3D-Scans of Railroad Wheel Flaws Exploit New LabVIEW Features

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NI Product(s) Used:
NI VXI-USB
NI-LabVIEW 2010

Category:
Advanced Control Systems
Education
Automated Test
Structural Test and Monitoring
Transportation

The Challenge
C-Scans have been the standard method of displaying the results of Non-Destructive Tests (NDT) for years. C-Scans can reveal small flaws hidden deep in material. They present a challenge when attempting to use the C-Scans to correlate the flaw to the physical location in the Device Under Test (DUT).

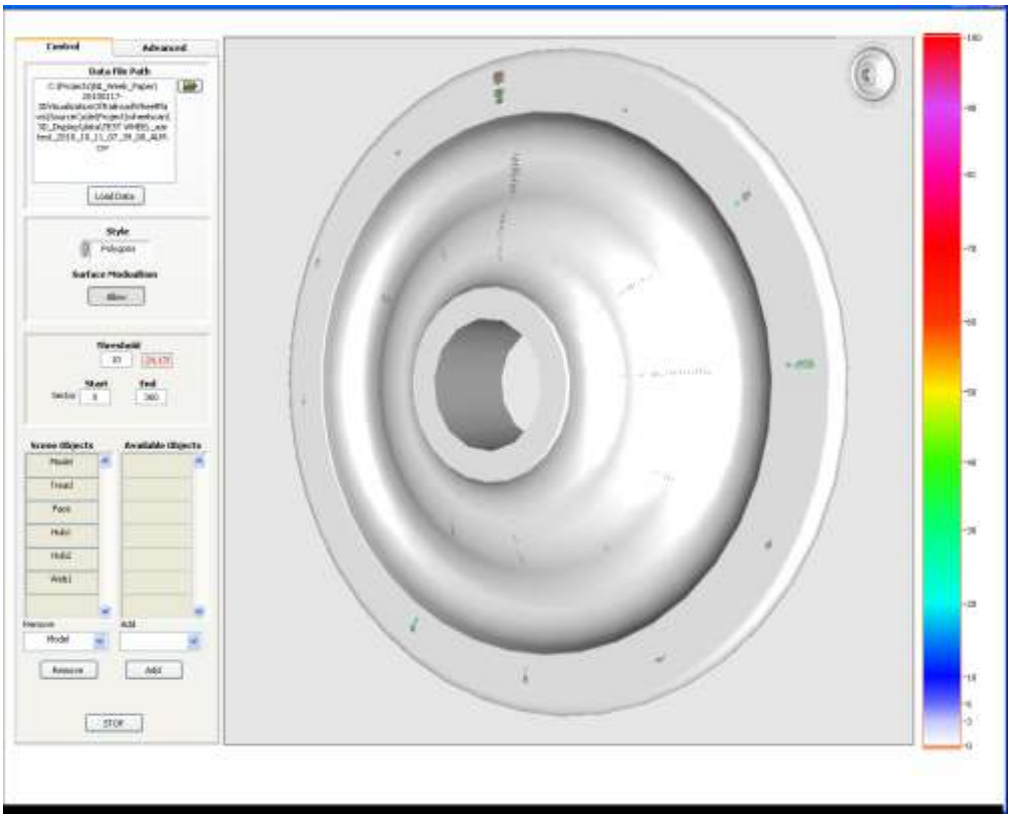

Figure 1. 3D-Scan maps C-Scan data onto a model of the DUT.

The Solution
A new display called a "3D-Scan" was developed utilizing many of the new features of LabVIEW to superimpose the C-Scan information on a SolidWorks model of the railroad wheel. The 3D-Scan positions the flaw information acquired from multiple probes onto a single 3D image that can be easily understood even by persons not experienced in reading C-Scans.

Introduction
Data Science Automation (DSA) is the premier National Instruments Alliance Partner. DSA integrates commercial off-the-shelf (COTS) components from automation technology vendors to create custom, adaptive automation solutions for research, manufacturing, government and business operations to:

- acquire, analyze, present and manage data
- design, simulate, test and validate products
- monitor, predict, control and optimize processes
- invent, draft, prototype and build machines

for maximum productivity, quality, profit and understanding.

DSA is a certified member of the Control Systems Integrators Association (CSIA) and staffs multiple National Instruments Certified Training Centers with more certified LabVIEW Architects than other integrators

DSA was chosen for this project because of our many years of quick response with the client developing demanding, custom applications while following our certified, disciplined software development process. The client was able to compound their investment because of DSA's Adaptive Automation approach.

Overview of 3D-Scan Capabilities:
The 3D-Scan Viewer (Figure 1) was developed as an enhancement to an existing application that is being used around the world to perform NDT testing of railroad wheels. The 3D-Scan Viewer was developed to allow rendering C-Scan data in 3D-space for any DUT where a model is available. It provides mechanisms to change the model and the methods used to render the image to allow it to be quickly adapted to any testing where the position of the phased-array probes relative to the DUT can be clearly defined. Examples of the surfaces used in the current implementation include Cylinders, Conic sections, Disks, and a Rotated Spline.

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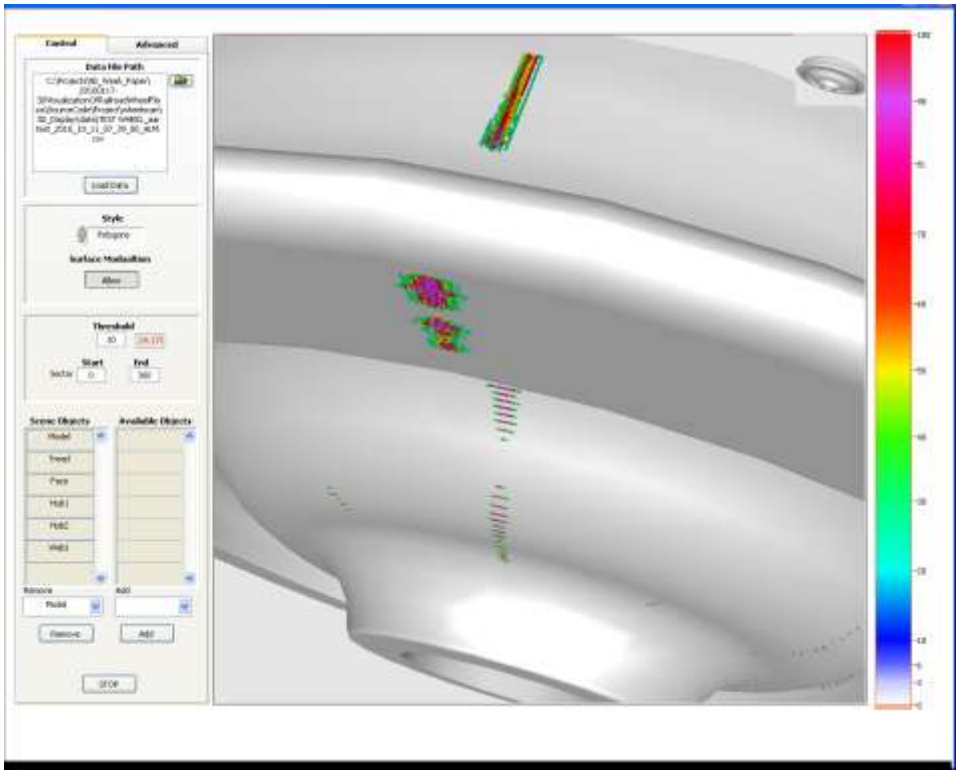

Figure 2. User can adjust the viewing angle and zoom factor. A Navigation thumbnail aides in navigating the scene.

The application allows a user to select a data set at allows them to adjust the rendered image to help achieve the goal of evaluating the nature of flaws. The user has the option to specify what part of the data should be displayed, while also allowing them to choose which probes are included in the analysis and how they are displayed. A navigation window (Figure 2) provides a "bird-eye-view" and is particularly useful when zoomed in.

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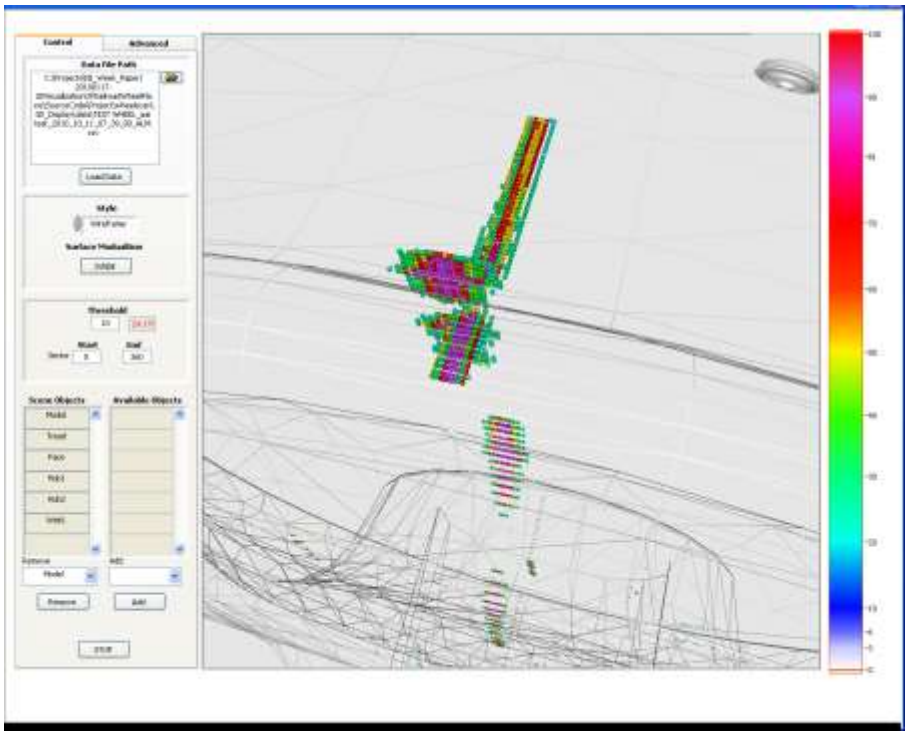

Figure 3. Wire-Frame view.

As illustrated in Figure 3 the user can select "Wire-Frame View" to be able to "look inside" the wheel. Wire Frame and Modelless (Figure 4) give the user superhero capabilities without the tights.

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Figure 4. Model removed (Modelless)

LabVIEW was the obvious answer when choosing what development environment to use to develop the 3D-Scan application for many reasons as enumerated below.

C-Scan Data Acquired Using LabVIEW:
The primary reason for using LabVIEW to develop the Viewer is that the control and acquisition system that acquires the C-Scan data was written in LabVIEW version 2 and has been growing along side LabVIEW ever since. The same functions used to read the C-Scan data were incorporated into the 3D-Scan. As the acquisition data format changes of the years, the 3D-Scan Viewer will automatically adapt. When computer performance improves over time, the 3D-Scan can be easily integrated for "Real-Time" flaw rendering.

3D Picture Harnesses the Power of OpenGL:
National Instruments has been gradually adding to and building on the capabilities of OpenGL for the LabVIEW 3D Picture Control. The recent enhancements to the 3D Picture Control have exposed methods that make interacting with the 3D image easy and straight forward. Adding a point to the 3D Picture uses functions native to LabVIEW. These functions allow developers to define the Shape, Size, Color, and position of the data point. All translation and rotation are handled automatically by the 3D-Picture once they are inserted into the scene.

LabVIEW also includes functions to render the model from file (*.wrl format) and only required a path to the model file to work. The ease of loading the model was also used to implement the "Navigation Window" (see figures 1-4). The Navigation Window is simple a small copy or thumbnail of the model shown in the main display. Any translations applied to the main display are copied to the Navigation Window after removing any zooming action that may have been applied. Special thanks to Darin Kinion, Lawrence Livermore Laboratories, LabVIEW Champion who helped with the ModelView Matrix in the National Instruments Developer Exchange.

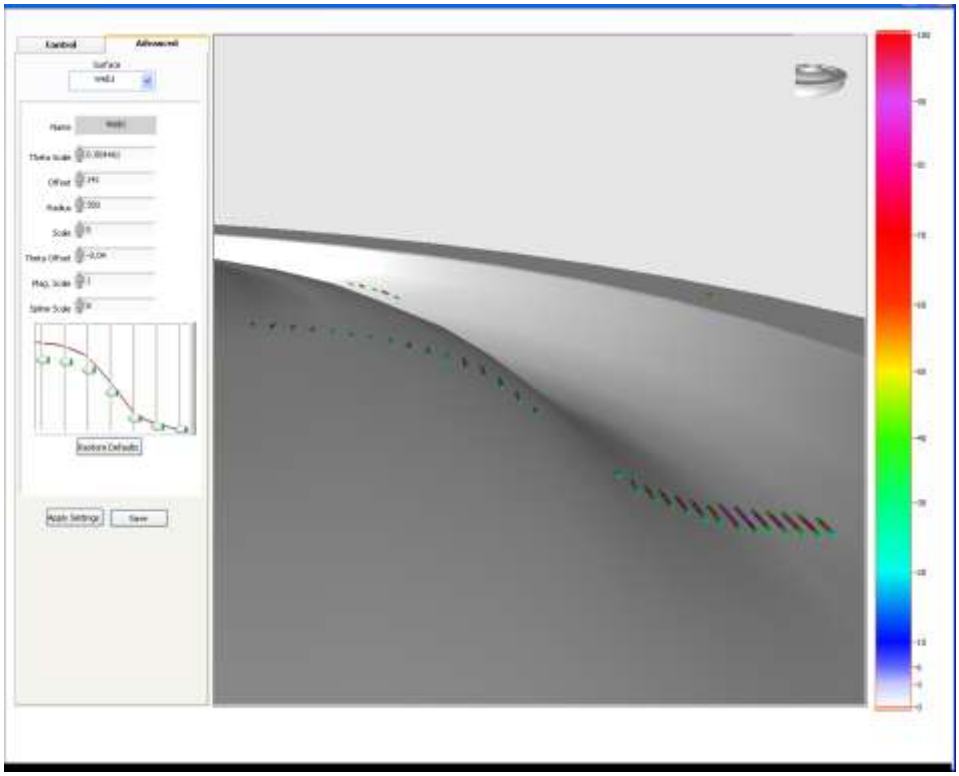

Figure 5, Complex Surface mapping

Advanced Mathematical Functions Define Complex Surfaces:
The web of the railroad wheel presented a special challenge since it is composed of a compound curve and would be complicated to define using standard geometric rotations. The advanced math functions added in LabVIEW 8 included a Hermite Interpolation that produces a "bumpless" spline fit (Figure 6). Users can simply drag sliders (Figure 5) to map the data to the surface.

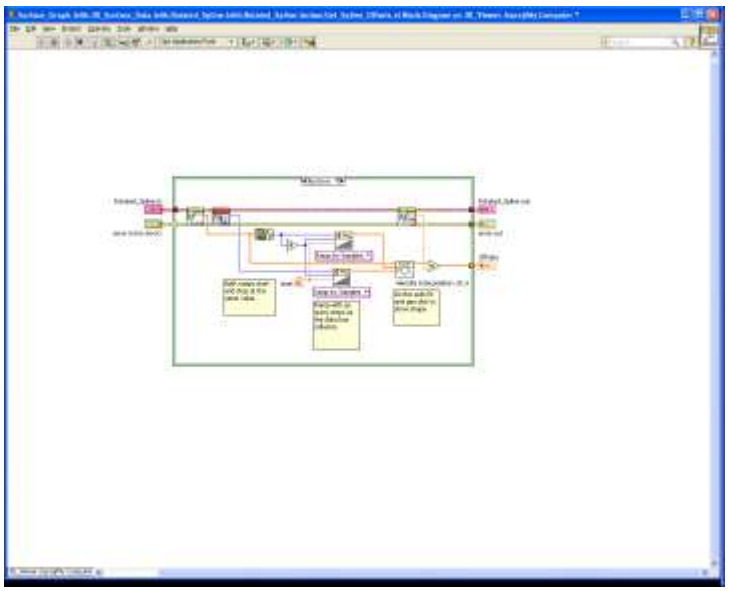

Figure 6. Hermite Interpolation functions ships with LabVIEW

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LVOOP Saves Development Time and Effort:
Even with the features of LabVIEW mentioned above that made development easier, the application would have taken considerably longer to develop if LVOOP (LabVIEW Object Oriented Programming) had not been available. As illustrated in figure 7, the class hierarchy of the application was developed to minimize development efforts. The "Point" Class is utilized by "3D Plot" class which is the parent of the "Surface" class. Surfaces are used by 3D Data Class which is the parent of the various Classes that implement the assorted surfaces.

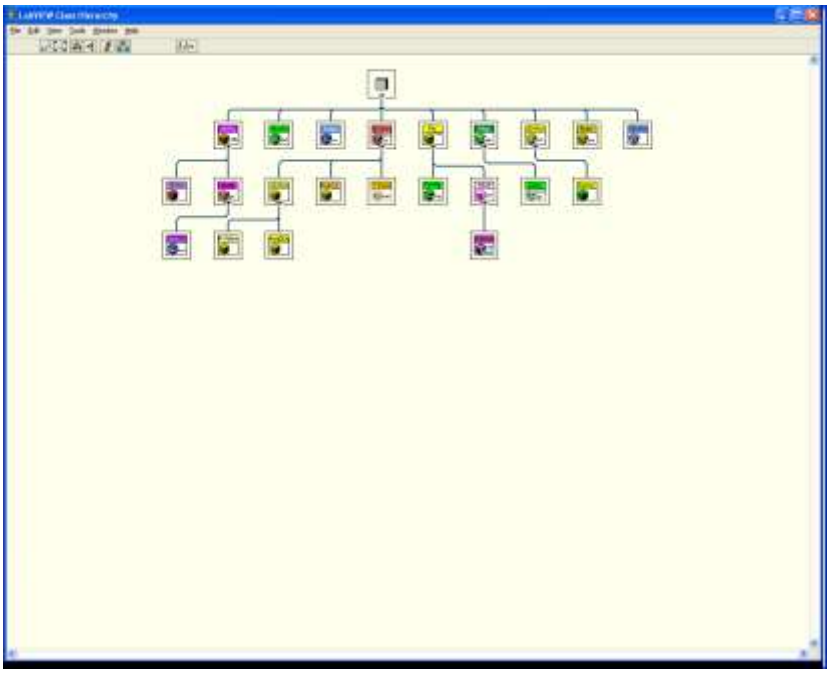

Figure 7. Class Hierarchy
The degree to which LVOOP simplified development is illustrated in Figure 8 where only a handful of Over-Ride Vis were required to realize the Rotated Spline (See Hermite Interpolation above). Due to the inheritance of LVOOP classes the Rotated Spline class can be used the same way as it ancestors.

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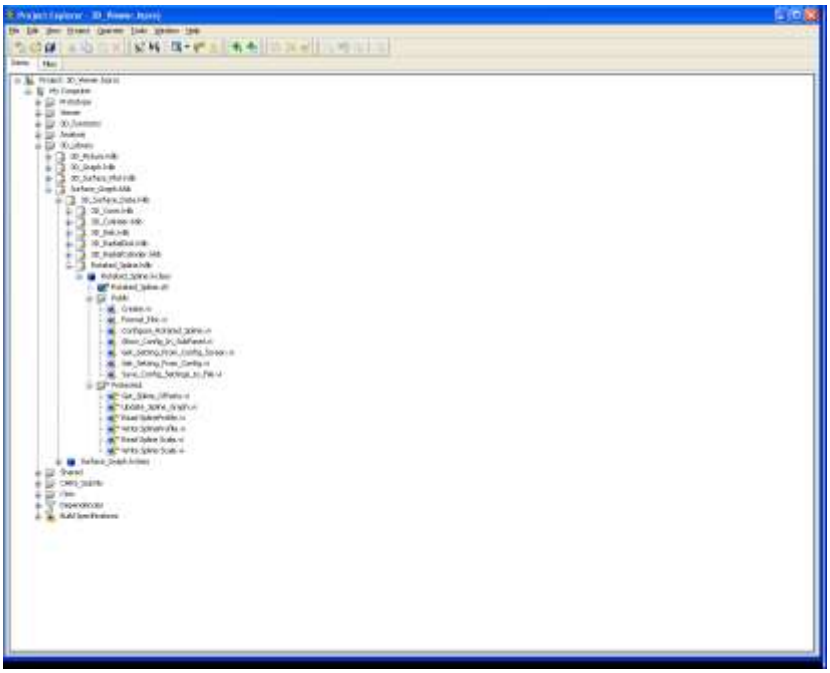

Figure 8. Rotated Spline Class contains only Over-Ride VIs

Benefits of 3D Scan:
The 3D Scan Viewer is capable of displaying any of the C-Scan data acquired from the various installations of its sister systems around the world. C-Scan data from multiple probes can be easily evaluated within the context of the device under test. The shapes of the defects are clearly rendered and their severity can be visualized. Future use of the 3D-Scan can help manufacturing departments better understand the nature of the defects and correct them expeditiously.

Goal Achieved:
The intent of the 3D-Scan Viewer was realized in less time than expected with results that were beyond the initial requirements. With time, the use of the 3D-Scan Viewer should improve the quality and safety of railroad wheels wherever it is used.

Contact Information
Ben Rayner, 724-942-6330, www.DSAutomation.com is proudly pictured in Figure 9.

Figure 9. Author in front of Test Station for railroad wheels

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