ELECTRONICS AND ELECTRICAL ENGINEERING

ISSN 1392 – 1215 *2008. No. 8(88)*

ELEKTRONIKA IR ELEKTROTECHNIKA

SYSTEM ENGINEERING, COMPUTER TECHNOLOGY

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SISTEMŲ INŽINERIJA, KOMPIUTERINĖS TECHNOLOGIJOS

Shooting Simulator System

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Introduction

Conflicts including usage of modern weapons in large scale environments in different parts evolve in different regions time after time. To overcome these national and international crises helps different international political organizations based in the worst case on international military task forces. The area of conflicts geographically is very large and potentially the solders of different countries can be involved in the operations of international task forces missions in different world regions. With the membership in NATO National Armed Forces (NAF) are involved in global security policy [1, 2]. It forces to improve the practice of NAF solders individual qualification, their fitness and especially skills of using their *individual* weapons. It can be crucial to survive in the battlefield.

The NAF trains hundreds new recruits annually. These young men and women must be trained to operate complicated weapon systems, make quick, multi-faceted decisions, and participate in mentally high pressure, complex missions where the consequences for the mistakes can be severe. The most effective training can be done with different simulation systems and the basic one is the Small Arms simulator.

The Small Arms simulator provides training for all ranks and branches of the armed forces and it provides a more efficient way to train both new recruits and experienced soldiers in marksmanship skills.

The simulators, in particular the shooting simulators, give the advantages better train the solders marksmanship skills and through simulators virtual environment can play different battle scenarios next to real ones. The most important benefits of the Small Arms simulators usage are essential budget and the tuition time economy.

Types of simulation

Simulation (definition): The execution over time the models representing the attributes of one or more entities or processes. Human-in-the-loop simulations, also known as *simulators*, are a special class of simulations [3].
According the NATO classification all simulations are split in the three groups or Types:

1. *Live* simulation - this simulation involves REAL people operating in REAL systems.

Live simulations are often the easiest way for users to accomplish the training because all the components - people and equipment, are readily at hand.

2. *Virtual* simulation - this type of simulation involves REAL people using SIMULATED systems.

This type of simulators is known as "human-in-the-loop" simulations or simulators. A virtual simulation allows a person to feed control inputs to a simulated entity or entities, while a simulator allows a person physically manipulate a representation of an entity - usually a physical representation.

The virtual simulations and simulators are familiar to us as the commercially produced video games, consoles and computer games. They are used for example to train individuals in driving skills, different decision approval skills, communication skills and etc.

The virtual simulations and simulators can be found at the platform or individual combatant level. They can be connected together in a network when used at a group or collective level. A major advantage of virtual simulation is that anyone can practice the certain tasks that would be dangerous in the *live* simulation. This category includes Crew & Skill Trainers like a Small Arms simulators.

3. *Constructive* simulation **–** this simulation involves SIMULATED people operating SIMULATED systems.

Real people *simulate (make inputs) to these simulations, but are not involved in determining the outcomes.*

The *Constructive simulation* deals in following way (see Table 1):

- Real people input data into particular computer programs. These programs are engineered to take

in this data, combine it with the effects of the environment and threat activity, and produce the result.

Table 1. Constructive simulation properties

Constructive Simulations Offer the Ability to:	**Three Strengths of Constructive Simulations:**
1. Analyze Concepts	1. Make Measurements
2. Predict Possible Outcomes	2. Generate Statistics
3. Stress Large Organizations	3. Perform Analysis

Constructive simulations are used mainly to train large unit commanders and staffs or organizations. They can provide an analytical platform for variety types of assessment. A key point to remember is that there are many good constructive simulations in use today. Many of these were developed with a single user in mind. The constructive simulations that have been around for a long time may not have been developed with sharing of information in mind. Sharing of information and interoperability are priority areas for NATO M&S.
This type of simulation has been used for:

- Command & Staff Training,
- War gaming,
- Tactical Command Training,
- Simulation Based Acquisition,
- Analysis and doctrines.

The precise classification all simulations into three categories are problematic because the degree of human participation in each of simulation is infinitely variable, as well as the degree of equipment realism.
There are used many others systems for more precise description of the simulation process, for example:

- Real time (RT) <=>Non real-time simulations (NRT) ("logical time" in NRT simulations).

The examples of RT simulation are:

- Manned simulators,
- Hardware in the loop simulators.

The example of NRT simulation is:

- Event-driven simulation.

Examples of others simulation systems:

- Interactive Simulation <=> Closed Simulation,
- Stand-alone Simulation <=> Distributed Simulation,
- Deterministic Simulation <=> Stochastic Simulation, etc.

Principles of shooting simulation and performance

The modern Small Arms shooting simulator is performed by high level of validity real time system, using precise modeling programs with simulator control system and has his ***modeling computer*** that realizes modeling programs. The modeling computer is connecting through data transfer system to user interface. User interface can be realized in two ways – like a control panel or like a video terminal. Modeling computer can be performed like ordinary one processor PC or like a multi processor system. It depends of simulation mission and complexity. Modeling computer can realize the ***imitation model*** - a program reflecting all imitation process or shooting system properties and mutual relation with different components of this system.

There is useful to divide program performance in three levels describing the certain shooting simulation program (see Figure 1):

1. ***Biological level*** - most complicated level.

This is a program performance strategic level and is responsible for simulator proper work. Programs at this level are most complex then in others levels and use elements of virtual environment. In this level there is not necessary high speed and delay time can be longer then 50 ms. Biological level provides system reaction that is close to human reaction on natural irritants.

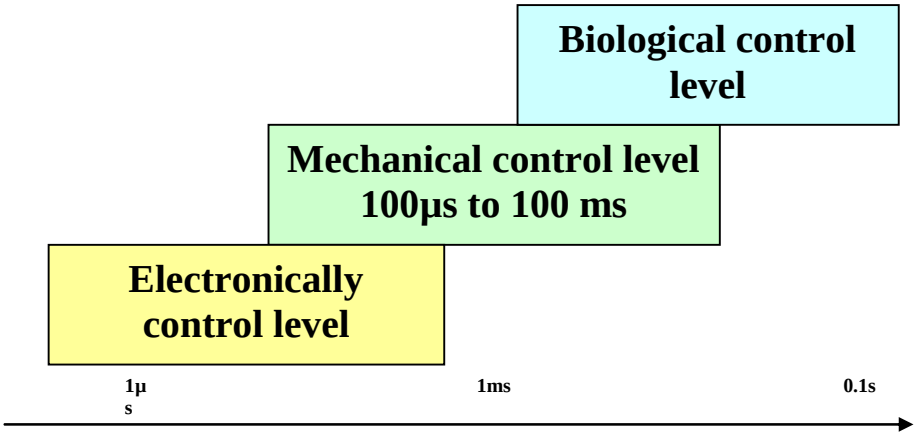

Fig. 1. Simulation control levels

2. ***Mechanical control level*** provides proper work sequence of simulator mechanical parts: for example motors, electrical flaps etc.

This is a most simple level from programming point of view and in this level the simulator operates with its mechanical parts. Time delay can be about 100μs to 100 ms. In this level operating with microcontrollers give the best results.

3. ***Electronically control level*** manages proper and concerted work of system's electronics and realizes the input/output functions. These functions execution with maximal high speed performance are mandatory necessary to increase the data exchange inside the system. Usually the program code is not complicated, but it needs the synchronization with other control unit [4].

Fig. 2. CO_2 gas recoil system for M16

Modern Small Arms shooting simulators are complex appliances that are suitable for performance a complicate complex challenges. From simple marksmanship trainer shooting simulator it can be adapted to group - collective training system and execute the complex exercises. In modern shooting simulator is necessary to simulate the ***recoiling effects.*** For this purpose the compress air or CO_2 gas are commonly used (see Figure 2).

The arms equipped with the Optical Units simulated the shot allow to use the pneumatic Recoil System, which reloads the weapon, generates a recoil effect and allows rapid shooting. The weapon transformations are not required using the recoil system - it needs simply replaces weapon some internal parts. The pipe less recoil system is more convenient and the pressurized gas cylinder commonly is mounted in the magazine [5]. The use of compressed air pipelines systems for weapons recoil system are recommended in the case of the collective training system, specially for the weapons with height level of compress air expenditure such a machineguns. In this case it is necessary to use special compress air spreader and this device limits the potential shooting volume in a range of 250 to 300 shoots per minutes.

In shooting training also is important discovered the shooters physical factors – breezing, pulse and level of biological tremor. For this purpose some simulators contain a special shooters conditions sensor. For example Russian simulator SCATT Professional pull together at least two tips of these sensors [6] (see Fig. 3).

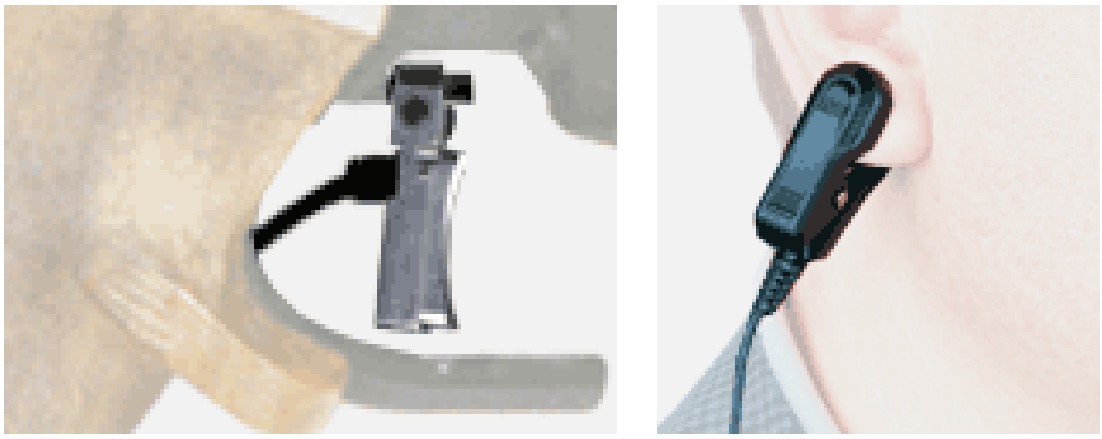

Fig. 3. Trigger pushing and pulse sensors

Especially in force enforcement shooting simulators is very important trained reaction on posit side actions. Usually for this purposes use timing control, bat this method, gives only approximate understand about opposite sides shot back possibility.

Small Arms shooting simulators are very important in law enforcement force for training reaction in extreme situation. Usually for this purpose the timing control system is used, but this method gives only approximate understand about opposite sides shot back possibility.

The special devices are developed to realize *shoot back effects*, for example 3rd Space Vest is produced by company NT Games for games Call of Duty 2. TN Games patented impact-generating 3rd Space technology utilizes a quiet and durable air source to fire 8 pneumatic cells embedded in the vest (see Figure 4). The cells are designed to simulate the direction and force of bullet fire in a first-person shooter game. In addition, a wide array of sensory experiences, from crushing explosions to fear-inducing finger taps on the gamers' shoulders, can be experienced with the 3rd Space FPS Vest [7].

The quantity of data grows exponent in the complex task and one processor systems can't operate properly in real time. The multi-processor system is needed to apply for complex simulation performance. These systems can synchronize the works of simulation with external sensors data stream.

The lasers simulating the shot are used on the weapons to simulate ballistic characteristics of live–fire weapons. Multiple Integrated laser Engagement System (MILES) [8] is the most frequently used laser training system, which is dealing with laser diode technology. The MILES training system provides a realistic battlefield environment for soldiers involved in training exercises. MILES provides tactical engagement simulation for direct fire force-on-force training using eye safe laser "bullets". Each individual and vehicle in the training exercise has a detection system to sense hits and perform casualty assessment. Laser transmitters are attached to each individual and vehicle weapon system and accurately replicate actual ranges and lethality of the specified weapon systems.

Fig. 4. Patented Impact Generating Technology 3rd Space Vest

The eye safe laser diode on GeAs operating in the 905 nm region of the spectrum is used. The laser diodes are programmed to emit a code of pulse to simulate a particular weapons system. The sensors attached to the target (such as a tank, an aircraft or personnel) receive the code of laser pulse and interpret the code as a "kill" or a "near miss". A "near miss" will signal the target as being engaged, and a "kill" - will shut down the MILESS. MILES requires the sound of a blank cartridge to discharge a laser transmitter that sends simulated laser "bullet" to kill or wound opposing forces.

Methods of shooting accuracy evaluation

Virtual Real time - hardware in the loop simulators are most widely used simulators. The methods of shooting accuracy evaluation for this type simulators mostly are based on analyzing the accuracy of used physical sensors, accessories and sensors' configuration on/or against the target field.

In *Real time* shooting simulators mainly are used 3 types of sensors:

- Digital video camera (digital CCD matrix),
- Laser beam deviation sensor,
- Sound sensors.

The CCD sensors are used mostly for all types of laser shooting simulators beginning with simple one's to most sophisticated – multimedia shooting simulators used in the room. The simple shooting simulator uses low resolution CCD matrix, e.g. 480 x 620 pix with simple optical objective for target image (projected or fixed to transparent screen). Each gunner has *his own* target. This type of shooting simulator allows training as first acquirements for beginners as well as marksmanship skills including weapon pre and post aiming treks determination. With the simple means the high accuracy till some centimeters to imaginable distance up to 100 m can be achieved. The main shortcomings of these shooting simulators are impossibility of group or tactical trainings as well as using real warfare shooting distance of the targets: from 200 m up to 400 m. For the last – high resolution CCD matrix must be applied and high accuracy optical systems must be used and calibrated.

The laser beam deviation sensor is used in some shooting simulators [5]. These are complicated devices with the same order of accuracy as mentioned above and mostly used in the field, but also with limited shooting distance – till 100 m up to 200 m.

The sound sensors are used in the REAL TIME shooting simulators hardware with real gun cartridges - mostly for law enforcement forces for distances from 10 m up to 50 m in shooting grounds as in a trap-shooting so as in a multimedia shooting simulators. The accuracy depends on the sound sensors' configuration on and in the target field and is about some mm for the trap-shooting targets till some cm for multimedia shooting simulators.

Shooting simulator in Latvia

Ministry of Defense of Latvia was ordered shooting simulator for recruits and solders group training and marksmanship skills in 2004. The shooting simulator SAIKU-8 [9] had been presented after 9 months. The basic model supports 8 shooting places.

Fig. 5. Shooting simulator SAIKU-8

Simulator can operate with 8 AK-4 automatic rifles or one of them can be replaced with machinegun KSP-58. Beside these tips of weapons there are possible to use additional grenade launchers CG M2 and AT-4 in the shooting simulator (see Fig. 5).

The targets and background are projected on screen on the wall with high resolution projector. Hit mark the target by laser beam impulse in visible spectrum of light. Hit identification is realized with high speed and high resolution video camera.

Shooting results data analysis is provided by PC, which calculate the hit and initiate changes in projected image. The data of all shooting sequence data is collected in the data base and can be used later in post exercise report. The weapon recoil effect is realized with pneumatic cylinder and is controlled electronically by microcontroller. This technical decision allows drive the weapons recoil systems in all shooting modes and allows use low pressure air from air pipe line. This shooting simulator is under upgrade now for using in interactive scenario. This task requires solving the weapons identifications problem.

Development perspectives

The future developments of military shooting simulations in general are involving the Computer Generated Forces (CGF), which is a significant component of military modeling and simulation [10], but creation of artificial agents with human-like decision-making is difficult till now. By using a Turing Test in a virtual environment that relates to military scenarios, areas in which CGF need to improve environment in order to help direct future studies are probed. The main areas determined for improvement are: environment awareness, human variance, persistence, vengeance, anticipation, learning and teaming. The CGF show consistent weakness in these areas across all virtual environments and should be considered in future studies. The technical challenge in adoption of CGF as surrogate players in computer supported simulation activity for training, mission rehearsal, operations research and military experimentation including the Small Arms shooting simulators as a system's part is the future task.

Future studies should explore differences between military simulations and computer games with a view of using Bots (**bots** – the software applications running automated tasks over the Internet) along with CGF are appropriate. Computer games need to be monitored for significant developments in Bots and other Al characters that will be useful to military simulations.

Conclusions

This paper deals with common shooting simulation systems and their analysis currently used in armed forces and law enforcement

1. The evaluation of the effectiveness of new weapons systems and tactics would be incomplete, if there was little or no variability in the computer generated forces (even if we can produce the behavior of average human participants).
2. Testing new systems and tactics against a range of responses to a situation, often at the extremes, allows the experts to learn not only their strengths, but also their limitations.
3. A new tactic or weapon that works only with the average friendly soldier vs. the average enemy soldier may completely fail when used within the variability that exists across the capabilities and behavior of real forces.

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Received 2008 04 03

I. Rankis, J. Kiploks, J. Vjaters. Shooting Simulator System // Electronics and Electrical Engineering. – Kaunas: Technologija, 2008. – No. 8(88). – P. 19–24.

This paper deals with common shooting simulation systems and their analysis currently used in armed forces and law enforcement. The description and the main sets of requirements for platoon shooting simulation systems, their properties and shortcomings are described. This paper contains information about main parts of shooting simulators and data about shooting simulator SAIKU-8. Ill. 5, bibl. 10 (in English; summaries in English, Russian and Lithuanian).

И. Ранкис, Ю. Киплокс, Я. Вятерс. Стрелковые имитаторы // Электроника и электротехника. – Каунас: Технология, 2008. – № 8(88). – С. 19–24.

Приводится общее описание и анализ имитаторов для обучения стрельбе со стрелкового оружия, используемого для обучения как военнослужущих, так и работников правохранительных органов. Коротко описаны главные требования и особенности имитаторов для стрелкового оружия. Дано общее описание стрелковых имитаторов и основных функциональных блоков. Ил. 5, библ. 10 (на английском языке; рефераты на английском, русском и литовском яз.).

I. Rankis, J. Kiploks, J. Vjaters. Šaudymo imitatoriaus sistema // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2008. – Nr. 8(88). – P. 19–24.

Pateiktas bendras šaulių mokymo imitatorių aprašymas ir analizė. Šauliai mokomi naudotis mokomaisiais karinės paskirties bei teisėsaugos pareigūnams skirtais šaunamaisiais ginklais. Trumpai aprašyti pagrindiniai reikalavimai ir šaunamųjų ginklų imitatorių ypatumai. Pateiktas bendras šaunamųjų ginklų stimuliatorių funkcinių blokų aprašymas. Il. 5, bibl. 10 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).

DOI: 10.5755/j02.eie.11226