Reproduction of managerial activity in the system of simulation of military operations

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***Abstract*—The main requirement for modeling is adequacy. Obviously, in order to obtain adequate results in the simulation system, it is necessary to organize control over the behavior of agents in certain conditions of the emerging situation on the basis of the logic of common sense and the requirements of the statutory documents. For the purpose of forming algorithms for the actions of the opposing sides, it is proposed to use a visual designer that allows you to set sequences for performing various tasks of objects, synchronize them, describe events and set reactions to them. In addition, an approach based on the use of the fuzzy inference algorithm is proposed, which allows automatic selection of one of the alternatives of behavior at an arbitrary point of decision making during simulation. Using the hierarchy analysis method allows you to operate with high-level categories that are understandable to the military specialist when building the base of decisive rules.**

***Keywords*—military operations, imitating modeling, decision-making, fuzzy logic.**

I. INTRODUCTION

Currently, the developed countries of the world are actively developing systems for the simulation of military operations (MIS). Examples of this are the Joint Warfare System (USA) [1, 2], the product line of JSC "NPO RusBitekh" (RF) [3], the simulation system for assessing the effectiveness of the air force and air defense troops "Svisloch-1" (RB) [4], etc. The expediency of such developments has long been proven, significant financial resources are allocated to their creation. In the research center for modeling military operations, the bottom-up approach was chosen as the basis for constructing the modeling system being developed, involving the initial creation of models at the lower level of the composition and their subsequent aggregation into larger ones [5]. So, the models of individual modules - the chassis, gun, reconnaissance means, etc. - form a set of base objects, from which autonomous model objects can later be configured - a tank, an infantry fighting vehicle, an archer. Each object is modeled separately, with a high degree of detail. From the model objects are formed group objects corresponding to the organizational and staff structure of military units - Fig.1.

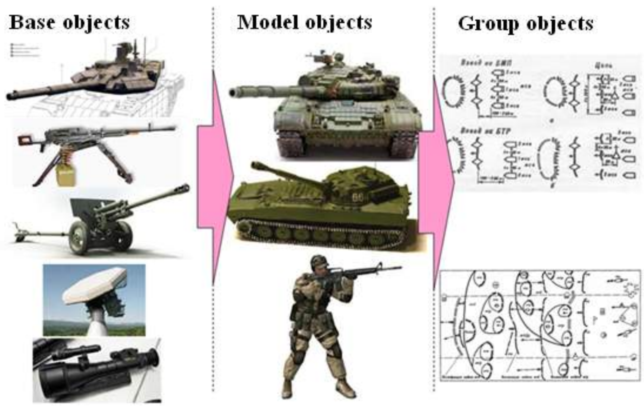

Figure 1. The mechanism of structural composition of objects in the system of simulation of military operations.

To implement the control of the behavior of objects in the system, a mechanism is implemented for the formation of tasks - functional actions performed by model or group objects, for example, "routeing", "attacking the enemy", "defense of designated lines and positions", "fixed barrage" of artillery and The tasks for model objects are set by the user. Major tasks, such as "attacking the enemy," are built on the basis of smaller ones, such as "moving with the exit to the line", "unfolding in line", etc. During the implementation of the task of the group model object, the tasks of model objects included in the its composition. Tasks in most cases require the user to input the original data. So, when the company comes, it is necessary to indicate the line of transition to the line of platoon columns. However, the logic of performing such tasks is set fairly rigidly in the code of the modeling system and can not be changed by the user. Within the framework of simulation modeling, elements of a complex model can act according to a rigid, preset scenario or adaptively, in accordance with a changing environment. Obviously, the second option is more preferable from the point of view of ensuring adequate reproduction of the behavior of real objects, which makes it necessary to develop appropriate mechanisms.

II. VISUAL CONSTRUCTOR

In the course of the research, the following technological approaches to creating tools for managing model objects were tested and tested in practice, allowing them to flexibly change their behavior during the simulation process: the use of an external object-oriented programming language (DSL) [6]. use of scenario (scripting) programming languages, the source code of which can be changed during the work of the modeling system without recompilation; Use the mechanism of compiling source code in C Sharp, which describes the required behavior of objects at runtime; Use of visual programming languages, in which instead of writing code in textual form, manipulation of graphic objects is carried out. Based on the results of the research, it was decided to develop its own visual design tool - a visual designer for controlling the behavior of objects - Fig.2.

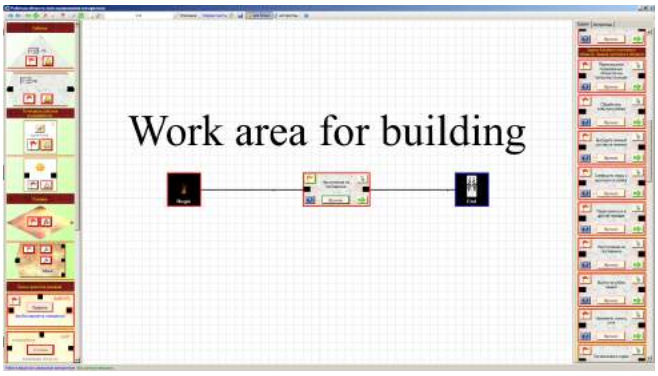

Figure 2. Work area.

Each task in the designer window has its own visual representation in the form of a graphic block having an input and an output - Fig.3.

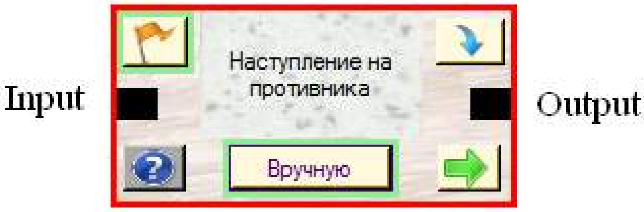

Figure 3. Visual representation of the task block.

Further, the visual scheme, compiled with the help of the designer and describing the behavior of the object, will be called an algorithm. For each task, a specific executing object must be assigned, and the required initial data is entered. Blocks can be connected to each other by directional control transmission lines. The principle of the designer is to sequentially execute the blocks in accordance with the established relationships. To this end, implemented a special program pipeline execution of blocks. Each of the blocks allows you to visualize the current execution status. Due to the hierarchical structure of model objects, at each level of management objects will perform tasks corresponding to their level. Thus, as part of the company's mission to attack the enemy, each of the platoons will carry out its task of attack with its routes of nomination, milestones, etc., but on the whole this can be regarded as the company's actions. In this regard, in addition to the task blocks, block algorithms are used that encapsulate the set of blocks entered by the user, into which, in turn, other algorithm blocks can be included, which results in a hierarchy of subdivision operations - Fig.4.

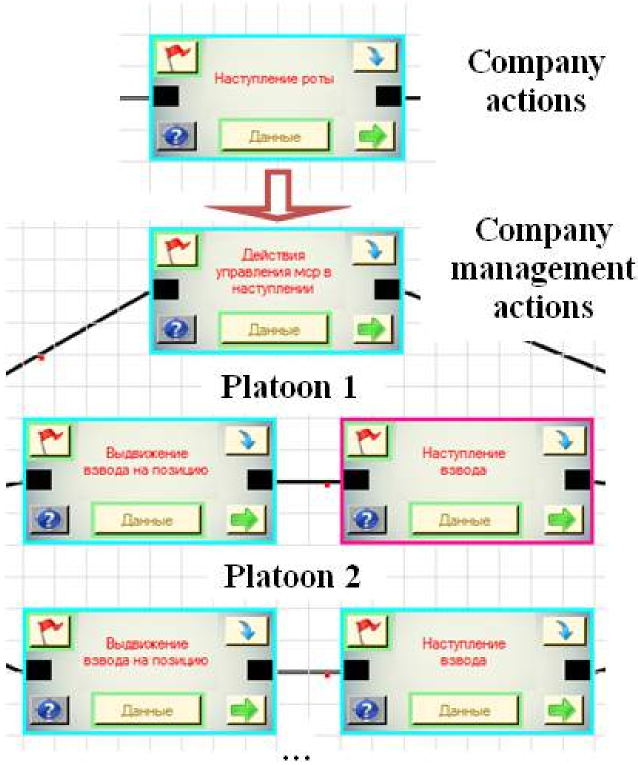

Figure 4. Nested action structure.

In addition to the task blocks and algorithm blocks, there are a number of control blocks: event blocks, logical condition blocks, time "Ch" generation and control blocks, time delay block and others - Fig.5.

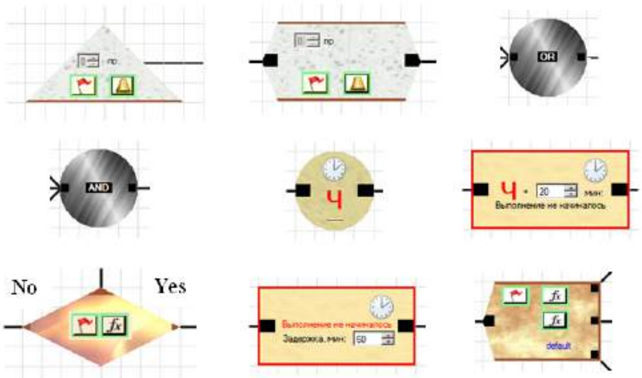

Figure 5. Control Units.

So, for example, the condition block "AND" sends control of the blocks connected to its output once, if control comes from each of the blocks connected to its input. This allows you to perform some actions to comply with the system of conditions. Thus, an offensive against the enemy can be carried out by the unit only after it leaves the concentration area, takes appropriate lines, and the artillery preparation of the prospective area of enemy forces is completed - Fig.6.

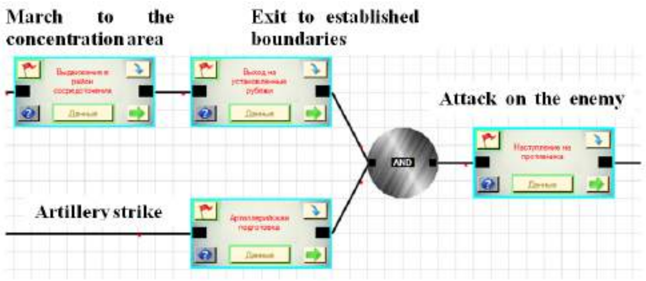

Figure 6. Using the condition block "AND".

With the help of the designer, it is possible to create potential algorithms - templates that define a general order of operations, in which there are no specific initial data. These algorithms can be used in other algorithms of a higher level. In the process of constructing the algorithm, the user is provided with a list of already created potential algorithms for the object of the given and lower levels. There is a special kind of algorithm - the scheme for managing the experiment, within the framework of which control is carried out not by any of the objects, but by the whole set of available objects on the map for one side of the troops (RED or BLUE). Each of the parties can have only one updated, that is, the current management scheme. Likewise, there are potential control schemes that represent a template for conducting the entire experiment for one side or the other. The control schemes can be prepared - they are not executed, but they contain all the data necessary for execution and can be updated at any time. The updated and prepared control schemes are stored together with an example of the situation.

III. Decision making

At the same time, the question of organization of rational choice of behavior alternatives by model objects in the process of simulation experiment at given points of decision-making remains open. In fact, this creates the need to develop a mechanism that allows to formalize the managerial experience of commanders of appropriate levels and automatically choose the preferred behavior from pre-prepared on the basis of the parameters of the current situation and pre-defined decision rules. As a rule, in the decision-making process, the commander operates with difficultly formalized information at the level of complex categories [7]. In contrast, the state of the object in the modeling system is described as a set of values of specific parameters. To convert a set of object parameters to higher-level parameters, it is suggested to use the hierarchy analysis method [8, 9]. For example, the parameter "Unit losses" can be represented in the form of ranked systems of other parameters - Fig.7.

The second task, which requires its solution, is the synthesis of the apparatus of decision-making on the basis of the

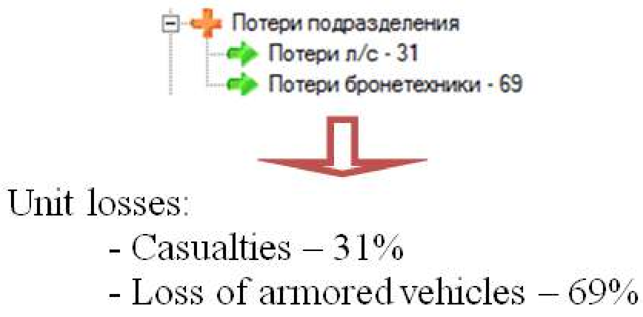

Figure 7. Complex parameter "Unit losses".

complex concepts obtained. For this, the use of the fuzzy inference mechanism is proposed [10, 11]. In this case, the membership functions of fuzzy sets are constructed on the axes of previously formed complex parameters. Each of the membership functions corresponds to a certain logical variable that the military specialist understands. So on the axis of the "unit loss" parameter, fuzzy sets with linguistic variables "low", "tangible", "high", "critical" can be located. Further, using the data of linguistic variables, the formation of the base of decision rules is carried out with indication of their coefficient of certainty:

1) "IF 'Unit losses = critical' THEN 'Waste' (0.8);
2) "IF 'Unit loss = high' AND 'Loss of the enemy = critical' THEN 'Defense' (0.5);
3) "IF 'Unit loss = high' AND 'Loss of the enemy = high' THEN 'Defense' (0.5);

and so on...

At the decision point, the value of the complex parameter is calculated and the values of the membership functions are determined - Fig.8.

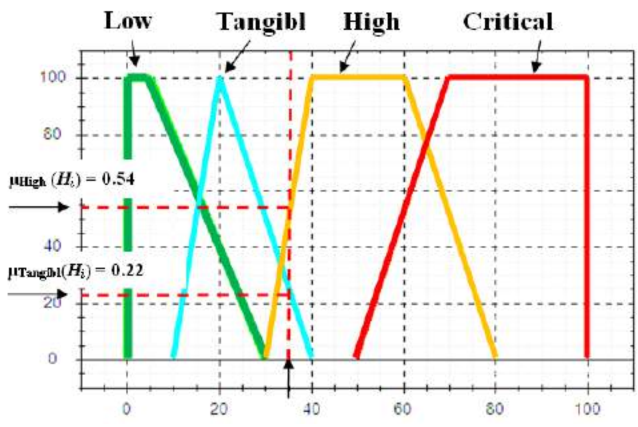

Figure 8. Determining the values of membership functions.

Further calculations assume the fulfillment of the main stages of fuzzy inference. In this case, pre-formed strategies for the behavior of model objects act as consecutive factors of the decisive rules; in this connection, the proposed algorithm does not actually have a stage of defuzzification, and for the accumulation of conclusions, the algebraic union formula is used. All this makes it possible to automatically select an alternative to the behavior at the decision point given in the form of an appropriate algorithm in the designer, by the model object itself in the simulation process without operator participation - Fig.9.

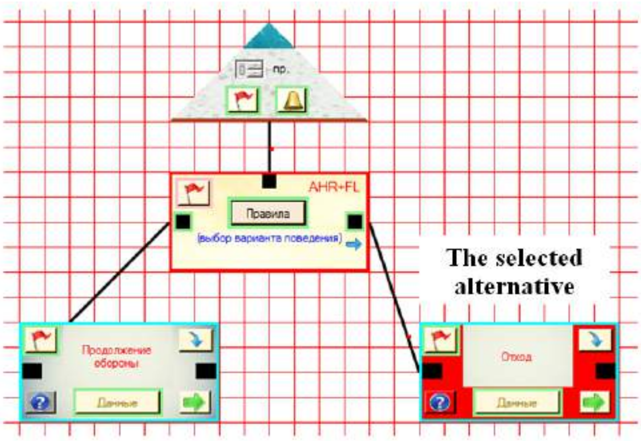

Figure 9. Choice of behavior in the modeling process.

IV. Conclusions

As a result, the proposed set of solutions allows for the formalization of the behavior of objects in the system of modeling military operations by creating event-time schemes of actions of the opposing sides, within which decision-making by objects is carried out on the basis of the fuzzy logic inference algorithm using the hierarchy analysis method. This, in fact, allows you to formulate strategies for the behavior of the parties, determining the sequence of their performance of the task and the response to emerging events.

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ВОСПРОИЗВЕДЕНИЕ УПРАВЛЕНЧЕСКОЙ ДЕЯТЕЛЬНОСТИ В СИСТЕМЕ ИМИТАЦИОННОГО МОДЕЛИРОВАНИЯ ВОЕННЫХ ДЕЙСТВИЙ

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Главное требование к моделированию – адекватность. Очевидно, что для получения адекватных результатов в системе имитационного моделирования, необходимо организовывать управление поведением агентов на основании логики здравого смысла и требований уставных документов. С целью формирования алгоритмов действий противоборствующих сторон предлагается использование визуального конструктора, позволяющего задавать последовательности выполнения различных задач объектов, осуществлять их синхронизацию, описывать события и задавать реакции на них. Для имитации процесса принятия решений объектами предлагается использование подхода на основе использования метода анализа иерархий и алгоритма нечеткого логического вывода. Это позволят осуществлять автоматический выбор одной из альтернатив поведения в произвольной точке принятия решения в ходе имитационного моделирования. Всё это даёт возможность формировать набор стратегий поведения противоборствующих сторон и позволяет оценить каждую из возможных стратегий в сочетании не с одиночным сценарием поведения оппонента, а с системой его возможных действий, что позволяет получить комплексную и всестороннюю оценку рассматриваемой стратегии.