Team 29 Engineering Technology Capstone Project

Hybrid Scanning Model

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HOWMET AEROSPACE

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PROBLEM OVERVIEW

At Howmet's LaPorte facility, a *ZEISS ScanBox* is used to inspect manufactured parts for defects. The ScanBox, which has been donated to Purdue by Howmet, is an industrial 3D scanner that creates a digital twin of the manufactured part and compares it to its nominal counterpart. Team 29 has been tasked with automating the scanning and inspection process to eliminate the need for time consuming hand inspections.

PROJECT REQUIREMENTS AND DELIVERABLES

Team 29 had to design and manufacture a fixture that could hold Howmet's casting in an ideal position such that scanning and inspection would be complete in as little time as possible. Due to delays in receiving a scrapped part, Team 29 developed analogous test parts that mimicked the geometry of the Howmet turbine as well as corresponding fixtures for them. Discoveries made using them led to the realization that for the actual, part it would be best to have it sit centrally on the table and raised up so that the scanner could be still as the table rotated, capturing the most amount of data while moving the part minimally.

It was also necessary to learn how to use the ScanBox's companion software, *ZEISS Inspect*, which controls the scanning and inspection of parts. ZEISS Inspect natively supports Python scripting to automate nearly any function in the program.

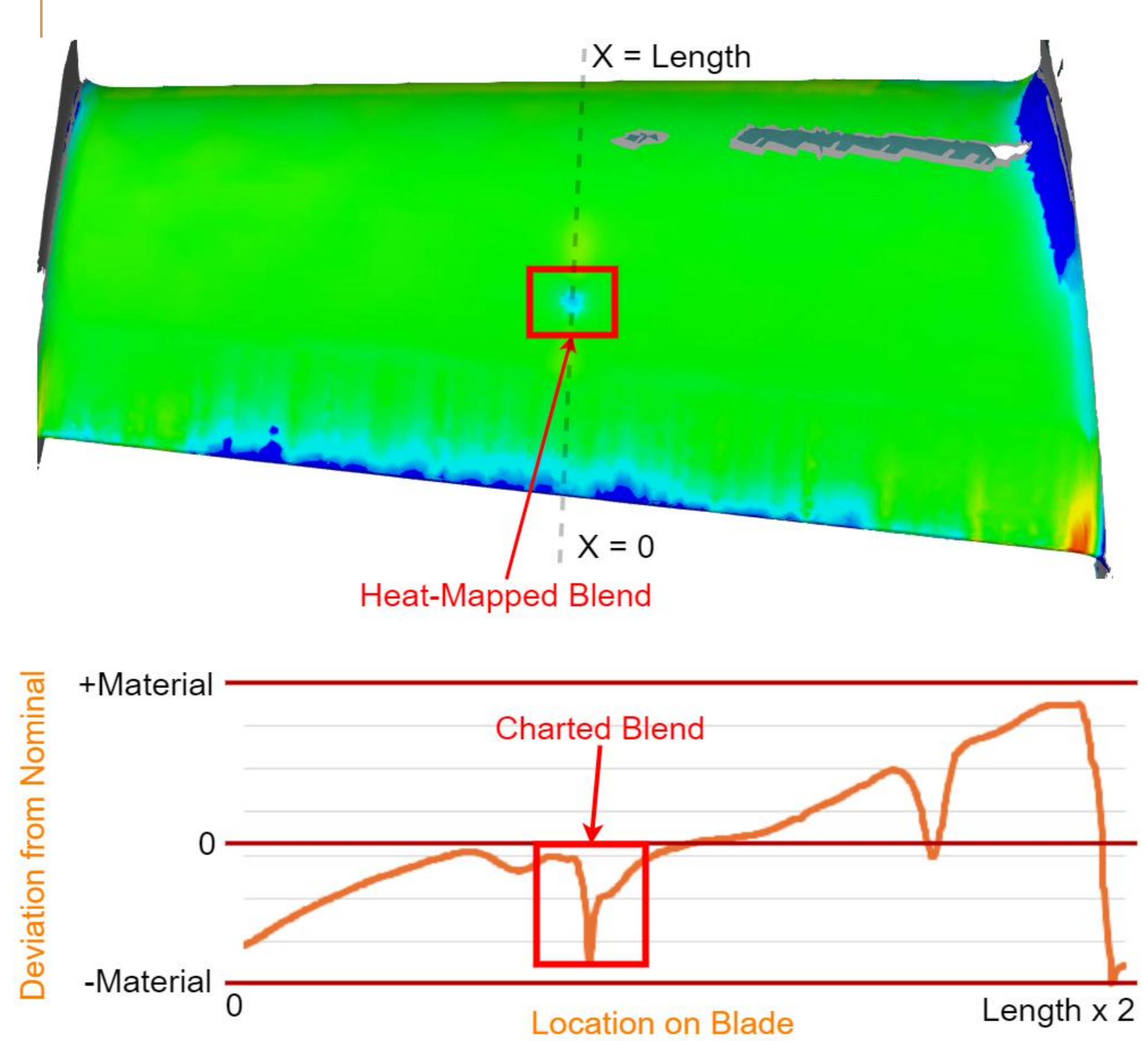
Team 29 has been tasked with delivering a ZEISS Inspect program that automates the entire scanning and inspection of a single casting within 50 minutes while identifying defects. The program must then accept or reject the part based on customer specification and allowable tolerances.

EXPERIMENTATION, CONCEPTS, AND TESTING

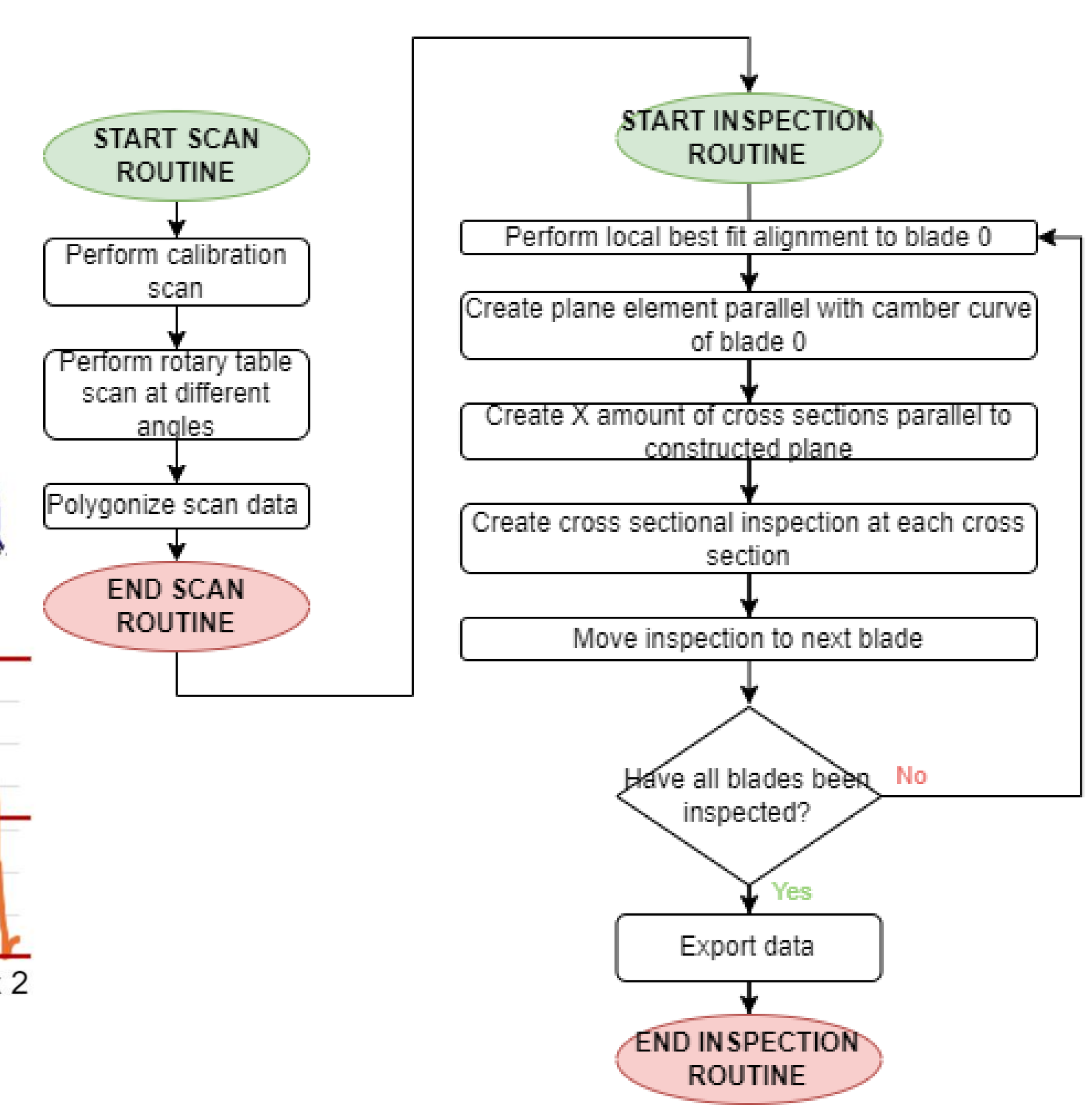
The first analogous part was an off the shelf fan blade from McMaster-Carr. Upon developing a fixture for scanning it, the geometry was shown to deviate too much from the nominal / provided CAD file that it was unusable. The second part was a 3D printed turbine sections glued together that was set on the first fixture with slight modifications. The final fixture aimed to increase compatibility, specifically for radial symmetry parts, by adapting a commercial off-the-shelf (COTS) lathe chuck atop a plate and rod to ensure precise and secure mounting for more efficient and accurate operations. At one point there was development for chuck jaw extensions but by acquiring a bigger sized chuck those additional parts weren't necessary. This initiative not only boosted current capabilities but also paves the way for future advancements through providing a robust, dynamic, and adaptable framework for part mounting.

Team 29 began software experimentation using the 3D printed part by developing a Python script within ZEISS Inspect that follows the procedures as depicted in the flowchart below. Ultimately, the output of these procedures is a cross-sectional analysis. This analysis provides insight into the areas of each airfoil that lack or have an excess of material. From the script, a heatmap can also be applied to the airfoil. In the figure below, areas of green on the heatmap are within the expected tolerance, while areas in blue are lacking material. If the part were to have excess material, those sections would be red. The script uses simple trigonometry to locate and index each airfoil blade on the turbine. Indexing the blades allows potential ScanBox operators to more easily locate the defects after the scan.

CROSS-SECTIONAL ANALYSIS



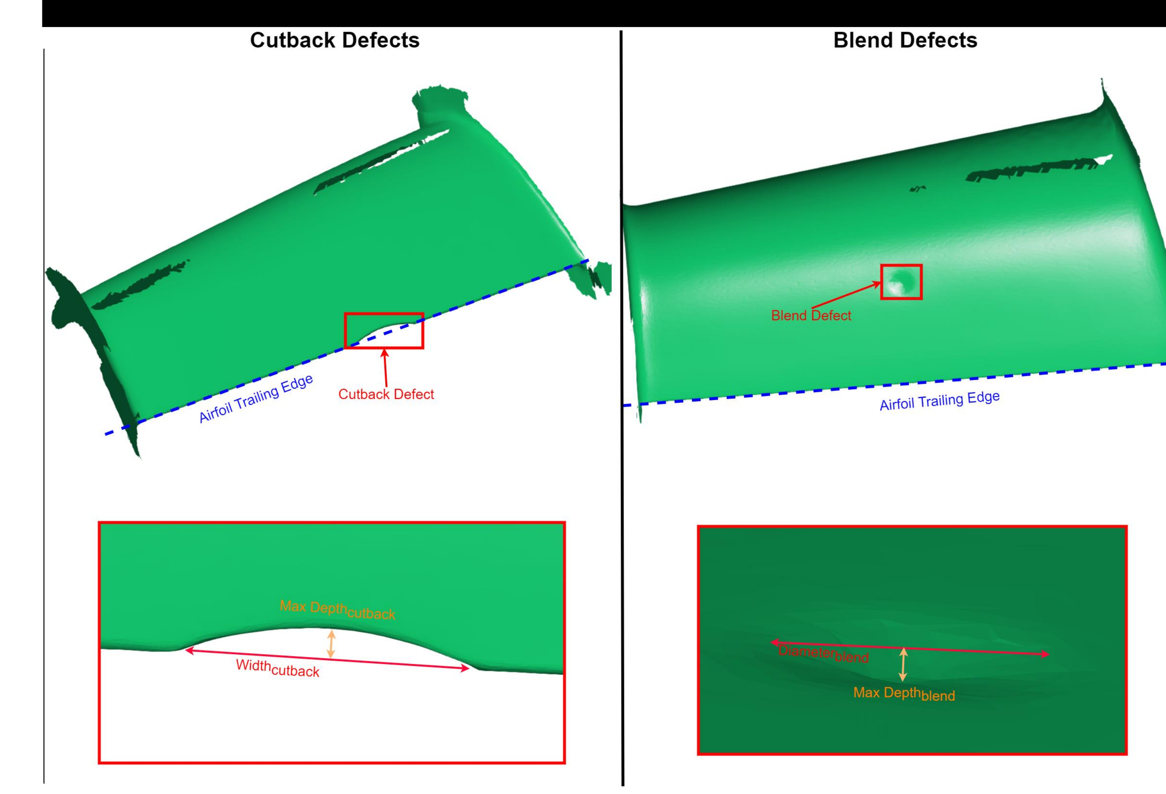
SIMPLIFIED SOFTWARE FLOWCHART



CUSTOMER BACKGROUND

Howmet Aerospace manufactures jet engine components for military and commercial applications. Their expertise lies in metallurgical castings. Howmet produces over 90% of all structural and rotating aero engine components and invented 90% of all aluminum alloys that have flown.

AIRFOIL DEFECT CLASSIFICATIONS



FINAL DESIGN & PLANS

To achieve the highest quality scan, the rotary table was used to adjust the angle of the part while the camera head remained stationary. The final fixture was manufactured with cutting and drilling techniques by hand to increase the speed at which the team could scan the part. For future capstone teams, the material choice could be changed to have greater strength with parts of the same shape.

The future of the software involves adapting the output data to be easier to read while displaying a clear "red-light or green-light" display based on the data. Currently, data from the cross-sectional analysis can be displayed using Microsoft Excel to show the part's deviation from its nominal geometry. The next step is to interpret this data to be able to classify cutback and blend defects. After locating and classifying the defects, they must be checked against the specification provided to Howmet by their customers. If the parameters (max depth, width, depth, diameter, etc.) and counts of the defects fall within specification, the part will be accepted, otherwise the part will be rejected.