Method for development of Human behaviour models for simulation based training

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ABSTRACT: There is a growing interest in Human Behavior models for training purposes. The reason for this is twofold: Firstly, the cost of training will drop by using cognitive agents as team members or adversaries, because the number of human participants will decrease. Secondly, cognitive agents can enhance training effectiveness. Therefore a new research program was started for the Royal Netherlands Navy to enhance their tactical training facilities. Human behavior models were developed in CogNet to act as opposing forces. This will dramatically decrease the number of human participants during training exercises. The scenario's were developed within VR-forces from MAK technologies. This paper describes the first phase of the program in which cognitive tasks analysis were used to describe the behavior of opposing forces and their implementation in CogNet. Furthermore the use of the Critical Event and Behavior Specification (CEBS) method for designing a cognitive model supported tactical training (CMSTT) are described.

Introduction

There is a world-wide growing interest in the use of human behavior models [1]. The use of Human Behavior Modeling (HBM) is required for the development of constructive simulations, scenario based training (SBT) and other forms of adaptive training such as simulation based testing, virtual instructors, agent based training and team training. The reason for this growing interest is twofold [2]. First of all the cost of training will drop by using cognitive agents as team members or adversaries, because the number of human participants will decrease during training. This is one of the main reasons for the Royal Netherlands Navy large interest in this subject. For instance, training one member of the command center of a frigate is very cost intensive. Specifically, gathering all of the team members, instructors and support personnel to conduct the training is hardly possible and very costly, let alone the costs involved with the lost productivity associated with the other tasks that those personnel are not doing. In other synthetic environments instructors or other team members have to play the role of adversaries because the models charged with this task are insufficiently intelligent to execute this task alone. Or, even worse, there are no models at all to perform the task at hand.
Secondly, cognitive agents can enhance training effectiveness. Using fellow students as role players is common in the Netherlands Navy. One assumes that these persons have a thorough understanding of the task at hand. This may not be the case, especially early on in training. Therefore, it is questionable whether using students as role players in synthetic environments enhances training effectiveness.

A major challenge in the field of HBM is the sheer complexity of human behavior. In addition, there are many complex jobs in which the outcome of thinking does not emerge in observable actions. To elicit the knowledge of experts, several methodological techniques have been developed. Usually the knowledge of experts is elicited using cognitive task analyses (CTA) [3].
Furthermore, people usually have problems with making there thoughts explicit. As a consequence, experts often differ in opinion about which skills are important for task execution. This may be the result of diverse educational backgrounds or differences in experience. For training purposes it is essential that the description of expert behavior elicited, with the use of CTA, is embedded in a model in such a way that the model represents human behavior in a valid

manner within training scenarios [4].
To understand the information that is elicited in the CTA process, the uncovered information has to be placed in a more comprehensive conceptual framework. Recognition Primed Decision-making (RPD) is a theory of decision making that was developed to explain how decision-makers interpret cues to identify a task and what strategies are used in natural complex and dynamic decision making situations [5]. Decision-making in a complex and dynamic situation is a hallmark of tactical decision making in the military [1].

Critical Event and Behavior Specification (CEBS) method for designing a cognitive model supported tactical training (CMSTT).

When developing a tactical training simulation, one needs to consolidate the methods and theory mentioned to create a training that builds on existing research. However, more than existing research is needed in the creation of a Cognitive Model Supported Tactical Training (CMSTT). There is currently a lack of knowledge and guidelines that support the design of training simulations that seek to enhance training by the use of human behavior representations. What simulated behavior supports the student in reaching training objectives? How can simulated behavior be realistic and humanlike while still supporting the training? How general or specific does a human behavior model need to be? A method is needed that links existing knowledge to the use of human behavior representation in training decision-making in complex and dynamic situations.
The Critical Event and Behavior Specification CEBS method aims to consolidate the theory and methods available and to extend these for use in developing a CMSTT. The method aims to create a cognitive model for use in a tactical simulation for training purposes. The general process consists of five phases.

1) Identifying training objectives.
2) In the second phase a general tactical topic needs to be established which results in a Tactical Decision Game or TDG.
3) Specifiying learning objectives and critical events derived from the TDG in a formal way.
4) Additional behavior needs to be identified that may occur during the simulation, this is done using cognitive analysis techniques. This is usually due to the fact that the critical event specification derived from phase 3 yields too little information about the behavior of simulated units.
5) The final phase validates the working tactical training simulation with subject matter experts (SME).

Phase 1: Establish Training objectives

In this phase a set of training objectives is identified. Training objectives should be inspired by the inventory of skills of the target student(s) [6]. General means of identifying training objectives suffice for our purpose. In some situations training objectives are already available. When this is not the case analysis is needed of the training needs. Training needs are established by identifying what knowledge, skill and attitudes would boost performance. An accepted approach for investigating the knowledge, skills and attitudes that underlie effective performance is the use of traditional task analysis methods [7].

Phase 2:Tactical Decision Game

Once training objectives are established, a tactical problem needs to be formulated. This tactical problem fixes the setting and environment in which the simulation will take place. The tactical problem is formulated in the form of a so called Tactical Decision Game or TDG. The TDG contains:

- A summary of the units that play a part in the scenario;
- A background story about the scenario that describes the context and the tactical problem that needs be resolved;
- A map that shows the topography of the situation and the position of the student's forces.
- Parameters of the scenario (i.e. ammunition loaded, fire rate, min-max speed, weather conditions, etc.);
- Suggestions and remarks that allow support the student in the thought process.

For the designers of the simulation there is additional information generated during this phase of the design. Simulation developers need to know moe of the scenario compared to students otherwise they're unable to implement the scenario into hardware. These requirements are described in a requirements document. Examples of information that needs to be included in the requirement document are:

- Possible relevant (inter)actions of the student.
- Possible reactions of the opposing forces and other units that are relevant in the simulation.
- The topographical layout of the theater of war.
- Capabilities of all the equipment and vehicles that are used in the scenario.

This is just to give an example requirements that should be given to the simulation developers, the final requirements specification should be much more comprehensive. Requirement specification remains one of the most difficult and time intensive processes in software development [8]. Requirement specification is important because the capabilities of the simulation constrain the possibilities of training.

Phase 3: Critical Event Specification

In accordance with the training objectives a general

idea of the scenario is specified in phase 2. To further clarify what requirements can be derived from the training objectives and the scenario for the specification of the behaviour of representations and feedback one needs to specify what events are critical within the scenario. The specification of events is not a new concept. The importance of a good specification of particular events has been recognized in the event-based approach to training or EBAT and the scenario-based training or SBTmethods [6] [9]. EBAT stresses the link between training objectives and scenario events in order to enhance scenario control. SBT entails the occurrence of specified events within the scenario which standardizes a scenario. A Problem with these methods is that it is not designed for training situations that require dynamic and specifically unstructured training scenarios. Furthermore, EBAT does not provide a description of the process of specification of events. There is long road from training objectives to event specification [10]. So a method needs to be developped to to establish a format for describing events in a scenario in a structured way that supports the development of an unstructured event-based training i.e. events that may occur in any order within the scenario.
SBT offers a structured method of designing a training scenario, see figure 1(a). It does provide a description of the way to proceed from learning objectives to scenario events. But it lacks the provision for the specification of behavior that is required from behavior representations that are included within a scenario. This study proposes to extend the process of scenario-based training and the event specification of EBAT for design of CMSTT.

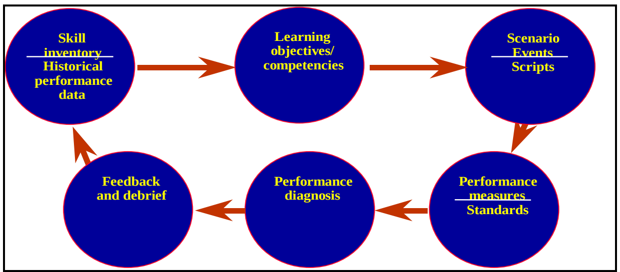

Figure 1. (a) The six steps of the original SBT process.

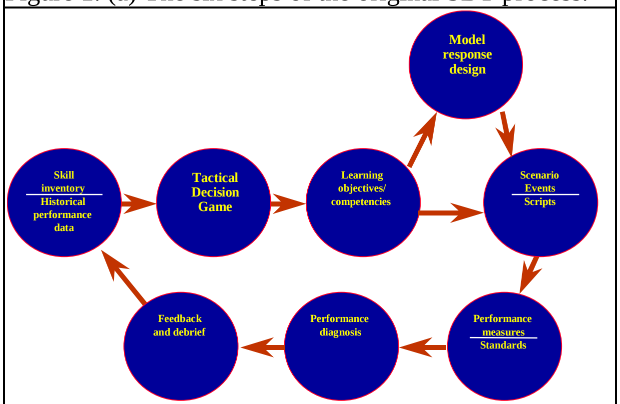

Figure 1. (b) The Enhanced process in CEBS adds the design of model responses.

When designing a scenario for complex and dynamic situations, rigid scenarios impede the creative process of the student. In tactical decision making it is important to have the ability to outwit the opponent. This is a creative process of thinking outside the rigid doctrinal rules. This implicates that the order of events within the scenario is not fixed.
The way events come to pass in the scenario should be dependent on the actions of both the student and the behavior representations in the simulation. The challenge is to find a way to identify what event is happening at any given moment. Since events are allowed to occur in random order one cannot use the completion of one event as the cue for the next. Events are identified by parameters of the simulation. To completely describe an event we need to include the following properties in the Critical Event Specification:

- Training objective.
- Event description /identification parameters.
- Required action of student.
- Reaction of cognitive model when student fails to act.
- Performance measure
- Unit of performance
- Minimum performance level
- Feedback

Phase 4: Cognitive Task analysis

In the critical event specification we have specified what behaviors of the human behavior representations are relevant for supporting the training objectives. However not all behavior that is needed in a simulation supports training. The behavior of the models should be representative even when events occur within a specific scenario that are not directly linked to the training objectives. A cognitive model of such a representation should include declarative knowledge, experience knowledge, goals, a decision model, reasoning strategies, ways to act and ways to perceive. Thus behavior irrelevant to training objectives also needs to be analyzed.
Previous research proposes a model of human decision making that is observed in complex and dynamic situations [5]. In order to create a human behavior models that are capable of making decisions under complex and dynamic circumstances one has to have a way of representing the decision-making process and knowledge structures as proposed in RPD. Currently software architectures are available that can implement an executable model of the process described in RPD, these are mainly so called a blackboard system [11]. Such a system needs to be fed with specific information that is relevant to the underlying theory. In a Blackboard system like CogNet one needs to specify all the knowledge required to model the decision making process. This means knowledge on cues from the task environment,

how these cues are encoded, what declarative knowledge is relevant for these specific cues, what procedural knowledge is needed to make a (partial) decision. Also, when a decision is made, one needs to specify the way to execute the corresponding action.

Phase 5: Validation

A philosophical question needs to be ansewered in this section: is the validation of the CMSTT the validation of the training scenario i.e. do students learn during training or is validating the representative behavior of the modelled forces enough. In our method the simulation will be validated on both criteria by subject matter experts SME's who will perform a training session with the CMSTT. Several SME's will be asked to perform a training session using the CMSTT. At the end of the CMSTT they will be asked to fill out a questionnaire. The questionnaire will address the following judgement criteria:

- Appropriateness of the training objectives
- Consistency of the interaction possibilities with the simulation with what they consider important courses of action.
- Representativity of decision-strategies of the opposing forces.
- Whether or not the behavior supports the student in critically assessing own decisions

SME's that validate the CMSTT will also be asked to judge the usability of the CMSTT. Usability issues need to be inventoried to assess whether the training as a whole has enough face validity to keep students interested in training with this sort of training instrument. Usability questionnaire items include:

- Satisfaction with the training duration
- Satisfaction with the training difficulty
- Satisfaction with method of training

Assessment if a CMSTT that was develop with the CEBS method can reliably attain good transfer of training in students is an important next step in the development of CMSTT training instruments. Time constraints prevent the inclusion of such a study in the current study.

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