Development of a Relap based Nuclear Plant Analyser with 3-D graphics using OpenGL and Object Relap

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1. Introduction

A 3-D Graphic Nuclear Plant Analyzer (NPA) program was developed using GLScene[1] and the TRelap[2]. GLScene is an OpenGL[3] based 3D graphics library for the Delphi[4] object-oriented program language, and it implements the OpenGL functions in forms suitable for programming with Delphi. TRelap is an object wrapper developed by the author to easily implement the Relap5[5] thermal hydraulic code under object oriented programming environment. The 3-D Graphic NPA was developed to demonstrate the superiority of the object oriented programming approach in developing complex programs.

2. Methods and Results

2.1 Thermal-Hydraulic Engine

TRelap is used as the thermal-hydraulic engine to drive the NPA. TRelap is an object developed to easily implement the Relap5 functionality in application programs. TRelap is written in Delphi and it is an object wrapper developed around the Relap5.dll. Relap5.dll was also developed by the author and it is the Relap5 code in the dynamic link library form.

Although Relap5.dll is written in old Fortran and is not written in object, its wrapper, TRelap, is a bona fide object in that it can be created, inherited, polymorphed and destroyed as needed. In addition, multiple instances of TRelap can be created with careful input/output/ rstplt file maintenance.

2.2 3-D Graphic Engine

The 3-D graphic engine was developed using GLScene library which implements OpenGL functions in forms suitable for the Delphi language. TGLScene is an object of the GLScene and has the 3-D scene container where instances of objects such as the 3-dimensional primitives (spheres, cubes, etc.), meshes, cameras, lights, etc can be created and contained. In this application, a single camera with a single scene was modeled but, multiple scenes with different views from many different cameras can be modeled with little effort.

2.3 Nodalisation

One of the difficulties in using the 3-D graphic NPA is in visualising the "3-D nodalisation". For this application, the ".3ds" format was chosen as the format for the 3-D objects. The ".3ds" file format is the base format used by the "3D Studio MAX" program developed by Autodesk Media and Entertainment[6]. The ".3ds" format consists of polygon mesh information. This format was selected because it is one of the most popular formats supported by most of the major CAD, 3-D Modelling and Rendering programs.

In order to use the ".3ds" format, it was necessary to develop a graphics routine, using the GLScene library, which can read-in the 3ds files to extract the polygon mesh information, and then convert the meshes to the graphic object format of the NPA program.

In order to make the 3D graphic input to the NPA, a CAD modelling of the nodalisation is needed, and it needs to be exported in the ".3ds" file format. In the current effort, a 3-D CAD program Rhinoceros [7] was used to create the 3D model and to generate the ".3ds" files. Figure 1 shows the snapshot of the Rhinoceros CAD program being used to generate a simple 3D model of a PWR nodalisation (typpwr nodalisation).
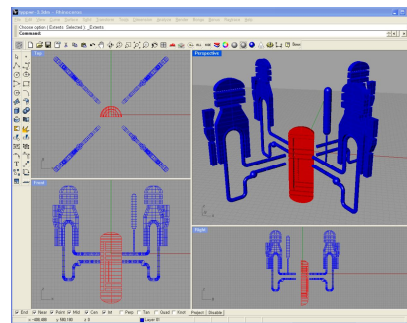

Figure 1. Use of a CAD program to Create 3D-Nodalisation

In Figure 1, a 1-D nodalisation diagram was extended into 3D diagram simply by giving each node a thickness. CAD diagrams with actual scales and dimensions may be used for accurate representation but it entails a great deal of manual work which is beyond the current scope.

2.4 Nodalisation to TH component Match-up

With the availability of the 3D nodalisation input in ".3ds" format and the Relap5 input, it is necessary to match-up the thermal-hydraulic components such as the volumes, junctions, and heat structures with the

meshes in the ".3ds" 3-D input file. This is accomplished on-screen with the NPA program itself. The NPA program processes the Relap5 input file and the ".3ds" file and generates the list of components and the meshes as shown in Figure 2.
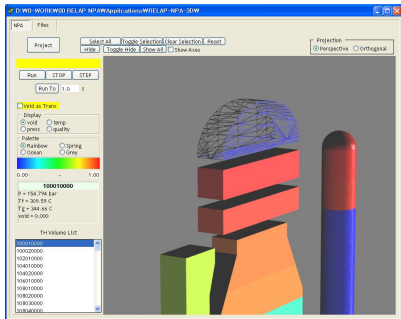

Figure 2. Snapshot of On-Screen Nodalisation to TH component Match-up

To complete the nodalisation to TH component match-up, the user first picks the 3D graphic component which turns visually into a mesh (from solid), and then double-clicks the desired volume number from the TH volume list. In Figure 2, a TH Volume List can be seen in the lower left side. At present only the TH volume list is available for the match-up but the extension to junctions and heat structures should be simple. The details of the match-up are saved in a configuration file with name associated with the ".3ds" file, and it is automatically loaded when the ".3ds" file is loaded.

2.5 Run and other Controls

The present NPA program has skeletal run controls which consist of the followings:
- Run : runs the Relap5 calculation
- Stop : stops the Relap5 calculation
- Step : advances Relap5 calculation by 1 time step
- Runto : advances Relap5 calculation to a set time

The radio group boxes are provided to control the display type and the palette. The mouse buttons are used for interactive GUI control. Left mouse-move controls the translational movement of the scene and the right mouse-move controls the rotational movement of the scene.

Other controls include a suite of controls for the volume selection, and a radio group box for the projection type selection.

2.6 TH Parameter Display

Figure 3 shows the NPA on-screen display during a calculation run. As can be seen in the Figure, the volumes are colour coded to represent the current TH values. The TH values such as temperatures can be traced by using the information on the nodalisation to

TH component match-up, and one of the TRelap methods that returns the TH values for a given component. Currently, four TH parameters can be selected interactively for volume components, and four colouring schemes (palettes) can be selected. In addition, a parameter display window is located in the middle of the left side of the screen which shows the TH parameters of the selected volume.
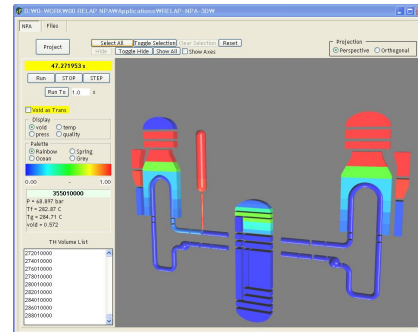

Figure 3. Snapshot of the On-Screen Display of the NPA Program

3. Conclusions

An NPA program was developed using TRelap object and GLScene 3-dimensional graphics library. The program was written using object-oriented programming techniques in which the thermal hydraulic engine is an instance of TRelap object class and the 3-d graphic elements are instances of graphic primitive object classes. Various other GUI elements are also instances of object classes. The program demonstrates that the use object-oriented program techniques greatly reduce the development effort to produce programs by simplifying the top-tier program structure. This program is planned to be used as the platform on which to build more sophisticated and complete versions of the NPA. "

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