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Dynamic Scenes Implementation for Radio Detector Echo Simulator

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Abstract: Up to now, the dynamic scene echo simulator for radio detector is still difficult to implementation with computer simulation. In this report, one dynamic scene implementation scheme was presented which was based on the radio detector scene models constructed by 3ds Max (3D studio Max) 2010. The idea is that the scene could be set up with more geometric data, material properties and other auxiliary information. Then, the scene must be converted into geometric data files and VRML 97 format files. The two file are actually the data version and VRML version and could be used separately from 3ds Max 2010. Thus, they could be integrated into the simulator constructed by our research project. During the simulation progress, the objects in the scene could have different location and movement states. And, these location and movement information could be updated timely in the geometric data files and VRML 97 scenes. Thus, the dynamic scene could be displayed by most VRML 97 browsers when the simulation last for a period time. At last, the echo simulator of radio detector verified the dynamic scene.

Key words: Radio detector, echo simulation, scene model, VRML

INTRODUCTION

As one important detecting technology, the radio detector apperceives its object information from their echo signals. Its received echo signal is actually the summation of the echo signals from objects and surroundings or jamming signals and other unwanted signals (Shi *et al*., 2008; Yang *et al*., 2009). So, the received signal of radio detecting receivers is unmanageable and has to be disposed to obtain the possible information for the objects in the working scene (Adekola, 2008; Hosseini *et al*., 2009).

In fact, the echo signals at the receiver of radio detector is useful as the test data to debug its function during its manufacture. However, the possible echo signal of specific working environments is difficult to obtain before the radio detector product was put in use. Therefore, two solutions appeared, i.e., the received signals of simplified objects in prepared specific working cases were used to debug the radio detector. Another scheme is to obtain the received echo signal by numerical simulation methods. The first scheme is mainly effected by the actual assumed objects (Sharma *et al*., 2005; Changlu, 2008) which maybe has biggish difference from the veritable objects. Therefore, there are many papers or reports that were devoted to the research about the numerical simulation of radio detector echo signal.

According to the postdoctoral research project, one echo simulation platform would be set up when the author finished the work. In this research project, the special working scene of radio detectors should be set up so that the echo simulation could be conducted dynamically in the working environments. Based on the RADAR equation of electromagnetism theory, the echo signals could be computed by combining the received signals from all the objects in the scenes. Here, we presented the implementation of dynamical scenes for echo simulations of radio detectors.

IDEAS FOR DYNAMICAL SCENES

In our postdoctoral research project, the scenes for radio detectors should consist of all the objects that maybe appear in practical working environments and their quantity could be increased or decreased according to the actual environment conditions. The scene is actually the scene models that consisted of the object models in one three dimensional (3D) space coordinate system (Adlband and Biguesh, 2011; Kusin and Zakaria, 2011). However, these models for those objects in radio detector

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working environments, was static and only contain geometry shape data which was not directly used to simulate the echo signals of radio detectors.

So, the model specification about the 3D objects in working scene models should be proposed and other more information should also be attached to these scene object models, i.e., material property, electronic parameters and other necessary information, whose details would be embodied in following content. Furthermore, the positions and moving state parameters should be also updated in different time. Thus, if one changed the positions and moving states of all the objects in radio detector working scenes, the dynamic scenes could be implemented (Meng *et al*., 2008). As a result, the dynamical scenes were realized by changing the real-time position and moving states. When the 3D scenes were displayed in virtual reality browsers, one could see the dynamic scenes.

As every one knows, 3ds Max is one popular 3D model software. In this study, we would present the implementation of dynamical scenes by way of 3ds Max. The 3D scene model constructed by 3ds Max would be put into further disposal and converted into other formats for dynamical display. All these details could be described in the following words. Firstly, we presented the necessary information for radio detector echo simulation. Then, the inner space coordinates in 3ds Max software, space model requirements, the forbidden 3ds Max tools and the display of dynamic scenes, were shown in details. At last, the implement results were present to all the readers of this paper with key source codes.

NECESSARY INFORMATION FOR ECHO SIMULATION

According to RADAR equation, the received signals of radio detector could be deduced as the function of the effective Radar Cross Section (RCS) objects and its relative distance from the radio detector (Onweremadu, 2007). In fact, the RCS for the objects with flat surface could be obtained according to the incident angle of radio signals upon the object surface (Rassol *et al*., 2002). But, the distance between the objects and radio detector, must be large so as that the objects could be disposed as point objects. Furthermore, its effective RCS has great relationships to the material electric parameters of objects, i.e., conductivity, permeability and permittivity (Kakakhel and Anjum, 2008). So, the relationships between object surface and its electric parameters were also investigated in our post-doctorial research projects. The information as presented above, should be given in the 3D scene constructed by 3ds Max.

Here, we presented the details about the information that provided in the 3D scene models which are all the necessary information to compute the echo signal of objects at the detector receivers.

Space geometric data: In the 3D scene models, the position coordinates and its relative coordinate origins are the important space geometric data. Based the relative coordinate systems and their conversion relations, one could the relative distance of radio detectors and objects. The incident angle of radio detectors about the object surface normal direction could also be deduced. Thus, the object positions, local coordinate center and its conversion matrix, the surface center coordinates, external normal direction, area, nesting relations among local coordinate systems and so on, are the necessary geometric data for the echo simulation of radio detectors. In our echo simulation scheme, one could use these space geometric data to compute the possible echo signal intensity and update the positions and geometric parameters of active objects at different times. Thus, the static scene constructed by 3ds Max could be dynamical according the moving parameters provided by our simulators.

Material electric property with backward scattering coefficients: In the 3ds Max 2010, one could specify the material to one object. However, the material information is used to display objects with better view effect. The material information specified by 3ds Max 2010 inner material, has no use in our simulators. So, the material electric property should be specified in the 3ds Max 2010 space scene models. According to the relative theory of the Backward Scattering Coefficients (BSC), the material electric parameters which consist of conductivity, permeability and permittivity, should be specified in the 3ds Max 2010 scene models.

Other auxiliary information: Except for those information above, some auxiliary information is also important to flag the objects with names, identification symbols, object type (interferers or detectors), active object or not and sub-object numbers. According to these information, the configuration interface could access the relative objects, specify the antenna parameters of detector or interfering machines, update the positions and conversion information.

By the custom property of objects in 3ds Max 2010, we could specify the type of objects, electric parameters and if active objects. Thus, six custom properties could be given as following, i.e., category, conductivity, permeability, permittivity, back reflector and activity. The

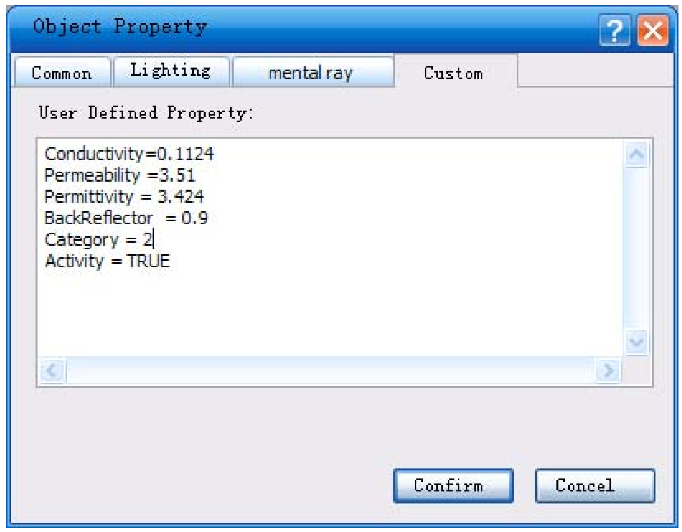

Fig. 1: Custom property for objects in 3ds Max 2010

Table 1: Custom property and its value/unit

Custom property	Value	Unit
Category	0, general object 1, interfering machine 2, detector	Integer, no unit
Conductivity	Float	10^8 S m^{-1}
Permeability	Float	F m^{-1}
Permittivity	Float	H m^{-1}
Back reflector	Float	Non-unit
Activity	TRUE, active object FLASE, static object	BOOL

Table 1 displays the definition of those custom properties. The following example showed one classic custom property definition, as displayed by Fig. 1.

INNER COORDINATES RELATIONS IN 3ds Max

According to the manual of 3ds Max 2010 and its SDK guide, the scene model consists of nodes which has its own local node coordinates. The node coordinates is defined in the world coordinates. Furthermore, every object could have its own object coordinates and the object coordinate systems is defined in node coordinate systems. Thus, the coordinate system relations with different levels could be described as Fig. 2, where the node coordinate system is expressed as the node transform matrix in the world coordinate system, while the object coordinate system is presented as the object offset matrix in its node coordinate system.

Thus, the three coordinate systems could be converted into other coordinates by two transform matrix, as shown in Fig. 3. It sticks out a mile to say that the

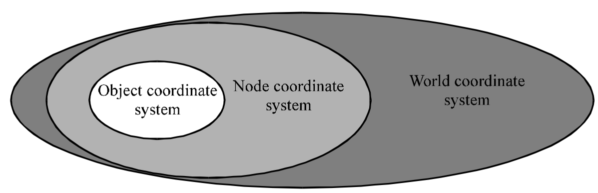

Fig. 2: Relationships of 3ds Max 2010 inner coordinate systems

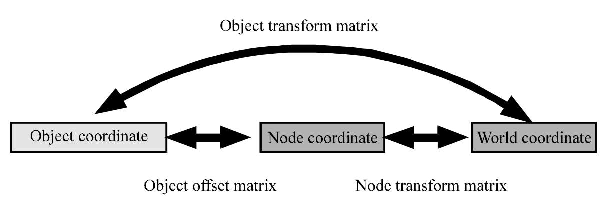

Fig. 3: The conversion of 3ds Max 2010 inner coordinate systems

object offset matrix could be obtained by the object transform matrix and node transform matrix.

IMPLEMENTATION OF DYNAMICAL SCENE

The scene models constructed by 3ds Max 2010, are static models which could be used the initial state of the dynamical scene in the radio detector echo simulation process. But, the 3D scene models could not be loaded into our simulator, as it's only displayed or edited in 3ds Max Windows. It could not be used solely without 3ds

Max 2010. Thus, it's a must to export the scene model data to one file which could be used independently from 3ds Max 2010. At the same time, the scene model should be also displayed by one browser without the support of 3ds Max 2010.

Thus, there are two work to do so that the scene model constructed by 3ds Max 2010 could be used in our simulator, i.e., one is to export the geometric data of scene model to one file so that the simulator could be directly, another one is to convert the scene models into virtual reality (VRML) which could be display by virtual reality browsers. The exported 3ds Max model data file has the sole relationship to the virtual reality version of scene models designed by 3ds Max 2010. They could be easily integrated into our radio detector echo simulator. When the 3D scene models were converted into virtual reality format files, the corresponding export plug-in could not dispose the container and lines in the models. So, the scene models could not be constructed by the container and lines in 3ds Max 2010.

Export the scene model geometric data: In fact, there are many export plug-in in 3ds Max 2010 but they could not export the necessary data. So, one specific scene model geometric data export plug-in is developed by us. According to the SDK of 3ds Max 2010, the geometric data export plug-in could save the geometric data of scene model into another file with extension name "*.gmd", i.e., geometry model data file. Its data structure is shown as following:

```
----------------------------
System unit (1 unit = xx meters)
----------------------------
Node information
----------------------------
General information for geometric entry
----------------------------
Face information 0
Face information 1
....
Face information n
----------------------------
Node information
----------------------------
General information for geometric entry
----------------------------
Face information 0
Face information 1
....
Face information n
----------------------------
...
Node information
----------------------------
General information for geometric entry
----------------------------
Face information 0
Face information 1
....
Face information n
----------------------------
```

As shown by above data format, the begin of scene exported file, i.e., *.gmd file, is the coordinate unit that used by 3ds Max 2010 when the scene model was set up. The following data is the geometric data, material information and other auxiliary information. They are saved as one whole by the way of data structure entry, i.e., node information, general information for geometric entry and its face information. In fact, this kind data structure could preserve the architectonic nodes in 3ds Max 2010 and it's also easily for our simulator to update the exported scene model with current position and state information.

The plug-in is developed based on the Software Development Kit (SDK) of 3ds Max 2010 which could make it possible to access the objects in the scene of 3ds Max 2010. At the same time, the VC Plug-in Wizard for the construction to access the inner Core of 3ds Max 2010, makes it easy to develop the export plug-in in 3ds Max 21010. By calling the functions of 3ds Max 2010 internal core, one could obtain the geometric data of all the objects in the scenes. In order to export the geometric data, there are several works to study the SDK of 3ds Max 2010, as presented as following:

- One must have known the way to develop 3ds Max 2010 export plug-in
- The architecture of scene objects in 3ds Max 2010, is vital for the traversal of all the objects in 3ds Max scene models. It's is a must to know about it
- How to make a traversal to all the objects by the core functions of 3ds Max 2010, is also one problem which make one examine all the relative functions of SDK
- In the scene of 3ds Max 2010, there are many non-entry objects which could not be exported as geometric entry, i.e., light, lines and other scene objects. For the geometric data file export plug-in, the object type should be known firstly. According to the object types, it could make a disposal of them, respectively
- For the geometric entries in 3ds Max 2010, their architecture of geometric data is one hierarchy. Its details and the access function in the SDK need pay great effort to be known about. According the hierarchy, the exported geometric data would also be saved in the way of hierarchy
- As presented above, there are three typical coordinates in 3ds Max, i.e., the world coordinate, node coordinate and object coordinate. One must know the conversion of different coordinates and their coordinate systems and save them into the exported geometric data files

- A exported file format must be designed to save all the geometric information of 3ds Max scenes based the SDK function library of 3ds Max

Therefore, all the relative technologies in 3ds Max 2010 and its SDK, should be pay more effort to know about. Otherwise, the geometric data export plug-in could not be developed. When all these works were finished, we developed the geometric data export plug-in. Its source codes could be provided to the readers of this study if they want these codes. Here, the results are listed only.

Thus, the geometric data export plug-in, i.e., mxGeoExporter.dle, is located in the install directory of 3ds Max 2010, as shown by Fig. 4. When one wants to export the geometric data to one geometry model data file, one could select the start menu of 3ds Max 2010, i.e., 3ds_export and the file export dialog would appear, as displayed by Fig. 5. Then, the save type in the dialog

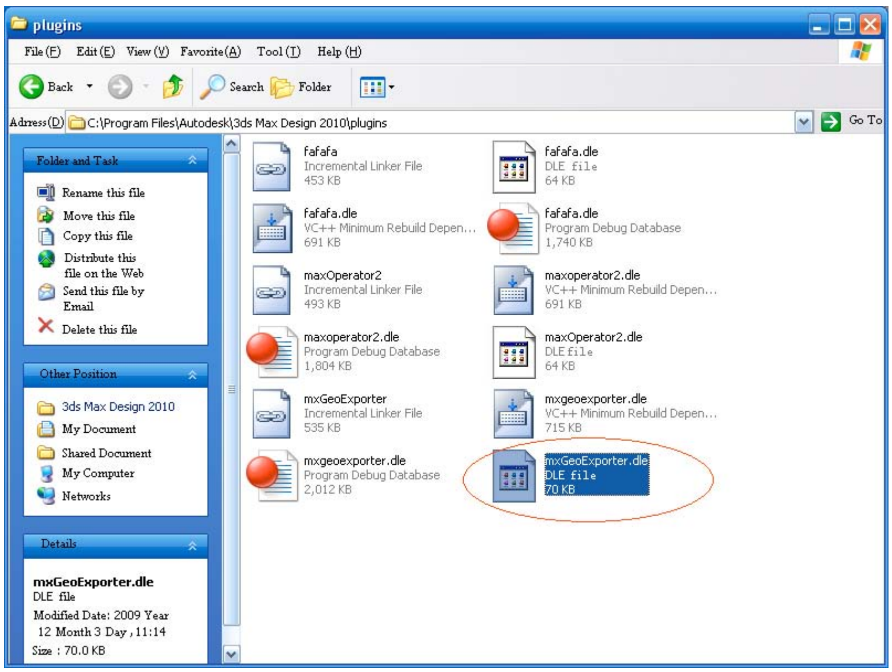

Fig. 4: Geometric model data export plug-in in 3ds Max 2010 install directory

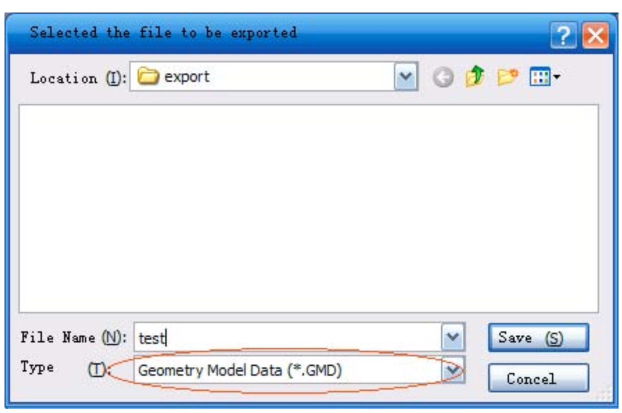

Fig. 5: The file export dialog in 3ds Max 2010

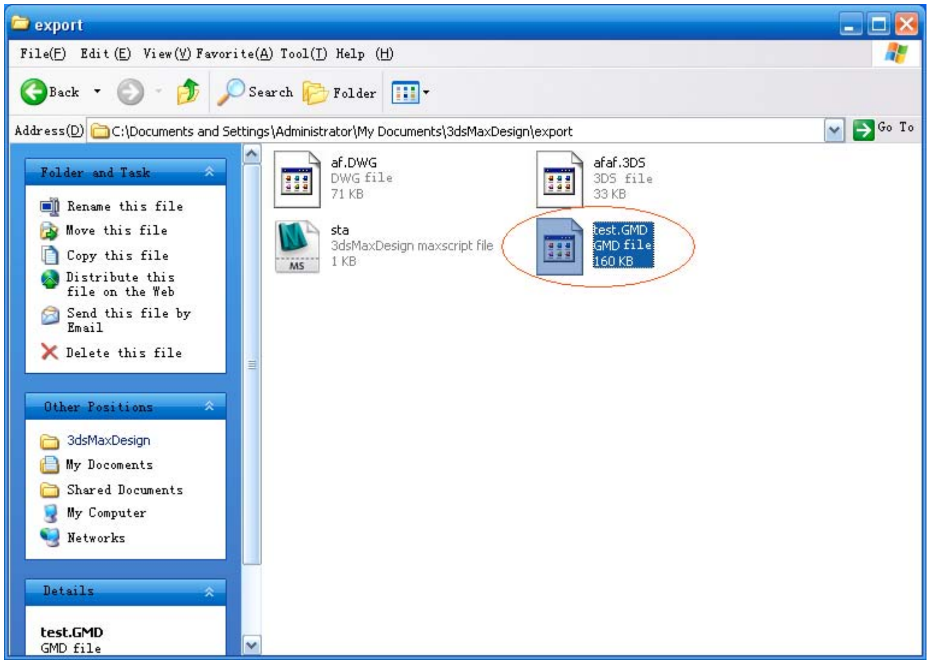

Fig. 6: The export geometric model data files by mxGeoExporter plug-in

should be selected as geometry model data (*.gmd). After the save file name was specified, one could press the button 'save' to export the geometric data of 3ds Max scene to one files. The exported geometric data file has the extension name as '*.gmd'. Figure 6 displays the exported geometric model data files of one test scene in 3ds Max 2010 which was named as 'test.gmd'.

Convert the scene model into virtual reality: When the geometric model data of scene objects in 3ds Max were exported into the geometric model data file by the mxGeoExporter.dle plug-in, the data could not be used for scene display. In fact, the scene model in 3ds Max 2010 could be converted to virtual reality format, i.e., VRML format scene which can be browser by most of VRML browsers. Therefore, as the ideas of dynamic scene presented in the content above in this report, the scene model would be converted into VRML format by the VRML export plug-in of 3ds Max 2010.

According to the VRML export plug-in of 3ds Max 2010, i.e., vrmlexp.dl, its scene model could be converted into VRML 97 format. The VRML 97 format file would be saved as the general VRML 97 file format, i.e., *.wrl file that was supported by most VRML browsers. In order to convert the F16 aircraft of 3ds Max 2010 (Fig. 7) into the VRML 97 Format (*.wrl), one has to select the 3ds Max 2010 menu, '3ds->export' and the export dialog would appear as shown by Fig. 8. Then, the save file format is selected as VRML97 (*.wrl) and the scene model in 3ds Max 2010 would be converted into VRML 97 format file (f16in.wrl), as shown by Fig. 9.

However, when the VRML 97 export plug-in converts the 3ds Max scene into VRML 97 Format, there are two limits, i.e., the lines and containers in 3ds Max 2010 could not be converted into the relevant object in VRML scenes. Therefore, the scene in 3ds Max should avoid the use of lines and containers.

When one obtains the relevant VRML 97 format scene of the scene model in 3ds Max 2010, the VRML 97 scene could be used the dynamic scene display. The dynamic scene is displayed by updating the real-time position coordinates of active objects in the VRML 97 scene. This is the basic idea about how to display the dynamic scene in our simulator for radio detectors.

According to our post-doctorial research scheme, the radio detector echo simulator is implemented as one general block in MATLAB 7.0 Simulink. So, the dynamic scene display must be used in MATLAB 7.0 Simulink and the real-time position information could be easily updated into the VRML 97 scene model. Thus, one VB ActiveX control (crtaControl) is developed which includes one Cortona 3D VRML display control, four interface functions to update the real-time position in the VRML 97 scene model, i.e., SetScaleOrientationOffset,

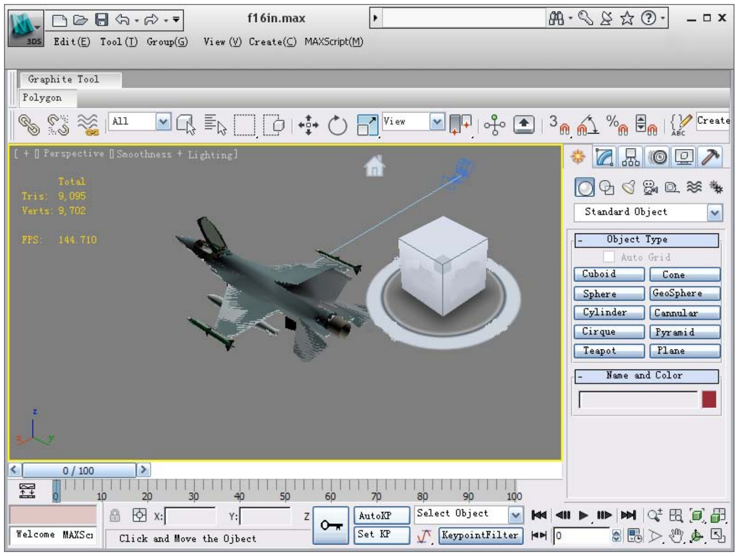

Fig. 7: The F16 aircraft scene model in 3ds Max 2010

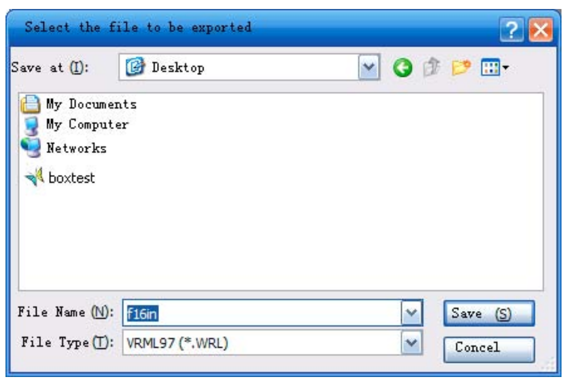

Fig. 8: The export dialog of VRML 97 file format in 3ds Max 2010

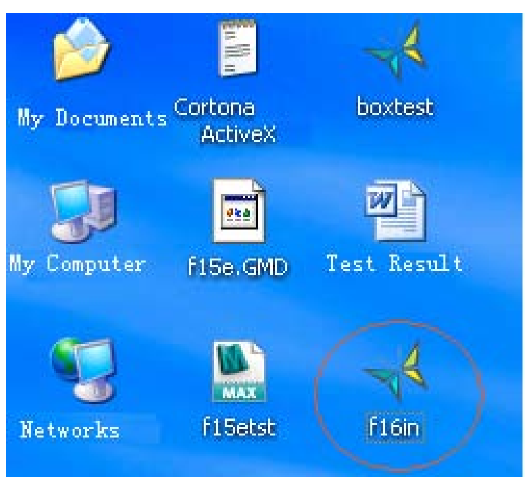

Fig. 9: The export VRML97 format scene file f16 in wrl

Fig. 10: Dynamic scene display

SetScaleOffset, SetRotationOffset, SetTranslationOffset. They are used for setting the direction scale transform matrix, scale transform Matrix, rotation transform matrix and position transform matrix, respectively. At the same time, two functions about setting the scene name are also provided by us, i.e., SetSceneName and GetSceneName.

The dynamic scene display (crtaSink) was presented as Fig. 10 which is the display window. It has one input port, by which the moving state information of objects in 3ds Max 2010 could be updated in the window. Its data format could be shown as following:

```
    //Rotation information relative to object coordinate:
    rotX, rotY, rotZ
    //Scale information relative to object coordinate: Sx,
    Sy, Sz
    //Position information relative to object coordinate:
    Tx, Ty, Tz (unit, meter)
//The details of input data format:
    //entry1 entry2... entryN
    //-------------------------------------
    //Sx1 Sx2... SxN
    //Sy1 Sy2... SyN
    //Sz1 Sz2... SzN
    //rotX1 rotX2... rotXN
    //rotY1 rotY2... rotXN
    //rotZ1 rotZ2... rotZN
    //Tx1 Tx2... TxN
    //Ty1 Ty2... TyN
    //Tz1 Tz2... TzN
    //-------------------------------------
```

Thus, the input data of the dynamic scene display (crtaSink) is one 9×N matrix, where N is the total number of active objects in the scene. The relationship between the active objects and the input data, are configured in the configuration interface of the echo simulator. Here, the moving information of active objects are given according to the coordinate system in 3ds Max 2010. However, the coordinate in 3ds Max 2010 is different from that in VRML 97 scene. The former is defined as Fig. 11, while the latter is indicated by Fig. 12. If the coordinate in 3ds Max 2010 is express as one triple elements, i.e.":

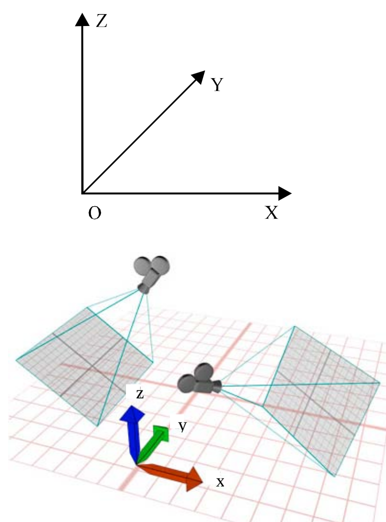

Fig. 11: The coordinates in 3ds Max 2010

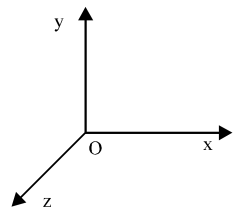

Fig. 12: The coordinate system in VRML 97

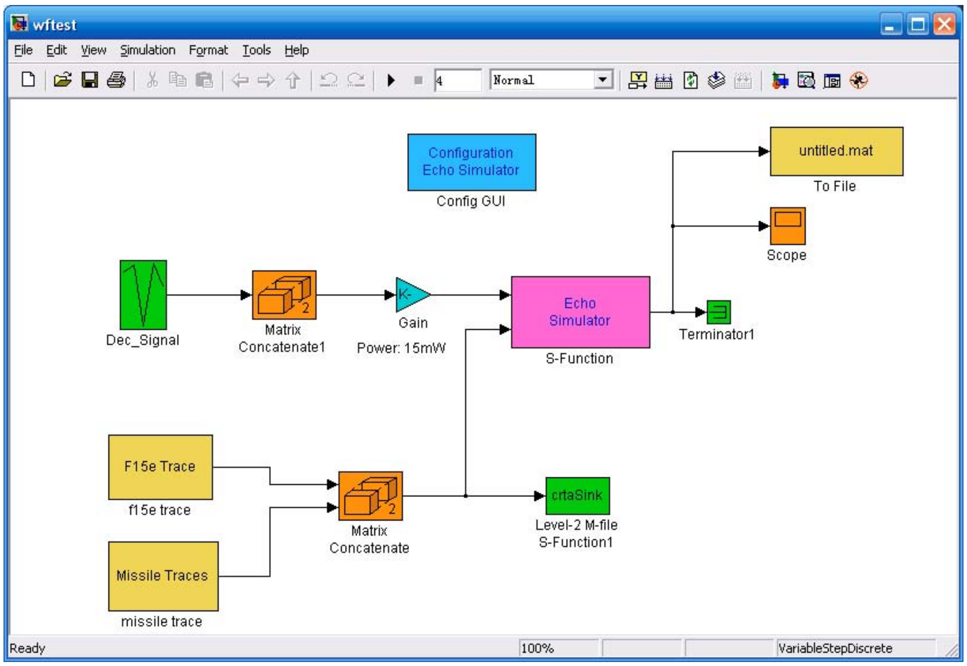

Fig. 13: The echo simulator conducted by our post-doctorial research project

$$C_{max} = (x_{max}, y_{max}, z_{max})$$

While, the coordinate in VRML 97 scene could be express as:

$$C_{VRML} = (x_{VRML}, y_{VRML}, z_{VRML})$$

Then, the coordinate C_{VRML} in VRML 97 could be expressed by that C_{max} in 3ds Max 2010, i.e.:

$$C_{VRML} = (x_{max}, y_{max}, z_{max})$$

DYNAMIC SCENE RESULTS

In our post-doctorial research report, one scene was constructed by 3ds Max 2010 which has two simple objects, i.e., one F15e aircraft and one missile detector. They are all active objects with high movement. In order to use this scene in our simulator, the geometric data of this scene was exported into geometric model data file ‘f16e.gmd’, by the mxGeoExporter.dle plug-in, while the scene VRML version ‘f16e.wrl’ was also obtained by the VRML 97 export plug-in.

According to the simulation system based MATLAB 7.0 Simulink, as shown by Fig. 13, the geometric data file was loaded by the ‘echo simulator’ when the simulation began, while the ‘crtaSink’ is the dynamic scene display. During the simulation, the missile and f16e were located at different location as they were moving at the speed 680 and 800 m sec^{-1}, respectively. So, their new location in the dynamic scene must be updated timely and saved in the geometric data files ‘f16e.gmd’ and the corresponding VRML 97 file ‘f16e.wrl’. Thus, if the simulation could last for a long time, the dynamic scene

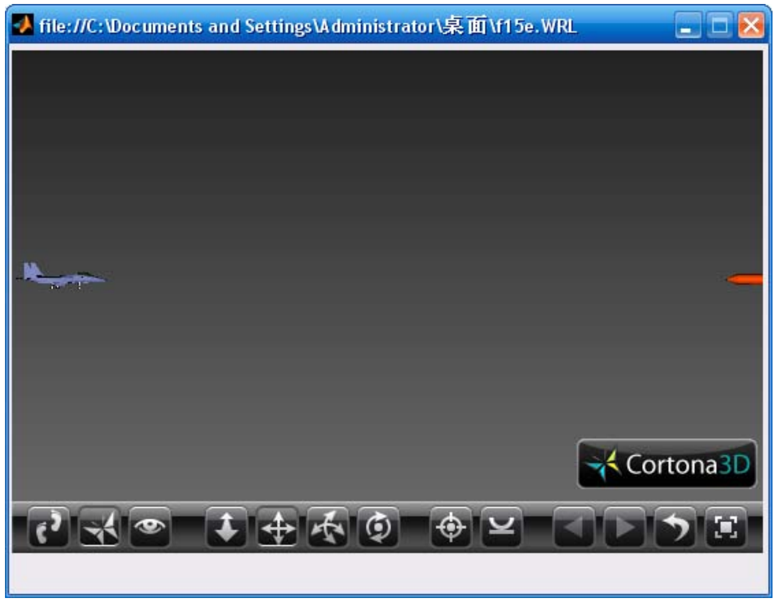

Fig. 14: The dynamic scene window in the simulator

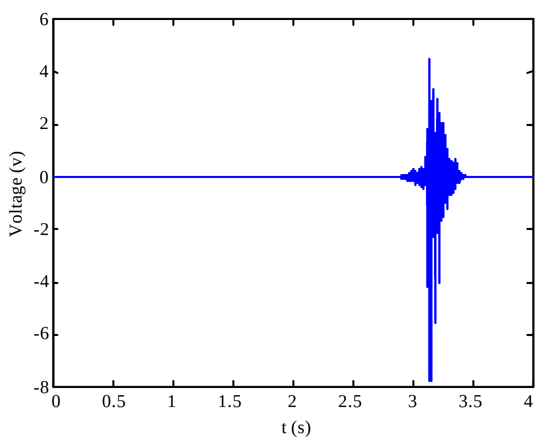

Fig. 15: The echo signal obtained from the simulator in Fig. 12

could be realized. The dynamic scene and echo signal were displayed by Fig. 14 and 15, respectively.

CONCLUSION

In this study, we presented one dynamic scene implementation scheme which was one important work project in our post-doctorial research project. Based on the 3ds Max 2010, the scene model could be constructed for the working environments of radio detectors. This scene model must be exported to a geometric data file which are the geometric data needed by our radio detector simulator. At the same time, the scene model constructed by 3ds Max could be further converted into VRML 97 Format file which could be displayed easily by most VRML 97 browser. Thus, the geometric model data files and the VRML 97 File are the data version and VR display version. It is them that make it possible to display a dynamic scene.

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