

Organizational Behavior, Decision Making and Virtual Simulations in Military Personnel

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Abstract—The aim of this study is to make a brief review of the research on Human Behavior Models (HBMs) in military simulations. The need to represent the behavior of individual combatants as well as teams and larger organizations is expanding as a result of increasing use of simulations for training, systems analysis, mission rehearsal, systems acquisition, joint force analysis and command decision aiding. Both for training and command decision aiding, the behaviors that are important to represent realistically are those that can be observed by the other participants in the simulation, including physical movement, detection and identification of enemy forces, as well as the aspects of behavior influenced by the cultural background, such as Beliefs, Desires and Intentions. Innovative technologies provide opportunities to train the required skills in an interactive and realistic setting, for this reason are needed adequate models that generate the behavior of virtual players. Areas of modelling human behaviors are combat field situations and situations of high risk decision making, teamwork, culturally and emotionally affected behavior. In this paper we provide an overview of current research on human behavior models in military simulation, in order to be used to train military forces, develop force structures and design weapon systems. Implications for further research are made.

Index Terms—Decision Making, Human Behavior, Military, Simulation.

I. INTRODUCTION

Military personnel must be high qualified, with great resilience in crisis management, excellent trained in decision making processes, in operation strategies and behaviors. Virtual simulations in military education provide the opportunity of good preparation, exercising self-resilience and stress management. Experiences of previous satisfying self-efficacy are kept in memory and help individual to adopt a perception of high self-efficacy and an inner motivation to regulate stress, forget fear, be more efficacious and make decisions of high quality [1].

Human and organizational behavior can be represented by computational formulas, programs or simulations. Representation of human behavior is a computer based model that mimics either an individual's behavior or a collective action of a team or a group. The modelling of cognition and action by individuals and groups is quite possibly the most difficult task humans have yet undertaken. Human behavior representation is critical for the military services as they expand their reliance on the outputs from

models and simulations for their activities in management, decision making, and training [2].

On the other hand, for team level models, as well as for models of command and control, information and general input from teams of psychologists, sociologists, organizational scientists, physiologists, computer scientists and military scientists are needed. This relevant knowledge would be the result of the simulations and the solutions that have been developed from the aforementioned teams for analyzing and representing human behavior [2] [3]. Military human behavior models and simulations are needed in order to create more realistic and believable agents who ultimately help reduce barriers to interacting with as well as to creating behaviors of empathetic avatars, electronic training world opponents and allies and so to satisfy a wide and expanding range of scenario concerns. For that purpose, data from real world, war game and laboratory should be gathered and used. Decreasing training time as well as the cost of training, and increasing the realism of training events are the key objectives of the Army's use of simulations.

Psychologists (social, community, clinical and organizational) may play a special role in constructing models of human behavior and simulations because of their big experience and theoretical background in human abilities based on theories, data and case studies in real life and in computational theories of human abilities. Theoretical ideas and background is tested by running computed and virtual programs, that may be generated and create predictions of human behaviors.

II. BACKGROUND READING

A. Commanding and high risk decision making in military operations

Decision making can be considered as the cornerstone of simulations' application in the army and a wide spectrum of models has been developed in this direction.

One of the earliest and most widely referenced models for human decision making is that of H. A. Simon, a Nobel laureate psychologist [4]. This model sub-divides decision-making into the following phases:

- Intelligence Problem identification and data collection,
- Design Planning for alternative solutions, and
- Choice Selecting a solution and monitoring its application.

Leigh et al. [5] emphasize the potential for simulation to assist in military decision-making by stating that the use of computers to evaluate offensive options during the Gulf War, show the promise that modern simulation holds for commanders in the field. Course of Action (COA) are "war gamed by the staff and then presented to the Commander

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with the advantages and disadvantages of each, along with a formal recommendation for the adoption of a particular COA". [5, p. 3]

B. Simulations of cultural affected behaviors

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.

Across societies, cultures, and geographic regions, reoccurring patterns of generalizable human behavior emerge, and within a given sociocultural context, recognizable and reasonably stable patterns of life can be observed, enabling the mental creation of a "baseline" of normal activity.

Enabling personnel to develop these nuanced sociocultural perceptual skills presents several science-and-technology challenges. For instance, available training products may effectively train region-specific competencies or even general cultural awareness, but these programs rarely emphasize archetypal patterns or strategies for identifying anomalies in operational settings. Also, additional work must be conducted to construct appropriate constructive simulations in which to practice these skills; that is, the community must define more computationally grounded principles for integrated, realistic behaviors. [6]

C. Human behavior in combat field simulations

Both training and command decision making demand the representation of the observable behavior by the other participants in military simulations, such as physical movement, detection and identification of enemy forces, these behaviors premise abilities such as attention, multitasking, memory and learning, decision making, planning, perception and situation awareness [2].

Besides, Wray and Laird [7] have inserted the importance of variability and its sources in several military simulation applications. The fact is that human behavior varies when humans are placed in the same situations. A situation could be described by the following factors:

- physical environment such as the terrain and its difficulties (i.e. forests, hills, rivers, lakes, etc.) where the simulation has been carried out,
- scenario in the field (i.e. combat, patrolling, operation, rules of engagement, etc.)
- weather conditions,
- structure of the team which participate in that simulation, and
- ability, the training and the experience of the participants.

Of course, the above factors, in a given scenario, vary and differentiate participant's behavior. The truth is that military personnel's behaviors vary as well in the real field. Furthermore, it should be mentioned that during a simulation, these behaviors could be divided in the observed and the expected behavior for both of allies and adversaries, besides these behaviors could be divided in ideal, average or incorrect behaviors.

However, all the aforementioned variables could differentiate the final result even if small changes have been made and in some cases small changes could lead to major differences in the final behavior. Hence, each time, during a

scenario, a different decision changes the situation, this possibly leads to different decisions and finally to different paths of behaviors.

Another variable which has to be examined and take into serious consideration is the training of the military personnel which participate into the simulation. Training prepares the human behavior of the personnel for a future real scenario. Untrained or bad training forces could behave in ways that are non-ideal or even dangerous for themselves and their teams. Therefore, in a simulation scenario it is suggested that the enemies should have the possible best enemy behavior that would be expected if they had the highest training. As a consequence, the military personnel must be prepared to respond to such behavior even if they have to:

- face more highly trained enemies,
- cooperate and work with military personnel and/or in a team with different skill levels between the members of the team,
- participate in the simulation knowing or not the enemy team,
- participate in a novel scenario.

As it has been mentioned above, human behavior in the combat field simulation drives two different people to do different things in essentially same circumstances. The additional factors which provide variability in the military personnel behavior include:

- perceptual capabilities
- health and fitness level
- education level
- intelligence level
- physical skills
- culture and religion awareness level
- emotional and psychological status
- social status
- personality, etc.

For example, considering a simulation where members of a team choose and engage different targets in the same situation, someone could base his decision on:

- target proximity,
- target which has immediate returning fire,
- target which holds heavy weapon in contrast to that who is light armed.

Another example is when in the same situation two different members of a team (both experts and well-trained soldiers) experience live enemy fire. It is reasonable that the soldier who experiences the enemy fire for the first time in his life would react differently from a veteran who has participated in couple of real wars or armed conflicts. In that case, the emotional and psychological response of the first soldier could lead him to observable behavioral differences.

Additionally, the fitness level can greatly affect human behavior setting. When participants in a simulation are tired, the fitness level will definitely affect both physical and mental clarity in such case for example of a patrol, in which participant should observe, recognize and shoot if necessary a target. Therefore, the upcoming fatigue differences in human behavior among the participants and it is difficult to differentiate physical fatigue, which appears while the participant is moving in the battlefield, with the mental fatigue that may not give the clarity to properly use his gun.

However, in these aforementioned situations, the experts

have invested in knowledge obtained from training and their own experiences.

D. Individual Level

The rise of information-processing theory in psychology after World War II was helped considerably by applying a metaphor: humans process information in a manner analogous to computer systems. Information is acquired, manipulated, stored, retrieved, and acted on in the furtherance of a given task by distinct mechanisms. Manipulating and using information can help in military education and achieving resilience in military environment.

Soldiers in operation field experience several emotions, which become burden to their performance, (influenced speed and performance accuracy), such as high levels of stress (workload and emotional). Enemy identification, target identification between units, target handoff, casualty evacuation, fratricide, the effects of stress and fatigue, the level of destruction desired, and civilian casualties are just a few issues to which combat decisions and the actions of military decision makers are affected.

Human Factors (HF) specialists may want to understand and describe specific aspects of human behavior (such as cultural values, decision making, tiredness, overheating, perception errors etc.), while Operational specialist may be interested in how HF propagate in the military organization and operations. Several studies focus on the way soldiers perceive and understand the behaviors of civilians and potential combatants in urban environments. Specifically, they are focused on how and which perceptual information variables, available in the visual scene, are used to classify behaviors in others. So scientists develop approaches to modelling and consequently generating civilian behaviors in virtual characters using non-linear behavioral dynamics. The aim is to develop statistical models of behavior categorization by analyzing the ways in which soldiers perceive and respond to the behaviors of virtual characters. The results of this line of work will benefit the modelling and simulation community and can transition to groups developing sensor technologies aimed at detecting potentially hazardous or threatening behaviors [8]. In addition, Human Behavior Representation (HBR), may help by increasing efficiency, in foresights on new ways of operation or in the assessment of the potential of new technologies [9].

A number of personality variables can facilitate behavior prediction and fluctuations in order to maximize beneficial impact of simulations in the army. Thus, in order to study human reactions in several environments scientists focus also on personality and behavior by checking several variables such as stress, extraversion, neurosis, culturally affected behavior, etc. (with scales such as BDI, Big Five, CAB etc.) in order to generate culturally determined reactions to events [9].

E. Organizational Level - Teamwork

Many of the activities in modern military combat operations involve teamwork. From constructive simulations at Corps and Division levels, to Platoon sized engagements in the virtual simulators, human behavior representation of simulated entities is an increasingly important part of modern training [9].

It is important that observable actions be based on realistic decision making and that communications, when they originate with a simulated unit, be interpretable as the result of sensible plans and operations. A team should manifest the range of behaviors required to be consistent with the degree of autonomy it is assigned, including detection and responding to expected and unexpected threats. It should be capable of carrying out actions on the basis of communications typically received from its next higher-echelon commander.

However, the benefits of teamwork do not always occur naturally, and teams can fail for many reasons. Factors such as poor combination of individual efforts, a breakdown in internal team processes (e.g. communication), and improper use of available information have been identified as potential sources of team failure. When people collaborate with autonomous systems, system complexity inevitably increases, and automation can change the way people coordinate with each other. Moreover, failure in human-agent teams can lead to severe consequences including loss of life, missing critical action time and monetary inefficiencies. To enable collaborative human automation team interactions, we must therefore understand the nature of such teamwork, including outcomes, processes and dynamics.

Simulation models are valuable in capturing the process and dynamics of human-agent teamwork. With a valid simulation models, we can test and compare proposed changes to the current system, or new designs of the system at a lower cost than testing directly in the real world. Previous research [11] has used queuing models for human-agent teams in which a single operator controls multiple robots. Human behavior and teamwork usually bring more complexity.

Much of the research on teamwork and tactical decision-making has been done in the context of air combat and anti-air warfare. Within this air-warfare context, many studies have been done on how teams interact to perform their tasks, how they respond to stress, etc. Several cognitive task analysis of AWACS weapons director teams are available [12]. Also, there have been several studies that have examined team naturalistic decision-making processes in air defense (AD/AAW) teams in the Combat Information Center (CIC) on ships such as the Aegis battlecruiser [13]. These studies which generally support the view that C2 teams in this domain are carrying out a distributed, recognition process that is focused on gathering and fusing information to produce team situational awareness. Similar behavior can be predicted for command groups and battle staff teams in ground combat, who face analogous challenges of uncertainty about spatially distributed and mobile threats.

Many aspects of teamwork were studied in this context, including effects of stress, leadership, communication, adaptiveness, monitoring and self-correction, etc., and recommendations were made for development of new training methods to enhance team effectiveness. A good example is the TACT training method [13], which was designed to get team members to adapt more effectively to changing workloads under stress through practicing scenarios that reinforce the use of shared mental models for implicit coordination.

Various air-warfare simulations have been developed as tools both for modelling team performance and for implementing and experimenting with novel simulation-based training methodologies [15]. Perhaps the most widely known and used simulation is the Dynamic Distributed Decision (DDD) making, which can be used to simulate a variety of teamwork domains (especially those involving use of workstations with a scope or map and moving threats or targets) and has a number of built-in process measures to facilitate team research. DDD has been used for a broad range of teamwork research studies [16] [17], as well as real exercises in distributed mission training [18].

Teamwork is often associated with Command-and-Control (C2). Historically, C2 has been seen as a hierarchical process of commanders directing their subordinates on the battlefield (though generalized command-and-control also has many non-military applications as well). However, more recently there has been an increasing appreciation of the distributed nature of information collection, often done by a staff in communication with various Recon elements in the field that supports decision-making. Often decisions must be coordinated laterally between multiple adjacent units involved, and occasionally there is a need to push decisions further down to smaller units closer to the battle, who have a better sense of tactical opportunities and consequences of actions. Hierarchical command is now even viewed by some as inflexible and sub-optimal. It was previously necessary for maintaining control in chaotic environments, but is no longer so clearly necessary with the advent of more powerful Command, Control and Communications (C3) networks and information technology, enabling instantaneous consultation and coordination over a distance. Command-and-control is a complex topic in its own right [19]. In a military context, C2 can be defined as the control of (spatially) distributed assets (weapons and sensors) in the most effective way to achieve tactical goals, which in the case of ground combat involves containing, attacking, defending, clearing, or denying enemy access to areas of 2D terrain (including assets on it, such as towns, airstrips, communication towers, ports, etc.).

Sukthankar and Sycara [20] have described a methodology for recording, representing and recognizing team behaviors performed by human players in an unreal tournament military operation in urban terrain.

Programs such as MANA, PYTHAGORAS, and ISAAC are commonly used to gain insights into human behaviors in conflict situations. However, these agents tend to be purely reactive, applying weighting rules and “attractions” to various events and entities within their world. True military teamwork behavior may also be governed, by and large, by such rules, but must also be projected against a more informed cognitive foundation. This foundation supports more sophisticated representation of the agents’ perception’s and interactions in order to shape each individual’s behavior.

Recent advances in intelligent agent research have opened up possibilities for more sophisticated simulations of teamwork and cooperative behavior. Agent models of teamwork are based on key concepts such as joint intentions [21] and shared plans [22], which formally encode how teams do things together. These concepts are derived from

the BDI framework [23], which postulates the importance of representing and reasoning about mental states such as beliefs, desires, and intentions when interacting with other agents. Jennings [24] GRATE system exemplifies how useful BDI concepts (especially joint responsibilities) can be to producing complex coordinated behaviors (the main application of GRATE is a distributed industrial manufacturing and distribution system).

Perhaps the most widely known agent-based teamwork system is STEAM [21]. STEAM is multi-agent system built on top of SOAR, a production-system-based agent architecture, to which it adds rules for establishing and maintaining commitments to joint intentions. STEAM produces robust behaviors even in unanticipated situations by automatically generating communications among team members to reconcile beliefs about achievability of goals and to re-assign tasks. Other multi-agent systems that employ some form of teamwork include RETSINA [25], SWARMM [26], and CAST [27].

III. CONCLUSION

The fact is that simulations of human behaviors could be used in the design, development and evaluation of new tactics, but mostly in military education, as a way of preparation and improving resilience in military environment.

In general, evaluating new strategies and systems during a simulation and often against extreme difficulties and highly trained enemies, allows to the observers to find out not only the strengths and the limits of the military personnel, but also their limitations. Otherwise, a simulation working with average military personnel against an average enemy may completely fail, because it might produce a range of human behaviors which would be completely different from those in the real field against real enemy forces.

This review summarized in a brief way the purpose and the main domains of human modelling and simulations used in military. Either on individual or on team – group level human modelling and virtual simulation models can be applied to carry out detailed analyses and evaluate the final design, and of course they can be used for education and training.

Finally, in order for the simulation to be useful validation must be checked, that means that it is needed a human judgement of adequacy in a given application, because in this case validation is not a statistical test.

There are several barriers in human modelling research, such as the unlimited combinations of personality traits, cultural features, specific situational variables for each special condition. Human behavior is neither stable nor totally predictable, on the contrary it is dynamic and rapidly changeable, so the greater limitation of research in human modelling is that simulations are representing human reaction and behavior and not presenting the real human reaction and behavior. The adoption of this reality can make researchers more modest with their findings and richer in designing and building new models.

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