic. The first aspect concerns the use of knowledge in context and the mechanisms for reasoning on it in context. The second aspect concerns the extension of existing representation formalisms to give a unified view of knowledge and context.

Cimatti and Serafini (IRST, Italy) discuss the issues related to the practical use of belief contexts in multi-agent systems, by showing the mechanized solution to some paradigmatic case studies. The main point is the easy implementation of inference strategies that exploit the structure of the problem. They show how reasoning about mutual and nested beliefs, common belief, ignorance and ignorance ascription, can be mechanized using belief context in a very general and structured way.

Serafini and Ghidini (IRST, Italy) show how a context-based semantics, called local model semantics, for federated databases modeling allows for an explicit representation of distribution, redundancy, partiality and autonomy for distributed database modeling.

Starting point from a formulation of modal logics, Giunchiglia and Ghidini (IRST, Italy) consider Hierarchical Multilanguage Belief (HMB) systems (and the current practice in the implementation of belief) to formalize the current practice in the implementation of propositional attitudes, and in particular belief, inside complex reasoning systems. They propose a new semantics for these systems, called local model semantics that captures their underlying intuitions. The proposal relies on two intuitions: (a) Each first order theory in a HMB system defines a set of first order models; and (b) The propagation of consequences across theories imposes constraints, captured inside (global) compatibility relations, among the (local) models associated to each theory.

Van der Torre and Tan (Erasmus University, The Netherlands) propose to introduce an unless clause similar to the justification in Reiter's default rules to solve certain aspects of contrary-to-duty paradox of dyadic deontic logic. Contextual defaults are defined as 'A is usually the case if B unless C is the case'. The advantage over Reiter's default logic is the introdution of justifications.

Teriyan and Puuronen (University of Jyvaskyla, Finland) propose a multilevel semantic network to represent knowledge with several levels of context. Domain knowledge first is represented in various contexts. Second the knowledge about contexts and their relationships is considered. Other levels define relationships among metacontexts. The last level is assumed to include knowledge which is considered to be “truth” in any possible context. Three types of problems can thus be solved: how to derive interpretation of knowledge in a context; how to derive knowledge that was interpreted; and, how to derive knowledge about the interpretation context.

As an extension of McCarthy's work (1993)--mainly the **ist(c, p)** formula used by Guha (1991) in the CYC project Gabbay and Nossum (Imperial College, United Kingdom) propose a metatheory of fibred models of context through self fibring of predicate logics to cover both propositional and quantificational logics. Fibred semantics is used as a formal basis for contextual reasoning with arbitrary structure in the terms that describe context. The authors consider that contexts are nested and that the truth of a formula depends on the pattern of surrounding contexts.

Works in logic focus on context at the level of the reasoning and knowledge representation. Papers presented at CONTEXT-97 are good illustrations of the current lines of research in logic. McCarthy was the first to propose an extension of logic to take

into account context in knowledge representation. Since this seminal work, there have been a number of proposals made in the spirit. Giunchiglia and his team attack the problem of context representation from the viewpoint of reasoning. Along this line of research, studies concern the strong connection between context and reasoning.

4.c. Context in natural language

In Natural Language, researchers work either on the understanding and analysis or on the generation of texts and discourses. These studies are ascribed in the realm of communication problems, especially crucial now with the multimedia dimension of communication. The context plays an important role in text and discourse interpretation, and must be considered at different levels. For example, Umberto Eco (1979) describes how the writer takes into account the reader context to adapt the context of the story that he is writing. At CONTEXT-97, the authors also study more specifically the problems of beliefs, presuppositions, interpretation and implicit meaning.

Krahmer and Piwek (Institute for Perception Research, The Netherlands) consider presupposition as a context-dependent phenomenon. They present a theory of presupposition, based on Van der Sandt's presuppositions-as-anaphora approach (1992), which employs a deductive system, Constructive Type Theory, to get a formal handle on the way context influences presuppositional behavior. In their perspective, presuppositions are treated as gaps that have to be filled by contextual information.

Starting from a notion of propositions developed in the Property Theory (Turner, 1987), Manara and De Roeck (University of Essex, United Kingdom) develop a formal model of contexts as partial beliefs entertained by agents, who do not necessarily hold compatible views. They show how this model can be exploited in the treatment of the projection problem for conditionals and demonstrate that a model along these lines does not suffer from the usual weaknesses. They formulated a treatment of satisfaction, failure and defeasibility of presuppositions with respect to a context drawn from an agent's beliefs. To reach this objective, the authors exploit the notion of consistency, whilst circumventing the problems caused by entailment in traditional approaches. Thus presuppositions are equated with accommodation.

Van Deemter and Odijk (Institute for Perception Research, The Netherlands) discuss the various ways in which the generation of an utterance requires the modeling of its linguistic context. They illustrate their claim through a system that supports browsing through a large database of musical information and generates a spoken monologue once a musical composition has been selected. They also devote a special attention to the differences between the 'practical' models of context used in language generation system, on the one hand, and the number of 'theoretical' models of context that have been proposed in theoretical linguistics and (declarative) artificial intelligence, as the other hand.

Reed et al. (University College London, United Kingdom) address the problem of text coherence as one of setting up and dynamically updating an appropriate context for each utterance, by maintaining a topic stack indicating the current focus of conversation. The notion of saliency of a proposition to the hearer plays a key role in their hierarchical planning process and the resultant focussing constraints.

McGough (University of Washington, USA) analyzes conversation of auction talks and treats context as a process of interpretation or meaning making. Under this view, context is described as a process that can be systematically described using three analytically related concepts: potential particulars, salient particulars and manifest meaning. The sequential patterning of the discourse in auction talk suggests that one way to conceive context in terms of turn-type pre-allocation.

Lavid (Universidad Complutense de Madrid, Spain) investigates the relationship between two contextual factors that contribute to the characterization of text types: the purpose and the subject matter of discourse, and the thematic structure of texts. The main result is that thematic selection in discourse is not randomly but contextually controlled, at

least, by contextual factors from the communicative context. The claim is empirically validated through an empirical analysis of a corpus of sixty discourses.

Zhai (Carnegie Mellon University, USA) takes a contextual approach to lexical semantics and studies the linguistic context of lexical atoms, or “sticky” phrases such as “hot dog.” The author proposes several heuristic approaches to exploit the linguistic context for identifying lexical atoms from arbitrary natural language text. He gives a context-dependent definition of lexical atoms in terms of phrase compositionality and proposes three implemented different statistical measures to quantitatively measure the uncertainty of phrase compositionality.

Bunt (Tilburg University, The Netherlands) has studied context in relation to language understanding, focussing on the interactive use of language in dialogues. If understanding not only requires contextual information in order to assign appropriate meaning to linguistic expressions, the very notions of language understanding and 'meaning' should be defined in terms of context changes. Five conceptual dimensions of contexts are identified: linguistic, cognitive, semantic, physical-perceptual, and social. The linguistic context is what surrounds linguistic material and is related to the dialogue history. The semantic context is the state of the underlying task. The cognitive context is the participants' states of processing and models of each other's states. The physical and perceptual context is the available channel of communication and perception, and the partners' presence and attention. The social context concerns the communicative rights, obligations and constraints of each participant. Context has global aspects, which are constant throughout the dialogue and local aspects, whose values change during and through the dialogue.

Galliker and Weimer (Psychologisches Institut der Universitat Heidelberg, Germany) discuss the concept of implicit meaning and its relationships with explicit meaning. Implicit meanings of sentences cannot be inferred directly from their contents or from the meanings of individual words within an utterance. They rather are understood from the context in which the utterance is made. The authors examine three hypotheses: (i) explicit discriminations between private and public discourses are apparent in the expression or content of utterances; (ii) Implicit discriminations are relationships between utterances and their context; and (iii) Implicit discriminations often become manifest by means of verbal cues and by separate utterances. The main conclusion is that verbal discrimination is the sum up (in-/out) categorization and (poitive/negative) evaluation. Context here appears mainly compose of "matter of fact expressions."

Moulin (Laval University, Canada) presents some of the key elements that sustain the conversational context. One of the key element is that a conversation can be viewed as a negotiation game in which participants negotiate on several levels: some of these levels are used to manage the communication (communication channel, information transfer, turn taking) while others (negotiation and environmental sub-contexts) are used to transfer concepts or mental states relative to various spatio-temporal situations between agents. The author presents the major ingredients of contexts: the agent's perspective that characterizes an agent's temporal position when uttering a sentence; the agent's positioning that specifies the action applied to mental states when an agent plays a move in the negotiation game; the mental states and their relations with temporal situations evoked in agents' utterances. He shows that all those knowledge structures are temporally situated with respect to a temporal frame of reference that maintain reference points are specified relative to agent's perspectives or deictically specified.

Descles et al. (Universite Paris Sorbonne, France) consider the context of use to identify semantic information. They developed a method called contextual exploration method that provides a framework for identifying specific semantic information contained in texts. The basic idea of the contextual exploration method is the process of going from a linguistic representation system to a semantic representation system. They consider four types of context to assign a semantic label to a sentence, to solve dangling anaphora, to identify textual sequences, and to identify special textual segments.

As in logic (and in a similar way indeed), work in Natural Language cover a large spectra of problems concerning context. However, one of the lessons learned during

CONTEXT-97 is the identification of different types of context that are interrelated (Bunt's work). Another lesson is the identification of the gap between the theoretical models of context that are elaborated and the practical ones that are developed from concrete problems as text understanding. Work in Natural Language is important because a number of tasks (e.g., knowledge acquisition and explanation) are strongly dependent of the communication means, and thus interaction context.

4.d. Context in applications

In applications, the goal is to represent context in the framework of a task (machine learning, image recognition, knowledge-based system, etc.) rather than to just model. Indeed, one of the lessons learned from the papers in the application area at CONTEXT-97 is that one cannot speak about context out of its context. As a consequence, each work presented at the conference focus on some aspects of context that are directly related to the task at hand. Again, one notes that approaches followed in applications differ significantly from formal approaches.

Bonzon (University of Lausanne, Switzerland) argues that a greater generality in machine learning could be achieved by learning meta-level operators representing sequences of partially defined (or generic) inference steps that lead to the discovery of object-level operators or concepts. The implementation of these ideas is based on a hierarchy of formalized contexts. Inference steps are represented as deduction traces that can be both derived from and forced back into a new kind of reflective contexts. Reflective contexts are defined as contexts that allow to keep track of deduction steps for **ist(C, P)** modalities. They involve a new kind of modalities **reflect (V, W)** meaning that the modality W holds because of the sequence of inference steps V.

Ozturk and Aamodt (University of Science and Technology, Norway) present a model of context based on the roles and elements of various context types. Two important roles are relevance and focus. Context plays an important role in two reasoning tasks: memory use and action planning. They propose in problem solving a distinction between internal and external context types to reflect the nature and demand of the process that takes place during learning and remembering, and the ground facts that happen to exist in a situation. Internal context imposes perspective via the problem solving goal, which in turn leads to a more focused and efficient reasoning process. External context imposes constraints for choosing a method, a specific line of reasoning, which in turn leads to a more relevant and quantitatively better solution.

Brézillon and col. (University Paris 6, France) present a context-based representation of knowledge in the domain of subways to support operators in their context-based solving of incident on subway lines. The key of their representation is based on a distinction between contextual knowledge and contextualized knowledge. Contextualized knowledge is directly used at a given step of the problem solving, when contextual knowledge constrains the problem solving without intervening in it directly. Moreover, it is shown that contextual knowledge can be organized in layers around the contextualized knowledge according to the onion metaphor. Contextual knowledge also ensures a link between the different steps of a given incident solving and across different incident solvings. Thus, if contexts at the level of problem-solving steps constitute a discrete set of contexts, there is a unique context at the level of the problem solving itself that evolves continuously along the solving.

Brémond and Thonnat (INRIA, France) study the representation of context in knowledge-based systems in scene interpretation process. Given a definition of context, they explain the role of the granularity level of processing and the role of the abstraction level of application in modeling context. This makes it possible to have a representation under different viewpoints on the one hand, and to gather all contextual information in one place in the other hand. They also propose a definition of the contextual information of a process as the information verifying that its value remains constant during processing, and its value changes when the process is used for another application.

Turner (University of Maine, USA) associates context-sensitive reasoning and fuzzy reasoning. The meaning of a fuzzy "linguistic" value such as "deep" depends very much on what the current context is. In this approach, a reasoner uses information about the meaning of fuzzy values contained in contextual schemas (c-schemas), which are knowledge structures representing kinds of problem-solving situations. The work is part of the Orca project; Orca being a schema-based, context-sensitive reasoner whose domain is intelligent autonomous underwater vehicle control. Orca deals with three types of context: the static context (portion of the agent, its environment, and its knowledge unlikely to change over the course of a mission); the dynamic context (features of the agent, its environment, and its knowledge that do change during the mission); and the ephemeral context (established by the focus of one of the Orca's module's reasoning). Fuzzy information interacts with each of these contexts.

Staff (University of Malta, Malta) presents a new model for adaptive hypertext that achieves adaptation of the information and hyper-links through explicit context. Context of an entity is composed of the entities of its environment that interact with it, to influence its state or its behavior. Objects of information obtain their context from their parent objects and in-links. The system HyperContext is a three-layer model. The Object layer is an unstructured collection of object representations. The Structure layer is a hypertextual representation of interpretations of the objects in the Object layer. Users interact with HyperContext through the Presentation layer. The author also presents three information retrieval methods that support context-free and context-sensitive search.

Using the framework of Multicriteria Decision Support Systems (MCDSSs), Brezillon and Pomerol (University of Paris 6, France) try to identify where the contextual knowledge is necessary. The MCDSS framework is a good model to specify the exact role of the context because it is rather well structured and thoroughly studied. Considering context at the level of decision maker-system interaction, it appears that contextual knowledge must be shared by both of them. The main conclusions are: (i) context affects more the relationships and mappings between concepts than concepts themselves, (ii) context modifies the extension of concepts and their surface, (iii) contextual knowledge concerns the future and consequences of actions, and (iv) context intervenes in decision maker's look ahead reasoning.

The development of information processing systems (IPSs) leads Mallen (University of Leeds, United Kingdom) to points out the need of intelligent help that ground on contextual information. Such contextual information is based on the design description of an IPS to provide an understanding of how the domain can change states (dynamic knowledge) and to indicate how the particular settings might have led to a particular effect. Although that Mallen does not consider it explicitly, there is a strong correlation between contextual information and explanation.

Bouzy and Cazenave (University of Paris 6, France) investigate the use of contextual knowledge to simplify knowledge representation in very complex domains and systems as the game of Go. Several types of context are pointed out: temporal, goal, spatial and global contexts. The temporal context is modelled by the three stages of the game (beginning, middle and endgame). The goal context is the context in which a particular set of rules applied by the player has to be matched. The spatial context contains information of the position of the coins on the board. The different types of context are represented in Go playing programs, thanks to an object-oriented approach that makes it possible to structure rules in packets. Three examples of Object-Oriented Program mechanisms that enable to deal with contexts are: a general class with specialized classes, a master slot of a class and slave slots, and a list of goals that depend on each other.

Edman and Hamfelt (Uppsala University, Sweden) propose a software architecture (in logic programming) for user-cooperation systems that incorporates notions for building up a context. Context here is the informal domain knowledge, that is the expertise embodied by the system and everything necessary to fully understand this expertise. As part of the context cannot be represented formally, a cooperation between the user and the system is needed.

In interface design, Funk and Miller (Honeywell Technology Center, USA) argue that three elements must exist to support effective context sensitive interfaces (rather than context-sensitive users): 1) the ability to accurately sense context, 2) the ability to modify the control and display configuration accordingly, and 3) the ability to effect (at least some of) the configuration changes autonomously. Salience of context aspects depends on the operator's goal and the task at hand. More generally, context is everything surrounding an item of interest, including the "mindset" of any humans involved in the context. An example of the proposed approach to context sensitive interface design is given as an implemented system in the aviation domain is presented.

Martini-Bigolin and Brezillon (University of Paris 6, France) use context to simplify the translation from system's requirements expressed in natural language to conceptual model (Entity-Relationship Model). This translation is made by a tool called Designer Assistant. The goal of the system is to identify the nature of objects that may be entities or attributes according to context rules. Contextual rules delimit the possible solutions during the translation from natural language requirements to entity-relation model. The contextual information is stored in dictionaries with the words of the language.

Sala (University Montpellier II, France) proposes an environment called SIGALE to assist scientists working in an experimental field in decision making to revise their knowledge by providing them with contextual explanations. A particular emphasis is made on the context of the tool design and the context of the tool use because some tools accomplish the same function but provide different results, especially when information is dispersed among several databases.

Yacef and Alem (CSIRO, Australia) analyze performances of operational skills for training purposes in context to assess the learning process, thus upgrading performance assessment. The context here is the relevant information of the training exercises that can be used for the assessment of the learning. It contains information about the traffic situation and the resource load.

Agabra and col. (University Paris 6, France) address the problem of stops in the alcoholic fermentation and the use of contextual information for stop predictions. This step of the wine-making process is strongly correlated with knowledge of the events that occur at previous steps that constitutes layers of contextual knowledge with respect to the knowledge directly used in fermentation process. Here, there is a process of contextualization that transforms contextual knowledge in contextualized knowledge when needed.

Some concerns emerge from the different works presented at CONTEXT-97. First, context, or contextual knowledge, contrains a problem solving without intervening directly in it. This observation is close from the view of Natural Language. Second, context is a means to manage knowledge bases, avoiding redundancy and optimizing retrieval. Third, the variety of definitions of context can be explain by the fact that one speaks of context without expliciting the level at which one is. The work of Bremond and Thonnat, and the work of Brezillon et al., give strong arguments for this. Four, the relationship between contextual and contextualized knowledge give a new vision of context, reconciling positions on dicrete versus continuous context, for example. Five, making context explicit may permit to provide user with relevant explanation, to incrementally acquire knowledge. This is the first step toward a real understanding of context.

5. DISCUSSION

One goal of this interdisciplinary conference was to address the problem of identifying context. Context intervenes in a number of domains where reasoning intervenes in understanding, interpretation, diagnosis, etc. The reason is that these activities of reasoning rely heavily on a background or experience that is generally not make explicit and gives a contextual dimension to knowledge. At this first conference, as at the

previous events, there are two contrasted positions on context aspects as static versus dynamic, and discrete versus continuous. This may be summed up by the two viewpoints: the Engineering viewpoint and the Science Cognitive viewpoint (Brezillon and Abu-Hakima, 1995).

The gap appears to be only superficial because the two sides of the gap do not address the same type of context. Indeed, each viewpoint can bring something to, and benefit, the other viewpoint. One viewpoint is at the level of the knowledge representation and reasoning (e.g., to focus the attention of the reasoner), even if the goal is to represent things as beliefs and presuppositions. The other is more concerned by the exchanges of information during human-machine interaction.

The most interesting conclusions of this conference are:

(1) Context is something surrounding an item and giving meaning to this item. It cannot be considered out of its use (as Suthers said at the IJCAI-93 workshop, one cannot speak about context apart from its context). Giving meaning to an item, context acts then more on the relationships between items than on items themselves.

(2) There are different types of context with respect to what we consider (knowledge, reasoning, interaction) and in which domain we are. All these contexts are interdependent, e.g. the interaction context is constrained by the knowledge context through, say, the model chosen to represent knowledge.

(3) There are different representations of the context depending if context is considered either as knowledge or as a process of contextualization. Context as knowledge implies that we must distinguish between contextualized knowledge (the knowledge effectively used at a given time) and contextual knowledge (the knowledge constraining the contextualized knowledge). The difficulty is that from one point in time to a subsequent one, contextualized knowledge may become contextual knowledge. Considering context as a process--a viewpoint close to the previous one--implies a distinction between knowledge, information and data. Data become information through the contextualization process on the basis of the available knowledge at the time of the observation.

(4) The lack of context representation in AI is responsible for the failures of knowledge-based systems, knowledge acquisition, machine learning, and explanation generation. Making context explicit will permit to develop powerful systems in complex tasks where the user plays a crucial role, generally having to take the final decision. One already speaks of contextual explanations, context-sensitive machine learning and of incremental knowledge acquisition for intelligent assistant systems.

We hope that this conclusion is only temporary and that other events focussing on context will develop the results obtained at this first international and interdisciplinary conference on context.

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