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EORCA : a collaborative activities representation for building guidelines from field observations

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Abstract. In the objective of building care team guidelines from field observations, this paper introduces a representation method for describing the medical collaborative activities during an ICU patient management. An event-centered representation of medical activities is built during a 3-step procedure, successively involving an event-centered observation phase, an action extraction and coding phase, and an event and collaborative representation phase. This method has been used for analyzing the management of 24 cases of neurological and multiple traumas. We have represented the different actions of the medical team members (clinicians, nurses and outside medical consultants), underlining collaborative information management and the strong interaction between information management and medical actions. This method also highlights the difficulty of cases management linked to diagnosis severity, complexity of the situation and time constraints.

KeyWords : cognitive modeling, protocols and guidelines, knowledge engineering, collaborative human problem solving, Intensive Care

1 Introduction

The current use of clinical guidelines and protocols is actually not fully integrated in usual medical activities, though both health organization and physicians widely recognized their usefulness to improve quality of clinical practices. Some proposed solutions to this unwillingness to use clinical guidelines and protocols were firstly, to implement computer-based guidelines to facilitate decision-support [1], secondly, to improve and verify the quality of clinical guidelines programs (as the program AGREE for "Appraisal of Guidelines Research and Evaluation" [2]) and thirdly to explore the existing links between the protocols, the variability of physicians' decision-making and behaviours [3]. In this context, a description of elements of patient medical management observed in real situations that is based upon a formal task analysis should contribute to fill the actual gap between formal medical guidelines and realistic medical activities.

In the project introduced here, our aim was to build a formal method of observation and Event Oriented Representation of Collaborative Activities (EORCA), to describe activities of team members during patient's management in an Intensive Care Unit. The event-centered characteristic of the representation was suggested by the fact that events are the observable parts of medical activities. The most important constraints imposed to this method was to be enough robust and reproducible to allow further qualitative and quantitative analyses of the situations, especially from the objective of improving the quality of patients' care and the reliability of medical decisions associated with the decisions algorithms or guidelines applied in this medical fields [4, 5]. Our method aims at contributing to build and validate protocols in the practice of such specialties in which medical decisions not only result from an isolated physician but also from a group of expert physicians in complex and time-constrained situation [6]. In the future, this method would also allow identifying clinical adverse events, such as potential incidents, dysfunctions and near miss events during patient managements [7].

The goal of this article is to introduce the EORCA main features, its building and the field studies that have been conducted to acquire observation data on the medical cases resolution during 2 years of patients' management observations. This paper is organized as follows. First, we introduce the method we used for analyzing medical team's activities, from observation methodology to the domain ontology that specifies and structures observables, actors and actions. Secondly we present the context of the studies in an ICU service in Marseille (France). In the Results section, we described the application of EORCA model on a set of real data to evaluate its quality as a representation of observed events.

2 EORCA's approach

Two main rationales have guided the development of EORCA.

Rationale 1: a standardized method of task observation and analysis usable by ICU team members

Identifying and formalizing ICU practitioners' actions and decisions during health care from team behavior observation may appear as particularly complex. Human factor approaches can give a complementary view of this problem [8], since some cognitive psychology and ergonomics studies focused on cognitive process involved in anesthesiology, emergency and intensive care tasks [9, 11] and, more recently, on the collective aspects of patient managements [11]. Intensive Care especially requires a coordinating work with a strong collaboration between various specialists such as radiologist, neurologist and nurses. This work situation is also seen as heterogeneous since each actor focused upon a single patient with different activities, motivations and concerns [12]. Our first choice was to base the method upon task observation and representation procedures that would take in account the collaborative dimension of health care as well as the human factors of decision-making in dynamic, complex and critical safety conditions [13]. Stress due to time pressure, specific situation awareness and mental workload, planning and cooperation processes in experts' teams are indeed influent and systematic element of medical decision making that must be considered. Our goal was to develop an accurate and usable task analysis-based tool for observing and representing medical tasks and activities that could be used recurrently by unit staff (doctors or nurses). In addition, the results should be enough stable to allow further qualitative and quantitative analyses of the situations. This method should also allow identifying clinical adverse events, such as potential incidents, dysfunctions and near miss events during patient managements. The resulting descriptive task model would then be the basis for developing the prescriptive task model.

Rationale 2: an event-centered representation of actions identified from observations

Observation methods for studying human actions are, in a general manner, restricted to the level of operations, which are the observable part of a whole, including the operators' underlying cognitive activities. This implies that events involving actors are the observable parts of medical activities, hence our choice of an event-centered representation. An event corresponds to the performance or occurrence of an action. If actions are time independent, defining activities that may be conducted by agents for changing world state, events are time and space dependent and may be temporally and spatially connected (i.e. sequential, simultaneous…).A domain-oriented ontology formalizes and organizes every concept involved in observations (Figure 1). This ontology aims at standardizing observation representations. In association with this ontology, an event-oriented language in first order logic (STEEL)[14] derived from Event Calculus, coupled with a graphical representation, allows the formal representation of medical team members' activities.

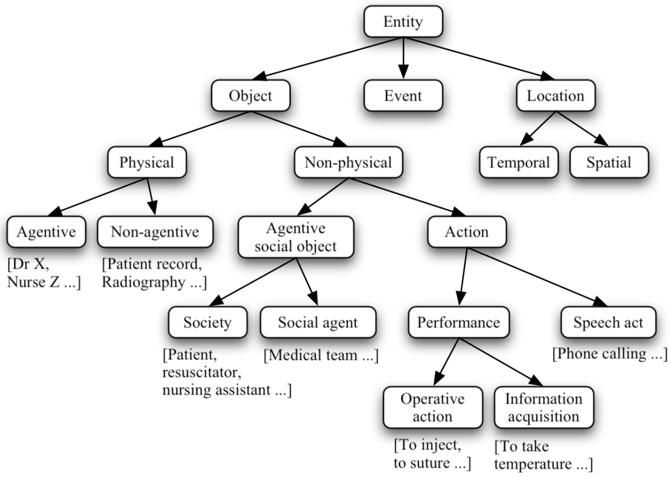

Fig. 1. Top-level categories of the domain-dependant ontology with some examples.

3 The Method

In accordance with previous rationales, EORCA is based on a three-manual-steps method that allows building the representation of activities from field observations, from patient's admission to his/her transfer or delegation. Figure 2 summarizes the method.

- *Step 1*: This step aims at collecting sequences of events by direct observation, and is ruled by some definite and mandatory instructions that enforce standardization of observation and recording. An "observed event" includes an action with an agentive social object. The action may be a deed or a verbal communication occurring between caregivers as explicit decision-making, requests or questions. Events are recorded in chronological order with non-systematic timestamps. Semi-directive post-task interviews with physicians about the observed cases complete observations. The result of this step is an accurate, constrained and event-oriented written description in natural language of patient's care scenario.
- *Step 2:* This step analyses the scenario for extracting events' components and sequencing. Actions and agents are identified and coded according to the ontology. The taxonomy of actions included in the ontology is based both upon a yet-existing national codification of medical acts and an analysis of data coming from a first tentative observation campaign. If needed, the lower ontology classes may be completed from observation during this step. The result is a scenario transcription where each event component (i.e. action, agent, time, location) is identified and coded.
- *Step 3*: This last phase consists in rewriting the coded scenario with the event-oriented first-order logic language. Each element of the representation is an event

occurrence component, identified during the previous step. A graphical representation of the scenario is directly derived. It allows representing in a single template the main elements of patient's management by medical team members. The result of this step is an event-oriented model of the scenario that may be processed for further analysis.

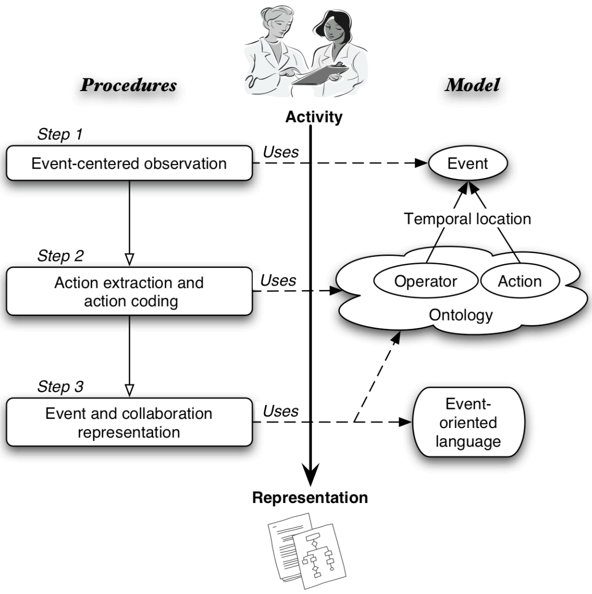

Fig. 2. Overall description of the EORCA's steps, showing correspondences between methods

4 Experiment context

Two studies were successively conducted in the ICU of a public hospital in Marseilles in 2001 and 2003, both of them during 4-5 months. The data we gathered dealt with the management of 24 cases of neurological and multiple traumas occurring during these periods.The data collection was carried out by two ergonomists, for the first study, and by one ergonomist for the second study. Concerning the patient pathologies, multiple traumas and neurological injuries are particularly representative of the kinds of medical problems that are encountered in the ICU, and especially represent the safety-critical characteristics of these problems. Moreover, in this studied unit, these cases constitute a homogeneous and important set of patients. Such pathologies were chosen for two main reasons. The first one is that this department is specialized in neurological traumatisms. Secondly, multiple traumatisms and neurological injuries are particularly representative of the kinds of medical problems that are encountered in the ICU, and especially represent the safety-critical dimension of these problems. The main features of these 24 cases are the various patients' ages (from 19 to 91 years old), and the kind of injuries mainly caused by road accidents.

The data acquisition was manual, directly performed by the observers without videotaped recording [15], computer-based methods using hand-held devices (the FIT technique in the Manser and Whener study [16]) or specific data acquisition tool (such as BabyWatch [17]). Two main reasons are adduced for this restrictive choice. First, the medical team did not accept videotaped recording for legal reasons (the patient cannot give his agreement during the admission). Secondly, we wanted to use the less sophisticated methods of information acquisition and, in the same time, the most opened possible without predefined observable categories. We applied these ecological methods to observe a larger scale of different actions during the patient management by the team members.

5 Results

Assessing the EORCA method implies analyzing its ability to accurately represent the observed events. Based on the data in the final representation, the goal was to identify elements of collaborative information management between the medical team members (clinicians, nurses and outside medical consultants) and interaction between information management and undertaken actions. For this purpose, two kind of analysis have been performed, a quantitative analysis of the observations into classes and sub-classes of actions and a more qualitative analysis of the final graphical representation.

Results about classes of observed actions

Three main classes of observed events were taken in account for analysing the 24 observed patients management:

- *Class of "Speech acts" between the actors*. We define as a speech (verbal or written) act, each information transmission between actors that have been observed and transcribed in the observation sheet. Several sub-classes were identified as for example, the requests for actions from one actor to another one, the explicit decisions for actions upon patient.
- *Class of "operative actions"* gathers actions performed by team members, which were recorded during the patient management as therapeutic deeds linked to major classes of medical acts. Non-strictly medical actions were also identified, essentially collective actions as mutual help, action attempts and actions of time management.
- *Class of "information acquisitions"* includes all actions implying an information acquisition performance as clinical and monitoring examinations, radiology consultations, monitoring and others situation parameters, such as control, observation and verification.

Concerning the repartition of the observations into these 3 main classes, we have hypothesized that information transmissions plays an important role to guide actions, to adjust behaviors when facing to difficulties, to make anticipations and previsions. In the data we gathered, a total amount of 1439 observed actions was obtained (see table 1). Among them, speech acts are the most frequent observations (49.48% of the totality of the identified events). The differences between the study modalities should be not aleatory (Pearson's Chi-squared test, X-squared = 7.9573, df = 2, p-value = 0.01871).

Cat. of Actions/ Years	Cases 2001	Cases 2003	Total/ Cat.
Speech acts	296 (53.1%)	416(47.2%)	712 (49.5%)
Operative actions	164 (29.4%)	323 (36.6%)	487 (33.8%)
Information acquisitions	97 (17.4%)	143 (16.2%)	240 (16.7%)
Total/Year	557 (38.7%)	882 (61.3%)	1439

Table 1. Distribution of the recorded observations by year set of management cases and by main categories of action. Percentages are putted into brackets.

The management of patients by this ICU team should be actually characterized by a majority of information transmissions between the actors of the situation and by care-related actions (operative actions). Events belonging to information acquisitions, essentially clinical examinations and radiological diagnosis are the less observed in these situations. Such activities concern essentially physicians and represent only one part of the overall actions undertaken by all team members, for example the nursing acts. An “Observers/Situations” effect is also observed in the difference between the number of recorded observations in 2001 and 2003. Such results strengthen our positions to build a more efficient observation tool, which would reduce such kind of effect to allow longitudinal studies of patient managements. The analysis of detailed events in the speech acts have highlighted that various kinds of oral communication have been identified as information transmissions per se (transmission of medical information, management of problems and difficulties, phone calling, actions planning), requests for actions or information, explicit decisions expressed to other team members, common discussions between partners...

Application of the formal description to a patient management case

Each case has been represented in a final graphical chart using ontology objects. Each chart illustrates explicitly the sequence of different kinds of events and the elements of distributed support for decisions during case resolution. Such distributed decision-making is encountered especially during comments upon radiological results, generally done between resuscitators and radiologists or others specialists. As example, we introduce an observed patient management. This case concerned a patient, age 48, with multiple injuries and neurological traumatisms (with a Glasgow Coma score ≤ 8) transferred to the unit by the fire brigade after a work accident. FA total amount of 12 persons participated to the patient management for total duration of 26 min:

- members of the ICU team (one attending physician, one resident, one anesthetist nurse, two nurses, one medical student were present in the unit)
- external medical consultants (a fire brigade physician, a radiologist, an orthopedist, two anesthetists and a vascular surgeon were required and present at the patient’s bedside).

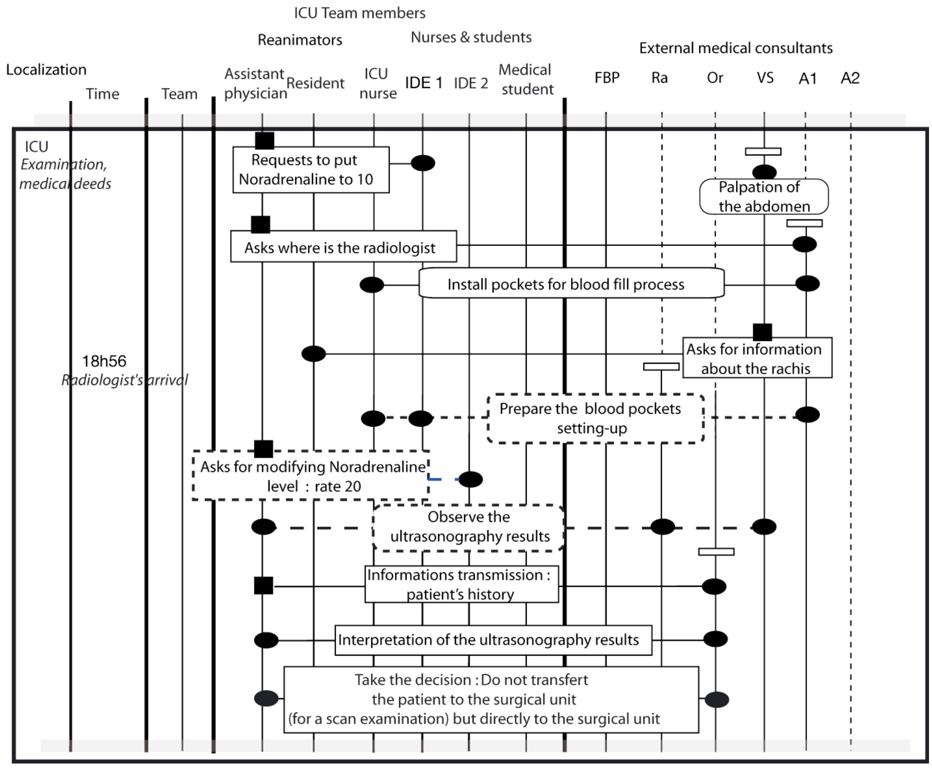

Fig. 3. Excerpt of a patient management by the ICU team. The abbreviations are following: FBP (fire brigade physician), Ra (radiologist), Or (orthopedist surgeon), VS (vascular surgeon), A1 (Anesthesist 1), A2 (Anesthesist 2)

Figure 3 is an excerpt from this example, 10-13 minutes after the beginning, where 9 persons are successively or in parallel participating to this patient management. As quantitative indicators, we have obtained an event density ratio of 1.42 observation/min (37 observations during 26 min of management). 22 speech acts, 8 operative actions and 7 information acquisitions were recorded. It was also possible to provide others indicators extracted from this final event representation such as the amount of 3 overlapping actions, 19 transmission origins (squares), 50 transmission receptions and undertaken actions (ovals) and 8 arrivals or departures. Such kinds of information may be interpreted as an expression of the case management complexity and of global team workload.

Thanks to this representation, it would be possible to describe some features of the caregivers' activity in a situation characterizes as a cognitive cooperation between actors [18]. This activity concerns both a set of individual performances conducted by several specialists and a management of all the required tasks by the actors belonging to the team (cooperation in action). The case of cooperative activity observed here could be described as a supervised cooperation implying planning and allocation of the future tasks and actions between staff members (cooperation in planning).

6 Conclusion

EORCA is a method using a representational model associated to a set of procedures for building an event-oriented representation of complex medical situations involving several caregivers. It has been applied upon observations of neurological and multiple traumas managements by an ICU team. The results show that this method is able to report the temporal organization of care management and especially the dynamics of communication and collaboration between actors. All these elements are gathered in a descriptive model of the situation that highlights the difficulties of case management linked to diagnosis severity, the complexity of the situation, and time constraints. It is then adapted to time-constraint and risky situations where a high level of cooperation and planning is required. This method should makes easier the transcription of a descriptive model of the situation to a prescriptive one in terms of designing or re-designing protocols to adjust them to relevant features of the situation from a social and individual perspective [19]. But at least two issues remain. The first one is the reproducibility of the method. The set of procedures and the ontology aim at giving this method its reproducibility, but this characteristic remains to be demonstrated. The second is to find the adequate level of abstraction, as for example actions sequences and scenarios, to describe such situations and their specificities with granularity appropriate for guideline writing [20].

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