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SPATIALNDE2: A LIBRARY TO FACILITATE THE USE OF GEOMETRY IN NDE MODELING AND DATA ANALYSIS

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ABSTRACT

Few NDE modeling and analysis codes are written to work with general geometry. This is partly because more general NDE models are more complicated and difficult to write, but partly because the needed software libraries to abstract out and easily work with general geometry have not been available. In this presentation we illustrate initial work on a new toolkit library to facilitate the use of geometry within NDE modeling and analysis codes. The toolkit is designed from the ground up to facilitate ray tracing and surface integrals across multiple objects. It is designed to support efficient computation based on CPU and GPU parallelism.

INTRODUCTION

Few NDE modeling and analysis codes are written to work with general geometry. This is partly because more general NDE models are more complicated and difficult to write, but partly because the needed software libraries to abstract out and easily work with general geometry have not been available. In this presentation we illustrate initial work on a new toolkit library to facilitate the use of geometry within NDE modeling and analysis codes. The toolkit is designed from the ground up to facilitate ray tracing and surface integrals across multiple objects for both meshed and NURBS (smooth) surfaces. It is designed to support efficient computation based on CPU and GPU parallelism.

GEOMETRY IN NDE MODELING

Traditionally, most NDE modelling work has been focused around very simple geometries such as flat surfaces. In other cases, NDE models have been developed for highly specialized but still quite regular geometries, such as for inspections around bolt holes. Tools such as Civa [1] allow and end user to perform point-and-click modeling of general geometries for the various CIVA models, but such tools are of little utility to the developer of new kinds of NDE models.

The simplest representation of geometry in NDE modeling is the triangular surface mesh. The object is represented by its boundary ("boundary representation") which is in turn represented by a very large number of flat triangular facets. It is relatively straightforward to perform calculations such as ray intersections against triangular facets. The disadvantages of a triangular surface mesh are the need for very large numbers of triangles, as well as the inability to directly represent curved surfaces.

A more sophisticated representation of geometry is the non-uniform rational B-spline (NURBS) surface. The NURBS surface is defined in terms of polynomials and thus can represent curved surfaces directly. Complicated shapes in CAD models are usually represented as (and always convertable to) NURBS surfaces. As with the mesh, an array of NURBS surfaces can represent the object by defining its outer boundary. NURBS provides the advantage of a direct representation of curved geometry. Mathematically NURBS surfaces are parametric surfaces, where the surface is represented using two parameters u and v.

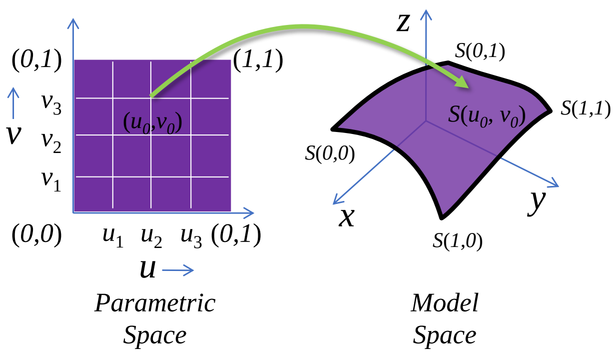

Figure 1. In a NURBS surface, any point in the (u,v) parametric domain is mapped to a 3D location (x,y,z) using polynomial equations.

Any point in the the (u,v) domain is then mapped to a point in 3D space (as shown in Fig. 1). The mapping is controlled by a set of control points and their parametric locations called knots.

TOPOLOGY

In implementing modeling algorithms, it is very useful for an algorithm to be able to explore the local geometry to perform an evaluation over a region, for example integrating over a beam footprint. Such an operation is facilitated by explicitly defining the topology of surface components in addition to the geometric elements. Triangle or NURBS face boundaries are defined in terms of edges, and edge boundaries in terms of vertices. Each edge crosslink its adjacent faces in what is known as a "winged edge" data structure, so that it is possible to algorithmically explore the surface.

SPATIALNDE2 LIBRARY

We have been developing the SpatialNDE2 library to facilitate the use of geometry in NDE modeling and analysis for open source publication. It is written in C++11 and is scriptable with Python bindings. It is designed to facilitate the needed calculations for NDE modeling. Often these calculations involve surface integration or the tracing of rays through an object to a flaw or other surface. This includes managing surface parameterizations that can be used to store data defined over an object boundary. The object geometry and other data on a graphics processing unit (GPU) so parallelizable algorithms can run extremely quickly. It also provides functionality to help with 3D rendering, as shown in Fig. 2

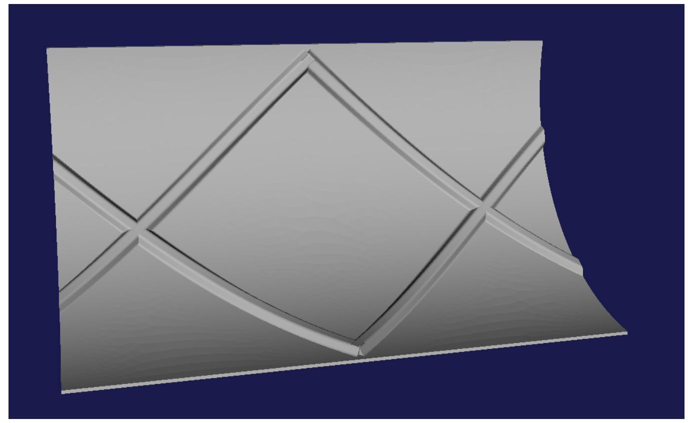

Figure 2. Rendering of a CAD model of an NDE system by an early prototype of the new SpatialNDE2 library.

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REFERENCES

[1] Extende S. A., CIVA 2017 `https://www.extende.com`