Data Analytics in Manufacturing

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Objectives

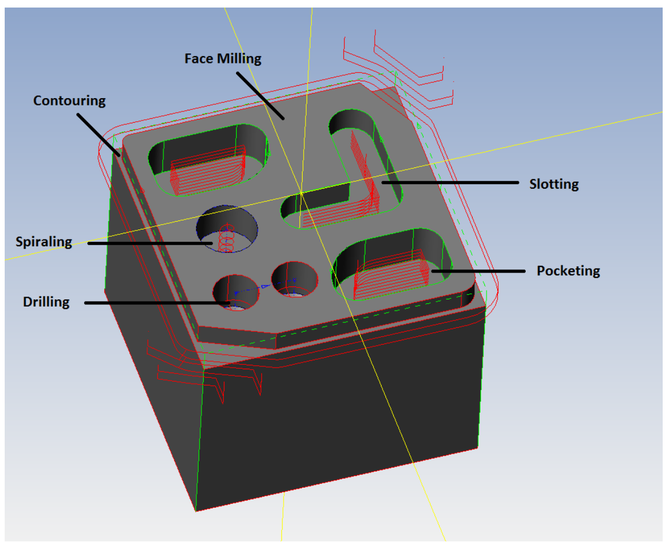
- LMAS has identified ‘Big Data’ applications in manufacturing as an important research area in the field of ‘Sustainable Manufacturing.’
- The main objectives of the on-going research in this field are:
  - Effective machine tool characterization
  - Real-time process monitoring
  - Intelligent parameter selection
  - Energy-efficient tool path planning
  - Improvement of machine tool efficiency
  - Sustainable manufacturing techniques
  - Intelligent tool life estimation and tool selection
  - Applications of data analysis in long term machine tool selection, planning and maintenance

Introduction

- With the increase in data availability and sensor fusion in the manufacturing industry, the role of data analytics in the development of smart manufacturing systems has grown tremendously.
- Manufacturing enterprises are striving towards greener and more energy-efficient manufacturing systems with the use of smart machine tools.
- The current project deals with the prediction of energy consumption in machine tools as a means of effective machine tool characterization in order to develop more energy-efficient tool paths and cutting strategies without compromising tool life.

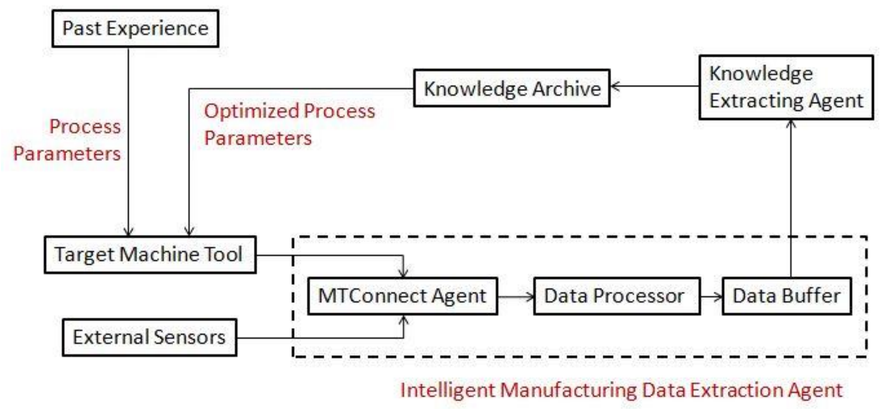
Experimental Setup

- 9 test parts were machined using a full factorial DOE, which involved a wide range of processes like face milling, contouring, pocketing, slotting, spiraling and drilling.
- Power consumption and machining data was collected using MTConnect, followed by tool wear measurements.



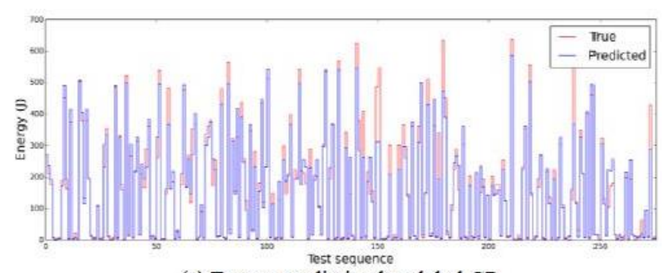
Data Extraction Agent

- The data extraction agent post-processes the data extracted from the MTConnect Agent by simulating the cutting process.
- Block-wise data is generated after cutting simulation, data condensation and transformation.

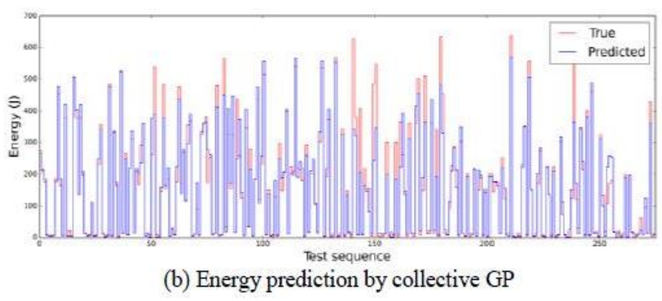


Energy Prediction Using the Gaussian Process

- The Gaussian Process, which employs the Gaussian Mixture Model, is used to predict the energy consumption
- The relative total error in prediction was observed to be 1.34% for the global GP model and 1.93% for the collective GP model



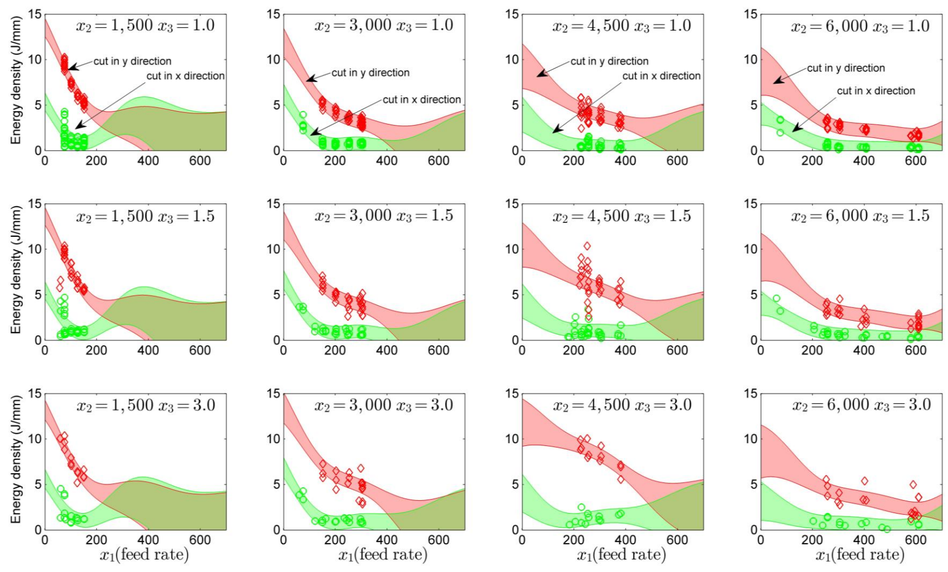
(a) Energy prediction by global GP



(b) Energy prediction by collective GP

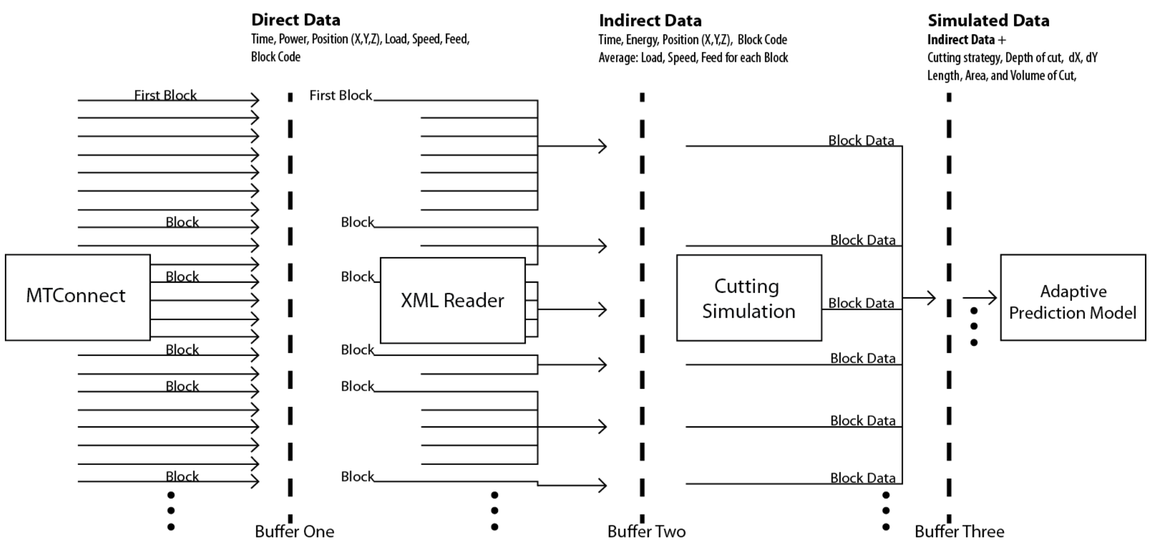
Feature Analysis

- Effects of individual features like machining direction and milling strategy are analyzed using the predicted energy function, in order to identify strategies for energy reduction.



Real-time Data Processing & Energy Prediction

- An architecture for real-time data processing and an adaptive energy prediction model is being developed and implemented.



Future Work

- Develop the real-time data processing and implement the adaptive energy prediction algorithm.
- Identify important energy-impacting features in order to determine new energy-efficient cutting strategies.
- Investigate the effect of tool wear and prediction of the same using graphical modeling techniques with latent variables.
- Develop an API for CAM software which use the developed models to predict tool wear and energy consumption for a chosen set of process parameters, cutting strategy, tool path strategy and workpiece orientation. Identify an optimized tool paths and process parameters for an energy-efficient process.

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