Thesis Project Portfolio

Automating Design for Manufacturability Testing on 3D CAD Models: Exploring the Capabilities of Elysium's Geode API

(Technical Report)

Balancing Automation and Human Expertise: An Analysis of the Toyota Production System

(STS Research Paper)

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Sociotechnical Synthesis

The technical report describes a project completed during my summer internship at Elysium GmbH, where I developed code for automated Design for Manufacturability (DFM) testing on 3D CAD models. DFM testing evaluates whether a product design can be efficiently and reliably manufactured by checking it against established rules. These rules vary by company, material, and intended use, and are informed by practical experience to prevent costly design flaws from reaching the production stage. With the increasing speed and volume of design iterations in modern engineering, automated DFM testing is critical for maintaining design quality at scale. The project's goal was to demonstrate the viability of Elysium's new product, the Geode API, as a replacement for a global aerospace manufacturer's legacy system. The API enables the extraction of precise geometric data from CAD models, which can then be evaluated against custom design rules programmed in Python. I analyzed the client's DFM rules, studied sample models, learned the API, and developed code to check features such as drill hole depth, corner fillets, and wall thickness. The code applied color-coded annotations and labeled measurements to clearly indicate passing and failing cases in each model. All tests were successfully implemented and demonstrated full accuracy on the provided models. The results were presented in a benchmark meeting and the clients decided to progress with further evaluations. The project demonstrated that Geode is an accessible, flexible, and scalable solution for automating DFM testing to streamline repetitive checks and allow human reviewers to focus on more complex design evaluations.

The STS research paper examines how automation can be implemented in manufacturing without sacrificing human expertise, using the Toyota Production System (TPS) as a case study. I applied Actor-Network Theory (ANT) to identify the human and non-human actors that interact

to sustain both operational efficiency and knowledge retention within Toyota. These actors include human workers, machines, operational tools, and business philosophies. TPS is built on two key pillars: Just-in-Time (JIT) production and Jidoka (automation with a human touch). These are reinforced by Toyota's values of Kaizen (continuous improvement) and Respect for People, which are then reflected in workflows that incorporate tools like Andon visual cues and Kanban scheduling cards. Together, these elements create a dynamic and responsive system that embeds worker insight into standardized workflows that preserve institutional knowledge. This analysis challenges the assumption that automation inherently replaces human labor. Instead, Toyota demonstrates that human judgement can be integrated into automated systems, resulting in a model where human and machine actors reinforce each other's strengths. ANT reveals that Toyota's success lies not just in technical innovation, but in cultivating a resilient, sociotechnical network that constantly recalibrates itself. This investigation offers broader implications for modern automation strategies, especially as industries deal with rapid technological change and shifts in the workforce. It highlights that automation is not just a technical venture, but something deeply shaped by relationships between people, tools, and organizational culture.

These two projects share the central theme of preserving human expertise in an age of increasing automation. While the technical project implements a specific solution to automate DFM testing, the STS research project analyzes how Toyota has achieved long-term success by carefully integrating human and machine actors into its processes. Both explore the dilemma of how to balance the use of automation for efficiently handling repetitive tasks while still preserving the crucial role of human workers in developing hands-on expertise and driving innovation. In the technical project, the client transformed their design knowledge into explicit rules that were programmed into Python code. The code can efficiently and consistently apply

rules, but the output annotated models are intended for review by human evaluators. The reviewers assess the results for borderline cases and manually evaluate designs for complex rules that cannot be reliably programmed. This process increases efficiency and brings essential human judgement and domain expertise into the process. As the client's needs evolve and new DFM tests emerge, the flexibility of the API allows for new checks to be programmed. This mirrors the TPS approach where standardized work procedures continuously incorporate employee insights. The STS paper's use of ANT helps explain why the long-term success of a technical solution depends not only on technical performance but how well it supports collaboration between human and non-human actors. Together, these projects demonstrate that automation is most effective when it enhances rather than replaces human roles. The Toyota case study offers valuable lessons for tools like Geode to increase productivity while enriching the roles of employees. This highlights that knowledge preservation within automation is a sociotechnical challenge in that tools should be engineered for efficiency but designed to evolve with people at its center.