Modeling Cultural Behavior for Military Virtual Training

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Abstract

Soldiers on mission in areas with unfamiliar cultures must be able to take into account the norms of the local culture when assessing a situation, and must be able to adapt their behavior accordingly. Innovative technologies provide opportunity to train the required skills in an interactive and realistic setting (e.g. serious games, or mixed-reality environments). Such training environments require adequate models that generate the behavior of virtual players. This paper presents an architecture for developing such models. The architecture integrates the Culturally Affected Behavior language (CAB) with modeling behavior as a function of Beliefs, Desires, and Intents (BDI). Culture is defined as norms stored in a separate data file of the agent. During interaction with a human player (e.g. trainee) the agent continuously evaluates whether events are in consistence with its cultural norms and responds accordingly. To prevent stereotyped behavior, the agent's behavior was also affected by its personality, defined in terms of Digman's Five Factor Model (1990). The architecture was implemented in JADEX. In a test, agents showed appropriate assessment for their culture and showed behavior consistent with its norms. It is concluded that the architecture may prove important for the development of agent-based training in cultural-aware behavior.

Introduction

Military deployment has shifted away from preparing for major battlefield conflicts towards small scale urban operations. An important aspect of this current military reality is frequent encounters with other forces and civilians in small and confined areas (e.g. streets, houses, markets, shops, etc). In the past decades, military missions have often been staged in far away countries with non-western cultures, and more often than not, a substantial part of the local population is skeptical towards the presence of western troops in their area. Furthermore, they tend not to speak English. Yet, when confronted with individuals, or a group of people, it is imperative for the commander and his team to interpret their behavior accurately and timely. Not recognizing a threat may endanger the own group. On the other hand, acting with violence against people or groups that have no evil intentions harms the respect and goodwill of the local population. Furthermore, it may endanger the mission as a whole and thus puts the safety of own forces at risk on subsequent occasions.

So assessing accurately the nature and intentions of individuals and groups is of central importance. As parties tend not to speak each other's language, other cues to interpret behavior must be used. Knowledge of how behavior is determined by local culture is a valuable source for interpreting behavior. For example, eating one's food with the left hand is considered unhygienic in many cultures, as the left hand is used for cleaning after a restroom visit.

Of course, culture is not the only aspect that should be taken into account when "reading" someone's behavior. Behavior is also affected by *personality* (two people belonging to the same culture but with different personalities may very well respond differently to a given situation), by *gender* (acts performed by a female may indicate something entirely different than the same acts carried out by male), by *emotional state* (emotions are useful for the sender of a message to bring his issue across, and useful for the receiver to interpret the message in the right way), and many other factors. In addition to language (if communication through language is at all possible), it is essential that commanders use all cues wisely to assess the nature of the situation as good as possible.

When people grow up, they unconsciously master the rules and values of the society and sub-societies they belong to. However, these values and rules may be invalid, or may have a different meaning in a foreign culture. There is a growing awareness that education and training can play an important role in preparing the modern soldier for missions in unfamiliar areas (Muller, van den Bosch, Kerbusch, & Freulings, 2011). Acquiring knowledge of a specific culture (e.g. by theoretical instruction) is an important component of that objective. However, certainly as important is practical training: people acquire skills by being confronted with a situation, assess the nature of the situation that is at hand by taking knowledge of the culture into account, determine an appropriate response -again by taking cultural norms into account-, and execute the behavior adequately. Skills in handling the dynamics of such situations can only be acquired in interactive practice settings.

At this point, the Netherlands Army recognizes a bottleneck. In order to establish such training, 'local' people should be available. On few occasions, role playing exercises are organized with staff members acting as 'local' people. However, staff members are often not available. When they are available, they often turn out not to behave authentically in accordance with the culture. As a result, situations with realistic locals are very rarely practiced. Soldiers therefore often acquire their skills and experience once they are in the mission area, through "on-the-job" training under supervision of an experienced commander.

Serious games offer an opportunity to develop a contextually rich and flexible environment for training intercultural communication (Core, Traum, Lane, Swartout, Gratch, van Lent, and Marsella, 2006). Despite the undisputable advantages of serious games, the interface between humans and agents (virtual players) is still very symbolic (e.g. the human player has to control his avatar with a mouse, indicating, for instance, that he looks "angry"). A more recent technology is the combination and integration of live, virtual, and constructive tools (Frank, Helms & Voor, 2000), abbreviated as LVC. In a LVC training prototype, Muller et al. (2011) developed a prototype of a setting where a trainee enters a (physical) room that represents a local house. Virtual players are projected on the walls of the room. By making use of tracking sensors, the virtual players know where the trainee is. This allows them to look in the right direction and make "eye-contact" with the trainee. The virtual players take position, make gestures, have facial expressions, and talk. It is the task of the trainee to assess the nature and intention of the virtual players. Like the virtual players, the trainee can position himself in the room (e.g. close to the door), can make or refrain from making eye contact (e.g. not staring at the spouse of the host). He can also make gestures with his hand, this being detected by the tracking devices. Finally the trainee can use a limited set of speech communications that becomes accessible to the virtual players through the use of speech recognition technology.

Both technologies (serious games and LVC training) share their promising outlook on preparing soldiers for missions in unfamiliar areas through realistic training of cultural awareness and cultural communication skills. What both technologies also have in common is their need for adequate models that generate the behavior of the virtual players. If cultural awareness and skills are the training objectives, these aspects should be included in the behavioral models. In this paper we present work on the development and evaluation of models that generate behavior in accordance with cultural norms.

Background

A recent development in this area of research has been the Culturally Affected Behavior (CAB) language (Solomon, Van Lent, Core, Carpenter and Rosenberg, 2008). CAB is an approach for specifying cultural representations and applying those representations to affect how AI characters (virtual players) behave and how they relate to other characters, objects and the world around them. A prototype agent was implemented by using this CAB language proving that it can represent a culture's norms (Solomon, Hays, Chen, & Rosenberg, 2009). The CAB language represents both cultural norms and cultural values through linked schemas, forming a 'socio-cultural network'. Each cultural value has an associated intrinsic value (indicating the importance of the value within the culture; e.g. both classic and modern western culture value *respect the elderly*, but to different extents) and a degree of belief. This degree of belief indicates to what extent the agent believes it is behaving in accordance with the cultural value. Each action the agent can perform or perceive has an effect on the agent's degree of belief in one or more cultural values. An example is graphically shown in Figure 1.

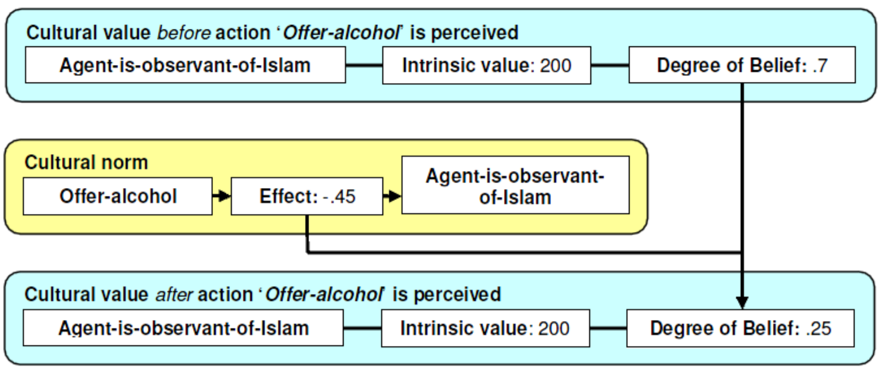

Figure 1: Example of an action being successfully matched against a cultural norm: The action 'offer-alcohol' results in a decrease of belief in the cultural value 'Agent-is-observant-of-Islam'.

The intrinsic values and the degrees of belief of all cultural values represented in the model are used to calculate an agent's Socio Cultural Satisfaction (SCS), which indicates the agent's appraisal of its interaction with another agent. This SCS score can be used in many ways. In Solomon et al.'s application (Solomon et al., 2008; Solomon et al., 2009) the SCS score is used in the agent's reasoning process and to determine the agent's immediate response to the actions of another agent.

CAB is developed as a conceptual approach that can be implemented in a multitude of agent architectures, not for any specific software implementation (Van Lent, Core, Rosenberg, McAlinden, Carpenter, & Solomon, 2007). There are many different approaches and platforms for developing behavior models (e.g. SOAR, Laird, Newell, & Rosenbloom (1987); ACT-R, Anderson, Bothell, Byrne, Douglass, Lebiere, & Qin (2004); COGNET, Zachary, Ross, Weiland, (1991)). Recently the concept of Beliefs-Desires-Intentions (BDI) has been successful for developing virtual players in simulation-based training systems (e.g. Van den Bosch, Harbers, Heuvelink, & Doesburg, 2009; Van Doesburg, Heuvelink, & Van den Broek, 2004). The emphasis in these BDI-models has been on the cognitive aspects, thus representing factual knowledge, procedures, and reasoning components. However, in order for BDI-modeling to be useful for training cultural awareness and cultural communication skills, it is worthwhile to investigate how CAB can be integrated into a BDI architecture.

BDI stems from a philosophical model of human practical reasoning originally proposed by Bratman (1987) and uses the notions ‘belief’, ‘desire’, and ‘intention’ as mental attitudes to represent possible world states (Rao & Georgeff, 1995). In particular, beliefs can be viewed as the informative state of the agent, desires as its motivational state and intentions as its deliberative state. BDI has been successfully used to model human behavior as its notions stem from folk psychology and closely resembles the way people talk about human behavior (Norling, 2004).

Model

In this paper we present the development of a BDI-model that generates culturally consistent behavior. The model is intended for use in the training of cultural awareness and cultural communication skills. This is achieved by integrating the CAB language into a BDI architecture.

When developing behavior models for training cultural skills, it is important that the model does not limit itself to producing cultural stereotypes. This would teach the student to expect a too narrow range of behaviors for that culture. A model should therefore include a mechanism that produces behavioral diversity. One way to achieve this diversity is by incorporating additional factors other than culture that are co-influencing behavior. Personality is such a factor. Personality is known to affect human reasoning and decision making, e.g. a neurotic person will get angry more quickly with others when they violate the rules of his culture. We decided to extend the CAB-BDI model with Digman’s (1990) Five Factor Model (FFM). The FFM is a descriptive model, which describes a personality along five dimensions: Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism.

The architecture of the developed model is shown in Figure 2 and should be read as follows. The agent (lower blue block) observes its environment (upper blue block). Observations are compared with the agent’s cultural norms stored in his belief base. An observation may be neutral, in conflict, or in agreement with its cultural norms. For example, *looking an elder into the eyes* is considered rude in most African cultures, whereas, in contrast, this is appreciated in western cultures. If the agent evaluates an interaction to be compliant with its cultural norms, then it feels satisfied and this has a positive effect on his emotional state. If, however, the agent evaluates an interaction to be violating its cultural norms, then it feels satisfied and this has a negative effect on his emotional state. The agent stores the evaluation results in the ‘cultural values’ component of his belief base. This, in other words, contains a record of all the cultural norms that have been respected or violated during the interaction. This enables the agent to make at any time an assessment as to how the interaction over-all complies with its cultural norms. The set of components in the belief base (including personality) jointly influence goal and plan selection.

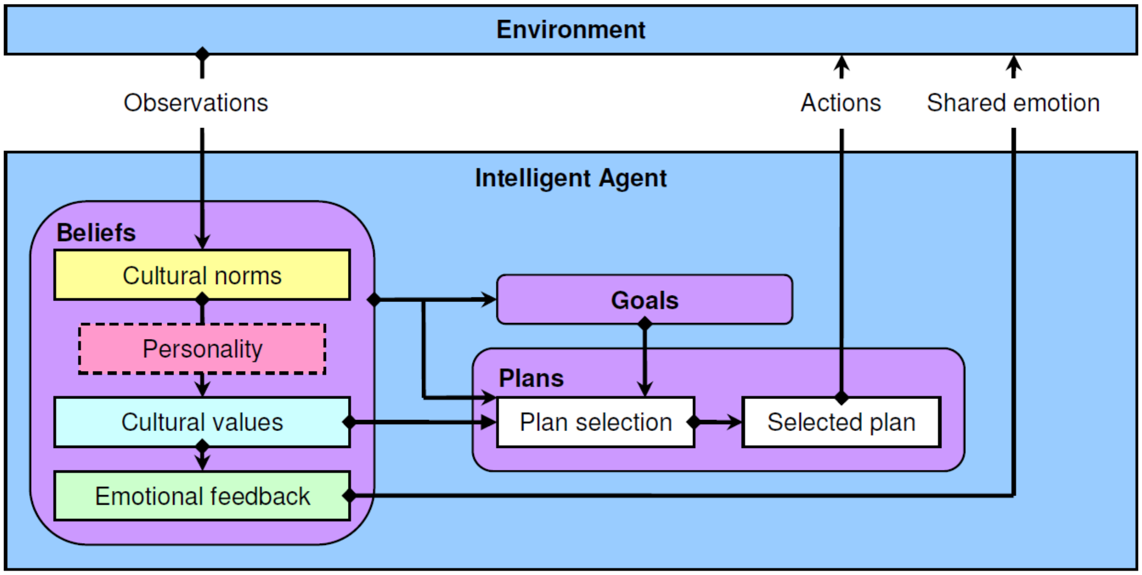

Figure 2. Model incorporating the CAB language with BDI and personality

In order to incorporate the CAB language into BDI, several transformations were required. CAB uses socio-cultural norms and values to create a network consisting of socio-cultural tasks and states that are linked through effects (Solomon et al., 2008). In order to link this concept to BDI-terms, we regarded tasks to be equivalent with events, and states with beliefs. Furthermore, the BDI-model should actively be involved with interpreting events in terms of cultural norms. This was done as follows: upon perceiving an event the model automatically adopts the desire (=goal) to value the event against the cultural norms and values in its belief base. The plan to do so is subsequently executed. The model uses the result to update the set of beliefs on (non)compliance with cultural norms.

A central concept in CAB is the agent's Socio Cultural Satisfaction (SCS) (Solomon et al., 2008). The SCS value represents the agent's appraisal of the current interaction (event/ observation) and is used to calculate intention probability, which in turn is used for plan deliberation. Plan deliberation entails that the agent attempts to select, from all options, the behavior that fits best with its cultural norms (or violates least its cultural norms). In BDI however, intention is discrete rather than continuous (as CAB's intention probability implies). This was solved in our model by determining how an intention would affect the SCS score. In particular, if an intention would *increase* the SCS score, then the agent considers the associated behavior as consistent with its cultural norms and values. If an intention would *decrease* the SCS score, then the agent considers the associated behavior as violating its cultural norms and values. Thus, our model will select the plan that leads to the highest increase or the lowest decrease of its SCS score. Furthermore, SCS-scores also affect the agent's selection of plans. Some plans require a particular level of SCS to be selected. For example, the agent will not select the plan to invite someone for dinner if the SCS score is low (indicating that the agent's cultural norms have been violated over the course of the interaction). Likewise, some plans will only be selected if the SCS-score is high.

As explained in the introduction, the model is intended to generate culture-compliant behavior of a virtual player in a simulation environment (e.g. a serious game). This should enable a trainee to practice in assessing culturally-determined behavior of others, and learn how his own behavior is appreciated by other people from a different culture. In order for the trainee to learn, feedback is necessary. It is, for example, important for the trainee to know whether the virtual player is content with the interaction, or whether the player feels that his cultural norms have been violated. Information on this can be taken from the SCS score. Our agent feeds back his SCS score to the trainee as one of the following emotional states: 'happy', 'neutral', 'angry', and 'furious'. The transitions between these states are set by thresholds. Whenever the SCS score crosses a threshold the agent will change its emotion accordingly. If the trainee brings about a situation that the agent reaches the state of 'furious', then the agent desires to discontinue the interaction.

As argued earlier, culture is self-evidently not the only factor influencing behavior. To make sure that our model produces behavioral diversity, personality was added as a co-influencing factor. Personality was modeled according to Digman's Five Factor Model (Digman, 1990), describing personality along five dimensions: Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. We are able to assign a unique personality to agents created with our model by assigning them a score on each of these dimensions. The dimensions 'Openness', 'Agreeableness', and 'Neuroticism' influence the effects of cultural norms. The dimensions 'Extraversion' and 'Neuroticism' also influence the agent's emotional state (i.e., happy, angry, or furious). The dimension 'Conscientiousness' does not have any influence in our model.

Implementation

There are several platforms for the implementation of BDI-models, like JACK, 2APL, JADEX, Jason, and many others. We choose to use JADEX (Pokahr, Braubach, Lamersdorf, 2005), because it is very well suited to model complex behavior while maintaining a high degree of flexibility and control. Also, in previous research we used JADEX in conjunction with simulation environments (e.g. QUEST 3D, VBS2), providing us the possibility to test and evaluate the developed model in a complete and versatile environment.

In JADEX, the programmer defines beliefs, goals, and plans and stores them in an Agent Definition File. The agent reacts to events (activated goals, incoming messages, and internal events caused by active plans) by selecting and executing the corresponding plans. Selection of a plan is achieved through means-end reasoning. Simultaneously, the agent continuously deliberates about its current goals and decides which goals to pursue (goal deliberation). The agent's means-end reasoning and goal deliberation are both influenced by the agent's current beliefs. Active plans can update beliefs, dispatch (sub)goals, and create internal events (leading to means-end reasoning).

The culture of an agent is defined in the Agent Definition File (e.g. north-west European, Japanese, rural Muslim society, etc). The properties of distinguished cultures are stored in a separate file and consist of cultural norms, cultural values, and thresholds for the emotional states. Defining a culture's properties in a separate file fosters flexibility and composability. It allows combining and changing the culture of an agent without having to change other components of an agent model, like personality, for example.

Evaluation

An evaluation of our combined model of culture, personality and emotion has been done by doing several small-scale studies. In these studies we tested whether the model functions and behaves as expected. Agents configured as either *Western* or *Arab* were confronted with a series of ten events that were either compliant or non-compliant to the culture. Results confirmed that the socio-cultural satisfaction score decreased when the agent was confronted with actions that violate its cultural norms. Socio-cultural satisfaction score increased when the agent experienced behavior that was respectful to his cultural norms. Furthermore, the agent selected actions according to its cultural norms. Tests showed that our model was able to use multiple definitions of cultural norms and values at the same time. Being able to do so allows the creation of different subcultures. Cultural definitions within such a subculture are weighted, making it possible to create agents that are, for example, very religious and agents that are not or hardly religious.

Results showed that agents with different personalities appreciated perceived actions differently, and acted in accordance with this appreciation. This enables us to achieve behavioral diversity within culturally determined behavior; diversity being mediated through personality.

Tests show that the model determined appropriate emotions for the agent; emotions were in accordance with their situation assessment and their behavior. Emotional state (i.e. the agent being happy, neutral, angry, or furious) is, in addition to the agent's actions, an output of our model. If the emotion output is linked to a virtual training environment, then the student can perceive the virtual player's emotions, thus receiving natural feedback on the effects of his behavior.

Discussion

An important aspect of today's military operations is coordination and communication with military forces, as well as with civilians from non-western nations. Internationally, defense organizations initiate research that opens opportunities to train these skills in virtual environments, like for example, serious games or Live-Virtual-Constructive training environments. Valid behavior models are required for developing virtual training in culture-aware communication. The models should be valid in the sense that the virtual player's behavior accurately reflects the culture that it represents. Behavior needs to be representative of a culture, but not rigid or stereotyped.

In this paper we have presented work on how to achieve such behavior models. We integrated earlier work of Salomon et al (2008) on modeling behavior as a function of culture (Culturally Affected Behavior (CAB)) with our own work (e.g. Van den Bosch et al., 2009) on modeling behavior as a function of Beliefs, Desires, and Intents (BDI). The integrated CAB/BDI agent is generic, meaning that it can be initiated with any culture. For a particular culture, data on cultural norms and norm-weights (the relative importance of a particular norm within the entire set of norms applying to the culture) are stored in a separate data file. During a scenario, the agent continuously evaluates occurring events (e.g. interactions with the trainee) in terms of consistency with its cultural norms. The agent dynamically calculates its appreciation with the evolving situation, expressed as a Socio Cultural Satisfaction (SCS) score. A high SCS makes the agent emotionally content, and makes it more likely to adopt plans that facilitate cooperation. A low SCS score makes the agent emotionally angry, and makes it more likely to terminate the interaction. In order to prevent rigid and stereotyped behavior, a factor other than culture influencing the agent's attitude towards the situation was included in the model: personality. Agents could be assigned a personality, defined in terms of scores on dimensions distinguished by Digman (1990). This enables us to vary the agent's response to behavior in compliance or non-compliance with cultural norms (e.g. an extravert agent being more likely to respond aggressively to norm violations than an introvert agent).

The model was implemented in JADEX, a BDI-platform. This allowed us to test whether the agent would produce behavior consistent with its cultural norms. We configured a *Western* agent and an *Arab* agent. Each of them was confronted with a series of ten events that were either compliant or non-compliant to its own culture. Results demonstrated that our agents showed appropriate emotions to these events and were able to select those plans that conformed to its cultural norms and values. Furthermore, the responses of the agents were influenced by their personality as intended, showing that we were able to establish the desired behavior diversity.

It is concluded that with the integration of CAB and BDI an agent architecture has been achieved that, in principle, allow us to develop agents that can be used to train soldiers how to behave culture-aware. In principle, because the development and deployment of practical training programs requires additional work. First, the definitions of cultures used in this study were developed for designing the model architecture. It was tried to achieve face validity in defining the cultural norms and their weights, but constructive validity of the culture definitions is not claimed. Yet this is important for practical training, as soldiers need to receive feedback that is valid for the specific culture. Secondly, tests were limited to main cultures only. Second, our model is currently only applicable to one-on-one interactions. How the model can be extended to deal with multiple interaction partners at the same time is an open question. Thirdly, field experiments are necessary to establish the effects of training. This is necessary to make sure that trainees develop the right knowledge and skills. Acknowledging the need for future work, this research may prove an important step towards the development of agent-based training in cultural-aware behavior.

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