An Approach to Advance Higher Order Cross-Cultural Awareness in Dismounted Soldiers

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Abstract

Cultural awareness is important for a range of operations from disaster assistance to active conflict. This paper illustrates the application of an acknowledged system of systems (SoS) to train dismounted soldiers in cultural awareness. Such training system is required to not only increase intelligence gathering opportunities but also minimize troop member loss during missions. Moreover, given the increase in the cultural interaction of dismounted soldiers, specific training is needed to raise cultural awareness. In this research an acknowledged (SoS) model of augmented cultural awareness centered on both agent-based simulation and body sensor networks is proposed. The immersive vest developed at Missouri University of Science and Technology helps assess the distributive intelligence (situational awareness) of both the dismounted soldier and civilians alike. This processed data is then used to train a similar prototype of the physical system environment as an agent based simulation. Strategies in agent’s behavior are also described. This description allows him/her to adapt specific behaviors in response to the foreign civilian.

Keywords: System of Systems; sensor networks; Agents; cultural awareness; training; biometric.

1. Introduction

Cross-cultural competence (3C) is currently one of the many priorities on the US. Department of Defense’s (DoD) list of priorities. The operational definition of 3C defines it as a skill set consisting of cognitive, behavioral, and motivational components [1]. These components enable soldiers to adapt effectively in intercultural environments. Soldiers often have little awareness of either the cultural norms, social norms or customs of foreign societies. Hence, they fail to comprehend the fundamental basis for civilian behaviors and actions. A model to train soldiers in cultural skills and provide appropriate feedback must be formulated to develop 3C. This model must be
both analyzed and simulated with realistic data to predict the system’s performance in actual scenarios. It should also aid in realistic, near combat and cultural interaction conditions.

This gap is addressed by identifying as well as modeling this problem as an acknowledged SoS. For a comprehensive discussion of an acknowledged SoS, please refer to [2]. 3C is dynamic in nature. Therefore, every soldier and civilian acts as a complex adaptive system in itself while retaining independent resources, development, and sustainment approaches. The situational awareness (SA) of an environment is captured through the physical setup in a laboratory from both soldiers and civilians. This model incorporates an immersive training vest (ITV), biometric data collection, position tracking, and a gesture recognition glove as a physical system developed at Missouri University of Science & Technology [3,4]. An agent-based model (ABM) was created to both complement and simulate the actual training environment. Previous attempts [5] have not integrated the SA with the ABM to model the significance of soldier interactions with local populations. The purpose of this study was to determine whether using automated agents to train soldiers can improve cultural interaction skills. These interactions involve not only negotiation but also coordination among multiple participants. This proposed research would assist in the development of a training environment capable of preparing armed forces to respond to a varying array of threats and communication issues. This model would also support the gathering of information over an extended period of time. The remainder of paper is structured as follows. Section 2 introduces work previously conducted on defining traits to measure 3C. These studies were based not only on real events but also interviews with soldiers. An outline of the modeling methodology is presented in Section 3. Both the application and integration of ABM and other computational intelligence tools, with introductory scenarios are also described in this section. Section 4 outlines the approach to construct the system of system architecture. This section illustrates the benefits of this modeling approach. Section 5 suggests potential future work that combines Bayesian belief networks (BBN) and ABM.

2. Seminal Work

Culture is a highly connected system in which changes in one particular aspect of the system can generate changes throughout other components. Though culture appears to be stable, it is overall adaptive in nature. 3C has two major components: the ability to learn about another culture (known as the cultural learning) and the ability to use what is previously understood (known as cultural agility) [6]. These terms can be used synonymously with procedural knowledge and declarative knowledge, respectively. Previously the United States army research institute for the Behavioral and Social Sciences defined the measures and various models for assessing the development of 3C in Soldiers [7]. A general framework for cross-cultural competence of 3C presented in [8] advocates cognitive, affective, and behavioral skills as adjudging measures. The factors those are most helpful in developing cross-cultural competence can be grouped in 4 categories, namely Knowledge and Cognition, Skills and Abilities, Affect and Motivation, and Personality or Dispositional Traits. These factors can be acquired through learning through reading text alone, learning influenced by personality, and learning dependent on textual knowledge and personal traits. Knowledge and cognition includes global, cultural and regional knowledge. Skills and abilities comprise of cognitive ability, communication, and negotiation capabilities in humans. Aspects that describe Affect and motivation are inclination and enthusiasm to learn new skills and implement them. Correspondingly Personality traits involve openness, curiosity, broadmindedness, and tractability.

The scope presented here directly supports effective intercultural communication, personal adaptability and work performance. The proposed architecture provides a firm ground to test the recommended models for training in 3C.

3. Proposed Modeling Approach

The basis of human decision making occurs as first fit pattern matching with previous experience and deducible conceived experience [9]. The central idea is to capture situational awareness from the trainees (including both soldiers and civilians) and then feed this awareness in real-time to a similar, agent-based simulation model. This process is done for various scenarios. Its previously identified physiological parameters are correlated with both emotions and gestures [10, 11]. This data is then processed within the cognitive architecture of the agent using adaptive neuro- fuzzy inference systems and fractals. The presence of fractal signatures in biometric and posture measurement data is used to process and provide an assessment of an individual’s health and posture [12]. Neuro-fuzzy inference systems are being used to cluster gestures and actions on the basis of data from the sensors in
immersive vests worn by trainees. The facial gesture and body posture clusters will act as memory database for processing the agent’s cognitive architectures. This system is used to not only predict but also transmit an automated response to the soldier before the civilian makes a move (see Fig. 1). The automated agents in this model are designed to support soldiers acting as proxies for individuals working autonomously. An SoS agent receives information on all interaction and provides relevant, user-centered feedback to improve performance. The following sub-sections describe both the ABM approach and how it serves to address the needs of the overall problem.

3.1. Agent Based Modeling: current status of work

The key characteristic of any agent-based model is that such a model is, essentially, decentralized. ABM takes a bottom-up view when producing a reflection from the real-world domain to the model’s domain. ABM focuses on individual behavior rules. The global behavior emerges as a result of many individual activities. The software AnyLogic™ has been used to develop an ABM cultural training system. This model had three ActiveObject classes declared as agents: Soldier, Civilian and Command. The Agent class is a special subclass of the ActiveObject class. Agents were embedded into the Main, a top-level object containing agents. Six soldier Agents, two Civilian Agents and one Command Agent were placed in the training environment. Environments dimension were 500x500 (width x height). An altitude layer of geographical information was added. The environment construct was defined at the level of Main to specify properties shared by the agents. Environment was set as continuous 2D. This construct is responsible for maintaining space in the model and gives access to all agents registered with it.

![Diagram](Fig. 1. Multi-agent-based acknowledged system of systems architecture)

AnyLogic™ allows users to extend simulation models with a Java code. Thus some textual scripting language was coded to better describe the ITV system. Figure 2 depicts all three agents and the environment’s topology. The soldier agents are placed in the environment with civilians. The SoS manager role was played by the command center. The network layout in the environment was set as a user-defined function. This function ensures that agents move randomly in the environment space and do not enter areas with altitude lower than zero meters above mean sea level. Every Agent class created in the simulation had its own state chart (a visual and executable construct that enables agents to define events and behavior). State charts consist of both states and transition. A state is a concentrated history of an agent and a set of reactions to external events. Transitions are needed to move through the states. Thus they have a trigger, such as either a message, a condition or a timeout.
Fig. 2. A model of the training environment in ANYLOGIC. This model simulates the ITV system’s complexity to augment the soldier’s cognitive competencies.

Fig. 3. (a) A state chart of the command center or the acknowledged SOS manager; (b) a state chart and transition states Keep talking, neutral and go away of soldier agents; (c) a state chart and transition states joy, neutral and fear of civilian agents.
During the simulation, soldiers walked randomly around the space, stopping when distance between them and civilians is a given distance. Stopping distance was initialized at 30 m. At the beginning of simulation, the command was in a “waiting state”, the soldiers were in a “walking random” state while civilian agents were in “not approached” state. As soon as the civilian and the soldier came within the predefined distance, the Civilian color changed from black to pink whereas the soldier changes from grey to red. Black color of civilian signifies that it has not been approached yet by any soldier. Pink color of the civilian means a soldier is within an approachable distance. Similarly gray color of soldier agents means that it is not near any civilian and red means vice-versa. At the same time, a message was sent from the soldier to both civilian and command using the function “send (‘Message, Agent destination’)”.

3.2. Facial gestures and Body Postures

Since ancient times Indian art has categorized human emotions into nine types or the Nava (Nine) Rasas (Emotions) [13]. Navarasas are used to express various emotions through a variety of facial gestures. These nine emotions are srinagara (amour), Hasyam (comic), karunam (pathetic), raudram (furious), viram (heroic), bhayanakam (terrible), bibhatsam (odious), adbhutham (wonder) and santam (tranquility). The idea is to capture soldier and civilian expressions using head mounted cameras on trainees during various scenarios. A correlation between the situation during interaction and the navarasas can then be established utilizing neuro-fuzzy systems. Similarly accelerometers on the wearable immersive vest can be used to classify trainee’s body postures [14]. The predicted classes for supervised learning will be sitting, standing, walking and running.

This association between the expressions and postures exhibited and the predefined classes can be used to train the ABM and provide a warning of a culturally inappropriate response to the trainee. This work is still in progress.

3.3. Addressing Distributive Intelligence

Two basic problems of distributed artificial intelligence are addressed here:

3.3.1. Communication and agent interaction

The civilian agent transitioned to one of the states described in Fig 3b. Based on his physiological parameters, the command agent was able to give provide feedback to the soldier. If the civilian agent was in a state of joy, the message sent to the soldier informed him to continue interaction. Hence, the soldier agent transitioned to the ‘keep talking’ state. Similarly, if the civilian agent was in a state of fear, the soldier received a message from command to transition to a ‘move away’ state. The soldier would move away from the respective civilian agent. Neutral transition states are dealt likewise.

3.3.2. Ensure the coherence of a distributed information system

A coupled map lattice (CML) is an intermediate technique between partial differential equations (PDE) and cellular automata (CA) [15]. Like CA, it is also discreet in both time and space. Unlike CA, however each node (or vertex) can represent an agent. Each node is also connected simultaneously to all other nodes with different bonding strengths. The concepts of trust and social distance are proposed to maintain coherence in agent’s decisions. Each agent’s decision is based on all other agents within its neighborhood. The structure assumed here is not that of a grid but a continuous 2D environment. Equation below represents a globally coupled map lattice: where

\[ x_n(i+1) = (1-B)f(x_n(i)) + \frac{B}{\eta(C)} \sum_{m \neq n}^{N} \frac{f(x_m(i))}{r_{mn}} \]  

(1)

\( x_n(i) \) are the state variables over the discrete time i and n is the spatial index . The neighborhood in this mode is defined as a circle of radius 50m. The constant (B) is the coupling strength of the system. The function \( f(x) \) is the logistic map described in equation (3), with the global nonlinearity parameter \( p \). The global coupling is given by the
sum of the logistic function values over all agents in the neighborhood. This value is then normalized by \( \eta (C) \) explained by equation (2). The sum of all inverse distances between agents in the neighborhood is the \( \eta(C) \). The trust is defined by the coupling parameter and the social distance is given by the neighborhood of each agent affecting its decision. The coupling strength value is 0.03. The bifurcation parameter in the logistic equation is 3.45.

\[
\eta(C) = \sum_{m=1}^{N} \frac{1}{|P_{mn}|} \eta(C)
\]

\[
f(x) = px(1-x)
\]

4. Remarks

This paper describes a generic architecture developed using agent based modeling and computational intelligence. Agents in this model can classified as deliberative agents. A deliberative agent has an internal view of its environment and is able to follow the plans defined for it. The proposed model is easily adaptable and evolvable to different human system integration scenarios and structures. Few contemporary systems have tried to model Situational Awareness in SoS environment in an unambiguous fashion. This model would be able to cater to different levels of expertise in soldiers and would improve team co-ordination during training scenarios. The research could be used in fusing data from other kinds of sensors to generate a more comprehensive picture of the operative environment. A study was conducted to teach social conversational verbal and non-verbal skills to humans assisted with immersive environment [16], The experimental results show users performed significantly better than the participants who studied from literature. A recent research used training experiments concerning two-sided negotiation and three-player coordination tasks performed by many human subjects [17]. It shows agents can be utilized as tools for training people in situational awareness tasks and a combined ABM with human system performs better as opposed to just humans training with their counterparts.

5. Future Work

To predict the intent of agents in multi-agent systems, a framework to process the cognitive thinking is needed. Also to model communication and negotiation among agents a measure is needed to represent the current state of environment. The Bayesian belief networks (BBN) fits as a standard for rationalizing about uncertainty and decision making which makes prediction easier [18]. A BBN is a directed acyclic graph and represents a complete probabilistic model of all the variables in a specified domain [19]. In our case the domain will be the soldiers interacting with foreign civilians to gain cultural awareness and predict civilian’s reaction and help the soldier adapt his behavior through feedback from the command center. BBN consists of three main components viz. Identifying important random variables, building the causal relationships among them, and finally setting the probability distribution values [20]. The idea is to implement the concepts of belief, desire and intention by Bratman [21] in a multi-agent framework. Previous knowledge and experience about a problem is translated in terms of variables and then classified into axioms, beliefs, goals and actions. Axioms (A) represent the views of the civilian or solider about themselves and serve as inputs or parent nodes to variables such as goals (G). Beliefs (B) represent opinions regarding the opponent and are parents to A and G. Goals are the desired end state of the agents. To close actions (A) are carried out to achieve the desired goals by agents. These four random variables are present in belief network structure of both civilians and soldiers.

Once you have this cognitive framework in the proposed agent based model, simulations will allow to anticipate how changes in beliefs affect decisions and actions at the cultural level of analysis. BBN also gives the capability to empirically validate the agent based architecture proposed here through real life data. An example case from a study of Afghan decision making illustrates the use cultural belief network simulator [22]. The ability of a BBN to learn from new evidence for its parameters makes it possible to build a model initially with the best existing information, and then to integrate new and upgraded evidence at a later stage[23].
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