Virtual Reality In Presentation Layer Of C3I System

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Keywords: *C3I system, virtual reality, sign language, visualization.*

EXTENDED ABSTRACT

The article deals with possibility of Czech Army C3I system architecture extension using virtual reality devices. It is focused on Ground Forces Tactical Command and Control System that is currently used by the Army of the Czech Republic.

It discusses common architecture of described solution and integration of virtual reality hardware devices (Head Mounted Display, Data Glove, Tracking Systems) into a presentation layer of C3I system as a rich client.

Firstly, the advantages of this architecture are compared with the current state of C3I system implementation. Also the interconnection of this two systems and visualization of C3I system data in the Virtual Reality system is described as well.

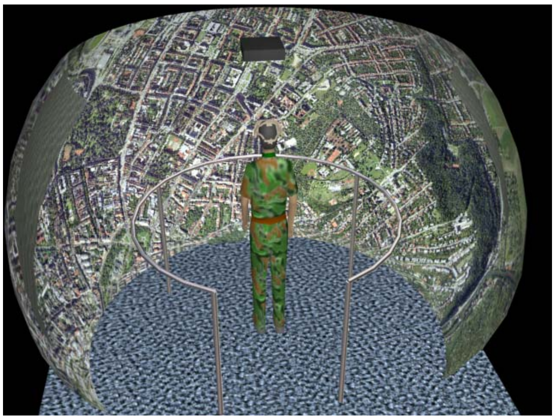

Fig. 1. The VR system station

Secondly is mentioned a way of mapping virtual reality devices data output into an input layer of C3I systems for top level decision making processes and library of functions for the gestures recognizing.

In conclusion, the current state of Virtual Reality system implementation in the Army of the Czech Republic C3I system is mentioned.

1. INTRODUCTION

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. After elaborating the requirements in 1999-2000 are considered as the main systems the Maneuver Control System (MCS) and the Battle Management Vehicular Information System (BMVIS). The requirement of the desktop solution came up from the basic philosophy of the GFTCCS system. In the time of design it was the only possible technological solution. The communication of an operator and GFTCCS was designed with consideration of current hardware technological potentialities. For the moral and technological up-to-date state of the GFTCCS system is necessary to use new and modern devices for visualization and interaction at high-level command and control.

Underlying impulse for the new variation of the presentation layer comes from the current requirements of the digital battlespace general control using the virtual reality devices. These trends illustrates an aspiration of the PfP (Partnership for Peace) countries for an overall coverage of the command and control processes by projects such as "Human Interactive Interface". This project realized as a Defense research project should be 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. Present type of visualization

In the GFTCCS system the presentation layer provides an interactive map together with units positions and a tactical situation overlay. The interaction is made by trackpoint and display equipment. This type of interaction is limiting user in communication due to following facts:

- *The final resolution of the display equipment (computer monitor) and speed of user communication with the system.* The current computer monitors are able to work in resolution 1600x1200 at maximum. This resolution is not sufficient enough for covering the area of interest without necessity of scrolling the map window in horizontal or vertical direction. For level of displayed details change is necessary the user's trackpoint device interaction with the system of controls displayed at the computer monitor.
- *Limitation of two-dimensional visualization causes a small lucidity of the tactical situation overlay.* Commander at high level of command needs to have an instant overview of the situation with an easy and simple interaction; he does not need to perform any complex action in GFTCCS system. The orders are passed verbally to his subordinates who works in desktop mode of GFTCCS system and they execute its. For this commander is an ideal solution the using of virtual reality devices for work with the GFTCCS system.

2. CURRENT ARCHITECTURE EXTENSION

Extension of the current architecture of the GFTCCS system using presentation layer in virtual reality design can be implemented independently on the already existing components. So it is not necessary to redesign any program structures. Thanks to implementation of the presentation layer as a rich client is the load of the server part of the GFTCCS system minimal.

Implementation of the virtual reality presentation layer is shown in the following picture.

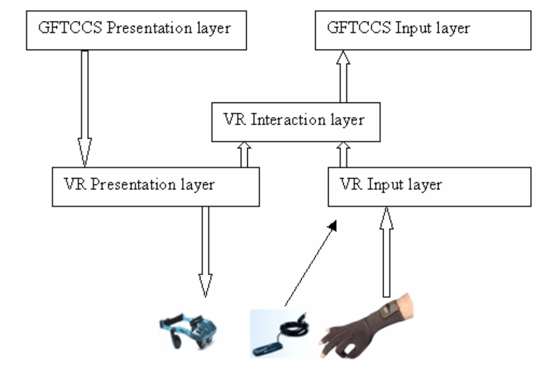

Fig.1. VR system scheme

Next picture describes current solution of the presentation layer as a desktop application

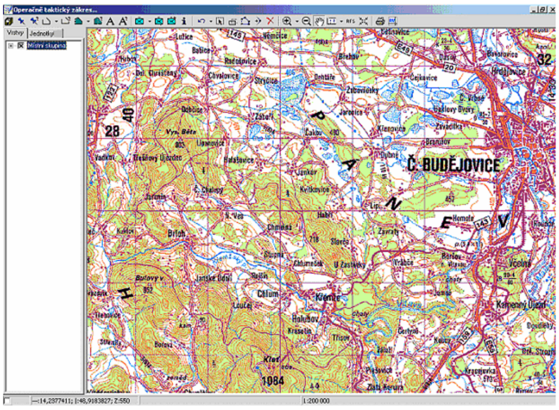

Fig.2. GFTCCS desktop application

3. INTERCONNECTION OF GFTCCS AND VR SYSTEM

Presentation layer of the VR system should work in the close collaboration with the GFTCCS presentation layer. First of all is necessary to assure the real time data consistency. The time consistency is a necessary condition of usability of this new system in the process of command and control.

Communication takes place between presentation and input/output layer of the VR system and the TAGIS component of the GFTCCS system. This component includes presentation and input layer of the GFTCCS system and arranges an interaction of a user and the GFTCCS system in desktop mode of work. This component uses the COM (Component Object Model) technology that allows data interchange and function calls between running processes. Therefore communication between layers of VR and GFTCCS systems utilize the COM technology and interface provided by the TAGIS component.

The TAGIS component should run as one of the nodes of the GFTCCS system on the computer running the VR system. The interface for the remote access – DCOM can not be used due to high data load which has to be transferred in short time intervals to provide time consistency of the displayed information. The TAGIS component and the VR systems run simultaneously on one powerful computer.

Provided services of the TAGIS component:

- map cut out together with tactical overlay and unit positions as is displayed in the GFTCCS system in real time.
- units and objects in tactical overlay information
- manipulation with units and objects in tactical overlay

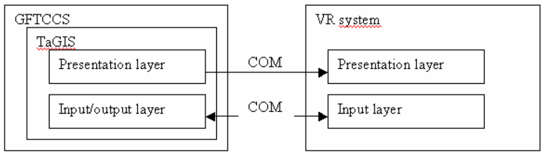

Fig.3. Interconnection of GFTCCS and VR systems

4. DESCRIPTION OF THE VR SYSTEM

4.1. VR user station

A user of the VR system should be moving in the sensors range. The base station which 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 delimiting sensors range and so the maximal allowed user motion range is surrounded by a fence.

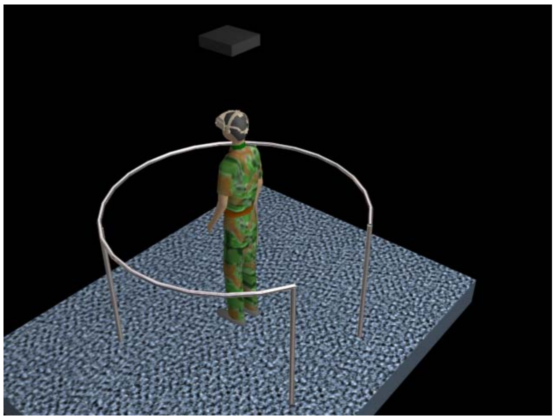

Fig. 4. VR system station

4.2. Map visualization

In the VR system the tactical map is projected on a virtual sphere slice. This virtual sphere slice surrounds the user placed in the center. The user can move inside of this sphere within the sensors range. The position and rotation of the user's head determine which part of this sphere with connected projection of the area of interest will be displayed in the head mounted display.

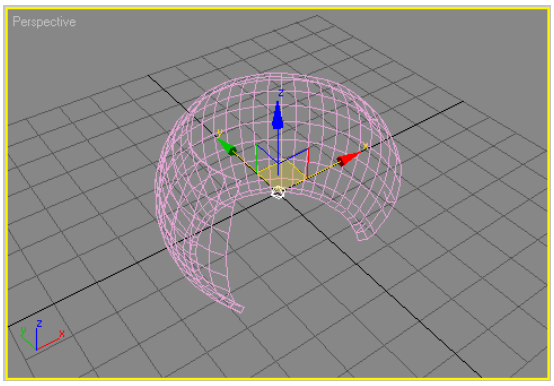

Fig. 5. Virtual sphere slice

User can comprise the whole area of interest by simple turning his head. Moving head closer to the virtual map causes resolution and detail level to increase. Moving head further from the virtual map causes resolution and detail level to decrease. User can move from an aggregative view to detailed view very simple and fast just by moving the head.

The tactical map has greater dimensions in the VR system than in the desktop mode in GFTCCS system this results in high data traffic between this two systems. Transferring the whole map cut out at every visualization state change (user's head move) would be technically impossible in the VR system so the presentation layer of the VR system includes image cache. This image cache has two levels. The first level serves for the VR visualization; it contains the tactical map covering the whole area of interest. The VR visualization module takes image data from this level. After the transformation of this data by the VR input layer data, the transformed image is send to a head mounted display.

Second level of the image cache is constantly filled by the raster map data from the GFTCCS system by virtue of VR input layer data and user move prediction. For example if the VR input layer detects head position sensor move towards the displayed virtual map the request for raster map data of the area of the interest in higher resolution is send to GFTCCS system. This data are loaded in sequence to the second level of the image cache and when this map data can cover the displayed map cut out they are transferred to the first level of the image cache and subsequently displayed. Meanwhile the high-resolution raster map data are loaded into the second level image cache and the data from the first level image cache are bilinear interpolated. User can seamlessly move between map visualization in different level of detail.

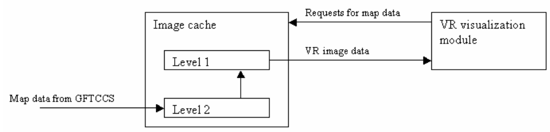

Fig. 6. Image cache diagram

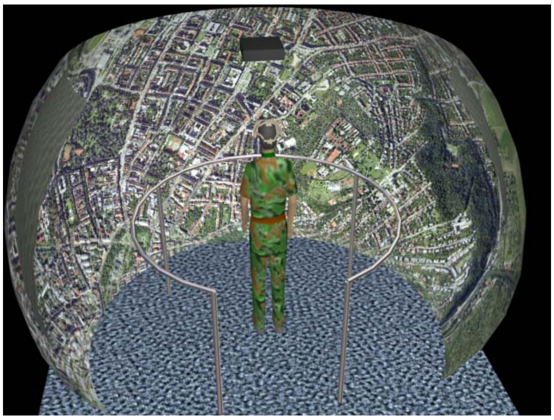

Fig.7. User station with projected virtual map

4.3. Visualization of actual situation in head mounted display

User has a projection of a virtual map cut out and 3d data gloves model displayed in his head mounted display. The size of the projected virtual map cut out depends on head position in reference to tracking system base station position. The zoom in and zoom out rate of the virtual map is not equal to real movements of the user's head. Zooming in and zooming out the virtual map with resolution and level of detail changing is much more bigger than relative movements of the user's head. Through that increased sensitivity it is necessary to neglect or to filter small movements of the user's head to avoid virtual map jittering.

Data gloves are projected as trivial 3D models into the head mounted display. These models reflect real situation of hand position, rotation and fingers position of data gloves to provide a user feedback. User can directly control his gestures that are going into the virtual reality input layer.

Fig. 7. Head mounted display image

Fig. 8. Head mounted display image

5. INPUT LAYER

Virtual reality system input layer operates head position sensor data, position of data gloves and also data from data gloves. Position sensors provide data in 6DOF (six degree of freedom) that means location and orientation information. A range of these sensors is usually about +/- 1.5 meter from the center of local vector basis (base station). The input layer processes these data and prepares two new sets of data. The first one is for gesture recognition module. These data are in relative coordinates in reference to the user's head position. The second one contains data about user's head position. These data are in absolute coordinates in reference to the base station of position sensors.

5.1. Function for communication with battlefield database

6DOF and data gloves can give us the possibilities to exactly define and consequently detect a data gloves position and gesture. We can also define potential questions that operator can ask the system.

A list of potential operator questions:

- Actual unit state
- Unit aggregation dividing into lower level (battalion- platoon, platoon – troop, troop - squadron)
- Actual unit fighting capacity, its expected equipment
- Expected unit movement time to position
- Expected weapon conflict results – special simulation model.
- A distance between two positions
- Exact position coordinates
- Exact position altitude
- Battlefield object relations evaluation

After these questions detection is necessary to identify them with particular gestures. The basis for the best selection is minimum probability of their mutual non – recognizing. It is necessary to choose gestures that are mutually different and also easily physically feasible and memorizeable. We can't search or define new gestures for virtual reality application. We can use yet defined letters in sign language. This way can bring us 27 combinations of gestures. That is enough to cover the whole basic communication with the system. There is also possibility to use only signs that use finger or fingers for contact indication with virtual reality map. These signs are: B, D, F, G, H, J, K, L, P, R, S, U, V, W, Z.

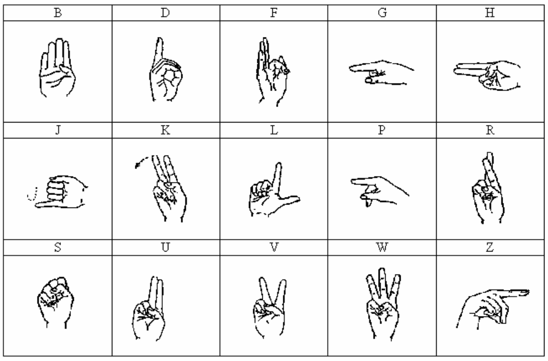

Fig. 9. Gesture table

The results of data gloves functionality are two kinds of information. The first is contact position with the virtual map in coordinates x,y,z a next one is an identified gesture. These information causes correspondent question call in SQL language and also call of predefined battlefield function from the battlefield database library.

The main library function:

- Acquirement of unit identification in position (x,y) -

  get_id_troop_on_position(x,y)

- Acquirement of identification of the nearest unit in position (x,y) - get_id_nearest_troop_on_possition (x,y)

- Map moving on the horizontal left side with slide step –

  move_map_left_one_slide ()

- Map moving on the horizontal right side with slide step –

  move_map_right_one_slide ()

- Map moving on the vertical up side with slide step –

  move_map_up_one_slide ()

- Map moving on the vertical down side with slide step –

  move_map_down_one_slide ()

- Map centering in chosen position of an object (x) –

  center_map_on_id (x)

Function for toleration setup of detection data gloves contact:

- Setting of toleration on exact square area in pixel –

  set_square_tolerance (x)

- Setting of toleration on exact circle area in pixel –

  set_circle_tolerance (x)

Function for conversion between relative and absolute coordinates of the battlefield map:

- Acquirement value of coordinates in the battlefield map from relative coordinates of data gloves contact in exact distance from referential point (sensor basis)-

  get_abs_xy_from_rel (x, y, distance)

6. CONCLUSION

One of the most preferred research goals is the virtual reality devices usage in projects of implementation and modernization of C3I systems in NATO and PfP Armies. The main project goal is definition and demonstration of virtual reality possibilities in the Czech Army command and control processes. We have suggested an approach how to implement virtual reality into the Ground Forces Tactical Command and Control System. We have developed first prototype in our research department that use one data glove, head mounted display and two tracking systems. We are able to zoom in and zoom out by head movements and also we are able to use data glove for basic communication with the system. This research will continue a will be finished by workshop organization with presentation of virtual reality system usage within the Czech Army Ground Forces Tactical Command and Control System.

7. REFERENCES

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