Modification to the Monte Carlo N-Particle (MCNP) Visual Editor (MCNPVised) to read in Computer Aided Design (CAD) files.

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1.0 Abstract

Monte Carlo N-Particle Transport Code (MCNP) (Reference 1) is the code of choice for doing complex neutron/photon/electron transport calculations for the nuclear industry and research institutions. The Visual Editor for Monte Carlo N-Particle (References 2 to 11) is recognized internationally as the best code for visually creating and graphically displaying input files for MCNP. The work performed in this grant enhanced the capabilities of the MCNP Visual Editor to allow it to read in a 2D Computer Aided Design (CAD) file, allowing the user to modify and view the 2D CAD file and then electronically generate a valid MCNP input geometry with a user specified axial extent.
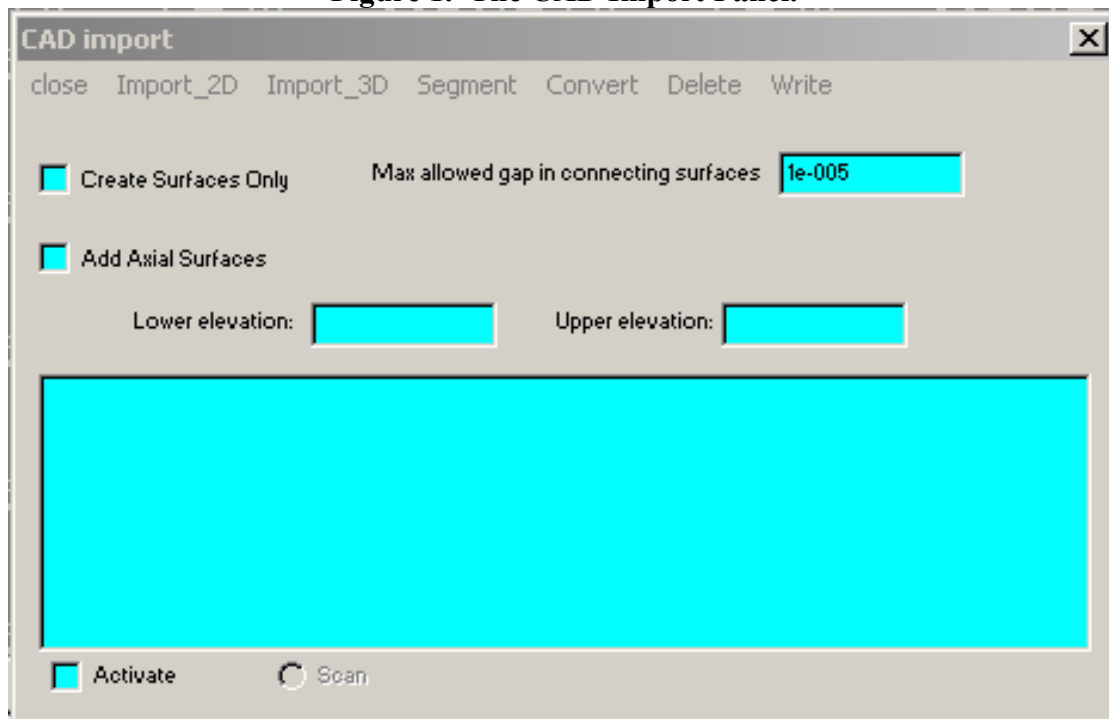
2.0 Conversion of a 2D CAD File

The CAD conversion program is part of the MCNP Visual Editor Code and as such consists of a graphical user interface, written in C++ that is linked to a set of Fortran routines that contain the MCNP Fortran source code. The MCNP Fortran has been modified and additional subroutines have been written to enable the Fortran to interact with the graphical user interface.

To implement the 2D CAD conversion, eleven new Fortran subroutines have been added. The C++ interface is used to read in the CAD file, convert the CAD surfaces to MCNP surfaces and send these surfaces to the Fortran code, which will then construct cells from these surfaces.

The 2D CAD file must be exported from CAD in a dxf format so it can be read into the Visual Editor. The dxf format was used because it is a universal format that can be written and read by most CAD packages. While this Visual Editor executable is based on Version 4C2 of MCNP, the resulting MCNP input file should be compatible with other versions of MCNP such as Version 5 (References 12 to 15). This new CAD conversion capability is currently not part of the standard Visual Editor Package, since it is still under development and is also being extended to 3D. The current status of the work can be obtained by contacting the authors through the development website (www.mcnpvised.com).
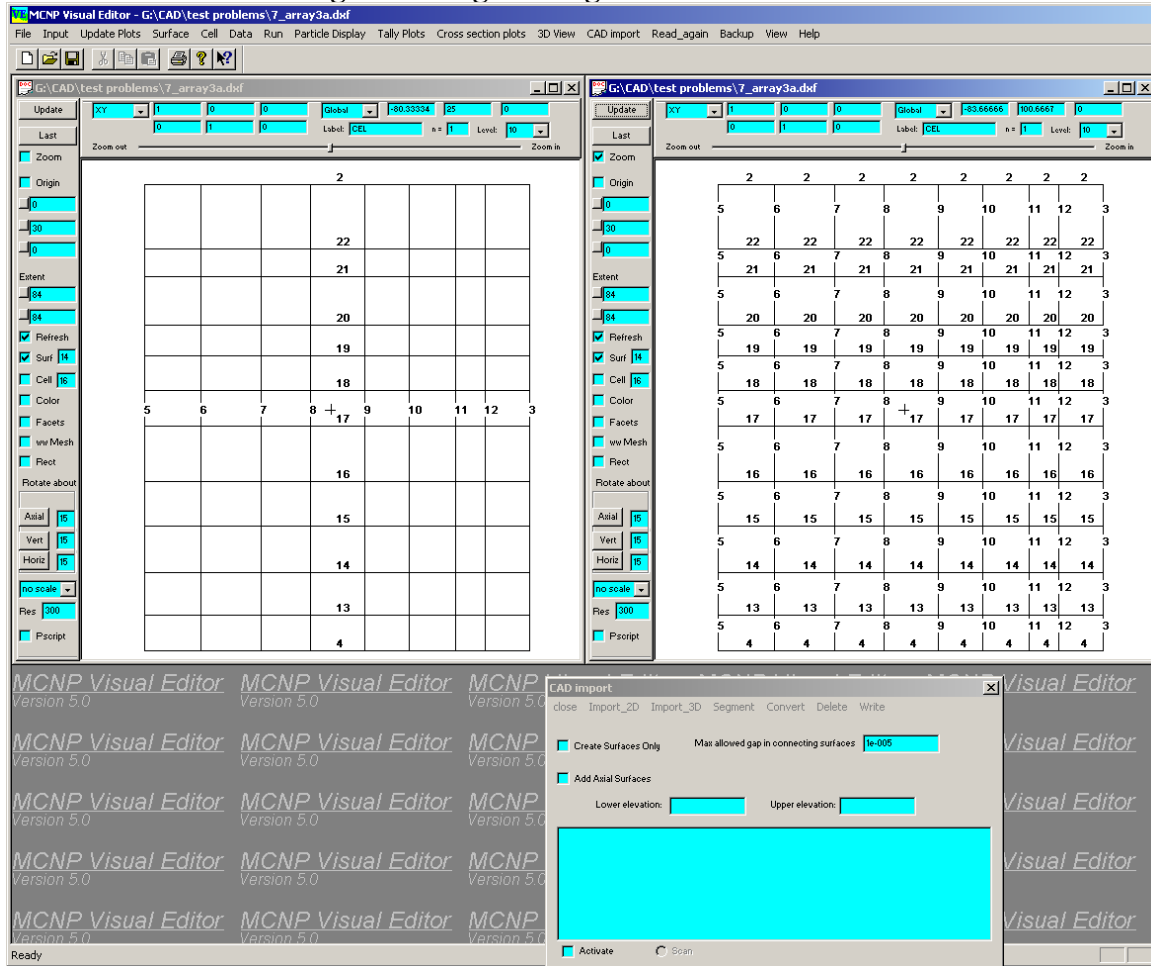
An algorithm was created to read in a CAD dxf file using a new dialog added to the MCNP Visual Editor. The "CAD Import" menu command brings up the "CAD Import" panel of Figure 1, and "Import_2D" is selected to allow the user to specify the name of the CAD dxf file to be displayed and converted. The CAD geometry can then be displayed prior to converting it to an MCNP format by selecting the "Update" button for one of the plots.

Figure 1. The CAD Import Panel.

For every line that crosses another line, the Visual Editor will segment the lines. This is necessary to prevent multiply defined spaces in the MCNP geometry. To segment the lines, the user selects "Segment" from the "CAD Import" panel. Figure 2 shows a plot of the surfaces before and after segmenting. The geometry has still not been converted to an MCNP format.
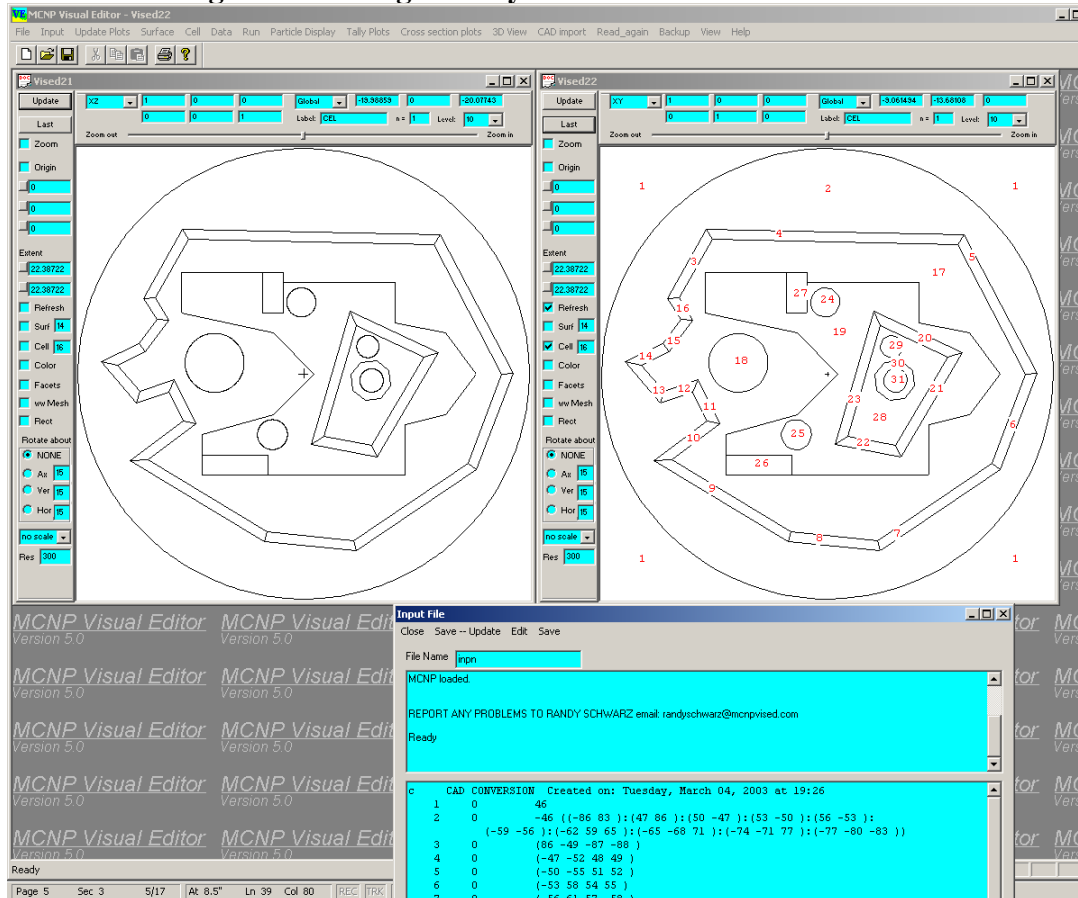
Figure 2. Segmenting the CAD Surfaces.

To convert the file, the user selects the "Convert" option to create the MCNP surfaces and MCNP cells. The user should then select "Input" from the main Visual Editor menu and do a "Save-Update" in the resulting "Input File" panel to display the MCNP plots.

This conversion works for most of the CAD geometric entities including, lines, polylines, multilines, circles, arcs and ellipses. These geometric entities include most of the 2D geometries that can be created by CAD. The Visual Editor will display these geometric entities and allow the user to select any of these items and remove them from the geometry (by scanning them and selecting the "Delete" button) before converting them to MCNP. This can be done either before or after segmenting the surfaces. The Visual Editor will also allow the insertion of an upper and lower surface to bound the 2D geometry in the axial direction.

This CAD conversion process has been tested on complex 2D CAD files. Figure 3 shows an example 2D CAD file that has been converted to MCNP. The original CAD file is shown in the left plot window and displayed using the new Visual Editor CAD plotting capabilities. The converted MCNP file is shown in the right plot window. The original CAD file contains lines, polylines, polygons, multilines and circles. The resulting MCNP geometry has 88 surfaces and 31 cells. The first few lines of the resulting MCNP input file can be seen in the input window at the bottom of the figure.

Figure 3. CAD geometry before and after conversion.

The CAD output file should conform to the usual type of things required of an MCNP input file. If the CAD-to-MCNP conversion doesn't work, it may be because the CAD regions are too complex to be converted to a MCNP cell. A MCNP cell is limited in the number of surfaces allowed to define the cell. If this is a problem, the user should try simplifying the CAD geometry by creating more regions by segmenting complex regions with lines to create a number of less complex regions (fewer surfaces per region). Also, the "outside world" beyond the outer perimeter should be bounded on the inside by a circle or a rectangle, or a boundary that involves all unions (angles facing the outside world greater than 180 degrees) to satisfy the usual MCNP "outside world" boundary condition.

Arcs (partial circles) can cause particular problems in the conversion. If there are problems converting arcs, additional regions in the CAD file should be created. This can be done by creating a chord that connects both ends of the arc, if one does not already exist, and then extending the chord across each arc in both directions to intersect with the cell bounding the arc.

3.0   Future Work

This effort concentrated on converting a 2D CAD geometry exported as a DXF file to an MCNP input file. Although this works for most cases, additional upgrades will be done to make this conversion work for special cases, in particular certain geometries involving ellipses.

Additional efforts will be made to improve the 2D conversion package. A complex CAD geometry could lead to an overly complex MCNP cell that exceeds the capabilities of MCNP. These complex cells will need to be simplified, either by the user or by the Visual Editor.

An upgrade is also underway to allow the conversion of a 3D CAD geometry to a MCNP geometry. The effort here will focus on the SAT file format, and being able to read this format and create a valid MCNP geometry.

In addition to the conversion of a 3D CAD geometry, a further upgrade is being made to allow the user to visualize the 3D geometry both before and after the conversion to MCNP. This 3D visualization will be used to verify the conversion and allow for the modification of the file prior to conversion in the same way that the 2D conversion was done.

4.0   References

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