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LOW COST CGI PLATFORM WITH NIGHTVISION IMAGERY

By

Avanindra Utukuri
Julius J. Grodski

Dynamic Visions Ltd.
504-200 Robert Speck Pkwy.
Mississauga, Ontario
L4Z 1S3

PWGSC Contract No. W7711-9-7573/001/TOR

On behalf of
DEPARTMENT OF NATIONAL DEFENCE

As represented by
Defence and Civil Institute of Environmental Medicine
1133 Sheppard Avenue West
North York, Ontario, Canada
M3M 3B9

DCIEM Scientific Authority:
Dr. Julius Grodski
(416) 635-2085

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EXECUTIVE SUMMARY

Computer rendering and the simulation of real world environments have traditionally required the use of expensive and dedicated graphics workstations. This is due to the fact that this rendering process is computationally expensive, and has a high bandwidth requirement in order to execute in real-time. First, in order to create a visually realistic environment, a large geometric database is required. It is computationally expensive to render a scene due to the mathematics involved in processing a large three-dimensional geometric database. The process by which 3D data is 'painted' onto the monitor screen is called scan conversion, which causes additional problems due to bandwidth limitations. For example, if an 800x600 resolution image with 8-bit color depth has to be rendered at 30 frames a second, 14,400,000 bytes have to be processed per second by the Central Processing Unit (CPU). At 24-bit color depth, three times as many bytes have to be processed, which causes a significant bandwidth issue, as this large amount of data has to be moved from the CPU to the video card every second.

The Company has already successfully completed a Department of National Defence (DND) contract, W7711-7-7394, aimed at researching various PC-based technologies and creating a proof of concept of what can be achieved using inexpensive platforms for military training uses. In the process, a relatively high end and detailed CG demo was created that is able to demonstrate the performance capabilities of these low-cost systems. The previous contract demonstrated the capability of a low end PC platform for simulating some highly realistic daytime visual imagery. A variety of different scenarios were demonstrated previously in desert and prairie conditions under a variety of different lighting conditions (night, fog, noon etc).

The current contract focused on the ability for this system to be extended to simulate Infra-Red (IR) images, as seen through a IR Imaging system commonly used by the Forces. In order to properly create this simulation, the engineering team went to Gagetown, New Brunswick, in order to capture actual footage of a variety of vehicles through a couple of sets of IR imaging systems operating at different wavelengths. Using this footage in combination with normal pictures, the team has been able to simulate the actual IR signatures of 4 different vehicles: the LAV Reece, Leopard tank, a standard truck and the Humvee. A scenario was then created that demonstrated the capabilities of the low-end PC hardware platform generating a very realistic IR based CG imagery. The capability to pursue the work toward cost-effective practical training devices has been successfully demonstrated to the sponsors in DLR and DLESS at a presentation at NDHQ. Characteristics, features and options for potential trainee and instructor PC stations have been presented and discussed at the presentation.

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1.0 Abstract

The current contract focused on the ability for a Computer Graphics (CG) system, previously developed in contract W7711-7-7394, to be extended to simulate Infra-Red (IR) images, as seen through a IR Imaging system commonly used by the Forces. In order to properly create this simulation, the engineering team went to Gagetown, New Brunswick, in order to capture actual footage of a variety of vehicles through a couple of sets of IR imaging systems operating at different wavelengths. Based on this footage, in combination with normal pictures, the team has been able to simulate the actual IR signatures of four different vehicles: the LAV Reece, Leopard tank, a standard truck and the Humvee. The created vehicle imagery was correct at every viewing angle as it was consistent with the acquired IR imagery. A scenario was then created that demonstrated the capabilities of the low-end PC hardware platform generating a very realistic IR based CG imagery. The capabilities of a low end PC hardware platform, which can be incorporated into future CG simulation and training systems, were demonstrated using daytime and IR scenarios on a current basic lap-top PC. The demonstrated capability forms the foundation for the development of an effective, low-cost military training means, potentially useable for various purposes, including the anti-armour gunnery training. It also has a potential for embedded simulation in anti-armour systems.

2.0 Technology Developed

2.1 Background

The objectives of this project began with the task of using the capabilities of low-end PC based hardware systems for the purpose of creating realistic IR CG simulations. In the process, a relatively high performance and detailed CG demo was created that is capable of demonstrating the abilities of a low-end PC platform.

Work performed in the previous contract was extended in capability in order to accommodate the IR scenery. The previous contract dealt with the issues involved in generating realistic daytime scenery that could be used in a future ERYX\TOW missile training system. The demonstration for the previous contract included a CG simulation engine capable of rendering highly realistic land scenarios with multiple articulated objects such as buildings, tanks, fences, trees, trucks, and a variety of other objects. All of the objects could also be lit under a variety of ambient, global directional or local coloured light sources. Special effects such as fire, weather effects (e.g. snow, fog), smoke effects and vapour trails were also incorporated.

2.2 Work Performed

Initially, some analysis was performed on how to generate realistic IR images using mathematical modeling techniques. Very quickly, it was realized that this method couldnot be implemented within the scope and budget of this contract. Various types of video footage of training sessions record using IR cameras were obtained and analyzed in order to determine if relevant information could be obtained. Unfortunately, none of the footage contained enough detailed information in order to properly create a CG simulation.

It was then determined that the best possible way of creating the simulation is to experience the training exercises and operate the IR camera equipment first-hand. A team of engineers was given access to watch and record an actual tank training exercise in Gagetown, New Brunswick during the winter of 1999. These exercises were then recorded using two different types of infrared camera systems.

Camera System	Wavelength	Description	Lenses	NETD
Agema 1000	8-12 µm	SPRITE scanning system	WFOV: 20°x13.3° NFOV: 5°x3.3°	< 0.1K
Amber Radiance	3-5 µm	56 x 256 InSb Focal plan Array	25mm Lens: 22.4° x 22.4° 50mm Lens: 11.2° x 11.2° 100mm Lens: 5.6° x 5.6°	0.025K

Footage of different types of vehicles warmıng up, with their engines running, and also tanks involved in the training scenarios was recorded using both camera systems. Once acquired on tape, the footage was then digitized, as a digital format, into a computer system and analyzed.

Using a variety of software packages, first accurate models of the vehicles were constructed using the digitized footage as a basis. Then, using the various views (left view, right view, front view, and back view) of the vehicles, texture maps were created and mapped to the proper faces of the CG models. Again using the original footage as a reference, a terrain model and various models for trees were created.

The original CG simulation engine that was created was also significantly overhauled for use for this project. Three years ago, when the original contract was first started, the 3DFx Voodoo based accelerator cards were considered to be the best 3D cards available on the market. However, since then 3DFx has gone bankrupt, and their products unsupported in the marketplace. Nvidia is considered to be current leader in graphics technologies. In order to be able to support the new generation of graphics cards and computing platforms, the entire rendering portion of the CG simulation was rewritten using Direct3D technology from Microsoft. By making this change, the software can be now executed on any computer platform with any 3D graphics chipset available in the marketplace.

Once the artwork and models were completed, they was imported into the simulation engine and a IR scenario was scripted.

2.3 Reference Screenshots

The following pictures demonstrate the data that was recorded by the IR cameras, of various vehicles, in Gagetown, New Brunswick.

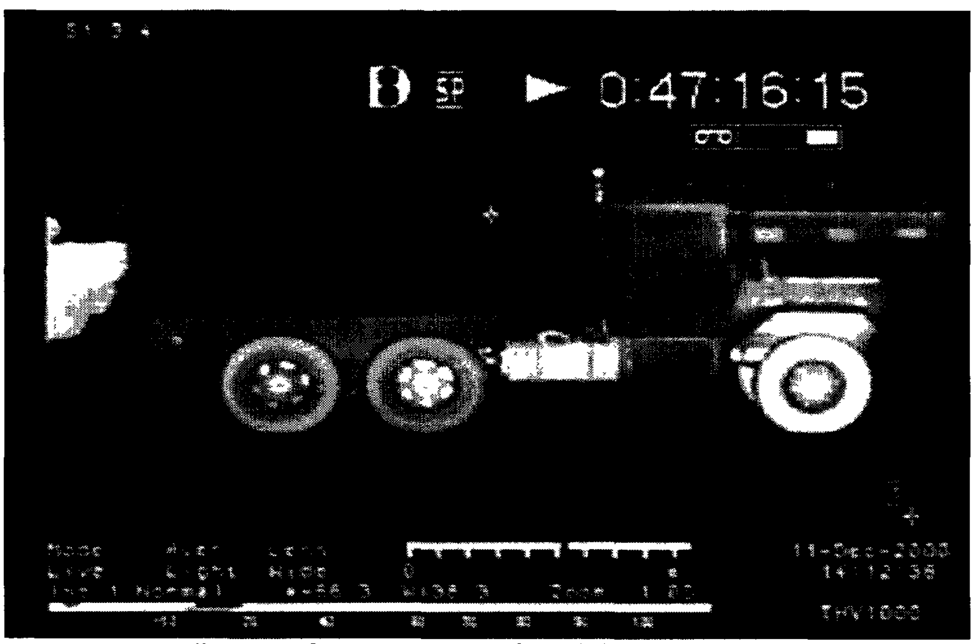

Fig. 1 – Reference IR image of Truck (passenger's side)

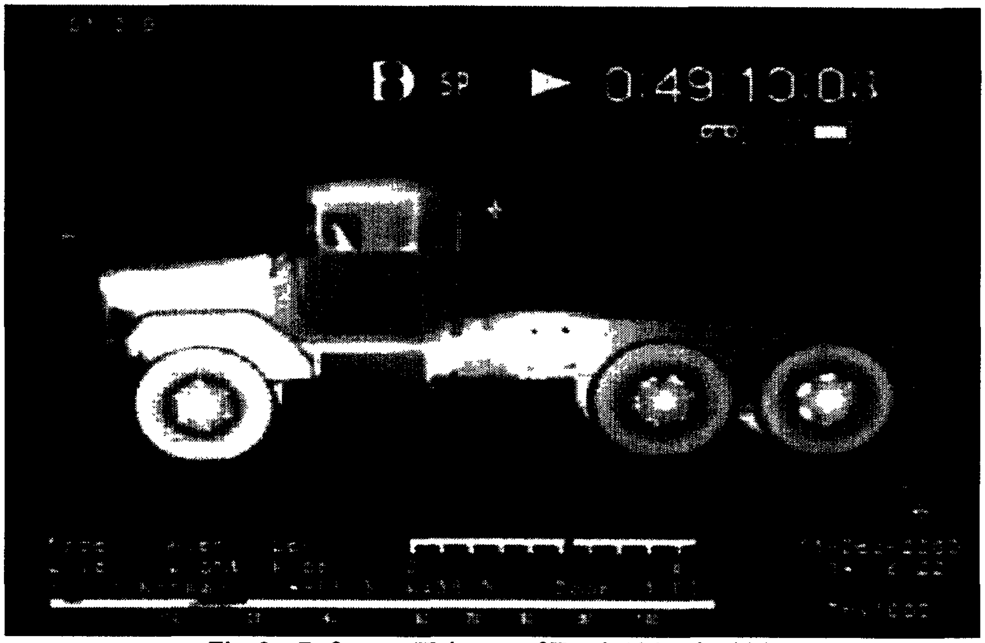

Fig. 2 – Reference IR image of Truck (driver's side)

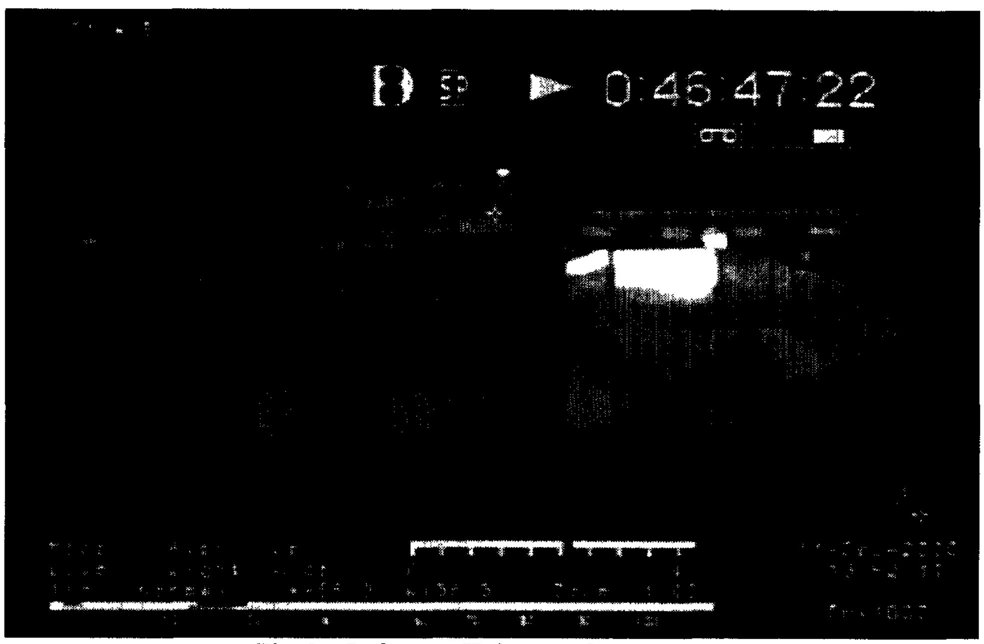

Fig. 3 – Reference IR image of LAV Reece

2.4 Actual Screenshots

The following images have been captured directly from the CG simulation that was created, based on the reference images above.

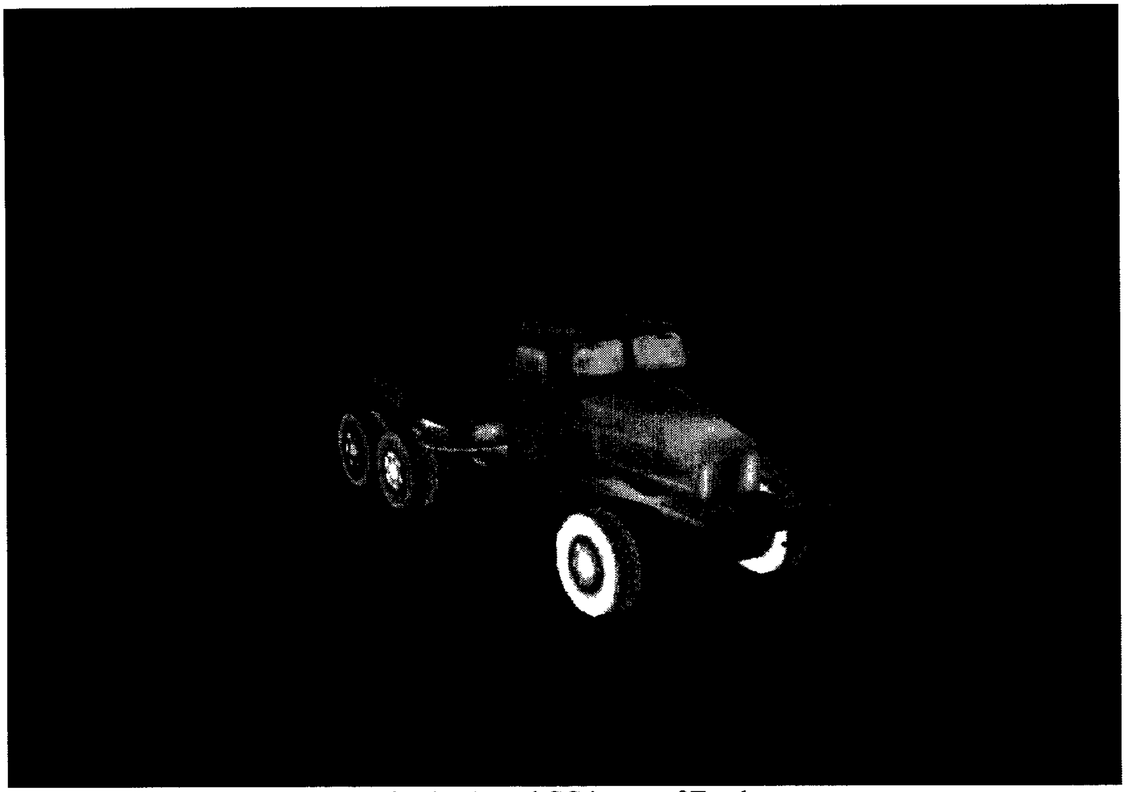

Fig. 4 – Actual CG image of Truck

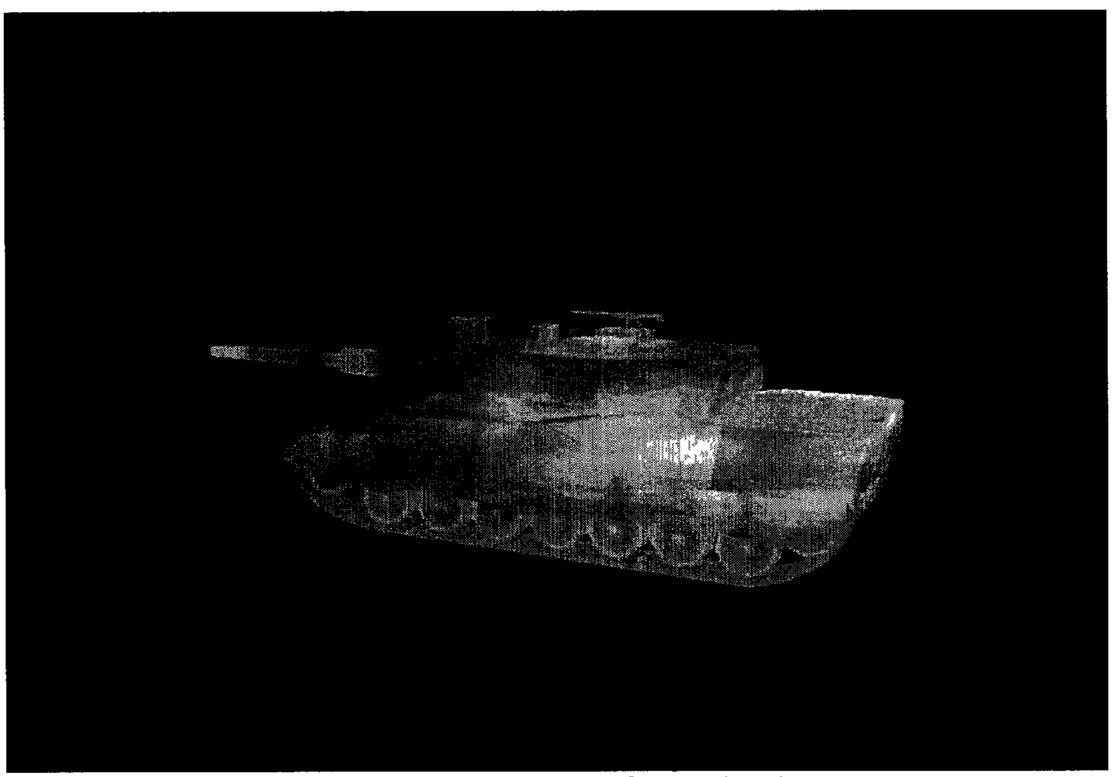

Fig. 5 – Actual CG ımage of Leopard Tank

Fig. 6 – Actual CG image of LAV Reece

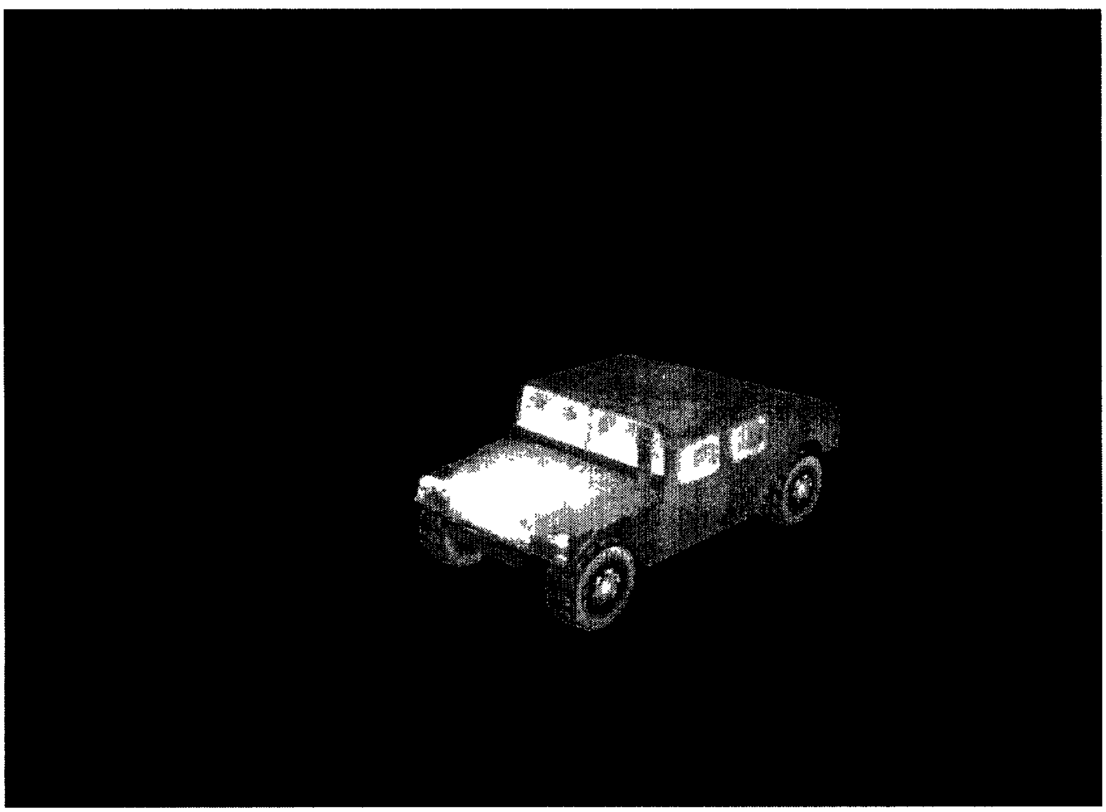

Fig. 7 – Actual CG image of Humvee

3.0 Future Development

At present, the purpose of this demo was to demonstrate the visual quality of the hardware platform, without any specific function in mind. Hence, this work can only serve as a guideline for future objectives. From a graphics and simulation standpoint, these are some of the issues that must be addressed in future work:

PHYSICAL SIMULATION: A full fledged physical simulator should be implemented in order to realistically model the objects and their interactions in the simulation. All parts and linkages (tire connected to body of truck) should have dynamic properties such as mass, friction, and spring constants, rotational and translational constraints, which would allow for proper simulation.

SPECIAL EFFECTS: Special effects such as rippling water, falling snow/rain could enhance the quality of the visual simulation. Also, effects such as blast marks and terrain deformations due to impacts would make the world seem more realistic.

As the current demo does not focus around any real application, significant work must be done in order to create the end product. The following recommendations are an example of what is required in order to create an EVIGS/TVIGS simulator for the Armed Forces.

MISSILE FLIGHT CHARACTERISTICS: This is the first step required in order to create a visual simulation of the flight of the missile. The missile must be modeled using appropriate flight equations.

USER INTERFACE: An advanced graphical editor would have to be created using a Graphical User Interface (GUI) such as Windows. The issue of user interface can be broken down into two categories: end user interface, and instructor interface.

The instructor must be able to easily and quickly generate different scenarios. The program must provide a simple and intuitive method by which the instructor can specify terrain types, skies, time of day, fog, visibility, location of gunner, targets etc. which are used to create the simulation with. The company can provide the instructor with various pre-created bases and landscapes, by which the final simulation could quickly be scripted from.

The end user's interface must allow for the realistic representation of parameters such as: crosshairs, reticule, field of view, and allow for the evaluation of the performance by the instructor. First, the instructor would 'download' the created scenario into the end user's console. During the simulation, the trainee's performance data would be monitored and 'uploaded' to the instructor's console. Next, using various tools and features, the instructor would be able to evaluate the performance and save the results for future use. It is also possible for the instructor to 're-play' the entire scenario frame by frame and even use various camera angles. For example, during re-play, the instructor could attach the view point to the target, and view the missile approaching from the target's perspective, or an overhead bird's eye view.

4.0 Conclusions

The work carried out in this contract shows that a CG simulation, capable of creating the necessary visual imagery required for a training system, can be achieved with a low-end PC platform. The system is capable of generating very realistic daytime and IR imagery that can be used effectively for creating realistic training scenarios.

The previous two contracts have demonstrated that the low end PC hardware architecture offers significant advantages over current proprietary systems used for CG simulation and training systems. The price per performance ratio, the ease of maintenance and the ability to upgrade the system are so greatly advantageous for gunnery training with these systems over the highly-priced propriety systems alternatives, that, in the final resolution, large cost savings in acquisition of such systems can be realized. The great variety of content – scenarios that can be developed for such a system would provide the advantage that the instructor could work with realistic scenarios and with such a variety of scenes that the trainee could be always challenged with new scenes and situations, thereby gaining enhanced effectiveness.

The work performed clearly demonstrates that the common PC platform is very capable of supporting the demanding tasks required in CG simulation and training systems. The time is right for future training systems to consider the use and deployment of these platforms, particularly as it applies to anti-armour and air defence training systems.

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Avanindra Utukuri Julius J. Grodski

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14. ABSTRACT

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15. KEYWORDS, DESCRIPTORS or IDENTIFIERS

(U) low cost CGI; CGI; infrared nightvision; nightvision