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SHOOTING SIMULATOR STRUCTURE

ŠAUŠANAS SIMULATORU UZBŪVE

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Introduction

Conflicts including usage of modern weapons in large scale arose in different parts of our world time after time. To overcome these national and international crises helps different political international organizations based in the worst case on international military task forces.

The area of conflicts geographically is very large and potentially the solders of international task forces missions can be involved in operations in different world regions. With the membership in NATO National Armed Forces (NAF) are involved in global security policy [1;2]. It makes to improve practice NAF solders individual qualification and fitness and especially skills of using their individual weapons. It can be crucial to survive in the battlefield.

The simulators, in particular the shooting simulators, give an advantage to better train solders marksmanship skills and through virtual environment play different battle scenarios next to real one. The main benefits of the simulators usage are essential budget and the tuition time economy.

Species of shooting simulators

Simulation (definition): The execution over time of 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" [27]. According the NATO classification all simulations are split in the three groups or Types:

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

- Can be mixed with virtual and constructive *Modeling and Simulations* (M&S) ;
- Uses actual equipment and has a similar area of operations ;
- May result in large resource expenditure;
- Can not be fully replicated .

Live simulations are often the easiest way for users to accomplish the training because all the components - people and equipment, are readily at hand. However, there are some drawbacks in **live** simulation:

- Live simulation can be very expensive: ammo, fuel, repair parts all are expensive.
- It can be dangerous: the weapons are designed to kill or destroy, in the case - they cannot differentiate between combat and simulated combat.
- Finally, live simulation can be very tough on the environment - vehicles and explosions can significantly damage the terrain.

In this category includes:

- Combat Training Centers,
- Exercise Control Systems,
- Area Weapon Effect Simulation,
- After/During Action Review,
- Military Operations on Urban Terrain [MOUT] / Fighting In Built Up Areas (FIBUA).

2. *Virtual* - this type of simulation involves REAL people using SIMULATED systems.
These simulators are also 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 the person to physically manipulate a representation of an entity - usually a physical representation.

Virtual simulations and simulators are familiar to us as a result of commercially produced video games, console and computer games. They are used mainly to train individuals in motor skills, decision skills, and/or communication skills and etc. The virtual simulations and simulators are normally found at the platform or individual combatant level. They are connected together in a network when used at a group or collective level. Examples of virtual simulations and simulators include:

- The aircraft cockpit simulators- virtual individual weapons and weapons ranges- vehicle driver simulators.
- The fire control in tanks, howitzers, and fighting vehicles.

A major advantage of virtual simulation is that anyone can practice tasks that would be dangerous if using the *live* simulation. The examples are: carrier landings and aircraft malfunctions.
Astronauts are trained largely using virtual simulation because the nature of their mission makes it impossible to prepare under live conditions. In this category includes:

- Crew Trainers,
- Gunnery Trainers,
- Fire Control Training,

- Forward Observer Training,
- Skill Trainers,
- ATC (Air Traffic Control) 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.

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

The *Constructive simulation* deals in following way:

- Real people input data into particular computer programs. These programs are engineered to take this data, combine it with the effects of the environment and threat activity, and produce the result.

Constructive simulations are used mainly to train large unit commanders and staffs or organizations. They can provide an analytical platform for a variety of 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 use for:

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

The classification of all simulations into these three categories is problematic because the degree of human participation in each is infinitely variable, as is the degree of equipment realism.

For more precise description of the simulation process there are used many others systems, for example:

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

The examples of RT:

- Manned simulators,
- Hardware in the loop simulators.

The example of NRT:

- Event-driven simulation.

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

Basic principles of shooting simulation

Modern simulators are performed by high level of validity in real time, using very precise modeling programs. ***Modeling computer*** is a device that realized modeling programs. 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 realized the ***imitation model*** - a program reflecting all imitation process or shooting system properties and mutual relation with different components of this system (Fig.1). Describing the certain simulation program is useful divide program performance in three levels.

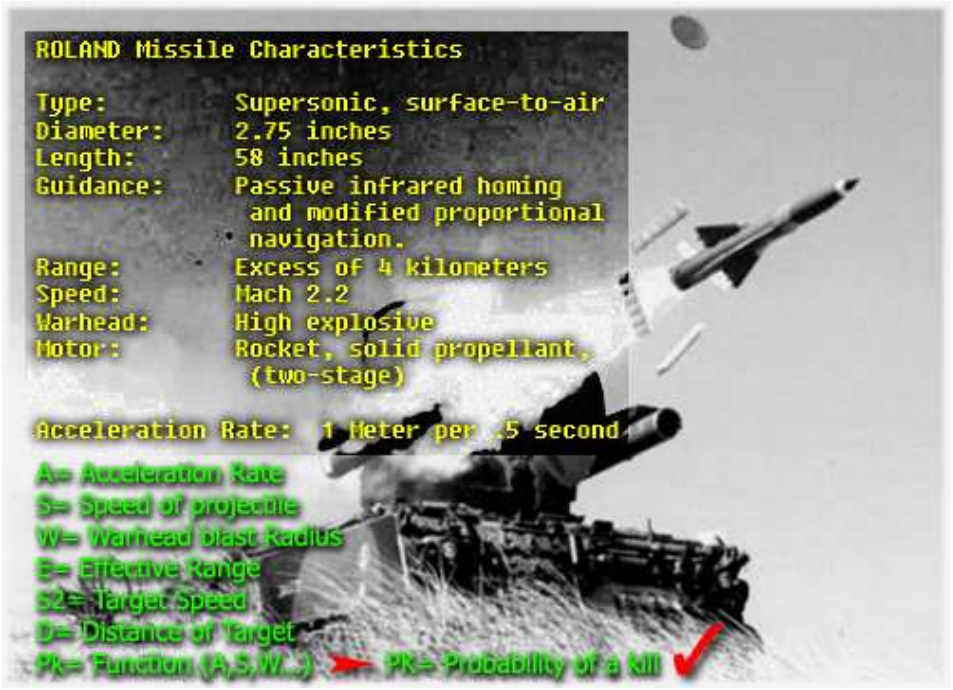

Fig. 1 - Example of a Model

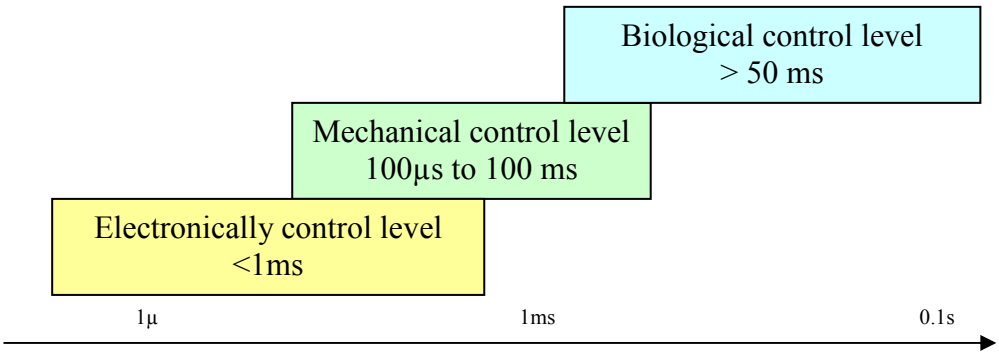

Fig. 2 - Simulation control levels

Biological level is most complicated level. It 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 irritant.

Mechanical control level provides proper work of simulator mechanical parts: for example motors, electrical flaps etc. It is a most simple level from programming point of view and in this level the simulator operates with triggers. Time delay can be about **100µs** to **100 ms**. Operating with microcontrollers in this level give the best results.

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

Modern shooting simulators are complex appliances that are suitable for performance a complicate complex challenges. From simple marksmanship trainer shooting simulator it can adapt to group - collective training and solving 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.

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.

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 sensors:

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

Fig. 3. Laser beam deviation sensor system

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 can be achieved till some cm to 100 m distance for the shooting simulators.

The main shortcomings of these shooting simulators is impossibility of group or tactical training as well as using real warfare shooting distance targets: for 200 to 400 m. For the last – high resolution CCD matrix must be used and optical objective must be calibrated.

The laser beam deviation sensor also is used in some companies shooting simulators [9]. These are complicated devices with the same order of accuracy, mostly used in the field, but also with limited shooting distance – till 100/200 m.

The sound sensors are used in the REAL *RT* shooting simulators hardware with real gun cartridges - mostly for law enforcement for distances 10 – 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 simulator.

Development perspectives

The Computer Generated Forces (CGF) is a significant component of military modeling and simulation. [28] The creation of artificial agents with human-like decision-making is difficult. 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. They present a technical challenge in adoption of CGF as surrogate players in computer supported simulation activity for training, mission rehearsal, operations research and military experimentation.

Future studies should explore differences between military simulations and computer games with a view of using Bots (**bots**, are software applications that run automated tasks over the Internet) instead of CGF where appropriate. Computer games need to be monitored for significant developments in Bots and other Al characters that will be useful to military simulations. This study has offered a way forward for future military simulation studies involving CGF.

Conclusions

1. Simple shooting simulator gives good and quick response in initial shooting practice.
2. The interactive shooting simulator for training solders marksmanship skills in particular with high shooting accuracy evaluation - next to real is complicated system with continuous and qualified maintenance.
3. To improve NAF solders individual qualification and better train solders marksmanship skills NAF needs more different shooting simulators.

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Ķiploks J., Vjaters J. Šaušanas simulatoru uzbūve.
Šajā rakstā vispārīgi analizēti militāro un tiesībsargājošo institūciju praksē izmantotie šaušanas simulatori, aprakstītas galvenās prasības šaušanas simulatoriem un to uzbūves īpatnības. Lai uzlabotu apmācības procesu, simulatoru pielietošana ir ļoti nepieciešama, jo tā samazina arī izmaksas, nodrošina vides aizsardzības prasības. Parādītas iespējas izveidot šaušanas simulatoru gan ar videomatricas, gan optisko un vai skaņas sensoru. Parādīti simulatoru vadības līmeņi, kā arī viņu tehniskā realizācija un vieta kopējā simulāciju sistēmā.

Parādītas attīstības iespējas, kā arī virtuālo mērķu izmantošana. Dota simulatoru iespējamā klasifikācijas sistēma, ietveror arī NATO prasības, kā arī aprakstītas metodes, kā novērtēt šaušanas precizitāti, akcentējot uzmanību uz lāzera stara novirzes sensoru pielietošanu. Aprakstītas dažādu sensoru nepilnības un priekšrocības, formulētas prasības sensoru pielietojumam.

Kiploks J., Vjaters J. Shooting Simulator Structure.
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 shooting simulation systems, their properties and shortcomings are described. Using of the simulators is important to the military and law enforcement training, it reduce expenses and improve environment protection needs. Papers shoves possibility's construct simulators with video camera (digital CCD matrix), laser beam deviation sensor and sound sensors methods of shooting accuracy evaluation. Reflected the levels of managing of simulators and the placement of shooting simulators in the NATO classification. Reflect the simulator improving possibilities and such with application of the virtual targets. Drawbacks and advantages of application of different sort sensors are evaluated putting accent on the improvement of shooting accuracy. It's described a levels of control organization and also their technical realization in the common system of the simulation.

Киплокс Ю., Вятерс Я. Устройство стрелковых симуляторов.
В этой статье дано общее описание и анализ симуляторов используемих в обучение военных и работников правоохранительных органов. Коротко описаны главные требования и особенности их устройства. Для того, чтобы улучшить обучение военных и работников правоохранительных органов, необходимо использовать симуляторы, что снижает затраты и улучшает соответствие требованиям охраны окружаюшей среды. Показаны возможности создания стрелковых симуляторов с изпользованием видеокамер, а также оптических и акустических сенсоров. Показаны уровни рализации управления симуляторами, описано их техническая реализация и их место в классификации НАТО. Показаны возможности улучшения симуляторов, в том числе с использованием с использованием виртуальных целей. Проведено сравнение разных типов сенсоров для определения точности стрельбы, а также показаны их недостатки и положительные свойства, использование которых позволило бы повысить точность оценки.