R&D | Industrial automation | Cycle time optimization | Feed-forward networks

Automation of NC Programming With Artificial Intelligence

AMERICAN INDUSTRIAL PARTNERS

BUSINESS PROBLEM

AIP portfolio company Orizon manufactures metallic structural assemblies for various hardware systems, but primarily aircraft aerostructures. These assemblies, fabricated using subtractive manufacturing methods on CNC machines, are often produced in high volumes, thus necessitating minimal machine time. A typical Orizon product has complex geometry, often requiring several months of engineering effort to develop the program governing the CNC machine operation. This development process, referred to as programming, is a bottleneck that precludes Orizon's operational efficiency and penetration to new markets.

DATA SOURCES

There are two relevant sources of data owned by Orizon: (1) the SyteLine ERP system, which contains labor process, time, and cost data; and (2) part design (CAD) and manufacturing (CAM) files. (1) is accessible via a direct server connection, while (2) is stored in various network locations. CAD/CAM data served as the basis for both the GRAP and DLATS approaches.

Data Types and Format

SyteLine/machine data have many formats (e.g., job IDs, timestamps, physical values, etc.). Part/manufacturing data include CAD models (i.e., .stp) and CAM files (i.e., G-code, .cls, and NX.prt).

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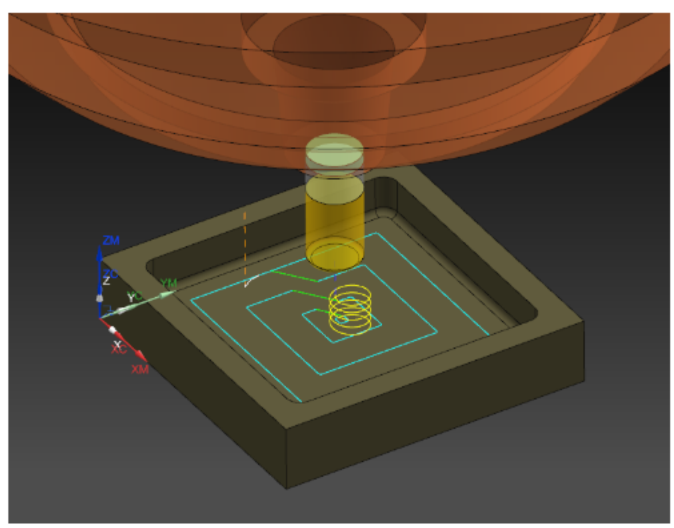
APPROACH

The following two solution approaches were created: Geometry Rule-based Automation of Programming (GRAP) is a rule-based system with the ability to recognize hole and pocket features and automatically create an associated program; Deep Learning for Automated Tool Selection (DLATS) is a machine learning algorithm with the ability to select the appropriate cutting tool for a hole drilling process.



IMPACT

Reducing the typical part programming time—and by extension, the onboarding time—has a substantial impact on Orizon's business in multiple ways. Most notably, with improved onboarding processes, Orizon will require less non-recurring engineering costs associated with developing machine programs; these lower costs will subsequently result in higher EBITDA for Orizon's existing revenue streams. Additionally, because programming is a bottleneck process, improved operational efficiency will increase production throughput and allow Orizon to take on more contracts and capture higher revenues. Furthermore, by investing in world-class machining assets and adopting a data-intensive strategy, Orizon has positioned itself as a market leader; however, continuous improvement of its existing data infrastructure and parallel development of machine learning techniques to automate CAM processes will further differentiate Orizon as a market leader and Industry 4.0 exemplar.

DRIVERS	Manufacturing companies increasingly utilize AI in order to optimize operations. CNC machining companies like Orizon are aware of the potential AI has to improve the NC programming and machining workflow, but concrete use cases have been difficult to establish due to (1) technical challenges and (2) resulting hesitation by management to invest. This "frontier" environment supported the creation of novel approaches to automate programming.
BARRIERS	Data access and formatting is the most significant barrier to achieving high accuracies in the DLATS algorithm and any other approaches utilizing machine learning to predict programming operations. Furthermore, the lack of computer vision system to recognize features in CAD models and output key geometrical attributes precludes automated creation of programs.
ENABLERS	Orizon takes an aggressive approach to investing in technologies that allow the company to deliver a quality product on time. This reception to new tech resulted in management support to ensure the proper resources were allocated to the projected described herein. Furthermore, intellectual curiosity by individual contributors to develop disruptive technology resulted in a highly aligned workforce.
ACTIONS	After conducting research into the latest approaches to programming automation, two solutions (GRAP and DLATS) were implemented in parallel. GRAP required feedback from programmers to build out a database of rules, which was iteratively improved based on automated programs created. DLATS required a deep dive into the available data sources and a flexible machine learning process as limitations were realized.
INNOVATION	GRAP required complex programming operations to be distilled into a simple, writeable set of rules. In comparison, DLATS demonstrated some intelligence by generating tool predictions at an accuracy much higher than that which can achieved by random selection; moreover, the machine learning algorithm underlying DLATS was created solely from Orizon's previously created program data, an approach which has never before been utilized.
IMPROVEMENT	Because neither solution was sufficiently developed such that it could be applied in production, there is no measurable, quantifiable improvement to report. However, if perfected, GRAP would have the capability to program several pockets in less than one minute, much less than the roughly one hour estimate required to program a single pocket.
BEST PRACTICES	Developing a rule-based system such as GRAP requires a substantial investment in knowledge engineering, which is the process of distilling expert knowledge into a codable set of rules. A proper machine learning approach requires a large dataset (i.e., 10,000 or more samples); a process to extract and collect data in an automated fashion should therefore be implemented in favor of manual data collection.
OTHER APPLICATIONS	The methodology of both GRAP and DLATS can be extended to programming of manufacturing equipment other than CNC tools. Within the context of the CNC machining industry, a machine learning approach such as DLATS can be extended beyond cutting tool selection to include operation parameter prediction, automated pricing and quoting, and automated workholding fixture design.