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Coding scheme for defining the behavior of a pedagogical agent

Mohamedade Farouk NANNE

Associate Professor, Dept. Of Maths and Computer Sciences, College of Sciences and Techniques, Al Aasriya University Of Nouakchott, Nouakchott - Mauritania
mohamedade@gmail.com

Abstract— The overall objective of our work is to define the verbal behavior and nonverbal behavior of a pedagogical agent. Our approach is an empirical approach based on the annotation of corpus videos. This approach we have used in several works. In this paper we focus on the annotation scheme that we put in place to define the verbal component of the future agent behavior

Keywords— **Coding scheme, pedagogical agents, corpus annotation, behavior**

I. INTRODUCTION

In a traditional learning environment, the teacher uses different methods to transmit information, an application, a statement or a question learner. In addition to verbal communication, the teacher uses to achieve an educational objective gestures, facial expressions, eyes, etc. [1]. This non-verbal aspect of communication, although it has been detailed evaluation studies in the more general context of HMI, has not so far been fully considered by the systems ILE. This could be explained by the difficulty to collect, analyze and integrate a large number of multimodal information while research ILE often favor an approach that consists of designing a learning software from educational theories, didactic or computer [2] [3].

The advanced research in Human Machine Interface (HMI) brought the Pedagogical Agents (PA). These agents allow integration into a HMI of nonverbal communication elements. Such agents may also be used in a context of ILE. We can then become interested in studying nonverbal communication that occurs in a traditional learning environment, for example in terms of facial expressions, gestures and gaze direction, to introduce elements of communication via an agent. in an ILE.

The impact assessment studies of these agents on the learner or learning were conducted ([4], for example, describes several evaluations of teaching staff). They showed an effect on performance and motivation related to the presence of a pedagogical agent. [5] showed that the presence of the agent Persona Ppp [6] has no effect on performance but only on subjective assessments. [7] was observed that the presence of an agent improving memorisation. [8] shows that students who learn with Herman the Bug agent [9] in the context of an application Botanical perform well on transfer tests and are more interested by the agent. The presence of the agent does not improve the results of retention tests. In addition to the studies reported above, further research study such memorization following a technical presentation by a conversational agent [10], or the impact of the realism of the agent, of his gender, cultural appearance and its educational role on learning [11]. Baylor and Kim found that 1) students show a learning transfer louder when the pedagogical agent is represented realistically (in contrast with representations of type "cartoon"), 2) the use of motivational messages (in the case of agents with a role of motivator and mentor) provides better regulation and effective learning.

Specify the behavior of a PA is very complex. An educational agent is composed of several layers. The high-level layers can describe the message to communicate. Low-level layers generate the observable behavior of the agent. The messages to communicate can be very varied. The event output of these messages, in terms of agent behavior can be very diverse. Computer modeling, first of these messages, and the other of these observable behaviors as well as the design of algorithms for generating the second according to the first, is difficult problems. The agent wants to imitate, or at least inspire the human behavior that have an infinite complexity of faculties enabling them to communicate.

Considered from the level of abstraction that interests us in the context of this work, a human body is composed of an envelope driven by muscles and a nervous system (the brain to control organ). From this point of view, the body results in movement the messages from the brain.

In this paper we will focus on verbal behavior. In another submission we focus on the correlation between nonverbal behavior with verbal behavior to deduce the pilotage rules of a pedagogical agent .

II. METHODOLOGY

Given the difficulty of this issue, the question of the methodology is central. Existing work borrow several approaches. For the most part, they are based on theoretical knowledge of psychology, education sciences or Cognitive science or just on general rules from the literature in sociolinguistics, they apply to an agent behavior definition .

We chose instead to adopt an experimental approach that integrates theoretical data but takes into account precisely the particular context of the integration of the pedagogical agent and is inspired by the experimental study of human-human communication .

The importance of this approach lies in its realism. The data on which this approach is based come from real situations, increasing the chances of producing a rather close to the simulated situation.

Wanting to design a generic pedagogical agent that can directly be used on a wide range of educational applications might render it ineffective or even useless. In other words, it is difficult to imagine an educational agent that could indifferently in mathematical teaching, philosophy, languages, music ... and that in all circumstances: courses, assessments of returns evaluation, and for any type of learning: individual, group, collaborative ...

So we decided to put us in a very specific context located. We need information such as the subject taught, the public targeted learners, the educational circumstance to develop educational agents that take into account the specificities of the learning situation in which they will intervene.

To carry out exploratory work, we adopted a methodological approach based on multi-modal video corpus study. Within a multidisciplinary team consisting of computer scientists and didactics of mathematics, we developed an educational situation in which a virtual pedagogical agent is likely. We have filmed dyadic interactions between teachers and learners late second early third (15-16 years) in a skills assessment interview in mathematics following the resolution of exercises by students with mathematical software. We have proposed a multi-level annotation scheme to annotate the observed behavior. This coding scheme, which is the verbal components of the behavior of the pedagogical agent, will be detailed later.

III. CODING SCHEME

Like any experimental approach, an approach based on the corpus of study begins with the identification of one or more theoretical questions that wants answers. These questions and theoretical objectives and the study of existing work should direct the collection of video data and constitution of the coding scheme.

We have formed a multi-level encoding scheme from the collected corpus and theoretical elements from the literature. This scheme has been retouched and validated by a team of researchers who come from many disciplines including linguistics, teaching and IT.

Many taxonomies to manually annotate observed behaviors have been developed at different levels, from the physical signs in different ways to more subjective levels related to the interpretation of such messages related to acts of dialogues or emotions [12] [13] [14] [15].

Taking into account existing studies mentioned above, and the particular situation that is the object of our study, we developed a multi-level annotation scheme. Our pattern of verbal behavior consists of four main levels: the intention of the teacher, the means used by the teacher to express this intention, the strategies used by the teacher and emotional parameters . We will detail later these levels:

A. Intention

In this level of annotation scheme, we place illocutionary goals of the teacher. [16] distinguishes three intentions of the teacher talk. These intentions are: information, evaluation and animation. We spotted these intentions in the corpus that we have collected. Annotation values in this category are divided between the three types of intention. We are inspired by the division made by Pariès into two types of functions: cognitive and non-cognitive. We rank among non-cognitive functions which is on the animation. For cognitive function we classify everything concerning information and evaluation.

All DAMSL taxonomy [*17*] categorization levels are present in the intent category. The Animate part is very close to the level "Information-level" of DAMSL and specifically the sub category "Communication-management". Other DAMSL levels are also present. This is "Forward looking functions" and "Backward looking functions" because some of our functions refer to functions related to the previous parts of speech (eg, "show cause") and other functions influencing the Following the conversation (eg, "to ask"). The fourth level DAMSL (Communicative status) is also present in the annotation value "interrupt point"), especially with his "Abandoned" value. For parties to assess and advise on the most appropriate DAMSL level is that of "information-level" in its parts "Task" and "Task management".

Annotation values that fall in the "animate" are:

- To ask: for this value we annotate the teacher's requests to the student. We do not distinguish whether the request is passed for the first time or if it is a repetition. An application may aim to accomplish a task, process an exercise, to correct an error, to summarize some of the session or the session, reformulate, to give an explanation ... etc.
- Justify (give reasons) we annotate this value by any form of justification. The teacher can justify a choice, a hypothesis, the origin of a misunderstanding, a mistake of the student, an unrealized work, etc.
- Establish / maintain communication relationship: to keep a communicative aspect and to make learners active player in the session, the student teacher reactive attention regularly
- Restore confidence after destabilization: by hearing the exposure of its weaknesses or its difficulties, the learner can destabilize and lose confidence. The teacher intervenes to restore that trust. This can be done by trying to motivate the learner or recalling its strengths.
- Enlist the learner / learner involve in the work: the teacher always tries to make the student actor of his learning. This mechanism generates motivation in students and allows teachers to not monopolize the discourse. It also enables students to make proposals and comment on their work.
- Introduce a step: for each part of the session, the teacher produced a keynote speech. This has the effect of orienting the learner and ask a landmark discussion. Different levels of granularity are possible: it may be to introduce the treatment of an exercise, to introduce the discussion of a strength or a weakness
- Interrupting a stage: the teacher notices that another element is a priority for the learner or to the coherence of the presentation and thus it stops the current step. The interruption can also be produced

by the learner: eg by asking a question that generates a digression in the teacher talk.

- Resume a missed step: after finishing the presentation of the element that caused the interruption of the stage, the teacher returns to continue the remaining part
- Set a general objective: the teacher sets a goal. It may be a method to be used by the learner to acquire knowledge, a know-how etc. For this value we annotate the times when the teacher refers to the learner that goal.
- Set a local objective (for part of the session): the teacher can target a local objective, that is to say the objective of a portion of the session, for example, show the learner that an approach is not appropriate.

The category "information" includes information transmitted teacher to the learner. Several types of content are concerned: math, teaching, learner skills diagnosis. Annotation values that fall within this category are:

- Inform: To this value we annotate situations where the teacher gives information. For example, information can be given about a year, its level of difficulty or well important. It can be given as to how the report is organized, etc.
- Justify the reasons: the teacher justifies why the student erred example, or those for which it has not responded to a question. These reasons can intervene to find excuses to keep motivation.
- Refer to a previous section: we annotate this value by any reminder by the teacher of what has been done previously during the session. We annotate any use know-how (the fact of reminding the student a previous job), while recourse to a previous discussion, parts of the session the handshake and the fact that a component was addressed.
- Refer to a knowledge of the area: to explain knowledge, teachers can remind students similar or contradictory knowledge already gained.
- Refer to assumptions about education received (program, habitual organization of education): sometimes the teacher is surprised at the fact that knowledge is not acquired by a student to grade level or the fact that a student is in advance relative to the level expected at this level. In this case it refers to assumptions about education received.
- Articulate two stages: the teacher makes connection between two steps to facilitate understanding of the learner and to remind him of a previous step, or consider a next step.
- Abandon a previous speech: when the teacher provides information to the learner on his work, sometimes it is wrong to for example saying, "you did well this thing," remarked before on the support that he has not done correctly. So he gives up his speech by giving the correct information.
- Give a qualitative result: we annotate this value by any non-numeric result given to the learner. For example the fact to say "well you master factoring" is a qualitative result.
- Give a quantitative result: by this value we annotate any given numerical result to the learner. These include a rate. This can express a success: the overall result of the test or a partial success rates. It can also express a number of treaties exercises: general or partial rates treaties exercises.
- Inform the learner of his difficulties: we annotate this value by the times when the teacher sets the student one or more of its difficulties.
- Present the strengths of the learner: by this value we annotate the times when the teacher presents the learner with the elements that control.
- Present weaknesses of the learner: by this value we annotate the times when the teacher presents the learner with its shortcomings.
- Report non mobilized knowledge: the learner can have certain knowledge without being able to use them. The moments when the teacher informs the learner's knowledge of these are annotated by this value.
- Report untreated parts: it happens that the learner does not address all of the exercises, forgetfulness, misunderstanding of the statement or simply do not know.
- Report a point to work: we annotate this value by the times when the teacher refers the student an unearned or partly earned points.
- Report a lever: by this value we annotate the times when the teacher informs the learner qualities that allow it to move forward on a learning axis.
- Report the use of domain knowledge: we annotate this value by the times when the teacher pointed out to the student that he used an acquaintance. This allows the learner to remember the reason for using this knowledge and circumstances which helps to better appropriate this knowledge and its use.
- Informing on the interface / use of the software: At certain times when the teacher explains to the student how the results are organized on the computer screen. Which parts bolded, italicized for example. This confirms the teacher talk and so reassures the learner. In addition, it diversifies the presentation of the balance sheet (adding new media to the presentation).
- Learn about how the software works: This value annotates the times when the teacher informs the learner about how the software works such as how to view details of the results of an evaluation axis.

The "Evaluation" is the third category of "Intention". We consider the following annotation values:

- Validate: by this value we annotate the times when the teacher approves work of the learner. This may be to validate the content of a learner's speech (eg validating a difficulty cited by the student) or judging his footsteps (validate acquired knowledge, validate a process initiated by the student, etc.)
- Invalidate: we annotate this value by the times when the teacher informs the student work, knowledge or incorrect knowledge do (to report an approach is not correct, report a knowledge not acquired, etc.)
- Report response incompleteness: it happens that the learner starts an answer and did not finish. There are several reasons that could cause this: among others, the fact that the learner is not sure of his

answer or that it lacks didactic elements required to meet, etc.

- Report an error: this value by we annotate the times when the teacher informs the learner an error. These moments are particularly important because they are usually accompanied by other educational and communicative acts, including motivation. Indeed, in reporting the error the teacher must be careful not to discourage the learner

The following annotations are classified in this category if they concern a precise mathematical exercise, else they are part of the previous category:

- Report the incorrect treatment of a question: it happens that the learner treats exercises an incorrectly. This treatment may be due to the lack of mastery of knowledge or expertise. We annotate this value by the times when the teacher informs the learner these treatments. Based on these treatments, the teacher highlights the weaknesses of the student's knowledge.
- Report the correct treatment of a question: the teacher presents the learner with the correct treatment he has done (answers and the correct steps he has begun). Based on these treatments, the teacher validates the acquisition of knowledge (annotation value to validate previously described).
- Report the correct treatment of a question previously unsuccessful: the teacher may well point out to the student a positive development of its powers. This value is interesting because it allows the teacher to promote one of its assumptions about the non-acquisition of knowledge or expertise, such as the statement of misunderstanding hypothesis.
- Report an inconsistency, contradiction: by this value we annotate the times when the teacher informs the learner a contradiction in the answers or inconsistency of his approach.

B. Linguistic means and other means

In this level of annotation scheme, we classify the means used by the teacher to express an intention. This is essentially linguistic means but also other resources that we have identified in the corpus.

Annotation values classified as "linguistic means" are:

- Ask a question: for this value we annotate any form of matter without distinguishing whether it is an issue that concerns the teaching field or the course of the meeting, if that question is asked for the first time or to again, etc.
- Explain: we annotate this value by the times when the teacher gives the student an explanation. This explanation is not necessarily a pedagogical or didactic nature. This may be for example to explain an organizational or term of a detail axis evaluation. As for the explanation for the Curriculum character, it can be applied to many objects: explain a purpose, untreated question, a student error. We annotate this value by the explanation and we do not mention if it is a repeated explanation or if it is given for the first time. We do not distinguish the method of explanation (explanation by example, by reformulation, etc).
- Complete: here we annotate the times when the full speech teacher of the student or a part of his work (eg complete a learner's reasoning ...)
- Comment: here we annotate the times when the teacher gives a comment. He can comment a success rate, part of the evaluation.
- Summarize: by this value we annotate the times when the teacher summarizes a speech, a portion of the session or the session.
- Be humorous: to facilitate understanding, the teacher occasionally uses humor.
- Read part of a support: the teacher reads a part of a support to remind students the statement of a year to pass a marked effect on the support or to remember a given himself on the student.

In the category "other means", the following annotations are classified:

- Place the pencil to the learner: This value marks the limit of the part 'summary' in the videos. Usually the teacher passes the pen to the student after asking him to perform a task.
- Identify an element on a support: This value generally marks the transition between two parts of the summary. For example, the teacher marking an element on a support while he was explaining something else causing the interruption of a step. The teacher can also continue his speech time to look to the support and identify an item, it interrupts his speech; it was quiet time to research, this marks the end of the period of silence. Here we do not distinguish whether the item is spotted after a search or suddenly spotted.
- Focus on a teaching support: by this value annotate we support change and the focus on educational support.
- Continue the speech time to seek out a support document: it is a way to maintain communication relationship. We have identified here as it has a complementary aspect of using media materials

C. Sreategies

We put in this category all the strategies used by the teacher to achieve a given objective.

The annotation values in this class are:

- Encourage learners to discover an error so that the student understands his mistake, the teacher pushes him to discover for himself.
- Encourage the student to discover a correct answer: the teacher can try to determine whether the learner is convinced by his answer or if there was a chance. It can be also maintain communication relationship.
- Encourage learners to use another method: there may be several reasons for this. For example, because the method that the learner is trying to use does not lead to the desired result, or that the latter is not relevant, or to the learner acquires a new method (or perfects).
- Destabilize a misconception: when the learner has a limited vision of a domain object or method, or

has a misconception, the teacher can try to make him aware of his error in several ways. It can for example highlight a contradiction to something trivial or previously proved.

- Spotting a difficulty of the learner: through the traces of the learner or his speech, the teacher noticed the difficulties of the learner. It may be mentioned immediately or keep them for later. Identifying these problems through consultation remarkable video is annotated by this value.
- Correct an error: the teacher corrects an error of the student to show him how to do and what is the correct answer. This generally occurs after asking him to discover the mistake and then correct
- Remedy a problem: one of the objectives of the meetings is to overcome the difficulties of the learner. Obviously, this step can take place only after the identification of a problem.
- Propose a mathematical exercise: The teacher proposes an exercise to the learner when deemed necessary. The causes are not always the same: lack of training, make him discover a new idea, etc.
- A point: eg the teacher can remind the learner a knowledge element, the statement of an exercise, a way to make an event that affects their learning.
- Stepping aside: the teacher stepped next door to help the learner understand what he wants to transmit. This may be an example of a cons-example or illustration. It is used among others to invalidate knowledge.
- Check: always the teacher needs to evaluate the understanding that the learner has the message it transmits. Moreover, it needs to know if such knowledge was good, little or nothing gained. He also needs to know at what point is the learner aware of his mistakes. The most direct way to check is to ask a question to the learner.
- Make sure that the teacher understands what the learner meant: for example, the teacher can ask the learner to reformulate, or he reformulates itself and asks the learner to validate this reformulation.
- Inform a success to question a difficulty: the teacher may need to refer to a success to highlight a difficulty. Besides the motivational aspect, there is the educational link between knowledge (similarity or divergence ...)
- Cut a complex issue in question: it is necessary to make the explanation easier by focusing on simpler questions.

D. Affective Parameters

At this level of annotation scheme, we classify the emotional parameters observed in the corpus. The affective dimensions marked in the corpus are:

- Mitigate a speech: sometimes the teacher realizes that his speech was too direct and tries to mitigate its intensity (eg, "you do not know how" before saying "I do not feel that you know how . "These moments are annotated by this value.
- Valuing the student: we annotate this value by the development of the learner (in terms of knowledge, skills, justification or in terms of support point). We are interested in assessing the teacher gives the student traces and methods used.
- Motivate the learner: by this value we annotate the times when the teacher motivates the learner. Typically this is done by highlighting its qualities or minimizing the task at hand.
- Reassure the learner: learners may be anxious and insecure, especially when dealing with issues that can not control. The teacher can then try to put the learner at ease. These moments are annotated by this value.
- Encourage the learner: when a task is difficult, learners do not perform easily. Thus the teacher encourages the learner to mobilize the knowledge he has. These encouraging moments are annotated by this value.
- Emotional behavior we annotate the emotions expressed by the teacher. An emotion can be expressed in a voluntary order to induce emotions of the learner. The emotions are represented by two values: what emotion was evident (the label : (surprise, satisfaction, dissatisfaction, disappointment, irritation, other (free text)), and in what sense it is used (valence : positive or negative).

IV. CONCLUSIONS

We have developed a multilevel coding scheme. Although the study was done on a mathematics learning software, we believe that most annotation values is applicable to other contexts of individual interviews post problem solving. Only values related to the handling of specific software supports are used. This makes our scheme independent general pattern of application areas.

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