

AI in Military Synthetic Simulation Environment of the Slovak Republic

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Abstract: *Currently, artificial intelligence elements are being applied in the synthetic simulation environment. The AI provides a flexible framework for the development of intelligent systems capable of acquiring information as well as deciding and applying automated management. Initial approach in the field of AI being focused on the universal aspects of this problem with limited success. The resulting data volumes, through which it was possible to deliver optimal results, were enormous, and so the heuristic tools were found which limited to find the processable sub-data. The SR is at the beginning of a long way to fully implement AI into the simulation systems and its tools which are being used currently. The article brings relevant information from the processes of its implementation into the practice and the usability in the educational and training environment of the Armed Forces of the Slovak Republic.*

Key Words: *simulation, synthetic environment, artificial intelligence, armed forces*

1. INTRODUCTION

From the historical point of view, the term of simulation has not been known for a long time. The term of simulation was introduced to the practice with the arrival of computer technologies in the last century. However, we have met with alternative concepts for a very long time. Military art, game theory or warfare in general represents the area where the means of simulation were fully exercised and also represents the registry of a formal, rational, mathematical method of the study of decision-making in conflict situations [1]. In the course of the entire history the simulations fulfilled significant educational and practical aspects. They were employed in warfare in case of war preparation phases, combat meetings, battles as well as directly during their realization.

Planning, prediction, decision taking, prognosis, creation of battle and war intentions and executive phase of battle activity itself represent the attributes of exploitability of simulations primarily due to diversity and broad-spectrum scope. Their rationalization could

be sought for in planning documentation of governing and regulatory authorities ranging from the highest to the lowest degrees. They were generated through creative mental activity of military theoreticians in diverse forms of their cognitive and information activity [2].

The twentieth century was a period of introduction of the computer technology to a number of spheres of human activities. Simulation technologies were employed right in the military sphere. Even the 1st World War proved the well-known principle of scissors referring to the idea that “the more complicated and the more expensive the military technology is, the less suitable for the military training it is”. Thus the need to be fulfilled emerged. Right the period was typical for demand of alternative training means (flight simulators, training equipment) and applications for shooting, imitation, training ammunition or material. Such training environment can be defined as modern model of actual combat means. From this point of view the period of the 2nd World War resulted in maximal utilization of the intellectual potential of both parts of the conflict. And that was demonstrated in enormous development of science and technology which was employed in warfare itself. Computer and information technique and technology contributed to rapid development of modelling and simulation.

Improvement and progress of information and communication technologies were further on developed along with possibilities of their use. One of the forms of computer utilization was and still rests in playing the computer games. Simple computer games have gradually become more complicated and more difficult. The programs designed for simulation of actual activities of battling forces emerged right from the games. Currently, simulation technologies are fully established in warfare and other spheres as well. They reach culmination of their use and utilization. New ways have been sought for which would allow utilization of higher quality such as reciprocal interconnectivity of diverse simulation tools or implementation of elements of artificial intelligence into the simulation environment [3].

The term of artificial intelligence (“AI“) has been around even for shorter period of time yet its employment disposes of broad-spectrum scope in all spheres of human activity. AI represents the interdisciplinary branch of science which draws on knowledge from mathematics, informatics, and formal logic. In simple terms, it is the case of an effort aimed at simulation of sophisticated utilization of knowledge in computer systems. Yet, computer systems must dispose of an exact programmed action line and they require unambiguously formulated and algorithmized data. On the other hand, a human can extract, forget, and parallelly process diverse data, has an intuition, etc. Therefore a computer system which could meet the conditions of intelligence (it would use artificial intelligence in the proper sense of the word), should independently generate only those variants which are meaningful and are taken into consideration during the final phase of decision taking [4].

The beginning of the AI history dates back to 1956 (conference at Dartmouth College held by J. McCarthy) yet in 1950 A. Turing elaborated a famous test and gathered a series of arguments against intelligent machines which he gradually disproved. Over the time with the support of scientific search and developing scientific and technical branches the used knowledge proved to be crucial for high efficiency of the AI systems and the general formal apparatus appeared to be offering only the tool for using the knowledge, i.e. it plays secondary role. The fundamental problem of AI does not rest in revealing of the general effective techniques yet it rests in a query how to represent a number of knowledge in a form which would allow their “effective utilization and interaction” [5].

The aforementioned thesis resulted in paying high attention to problems referring to gaining, representation and utilization of special and expert knowledge with the use of available methods and techniques of AI. Thus the computer systems were generated focusing

on quality, range and representation of knowledge – the expert systems. It is the case of computer programs simulating the decision taking activity of experts during solving the complicated tasks of decision taking and using adequately coded special knowledge taken over from experts with the aim to reach in case of the respective issue the quality of decision taking which would be equal to the one of an expert. The knowledge taken over from an expert represents so-called basis of knowledge which is usually implemented, administered and updated as an individual file.

Implementation of AI into diverse spheres depends on a number of factors. Currently, however, it is required to replace a human fully by a computer system in specific fields in case of which complicated and complex decision taking is inevitable. High computer performance creates sufficient conditions for simulation of human thinking and decision taking. Yet to what extent is it possible to implement AI into simulation tools established in the environment of the Armed Forces of the Slovak Republic?

2. AI IN SYNTHETIC ENVIRONMENT OF THE SLOVAK ARMED FORCES

Under conditions of simulation tools in foreign armies AI is not the term which would be unknown. Yet it is inevitable to consider the extent and the type of simulations in which AI is to be implemented.

Some types of simulations (constructive, live) are in major cases used in warfare and the AI application represents a specific frame. However, under conditions of virtual simulation it can be assumed that AI is fully implemented as the virtual simulation is to a large degree supported also by other commercial environments (for instance, computer games).

AI vs. Live Simulation

The instrumental simulation gets oriented towards possibility to approximate the behaviour of real individuals and real tactic groups armed with own real weapons and weapon systems by simulating gunfire.

In other words, the instrumented simulation allows realizing the operation which is commanded by real individuals, crews and squads using real weaponry with both training and imitation ammunition. Under the conditions of the Slovak Republic, the sole system of instrumented simulation has been implemented, i.e. Multiple Integrated Laser Engagement System (MILES). The universal laser system was supplied in 2008 for the needs of armed forces along with the training control centre of EXCON – Exercise Control. The entire training process is recorded, assessed and documented. The collected real data are transformed online to real map base.

With regards to the fact that the MILES system was produced a while ago, there is lack of many opportunities of AI implementation into such environment. In fact, in the context of instrumented simulation only two ways of AI implementation exist, i.e. into the environment of software assessment tools and into the environment of creation of humanoid individual (humanoid robotics) which would simulate, for instance, enemy forces. The other implementation variant falls rather into the Sci-Fi category than into the category of short-term application into practice.

With regards to the supplied assessment I-HITS system the first variant also does not create the conditions of AI implementation into such environment. From part of a supplier no support of AI implementation exists thus the first variant is non-applicable under the conditions of the Slovak Republic as well. AI in the process of assessment of trainings would

represent a significant benefit for the sphere. Under current conditions of computer systems and software engineering it is not difficult to define statistic algorithms for evaluation of combat activity which would represent a dynamic knowledge database. In fact, the database would stem from diverse reverse systems of AI problem solving.

AI vs. Virtual Simulation

Virtual simulation represents dynamically developing technology in the sphere of modelling and simulations and is part of general tendency of including new means, forms and methods into specific engagement of information development of members of armed forces. Virtual simulation can be defined as special means of training using computer technology with graphic engine to achieve authentic imitation of diverse objects and procedures of natural environment in the synthetic one. It is employed especially in case of training of pilots, vehicle and plane crews and commanders of small units for commanding the operations in synthetic environment which is identical to the real one. Right in virtual reality the forms of artificial intelligence are applied in a number of cases which enriches virtual games and thus offers higher interaction and attractiveness.

The Armed Forces of the Slovak Republic do not dispose of high number of real virtual simulators. Significant part is represented by aviation (flight and ATC) simulators which are interconnected.

Flight simulators come from the nineties of the last century and despite regular update of these simulators the AI elements have not been implemented in them. Flight simulators are classified as Real HiFi simulators. Generating of targets and of enemy is based upon semi-automatic behaviour of entities and it strictly stems from the programmed algorithm of behaviour an airborne entity in the air without possibility of "learning". The flight radar ATC simulator ranks among those having been installed rather recently yet neither in this type of simulator the AI logic is present [6]. The simulator generates targets according to defined scenario and flight entities behave in accordance with defined rules of scientific database BADA (Base of Aircraft Data) by EUROCONTROL. It allows application of suitable procedures of working load with the aim of scientific research [2]. Technically, air tower simulator ATC stems from stochastic (it contains minimally one relation with generated variable) and deterministic (it contains only exactly determined relation - algorithm) system the entities of which behave in a semi-automatic mode as well. All flight simulators are dislocated at different spots of armed forces and pursuant to scientific study of feasibility [7] they are connectable. Right the potential resting in flight simulators represents as a complex significant field in case of which implementation of the AI elements is desired. That must not be necessarily AI which would be directly integrated into simulation core of the simulator but it could be an external instance that would generate new entities on the basis of piloting abilities. The particularity of the instance would be interaction between a pilot and an operating staff so AI could allow higher level of interaction and load.

AI ver. Constructive Simulation

Constructive simulation is the most frequently used simulation and from the point of view of time it is the simulation with the longest application period and also it is the most utilized simulation with universal use and broad-spectrum scope of utilization. The basis of constructive simulation is use of logical and mathematical models expressed as a rule trough equations or through systems of mathematical equations, inequations (the algebraic ones, the differential ones, the integral ones, etc.) and algorithms or systems of closed or open algorithms and the parameters (the constant or the variable ones) and reciprocal relations of the systems have deterministic or stochastic interpretation of weight and energetic or mental

and information objects and processes of armed meeting or of conflict situation. [8] Constructive simulation is to the fullest used in case of staff preparation being in charge of planning and decision taking phase of operation or situation. This way the staff is prepared on individual staff positions as well as in administration functions in the process of commanding, control and verification of planning and decision taking activities. Currently, computer technologies and application software solutions are being used in case of which the relations and dependencies of mathematical and logical interpretation are implemented.

The Armed Forces of the Slovak Republic currently dispose of two tools of constructive simulation intended for training of commanders and of staff - OneSemiAutomated Testbed Baseline (OTB) and OneSAF (OOS). MASA – the tool of constructive simulation – is at disposal of the armed forces only in a testing mode with implemented AI elements. OTB is an “implementor” of computer supported trainings. It allows to create and to control the entities in simulated synthetic environment. OTB covers simulated people and organizational structures of units and their activity accords with commands and orders of real people operating the simulated systems [9]. Structure is connected to the computer network, and operation systems and application software provide possibilities of interactive simulation of any activity and situation yet without objective learning thinking.

Implementation of the AI elements into this environment would represent high level of effectiveness as it would allow to design, to assess and to optimize intensity and resistance of decision taking process, evacuation and rescue plans on the basis of joint operation procedures, doctrinal environment and not according to subjective stand point of higher command and control degree.

At the same time it would be possible to perform operation analysis which would provide space for comparing of, for instance, effectiveness (higher number of personnel members, equipment, weapon systems, etc.).

3. THE ARMED FORCES OF THE SLOVAK REPUBLIC IN THE UPCOMING PERIOD OF AI IMPLEMENTATION

The Armed Forces of the Slovak Republic are currently subjected to modernizing process in case of which high financial means are being invested into modernization not only of military technique. Alliance environment lays high demands upon the technique, systems and training in all spheres and made is an effort to share the joint capacities and to use them fully. The area of technological progress in case of application of new and constantly developing sophisticated tools or the area of human resources points out the apparentness that the process of preparation of military professionals is rather dynamic. Therefore the Slovak Republic must expend utmost endeavour in implementation of the AI elements (not only in case of those) into the environment of current simulation tools as the preparation tools of military professionals. And important is to be very particular about full implementation of AI in newly purchased technique and simulators.

The Slovak Republic shall be active especially in two AI spheres – in environment of constructive simulation and in environment of virtual simulation.

Challenges in Constructive Simulation

Theoretical literature states that decision taking is the process of solution of decision taking problems in case of which the main attribute is the process of selection. It means that it represents assessment of the individual variants and selection of the optima lone to its executive. [2] Through shifting into military environment it can be deduced that decision

taking is conditioned by definition of desired end state which is dependent on differences between real and desired states. The process of assessment and of selection of an optimal variant of further activity is aimed at achievement of final effect which is brought as close as possible to the desired state – operation design. The issue of military decision taking process is the character of the decision taking problems which are in general characterized as incorrectly structured decision taking problems. It means that in decision taking process a number of variables exist such as the following: behaviour or operation environment is characterized by high level of unpredictability; there exist a high amount of evaluating qualitative criteria for the individual variants of solution; as well as interpretation of data inevitable for decision taking is rather complicated as it is the case of joint decision taking of military staff units [10].

In fact, a commander and staff assess and take decisions regarding the selection of activity variant. Their selection depends on extent to which they are able on the basis of relevant data and disinformation to foresee the causes of the selected variant. However, the commander is not able to work simultaneously with several factors and assessment is performed sequential as one factor by other [11].

To be able to assess a complex influence of all factors they are reliant upon application of advanced mathematical methods of decision taking or upon application of simulation and modelling of combat activity.

Right in this point the space for application of the AI methods in decision taking process occurs, which is very difficult to be described in “artificial” language. In synthetic simulation environment as in testing environment all three basic expert systems of AI can be employed – i.e. diagnostic, planning, and hybrid systems.

Despite the fact that each expert system disposes of advantages and the hybrid one combines the task of both of them so on their own they would not be highly beneficial for decision taking process of the commander.

From this point of view the application of distributed artificial intelligence (DAI) appears to be suitable as it offer space for utilization of methods and of techniques for parallel use of several knowledge basis by a single expert system. Higher number of independent knowledge sources is rather frequently used in case of extensive problem solving such as decision taking and planning processes. (Fig. 1)

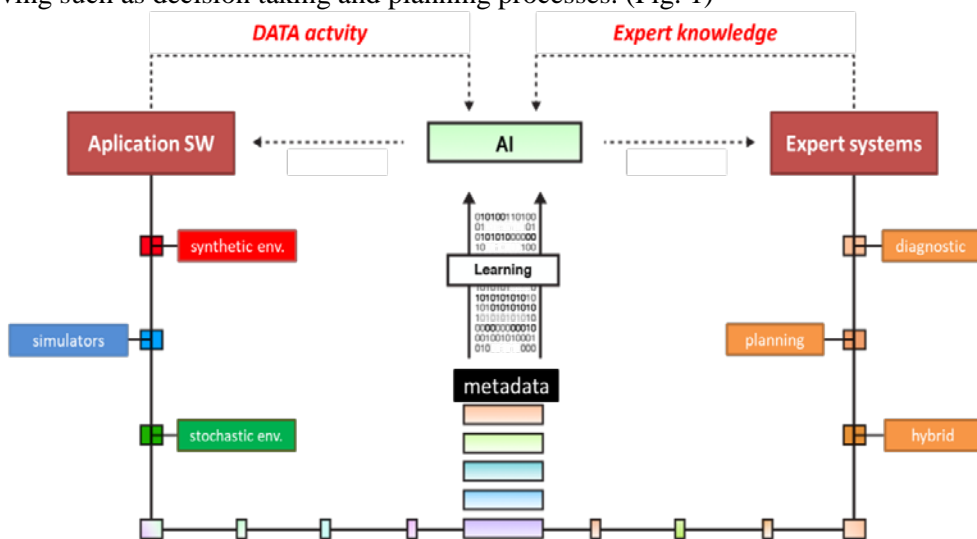


Fig. 1 – AI activity ver. Expert knowledge [own]

Prior to implementation of DAI into synthetic environment it is inevitable, without any doubt, to use methods and techniques of gaining, formalization, coding, preserving, testing and storing the knowledge. The sphere represents a significant element and the first step towards implementation of AI into environment of simulations. The Armed Forces of the Slovak Republic put the sphere of knowledge engineering on pedestal as knowledge engineering in the environment of constructive simulation for training of commanders and staff units represents sorting and cataloguing of available methods and techniques of representation of knowledge, explanatory mechanisms and creation of relevant methodologies.

By means of adequate data and knowledge (met knowledge) supply a desired goal shall be reached which rests in application of information in accordance with doctrinal principles in force and with potential restrictions and in adaptation of those in actual conditions of operation.

Challenges in Virtual Simulation

In the course of relatively short period of time the marked AI elements shall be implemented into aviation simulators. Those shall allow more rapid determination of adequate reaction in the air borne situations. Further on, they are able to select appropriate tactics, use of weapon systems and of loading and to eliminate enemy's missiles and to steer own missiles to several targets simultaneously. Except for the aforementioned, they shall allow coordination and cooperation of the entities within own group. The knowledge shall be achieved right by observation of enemy's actions and abilities and through learning from the obtained knowledge.

Such AI is built upon genetic algorithms using fuzzy logic (Genetic Fuzzy Tree, CGT). Definition of genetic algorithms allows creation of programs which is able to learn and to develop itself. (Fig. 2) They dispose of a file containing input values which are intercombined (crossing), they can change themselves (mutation) and also they allow themselves to be spread within the system (reproduction).

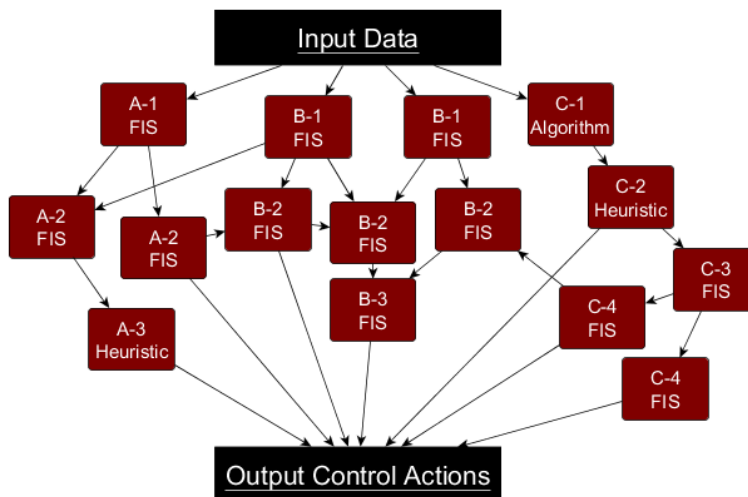


Fig. 2 – logic of GFT [11]

Further on the algorithms use the values during solution of required task. The closer to a final desired result of program work the result of the individual solution is, the higher the chance of further reproduction of the values is.

The reverse situation shall result in elimination (selection) of undesirable values and the program shall stop working with them.

Through multiple recapitulation such state of the program can be achieved which shall learn to solve the task according to our expectations.

With the use of fuzzy logic the binary logic is not employed (1 – 0) yet multivalued logic is applied which works with all values ranging from 1 – 0.

Currently, the Armed Forces do not dispose of capacities for development of independent aviation simulators yet their regular and intensive utilization is standard.

With the arrival of modern aviation technique it is thus inevitable to be particular about purchasing of modern aviation simulators with the elements of the aforementioned AI which would allow conducting the training in synthetic environment in interactive and dynamic way.

4. CONCLUSIONS

Any discussion regarding the AI issue could be rather extensive yet application of AI under conditions of synthetic environment of simulators acting as a testing environment is rather significant and interesting sphere for community which deals with modelling and simulation. Creation of programs and systems with AI requires broad scope of professionals, experts from diverse areas to supply data and knowledge databases. Yet the 21st century, issues of safety and potential of information and communication means require to make the utmost effort the aim of which is maximization of safety [12].

The elements actively influencing not only the executive phases of combat operations, operation design and level of safety guaranteed by military professionals represent a complex issue which is directly proportional to quality of provided training.

Currently, the armed forces are “equipped” by modern simulation tools to which the AI elements must be implemented to achieve the progress in training capacities that shall be demonstrated in ability to coordinate and to cooperate in the international environment.

Either on the level of technological progress in application of new and constantly developing sophisticated tools or on the level of human resources it becomes evident that preparation processes of military professionals is rather dynamic. To preserve safety, interoperability and compatibility in the sphere of warfare, the department of defence must search for new ways and methods of preparation.

One of the main attributes is disposable of highly educated and experienced personnel provided with constant professional and qualifying growth. Such personnel must transform their knowledge with the assistance of utilization of sophisticated tools which are constantly improved during education yet the level must be permanently increased as required and according to the needs.

It is correct for the armed forces as well as for the individual professionals not to remain on the same level of development, to eliminate fear and worries, to be prepared and to accept solution even at the expense of high investments so that the individual as well as the whole system moves towards the values of peace and safety.

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