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Title: ACCIDENT RESPONSE - X-RAY TO VIRTUAL ENVIRONMENT

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ACCIDENT RESPONSE - X-RAY TO VIRTUAL ENVIRONMENT

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Abstract

The Engineering Sciences and Applications (ESA) Division of Los Alamos National Laboratory (LANL) has been working to develop a process to extract topographical information from digital x-ray data for modeling in a Computer Aided Design (CAD) environment and translation into a virtual environment. Our application for this process is the evolution of a field deployable tool for use by our Accident Response Group (ARG) at the Laboratory. We have used both CT Scan and radiography data in our process development. The data is translated into a format recognizable by Pro/ENGINEER™ and then into a virtual environment that can be operated on by dVISE™. We have successfully taken both CT Scan and radiograph data of single components and created solid and virtual environment models for interrogation.

Keywords: Virtual environments, geometry inference, CAD modeling.

1. Introduction

The Engineering Sciences and Applications (ESA) Division of Los Alamos National Laboratory (LANL) has been working to develop a process to extract topographical information from digital x-ray data for modeling in a Computer Aided Design (CAD) environment and translation into a virtual environment. This paper will describe the process that we have developed and the philosophy behind our methods. Our application for this process is the evolution of a field deployable tool for use by our Accident Response Group (ARG) at the Laboratory. When mature, this tool will allow our field personnel to transfer x-ray data gathered at an accident scene into an engineering model. Once the engineering, or CAD, model has been created, the commercial applications that can then be applied to the data to assist the respondents in their requirement to safely transport, disassemble, and/or dispose of the assembly and it's components are myriad. Because time and safety are of the essence in the case of accident response, it is essential to provide the respondents with the maximum amount of information possible. The tool we are developing will provide respondents with information to allow them to make intelligent and informed decisions about accident response. They will also be able to orchestrate their actions in the most time efficient and safe manner possible.

2. Background

Extraction of topographical data into a point cloud to be used to create a solid CAD model in its most basic form has been discussed by Hefele and Dolin [1]. Inspection data, obtained from both automated and manual processes, has been used to create an accurate engineering model of single components that can be interrogated for information such as mass properties. This "as-built engineering" philosophy is the basis for the development of our data extraction process from x-ray data. The process works particularly well for fairly simple geometry and lends itself to automation. Inspection data works well for "as-built" representations of individual components of an assembly or fairly simple single layer assemblies. However, once an assembly becomes complicated, inspection data can only provide geometric definition of the outer assembly surface. The information regarding individual component interaction or modified components in the assembly is lost. This is particularly crucial information in an accident scenario.

X-rays can provide the necessary geometric definition and the modeling process developed for inspection data can provide the means to obtain an engineering model.

Much work has been done in the area of extracting geometry from x-ray data, particularly using Computed Tomography (CT) Scan data [2-5]. Most of these applications involve components with fairly complicated geometry and a large amount of data manipulation in order to obtain a fairly accurate CAD model. Our application involves fairly simple geometry. This has allowed us to develop a simpler software package to obtain the input data to the CAD package along with a straight-forward modeling process to obtain the engineering model.

3. Process Description

A software package developed here at Los Alamos National Laboratory by Thomas A. Kelley is used to extract data from CT Scans for input into the Pro/ENGINEER™ commercial software package [6]. Mr. Kelley's program is written in the Interactive Data Language (IDL) and extracts the edges of the part. The resulting data is output into a format recognized by Pro/ENGINEER's™ ScanTools module. The point data is used to create nonuniform B-splines (NURBS). The splines are used to create surfaces and the surfaces are used to create solids. The resulting solid model is then internally translated into a format which can be read into dVISE™, a virtual environment software package. Our geometry now not only provides us with a design and analysis basis, it can also be exercised in a virtual world to allow field personnel an opportunity to exercise "what-if" scenarios.

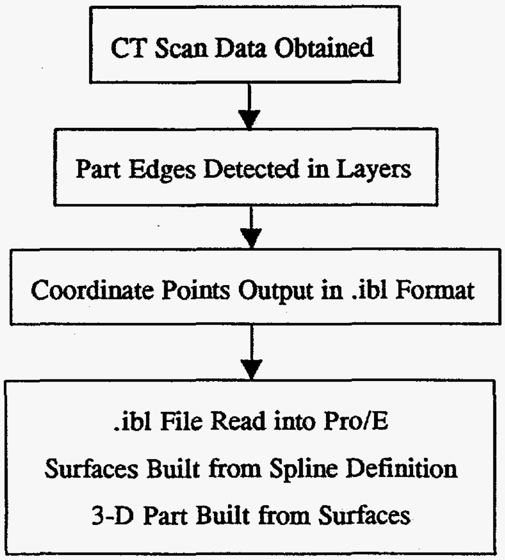

Figure 1 - Process Flow – CT Scan Data

Radiography data has also been used to create a solid model using Mr. Kelley's program. However, an additional step must be added to the process to reconstruct the two-dimensional radiography views into three-dimensional CT Scan data for input into Mr. Kelley's program. Matthew J. Sheats has written an IDL program which takes multi-view radiographs and recreates a composite, three-dimensional representation of the radiographed object. The data is output as if it came from the CT Scan process and can be read directly into Mr. Kelley's program. The rest of the process is identical to that used for CT Scan data.

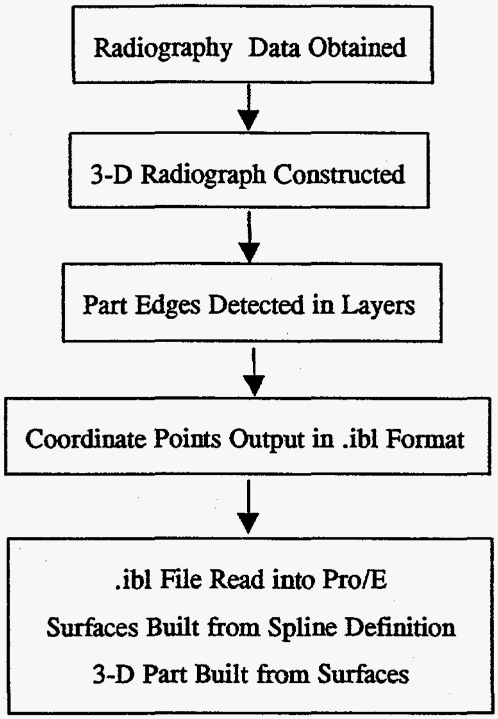

Figure 2 - Process Flow - Radiography Data

4. Data Formats

We have used both CT Scan and radiography data in our process development. The advantage to using CT Scan data is the inherent three-dimensional structure of data acquired. Use of CT Scan data simplifies the modeling process. However, CT systems are more limited than radiography systems in the size of object that can be scanned. CT systems also require either the source or the object be moved during data acquisition. This requirement presents problems in an accident scenario.

We scanned the partial Rocket Dome geometry pictured in Figure 3 using a CT unit and the resulting data was put through the process described in Figure 1. Each CT scan layer was processed for edge detection as illustrated in Figure 4. The resulting point cloud definition was organized into defining NURB's and read into Pro/ENGINEER™ (please see Figure 5). The NURB's were collected into a surface definition and the surfaces were operated on to create the resulting three dimensional part pictured in Figure 6.

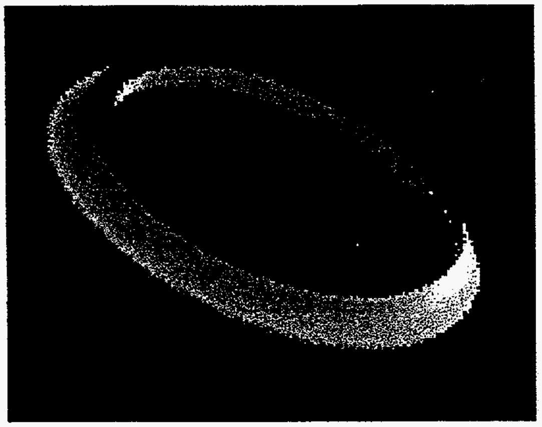

Figure 3 – Scanned Rocket Dome Geometry

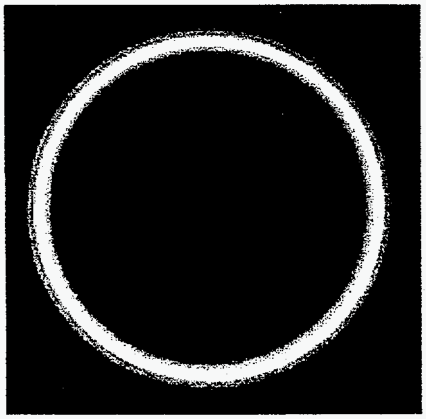

Figure 4 – CT Scan Edge Detection

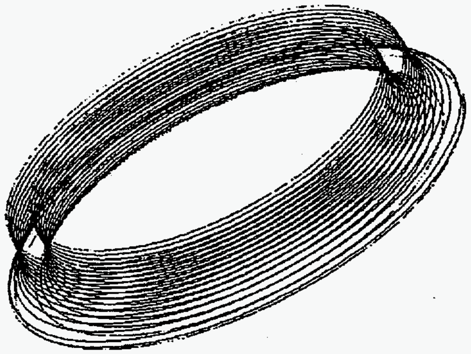

Figure 5 – NURB Rocket Dome Geometry Definition

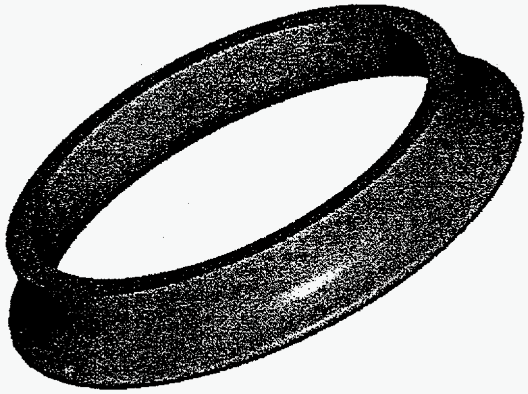

Figure 6 – Reconstructed Rocket Dome 3-D CAD Model

Presently, portable radiography systems are more abundant and accessible than portable CT Scan systems. However, radiographs present only a two dimensional slice of the object of interest and multiple views must be taken to reconstruct a three-dimensional view of the object. Creating a CAD model from radiographic data requires additional processing of the data.

We applied our process of reconstructing geometry defined using radiography data to an 'S' configuration. Three simulated radiograph views of the 'S' (Figure 7) were reconstructed into a three dimensional radiographic representation of the geometry. This data was then treated as if it originated as CT scans. The NURB 'S' geometry definition is pictured in Figure 8 and the reconstructed 'S' is pictured in Figure 9.

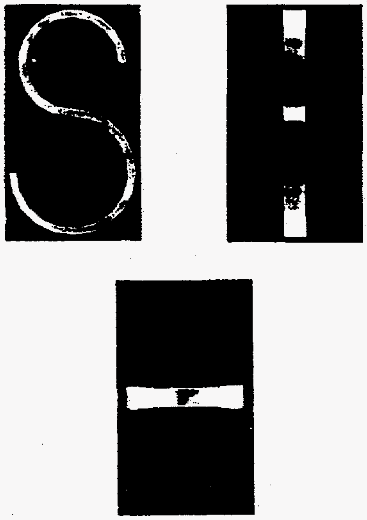

Figure 7 – Simulated Radiograph Images of 'S'

Figure 8 – NURB 'S' Geometry Definition

Figure 9 – Reconstructed 'S' 3-D CAD Model

5. Conclusion

We have successfully taken both CT Scan and radiograph data of single components and created solid and virtual environment models for interrogation. Once a solid model is created, it is a simple matter to not only obtain a virtual environment model, but also a finite element analysis (FEA) model, a .stl model for rapid prototyping, or design tooling for transport or disassembly of the unit of interest. Future work in this area must include operation on an assembly and automation or streamlining the process.

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