Advanced Presentation Layer in C3I Systems

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EXTENDED ABSTRACT

The paper follows on from the previously published paper "Virtual Reality presentation layer in C3I Systems" that was presented at MODSIM 2005. It covers the recent development of the system.

The first part depicts the former situation and state of the presentation layer in the Czech C3I system - Ground Forces Tactical Command and Control System (GFTCCS). This system was introduced in the Army of the Czech Republic in 1997 and was designed only with a 2D presentation layer.

The second part shows the current approach in implementation of presentation layer. GFTCCS is based on an exchange mechanism of standardized messages – ADatP3. It is necessary to decode this format and to translate it into the internal representation of virtual reality objects, unit positions, state information, weather conditions, etc.

The third part of the article deals with the implementation of a full 3D terrain map including 3D topographic objects and the terrain database generation process based on standard map sources.

The final part of the article outlines how Distributed Interactive Simulation (DIS) protocol or High Level Architecture (HLA) approach can be used to integrate the virtual reality graphical engine into the distributed simulation environment. The main idea is to use an already implemented gateway between the ADatP3 mechanism and DIS/HLA standard. This gateway is important for the possible interconnection between tactical simulator OneSAF and C3I – GFTCCS.

The figure followed shows the tactical situation created by the new presentation layer.

Figure 1. Real time tactical situation created by presentation layer Czech C3I system - GFTCCS

1. INTRODUCTION

The primary objective of current research projects is to increase the situational awareness for commanders to support their decision making process. Current advance in the computer graphics and virtual reality devices brings new possibilities in design of a user interface of C2 systems to reduce the uncertainty (fog of war) at the high level of command. Validity of a new approach in improvement of the user interface of the C2 systems confirms new products of the main leader companies in this field.

MÄK company offers the Stealth 3D visualization tool concentrated on representation of information and knowledge. This solution is only used in distributed simulation environment. Inputs are taken from DIS or HLA interfaces. (Summers 2005)

Company CG2 represents the current state in this field. Their product Command and Control in 3 Dimensions (C3D) combines Force Battle Command Brigade and Bellow (FBCB2) VMF messaging, a Quantum3D GeoScapeSE™ COTS McKenna MOUT geospecific terrain database, high-resolution digital map imagery and Mil-Std-2525B symbology into C4ISR application designed to provide war fighters with an enhanced, real-time view of the battlefield environment by including 3D terrain. But it is still only 3D engine without any VR devices such as data gloves or tracking systems. (CG2)

The Army of the Czech Republic defined a defense research project that should provide a new interface to the current C3I system. It is a pilot project for the integration of the virtual reality technologies into the command and control processes in the Army of the Czech Republic.

1.1. Former solution of presentation layer

The first design project of the Ground Forces Tactical Command and Control System (GFTCCS) was introduced in the Army of the Czech Republic (ACR) in 1997. The requirement for a 2D solution was sufficient in that time. Nowadays requirements are totally different. The reality level of the battlefield situation is the key factor. A headquarter staff do not only need to see the common picture but also have to understand the meaning of a situation. That shows us only one possible way of presentation; the 3D visualization. Computer Science Department at the University of Defense in the Czech Republic in 2005 brought the idea of a new presentation layer into life.

The presentation layer of the VR system was designed to work in close collaboration with the GFTCCS presentation layer. Communication took place between presentation and input/output layer of the VR system and the TAGIS component of the GFTCCS system. This component included presentation and input layer of the GFTCCS system and arranged an interaction of a user and the GFTCCS system in 2D mode of work. There was used COM technology to communicate between processes. Therefore communication between layers of VR and GFTCCS system used the COM technology and interface provided by the TAGIS as well. The TAGIS component and the VR systems run simultaneously on one powerful computer. (Františ 2005)

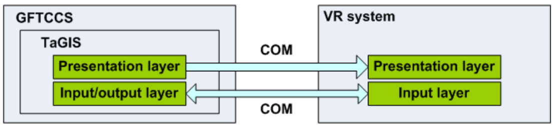

Figure 2. Interconnection of GFTCCS and VR systems

2. CURRENT APPROACH IN PRESENTATION LAYER

A new exchange mechanism of standardized messages ADatP3 was implemented in GFTCCS. This feature enables the representation of the data available from various C3I data interfaces. The architecture of the virtual reality system has to be changed. It was inevitable to implement VR graphical engine as an independent application that will use the parser to decode messages in ADatP3 format and will need its own approach or copies of databases with terrain, models, digital map etc. Figure 2 shows differences between a former and current implementation of VR graphical engine in GFTCCS.

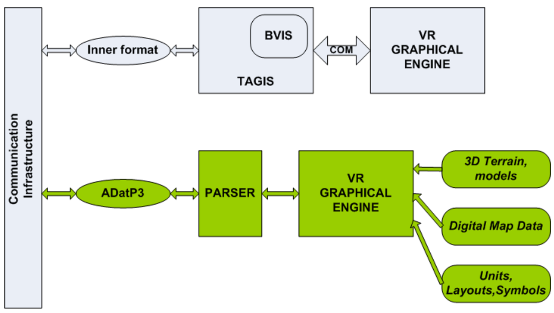

Figure 3. Differences in implementation of VR graphical engine in the Czech C3I system

3. VIRTUAL REALITY GRAPHICAL ENGINE

3.1. 3D terrain database generation process

The terrain database generation process is a key process for data preparation of modeling and simulation applications. The correct terrain database is an essential part to get useful results from the modeling and simulation. But not only traditional modeling and simulation application works with the terrain database. Nowadays the modeling and simulation application are getting mixed with the operation and tactical systems. The terrain databases are similar for these systems but the speed in which the terrain databases must be prepared is different. For the modeling and simulation systems the terrain database preparation is mostly human controlled process and it takes a noticeable time. On the contrary, the operation and tactical systems need their data prepared automatically in a very short time from the request. So a mechanism capable of generating terrain databases as easy as using the standard digital maps should be developed.

In our situation we needed to develop a simple system capable of generating full 3D terrain database from standard vector terrain sources of the Army of the Czech Republic to expand the functionality of GFTCCS.
The 3D terrain database should be generated in two levels of details:

- the low detailed version usable for an aerial view or overview with fast generation time and low data amount,
- the high detailed version usable for close-up view of the units or vehicles and surrounding area.

The terrain generating system must combine aerial photos or satellite images with vector map data and grid terrain model. The system must deal with different resolution of the data sources and also with low resolution of the satellite images. The missed details must be reconstructed from the vector data sources and the resulting database must be optimized for used image generators.

The low detailed version uses special algorithm for adding high-detailed topographic lines and contours – such as roads, railways, rivers and lakes to low-resolution satellite or aerial image that looks visually correct. But it uses the standard resolution of a 3D terrain grid model. The low detailed version also uses memory optimized simple texture mapping.

The high detailed version optimize the 3D terrain grid model according to the vector topographic data, a level of detail is added to surrounding area of these topographic features resulting in the more realistic look from a closer distance.

Both versions handle full 3D objects such as power lines, trees, bushes, fences and buildings according to the real topographic object database. All objects have correct dimensions and positions.

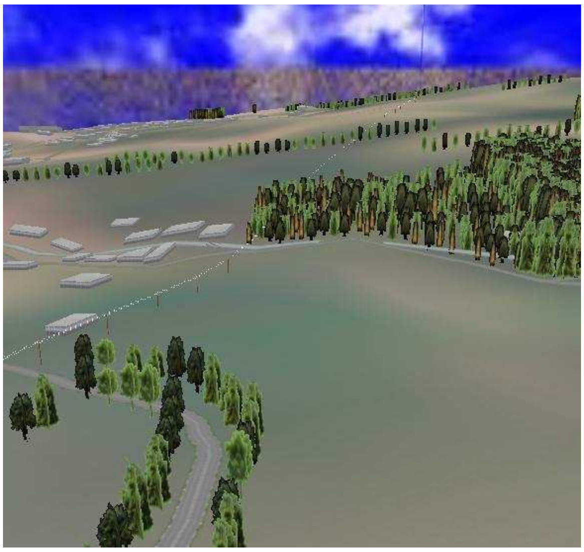

Figure 4. Sample screenshot of low-detail version

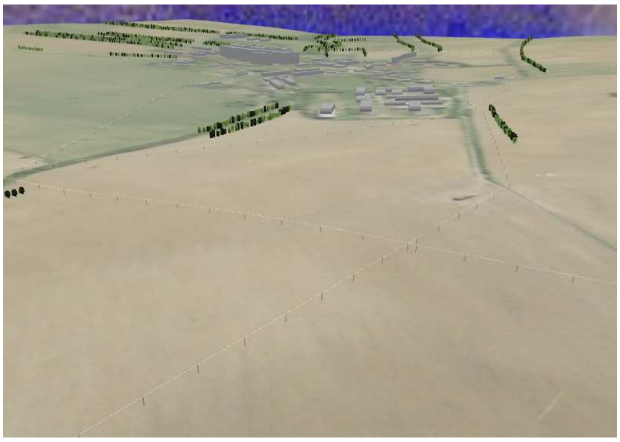

Figure 5. Sample screenshot of high-detail version

The resulting database is in WGS-84 coordinate system so it is fully compatible with navigation systems such are GPS and military paper maps. Also the resulting terrain database correlates with digital maps used in GFTCCS.

3.2. Tactical symbol representation

The GFTCCS uses military tactical symbols according to APP6a standard. There was an issue on representing them in 3D environment. Firstly we tried to represent them as a 2D billboard object. A billboard in the normal sense of the word is a sign along a roadway. For us the billboard is a picture of a military symbol applied as a texture to a rectangular primitive. The primitive is rotated so that it always faces the user. The problem with this representation is that the symbol represents only a single place in the 3d terrain. It is fine for representing single weapons, vehicles, points of interest or headquarters but for aggregated units like squads, platoons, battalions that are located at a larger area is this representation inaccurate. There is an uncertainty of which position of the billboard object should represent - the geometric center of the military object (platoon, battalion …), or commander's vehicle? Thus different tactical symbols representation was used.

A military symbol is represented as a square block that has a picture of the military symbol mapped on all its faces. The picture is semi-transparent so the user can see the area under this military symbol. The transparency value can be changed by the user. The dimensions of this square block represent an area covered by the unit. It can be taken from the unit database - the exact numbers for the particular unit or some general unit type dimensions.

3.3. Tactical line representation

The 3D visualization brings new challenges into tactical lines representation in a full 3D environment. There is a problem in representing a pure 2D object such as line to be clearly visible from different angles of view. After few experiments we decided to make the line from two rectangular primitives placed along the line and rotated 90 degrees of each other. These primitives are mapped by the line texture and rendered as a two sided set of triangles. These lines then float in a specified height above the 3D terrain. These 3D lines represented by such a technique are visible from various angles. Its thickness can be modified by the user to increase visibility from longer distances.

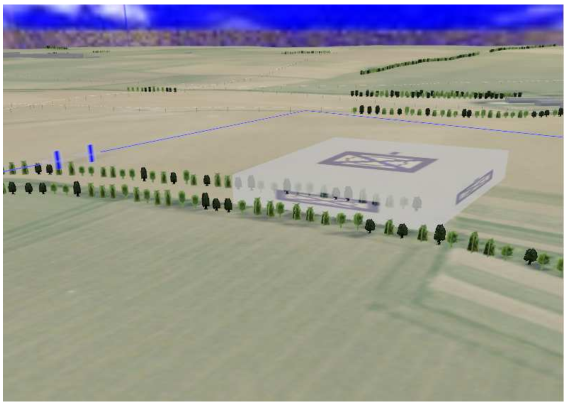

Figure 6. Sample screenshot of unit and tactical line representation

3.4. User interface

The user interface is based on the virtual reality devices. Its overall conception is taken from the former solution of the presentation layer. The user uses a head mounted displays (HMD) coupled with 6 degrees of freedom (6DOF) sensor. The interaction with the VR environment is made by VR gloves with 6DOF sensor on each one. A user of the VR system should be moving in the sensors range. The base station that serves as a reference point for the motion sensors and also as a bus place for all the data cables for the visualization device, data gloves and sensors (or receiver for optional wireless solution) is placed above the user's head in the center of the delimitative circle. The circle delimitates sensors range and so the maximal allowed user motion range is restricted by a fence.

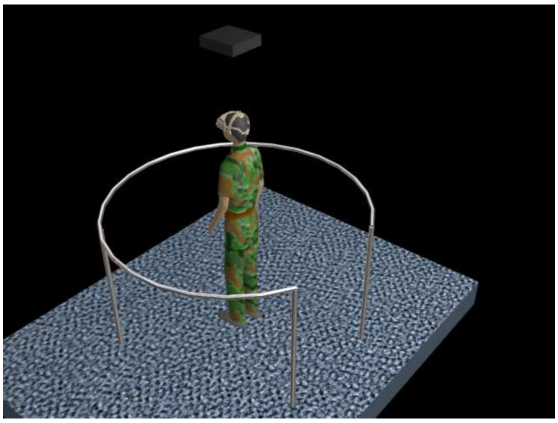

Figure 7. Working area on the battalion level

The input layer is similar to one used in the former solution. The data from the VR data gloves and its 6DOF sensors are processed by the input layer and correlated with the 3D data from the presentation layer. The user uses gestures to send commands to the presentation layer. The user can control the movements over the 3D terrain and can perform basic operations above the map and the displayed units. The free lookout is handled by the HMD and 6DOF head sensor.

Figure 8. Real time tactical situation created by presentation layer of GFTCCS

4. PRESENTATION LAYER AND DISTRIBUTED SIMULATION

The current costs of simulation and training capacities are so high that the question of appropriate investment is immediately raised. The already implemented presentation layer in virtual reality should be used not only for C3I system – GFTCCS but also for other simulation properties.

The next simulation capability used in the Czech Armed Forces is a tactical simulator OneSAF. This system creates the training capability for leaders and theirs staff from a platoon to a battalion level. The command and control of combat or non-combat operation are practiced there. OneSAF connection into the distributed simulation is provided by DIS standard protocol. The Czech Army Forces should obtain a new version of this tactical simulator - OneSAF Objective System (OOS). This tactical simulator uses HLA standard protocol in distributed simulation.

The presentation layer of VR engine can be used as a standard for new training facilities. The only problem is the different data and protocol formats of simulators. The presentation layer is currently able to decode only the ADatP3 formalized messages. There are two possibilities. The first one is to create a new parser. The other one is to implement a gateway between ADatP3 and DIS/HLA. The gateway solution seems to be more convenient and has already been tested in project of interconnection of a tactical simulator and C3I system. (Procházka 2005) If we use the gateway we have to implement a new SW application – filter. This filter will be responsible for getting rid of useless data from the presentation level point of view such are position of bullet, state information, etc.

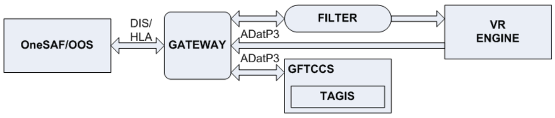

Figure 9. Architecture of interconnection in distributed simulation with VR engine

5. CONCLUSION

The presentation layer of VR system corresponded to internal formats and protocols of the former GFTCCS implementation. The internal communication protocols were changed to ADatP3 format in accordance with NATO NEC (Network Enabled Capability) requirements. Thus the VR presentation layer had to be changed. The changes in GFTCCS formats were significant enough that the major modification in the VR presentation layer architecture was required. The status of the VR presentation layer moved from just a plug-in module in the original GFTCCS presentation layer to the stand-alone client of the GFTCCS system. This new role opened door for using the VR presentation layer for different applications such are military distributed simulations.

The other major change is the new VR map visualization. We moved from 2D map wrapped around the user in the 3D VR environment to full 3D map with 3D objects. The military tactical symbols and lines have now full 3D implementation. This new visualization approach helps the user to better understand the depicted tactical situation.

Major problems came from two areas – a problem with the actual VR devices and a problem connected with the source GIS data.

The current presentation layer of the Czech C3I system is used at the level of individual weapon means and at the level from platoon to brigade as well. But this solution only offers 2D visualisation. The 3D approach will be used at the highest level of command and control process.

The VR presentation layer is expected to be tested in real conditions next year. Meanwhile the final adjustment of the user interface and the system functionality will be on going. The testing phase should answer question of possible advantages of

3D environment in command and control process at the tactical level of command.

6. REFERENCES

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