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Ph.D. DISSERTATION DEFENSE

Candidate:	Mariana R. Hernandez Rocha
Degree:	Doctor of Philosophy
School/Department:	Charles V. Schaefer Jr., School of Engineering and Science/Department of Mechanical Engineering
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Title:	AI-Assisted Generation of Parametric Surface and Solid Models from Point Clouds
Chairperson:	Dr. Kishore Pochiraju, Departments of Systems Engineering/Mechanical Engineering, Stevens Institute of Technology.
Committee Members:	Dr. Long Wang, Department of Mechanical Engineering, Stevens Institute of Technology. Dr. Jacqueline Libby, Department of Mechanical Engineering, Stevens Institute of Technology. Dr. Ting Liao, Department of Systems Engineering, Stevens Institute of Technology.

ABSTRACT

Point cloud data is often acquired in biomechanical and industrial applications to synthesize custom-fit components that conform to existing surface geometries. Converting these scans into usable CAD models remains largely manual, and automated alternatives fit surfaces with a single loss function applied across the entire geometry, yielding representations whose smoothness and fit quality are neither controlled nor quantified.

This dissertation presents an AI-assisted generative design automation framework that converts unstructured point clouds into parameterized solid models. A geometry-driven pipeline parameterizes scans at the edge curve level and reconstructs solids by lofting, reducing design and manufacturing time from days to hours, while quantifying reconstruction quality using Chamfer and Hausdorff distances, coverage, and curvature-based smoothness metrics. An AI-assisted approach then solves the inverse problem of recovering control-point representations directly from dense scans, using learned estimators, a non-local decomposition method, and surface reconstruction via boundary-assembly algorithms that enforce continuity across patch seams.

The framework was validated by generating several patient-specific ankle-foot orthosis designs and further generalized to other wearable components. The resulting methodologies can easily translate into tools that can be embedded in CAD systems to produce compact, differentiable geometric models that are efficient for use in bio-robotic simulation and manufacturing.