THE INTEGRATION OF C4I SYSTEM WITH FIRE CONTROL SYSTEMS

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The quest for an integrated system, a system which is ubiquitous, pervasive, robust, secure, easy to maintain and configure is still ongoing. One solution for this was found in the "system of systems" approach, IP transmission and standard interfaces between different systems which provide an excellent solution. However, this does not involve a unique system, but a federation of systems, which tends to develop a mount of intricate shortfalls when developing and modifying them. Probably, one possible way to solve this problem is to build a platform common for all the systems which all the developers can access and adapt their applications for. There is a need for an integrated system and this induces the justification of costs and effort. A refractory view about the real necessity of the armament systems being multilevel linked is not fully reasoned and may become detrimental. For many armament systems, Microsoft or Linux have become the developing operating systems. The data bases met in the systems are random (Oracle, MySQL etc.), and many of them use a standard IP for data transmission while some are using HTML for standardization.

There should be a unique system for all the applications within NATO and one of the important features would be the integration of artificial intelligence methods.

Keywords: *integration, artificial intelligence, module.*

An architectural approach of system integration

This article attempts to demonstrate a fully integrated system in the operational environment. First of all, the system is composed of modules and all the modules are written within the same software platform. For example a purpose only, the Matlab platform is chosen, but for a real purpose a dedicated platform should be used on the overarching architectural level.

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The architecture of the new system is based on modules[1]. One example of modular architecture is presented in figure 1: an example for the integration of C4ISR system of systems with fire control system (FCS).

This example will continue to be developed for the integration of systems with the extended use of artificial intelligence methods. One of the points is the increasing use of horizontal hierarchical collaboration, controlled by small modules integrated within the overarching architectural module.

This application in the example is modular and functionally built; each module has a submodule and each submodule has implemented some functions. This is based on a framework of architectural design and has the advantage of managing capabilities for a system.

Many of the horizontal links place a great burden on the computational power of the system which, in conjunction with artificial intelligence methods, determine the increase use of mainframe centers.

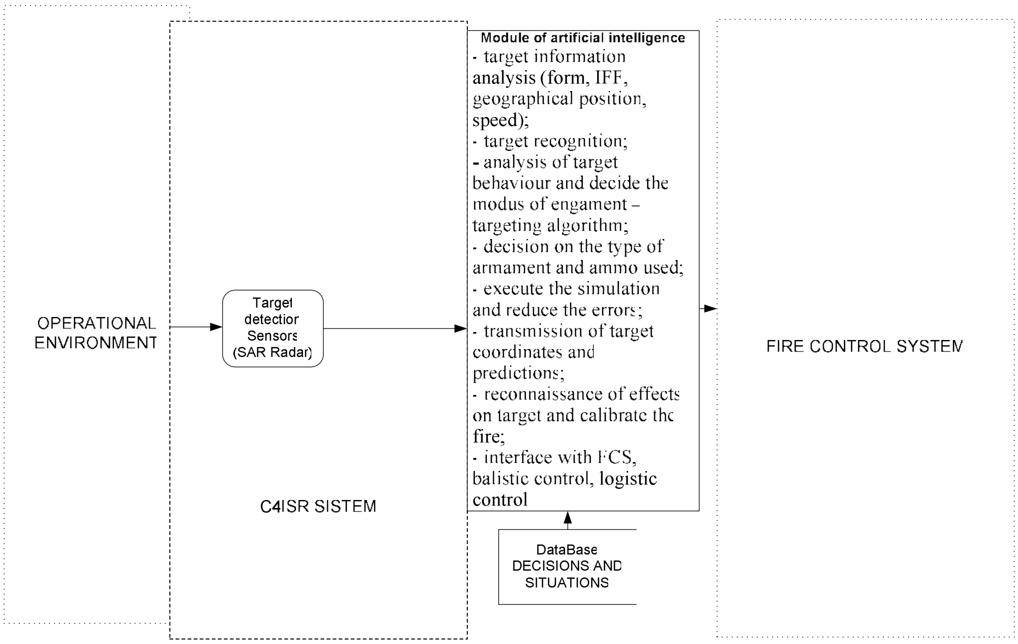

Fig. 1 *Module architecture approach between the C4ISR system and FCS*

Integration module for C4ISR and the submodule for target information

The *target information* submodule comprises two main functions: target acquisition and target recognition. First of all, the C4ISR system is programmed to send the information to the submodule. This receives the real time information about the targets and selects the targets according to the decision made by the targeting submodule. The process of recognizing the target is conducted by artificial intelligence. In this case, a back-propagation

[1] http://www.nhqc3s.nato.int/ARCHITECTURE/docs/NAF_v3/ANNEX1.pdf

network with three layers is used. For the weight function of the network, a *logsig(f)* function is used. Input layer has *10* neurons, the hidden layer has *100* neurons and the output layer has *1* neuron. This configuration returns good results for the terrestrial targets. For instance in the example (figure 2), *2* tanks are recognized from the raw image of the terrestrial sensor. The image in figure 2 is of the latest radar sensor, synthetic aperture radar (SAR) adapted for terrestrial use. With the use of artificial intelligence, the recognized targets appear in the common picture as pictograms, not as electronically footprints, which help the operational view and planning process.

The targets are identified as friend or foe by the C4ISR system and their information is sent to the module for further processing. After recognizing the targets and establishing the position, direction and speed, the data (or information) is sent to the *decision and simulation submodule*.

The decision and simulation submodule is responsible for conducting the targeting process. This submodule has the following functions: establishing the behavior of the target based on pervasive tracking using the image taken from the C4ISR sensors, target position prediction using artificial intelligence methods, execute the fire, and evaluate the effects.

This functional approach is similar to the NATO architectural approach[2].

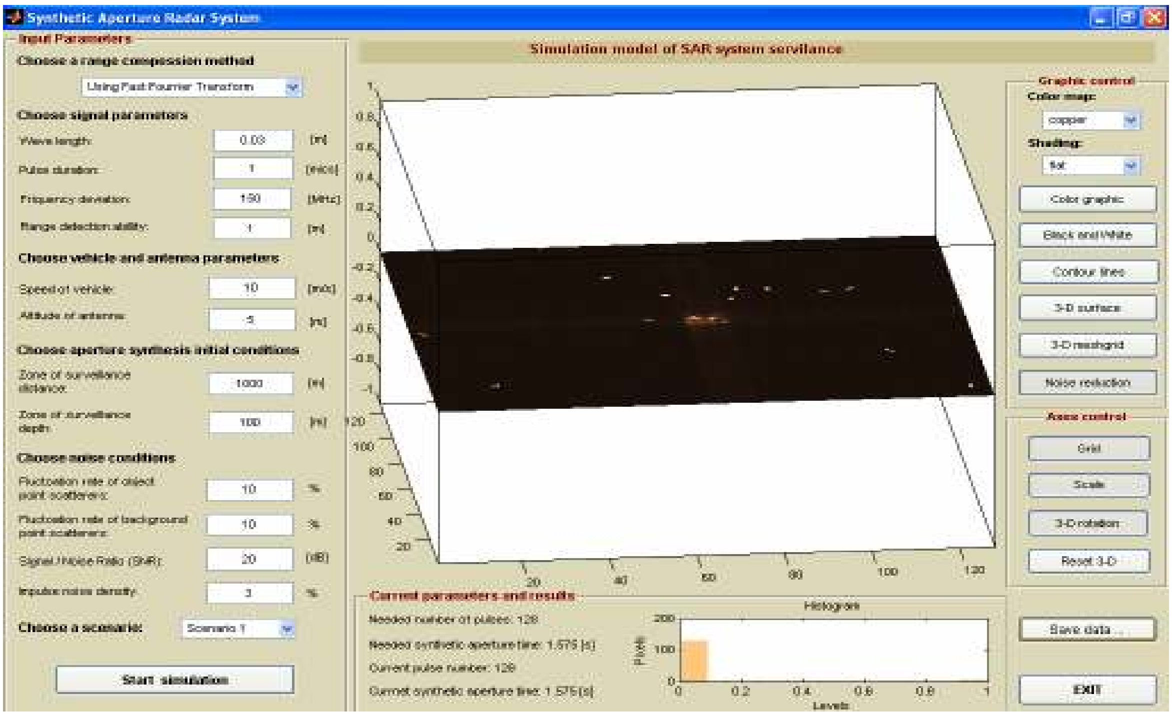

Fig. 2 *API for the target information submodule*

[2] *NATO architecture framework Version 3*, AC/322- D(2007)0048, NC3A, Chapter IV, p. 89.

The point for these fluent transitions is for the information about the target to be well processed and each application (module and submodule) to add some value and reasoning to the information. Therefore, the final steps of the information is to transform it into knowledge.

In the example, the next step is the submodule for decision and simulation, where the targeting process is carried on with all the steps and functions ("decide", "observe", "execute", "evaluate").Therefore, the C4ISR system and target information submodule are responsible for the functions; however, for the functions of "decide", "execute" and "evaluate", the decision and simulation submodule is consecrated.

The operating process of the submodule is shown in figure 3. The application programming interface (API) is simulating the tri-dimensional operational environment.

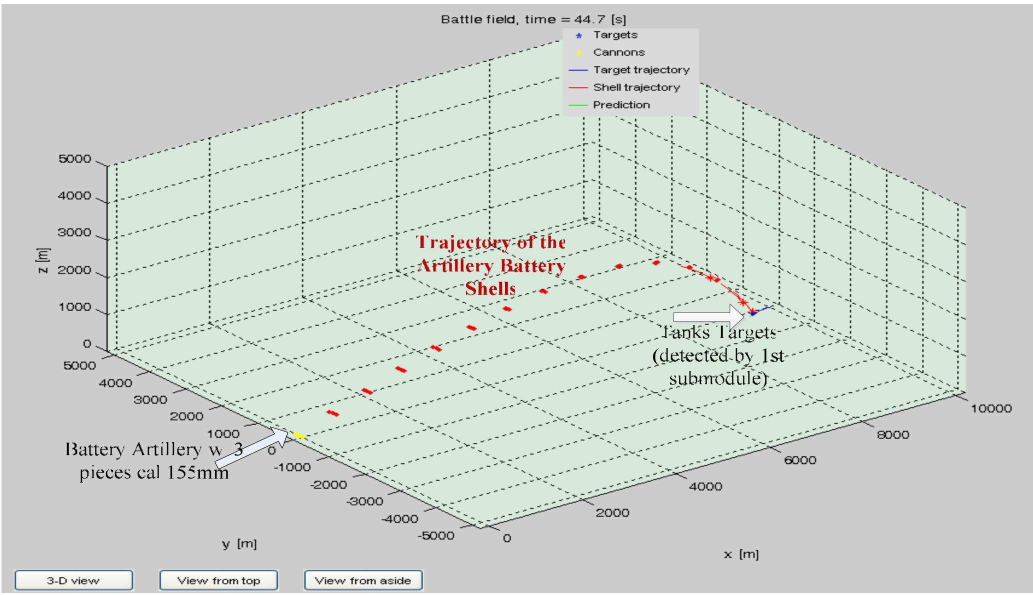

Fig. 3 *API for the 2nd submodule (decision and simulations)*

This submodule is built in a more complex manner, firstly because of the multitude of functions embedded and secondly for the choice not to break it down into submodules, which in this case, is very possibly and likely to yield better results. This submodule is also developed with the methods of artificial intelligence and here, neural networks with 3 layers are used. The input layer has 3 neurons; the hidden layer has 360 neurons and 1 neuron on the output layer. In this submodule, the neural networks which are used in the gun control domain are composed of one similar neural network for each direction (vertical and horizontal) for of the aiming process. The neural networks contain all the ballistic factors and continuously acquire data from the sensors of C4SIR system and armament system (artillery fire control), adapt the next action accordingly and execute the corrections from the previous fire. Moreover, neural networks (NN) execute predictions of the target's next positions so the fires are more and more accurate and precise, based on the targets' behavior studied continuously since the targets were acquired. Other two main advantages of using NNs in the operating system are that the training process can be made after each experience, so the system become more aware and that it can work in an "assisted" mode (continuously learning from the human decisions and reasoning) or autonomous mode (independent, but with limitation implied by programming) and the fact that using the artificial intelligence methods instantly induce full knowledge about the operational environment acquired by the learning process.

Conclusion

The integration module which is comprised of the two submodules permits the full integration of the targeting process functions. The advantage of breaking the module in submodules is the ease of developing, along with the seamless integration based on using the same platform and the same main coordinates for the program development. We have chosen this example because it is not necessary to complicate the development of an add-on for the C4ISR system or FCS, but it is easy to develop the module which integrates the two with the required functions.

Besides, this module must have the possibility and the technicality to interconnect with any other module or system. This is why it is best to select an operating system common for all the developments of the armament systems which is perpetually flexible for accommodating all the requirements for the developers. But the most important addition to a universal operating system is using the embedded methods of artificial intelligence; the mature mathematical context and the limitless developments are supporting the quality of this addition.

Three new ideas are introduced: the existence of an universal operating system; methods of artificial intelligence embedded in the artificial intelligence; and prior to achieving this, modules can be constructed using the same platform and being fully integrated with the existing systems and also among them. These are supported by the example developed and detailed here of a module which creates the integration of the FCS with the C4ISR system.

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