PANCHO needs Models of Collaborative Human Groups: A Mechanism for Teams Modeling

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Abstract. In this paper an automated mechanism for trainees and teams modeling is described; it is based on the human group interaction analysis. These models are obtained using a semi-structured communication interface into a Collaborative Virtual Environment, as part of Team Training Strategy. We also introduce the use of an Intelligent Virtual Agent called PANCHO, to improve the team learning and behaviour during the execution of a task of socio-technical nature.

Keywords: Collaborative Virtual Environment, Group Model, Intelligent Virtual Agent, Interaction Analysis, Team Training.

1. Introduction

The Group Models provide functional representations that help us to understand and explain the group's interaction, but they are also of paramount importance to be used for Intelligent Tutoring Systems (ITS) to improve the team learning and behavior, providing advice, help, feedback, tutoring strategy, etc.

We are proposed a Team Training Strategy (TTS) in which the human group to be trained follows an iterative process of self-assessment about the execution of a proposed task. The strategy proposes —during the task practice— to incorporate to the human group, an Intelligent Virtual Agent (IVA) with the intention of improving the performance of the team and providing scaffolding to the trainees. The IVA called PANCHO (Pedagogical AgeNt to support Collaborative Human grOups) will use Group and Trainee Models as part of its beliefs to generate desired behaviors —scaffolding actions— according to its concerns.

To obtain these models during the co-construction of an execution plan for the task, the human team uses a semi-structured communication interface into a Collaborative Virtual Environment (CVE). The workgroup allows us to obtain indicators about the interaction of the human group, specially, indicators about collaborative skills.

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In the following section, we briefly describe the TTS and the Virtual Environments used to obtain the collaborative skills indicators and to assist to the human group at the execution stage. In the third section, the mechanism for the analysis of the group interaction is detailed, and the process to transform the indicator values to values into PANCHOs Architecture. Finally, in the discussion section, another approach that we are considered to enhance the Human Team is introduced; both approaches will offer information to PANCHO to promote the collaborative learning and improve the performance of the Human Team.

2. A Team Training Strategy Assisted by Virtual Environments

The Team Training Strategy (TTS) proposed in [1], consists of five interrelated stages: *Integration*, *Planning*, *Execution*, *Evaluation*, and *Improvement*, in which the human team to be trained follows an iterative process of self-assessment about the execution of a plan to perform a proposed task. The iterative process followed by the team promotes activities that will generate situations which are expected to trigger learning mechanisms between the team members allowing a better performance during the teamwork.

In this paper, we will be centered into the *Planning* stage, although the models obtained will be used by the IVA at the *Execution* stage.

2.1. Stages of the Strategy for Training

Briefly, the *Integration* stage has the purpose of integrating the human team (with the support of a CVE) as well as providing the trainees with a first mental schema of the plan to be executed for a predefined task. In the following stage (*Planning*) the team members, in a collaborative virtual meeting, co-construct an execution plan for the task. In the third stage (*Execution*) the team uses an Intelligent Virtual Environment for Training (IVET) to execute the planned activities according to their assigned roles; in this stage PANCHO joins the group to improve the training experience. In the fourth stage (*Evaluation*) the team members will have to evaluate their previous performance and must identify both individual and group errors with the purpose of avoiding them in a future execution stage. Finally, in the last stage (*Improvement*) the team members co-construct a new plan for the task using as a baseline the experience acquired during the iterative execution and evaluation of the initial plan.

2.2. Virtual Environments to Assist the Training

A CVE is a computer-based, distributed, virtual space or set of virtual places in which people can meet and interact with other human users, agents or virtual objects [2]. CVEs —specially IVETs— can be used to train one or more trainees in the execution of a certain task, particularly in situations in which training in the real environments is either impossible or undesirable because it is costly or dangerous.

We have developed a CVE to assist the TTS proposed, and we have used it according to the activities proposed for the *Integration* stage [3]. This CVE will be used for the human team in the *Evaluation* and *Improvement* stages.

For the activities proposed at *Planning* stage, we have implemented a Planning Tool —integrated into the CVE—, it incorporates: an editor to co-construct the plans, a viewer to show a PERT graph to the plan designed by the team, and a builder that generates an execution plan script that can be saved in a plan repository. The knowledge about places, objects and individuals, as well as actions to perform in a virtual world is maintained in an Ontology, and will be managed by the CVE during the planning stage. The figure 1 shows the Planning Tool Architecture.

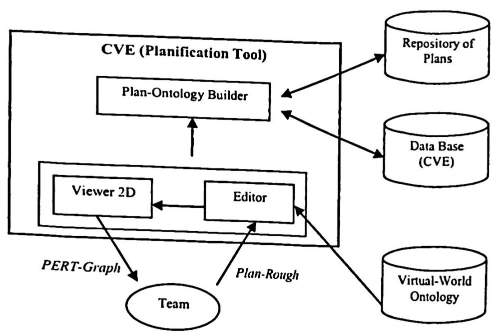


Fig. 1. The Planning Tool Architecture

In order to promote situations that generate sufficient levels of interaction to be considered collaborative, we are designed *Fictitious Scenarios* in which the group to be trained would have to play the rol of a SWAT team (Special Weapons and Tactics) with the mission to rescue several radioactive units in a geographic area; for this reason, the human group needs to design an action plan for the task proposed. The co-planning task is used as instructional activity to promote the interaction between team members and trigger learning mechanisms, to favor the collaborative learning.

Also, for the activity proposed at *Execution* stage —according to the TTS— we have proposed the development of an Intelligent Collaborative Virtual Environment in order to assist the human team. This Environment will incorporate an IVA called PANCHO [4]. PANCHO will join the human group with the aim to improving the performance of the team —inspired by the Team Roles Theory [5, 6] — and providing scaffolding to the trainees [1].

PANCHO will use the knowledge about the plan, the monitoring of the interaction with the teammates during the training, and the *Group and Trainee Models* obtained in a *Planning* stage, as part of its beliefs to generate desired behaviors —scaffolding actions— according to its concerns.

3. Interaction Analysis

Interaction promoted within the team, as a metric of the group cohesion, is a subject that has been approached in many different ways, like for example: the learning promoted through the environment [7], the communication interface of the CVE [8], the activity generated with shared work spaces [9], the type of knowledge that is shared when the used environment is intelligent [10], just to mention some.

Before the diversity of approaches to analyze the group interaction in order to improve some aspect related to the teamwork, we think that the collaboration management cycle is a good framework to drive any work [11]. This framework is defined by the following phases: collect interaction data, construct a model of interaction, select and computing indicators, compare the current state to the desired state, and advise/guide the interaction.

3.1. Collect Interaction Data

Because our intention is to identify the basic Collaborative Skills (*CSs*) [12]: *communication, providing leadership, building and maintaining trust, managing creative conflict* that so much owns the group as each of its members; the trainees use a semi-structured communication interface which is an adaptation of the collaborative skills network proposed by McManus & Aiken [13]. Each communication act has assigned a sentence opener indicating the act's intention by means of which it is possible to obtain indicators related to the collaboration skills.

For each trainee, a pair of values is maintained (Used: *Boolean*, Frequency: *Integer*) in relation to the 35 attributes that characterizes the considered collaborative skills (see table 1): Communication (CM: 10 attributes), Building and Maintaining Trust (MT: 5 attributes), Managing Conflict (MC: 12 attributes), and Providing Leadership (LS: 8 attributes). The group activity at the shared work space is not analyzed in this work.

Table 1. Group record.

Trainee	CM01	...	CM10	LS01	...	LS05	...
Trainee 01	(1, 8)		(0, 0)	(1, 5)		(1, 4)	
Trainee 02	(1, 5)		(1, 3)	(0, 0)		(0, 0)	
...							
Trainee n	(1, 3)		(1, 6)	(0, 0)		(1, 3)	

3.2. Construct Models

Dimitracopoulou, Dillenbourg & Hoppe [14] mention that the indicators offer some information related to the quality of individual activity, the mode or the quality of the collaboration, the process or the quality of the collaborative product. Other authors [15] have also proposed metrics in order to estimate collaborative learning process indicators.

In our analysis, the indicators related to the *CSs* try to give answer to the following questions:

A. Which are the collaborative skills —demonstrated by its use— that the trainees have?

Indicator of Personal Communication Skills: $$CMT_n = (\sum_{i=1}^{10} CM_i[1])/10 \quad (1)$$

Where $CM_i[1]$, $LS_l[1]$, $MT_k[1]$ & $MC_i[1] \in \{1, 0\}$ and T_n = Trainee n

The other three indicators: MTT_n, MCT_n and LST_n follow the same schema.

B. Which are the collaborative skills —demonstrated by its use— that the team has?

Indicator of Group Communication Skills: $$GCM = (\sum_{i=1}^{n} CMT_i)/n \quad (2)$$

Where n = Number of trainees

The other three indicators: GMT, GMC and GLS follow the same schema.

C. Which is the participation rate for the members of the group?

Indicator of Individual Participation: $$IPT_n = \sum_{i=1}^{10} CM_i[2] + \sum_{j=1}^{5} MT_j[2] + \sum_{k=1}^{12} MC_k[2] + \sum_{l=1}^{8} LS_l[2] \quad (3)$$

Where $CM_i[2]$, $MT_j[2]$, $MC_k[2]$ & $LS_l[2] \in N \cup \{0\}$

and T_n = Trainee n

D. Which is the total participation for the group during the meeting?

Total Participation: $$TP = \sum_{i=1}^{n} IPT_i \quad (4)$$

Where n = Number of trainees

E. How are used those collaborative skills owned by the trainees (% of use)?

Indicator of Personal Communications Skills Used:

$$\mathrm{CMUT}_n = (1/IPT_n)\sum_{i=1}^{10} CM_i[2]) \qquad (5)$$

Where $CM_i[2] \in N \cup \{0\}$ and T_n = Trainee n.

The other indicators ($LSUT_n$, $MTUT_n$ and $MCUT_n$) follow the same schema.

F. How are used those collaborative skills owned by the team (% of use)?

Indicator of Group Communications Skills Used:

$$\mathrm{GCMU} = (\sum_{i=1}^{n} CMUT_i)/n \qquad (6)$$

The other indicators (GLSU, GMTU and GMCU) follow the same schema and, where n = Number of trainees.

The models generated with the indicators obtained (with A and B) into the planning stage, allow us to know the degree of appropriateness of the four groups of collaborative skills that each one of the trainees owns, as well as the team. Also, with the answer to questions: C, D, E, and F, the models allow us to know the way in which the collaborative skills are used in interaction with other trainees.

3.3. Modeling Groups

In order to test our modeling approach, and obtain indicators about the collaborative skills used during a work session, a pilot test was developed. Eight human groups with three trainees each one were formed. Using the procedure proposed in [16], the groups co-construct an execution plan in relation to a fictitious scenario. The figure 2 shows a human team in a work session —in a virtual meeting—; the trainees whereas they chatting, they coordinate, propose actions, they discuss, and finally, they reach agreements.

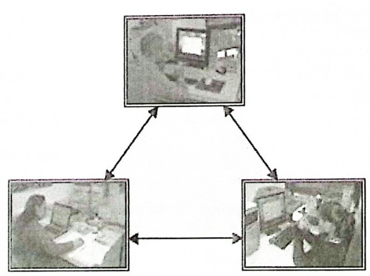
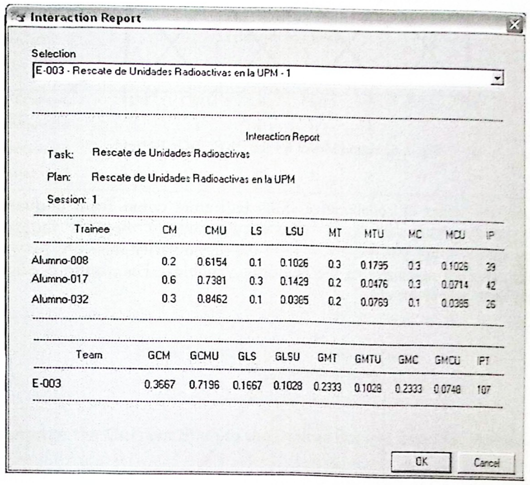


Fig. 2. Human Team in a Virtual Session

The figure 3 shows a report generated by the Collaborative Virtual Environment later to a workgroup session.


Interaction Report

Selection

E-003 - Rescate de Unidades Radioactivas en la UPM - 1

Interaction Report

Task: Rescate de Unidades Radioactivas

Plan: Rescate de Unidades Radioactivas en la UPM

Session: 1

Trainee	CM	CMU	LS	LSU	MT	MTU	MC	MCU	IP
Alumno-008	0.2	0.6154	0.1	0.1026	0.3	0.1795	0.3	0.1026	39
Alumno-017	0.6	0.7381	0.3	0.1429	0.2	0.0476	0.3	0.0714	42
Alumno-032	0.3	0.8462	0.1	0.0385	0.2	0.0769	0.1	0.0385	26

Team	GCM	GCMU	GLS	GLSU	GMT	GMTU	GMC	GMCU	IPT
E-003	0.3667	0.7196	0.1667	0.1028	0.2333	0.1028	0.2333	0.0748	107

OK Cancel

Fig. 3. Interaction report generated by the CVE

Jermann et al. in [11] have proposed a classification of Computer Supported Collaborative Learning Systems: a) those that just reflect the interaction actions, b) those that monitor the state of the interaction, and c) those that offer advice to the learners. In our work and according to the TTS, we propose use the models obtained into the P*lanning stage* to assist the team and trainees in a next stage to its generation (*Execution stage*).

3.4. Transforming Indicators in Beliefs for PANCHO

The values of the constructs —called beliefs— into the Cognitive Architecture [17] extended for our agent called PANCHO (e.g. Personality traits, Emotions, Attitudes, and so on), have been modeled with a fuzzy logic representation. We are used fuzzy logic linguistic labels [18] because are nearer to the way in which humans qualify the anthropomorphic properties. The figure 4 shows the semantic model that has been defined for the beliefs in PANCHO.

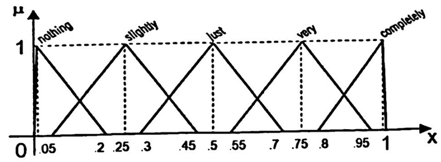


Fig. 4. Semantic Model for the PANCHOs Beliefs

Because the values of collaborative skills indicators come from a quantitative domain —*CSs* Indicators ∈ [0, 1]— we need transform the *CSs* indicators to linguistic variables. For this process, we use the dissimilarity measure between the triangular fuzzy set associates to the linguistic variables. The figure 5 shows the triangular fuzzy set parameters.

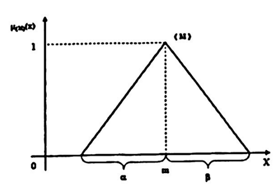


Fig. 5. Triangular fuzzy set representation.

Given ⟨A⟩ and ⟨B⟩, two fuzzy set associates, its dissimilarity measure (*DM*) will be obtained as follows:

$$DM(\langle A\rangle, \langle B\rangle) = \sqrt{\left(area(\langle A\rangle) - area(\langle B\rangle)\right)^2 + \left(bc(\langle A\rangle) - bc(\langle B\rangle)\right)^2}$$

$$\text{where } area(\langle A\rangle) = \frac{\alpha_a + \beta_a}{2}$$

$$\text{and } bc(\langle A\rangle) = a + \frac{\beta_a^2 - \alpha_a^2}{3(\alpha_a + \beta_a)}$$

Figure 6 shows the values obtained into a qualitative domain later to apply the dissimilarity measure to the values at report showed in the figure 3.

Interaction Report

⟨Nothing⟩ < ⟨Slightly⟩ < ⟨Just⟩ < ⟨Very⟩ < ⟨Completely⟩

Trainee	CM	CMU	LS	LSU	MT	MTU	MC	MCU
Alumno-008	S	J	N	N	S	S	S	N
Alumno-017	J	V	S	S	S	N	S	N
Alumno-032	S	V	N	N	S	N	N	N

Team	GCM	GCMU	GLS	GLSU	GMT	GMTU	GMC	GMCU
Team-003	S	V	S	N	S	N	S	N

Fig. 6. Interaction report (qualitative values).

3.5. Compare the Current State to the Desired one and Assist the Interaction

Accordingly with the TTS, the team will exercise in an IVET using like shared knowledge the previously co-constructed execution plan. Some psychological studies have shown that an effective team can use a shared knowledge to anticipate teamwork needs [19].

The TTS also has proposed —into the execution stage— incorporate to the human group an IVA with the intention of improving the performance of the team and providing scaffolding to the trainees. PANCHO will use for its pedagogical action, the knowledge about the execution plan, the models obtained in the previous stage, as well as a tutoring approach selected. Its pedagogical action as part from the group has as intention to promote the use of the collaborative skills in accordance with the grade of appropriation identifies in the modeled process.

PANCHO will execute two kinds of interaction actions with its teammates: actions related to the taskwork —instrumental actions: individual or cooperative— and actions related to the teamwork —socio emotional actions.

Also, the activities of the team will be classified according the task taxonomy proposed by McGrath [20]: *Generate*, *Choose*, *Negotiate*, and *Execute*. In the execution stage, we will use the task as way to promote the collaboration between trainees, for this reason the pedagogical intervention of PANCHO will always be during the execution of the task.

PANCHO will use the Group and Trainee Models to improve the training experience in situations as follows:

To promote *Communication skills*:

Situation: (Act_{N+3} = Cooperative(PANCHO, T_2)) $\wedge$ (Taxonomy(Act_{N+3}) = Execute)

If ($CMT_1 < CMT_2$) $\wedge$ (GCM $\in [\langle\text{nothing}\rangle, \langle\text{slightly}\rangle]$ $\rightarrow$

PANCHO invites to T_1 so that he reminds to the TEAM the description of the following actions in the execution-plan.

To promote *Building and maintaining trust skills*:

Situation: (Act_{N+1} = Cooperative(T_1, T_2)) $\wedge$ (Taxonomy(Act_{N+1}) = Negotiate)

If (GMT $\in [\langle\text{nothing}\rangle, \langle\text{slightly}\rangle]$) $\rightarrow$

PANCHO invites to the TEAM to express cooperative intentions.

To promote *Leadership skills*:

Situation: (Act_{N+1} = Individual(T_2)) $\wedge$ (Taxonomy(Act_{N+1}) = Execute)

If ($LST_1 > LST_2$) $\wedge$ (GLS $\in [\langle\text{nothing}\rangle, \langle\text{slightly}\rangle]$) $\rightarrow$

PANCHO invites to T_1 so that he assist to T_2 in the following action.

To promote *Managing Creative conflict skills*:

Situation: (Act_{N+1} = Cooperative(PANCHO, T_1, T_2)) $\wedge$ (Taxonomy(Act_{N+1}) = Choose)

If (GMC < $\in [\langle\text{nothing}\rangle, \langle\text{slightly}\rangle]$) $\rightarrow$

PANCHO describes to the TEAM the worst alternatives and requests the better one.

4. Discussion and Conclusions

The diagnostic process to obtain a group model that can be used to assist the team during the execution of a cooperative task, in order to jointly improve the process of learning and/or work, is particularly different from the traditional models that incorporate a set of beliefs about the learner's beliefs [21].

A first approach to obtain a modeled mechanism of the group, as Hoppe proposes [22], consists in using individual student models to anticipate and parameterize situations for group learning. Paiva [23] later introduces the concept of group modeling, independent to the student modeling. It incorporates aspects related, like beliefs, actions, and misconceptions about the group according to the activity in work spaces (shared space) trying in this way to maintain a registry about the shared knowledge.

In this work, the collaborative skills have been considered as aspects to be modeled for human groups, these models are obtained using a semi-structured communication interface and some collaboration process indicators are obtained as part of the team modeling.

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