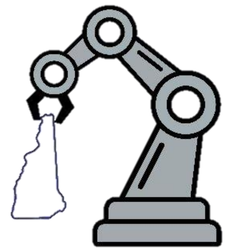
Analyzing CNC Spindle Health from Vibration Data

Presenter: Maya More

Coauthors: Charlotta Berglund and Anika Pant

Mentors: Zahid Fazal Shaik and Se Young Yoon

John Olson Advanced Manufacturing Center



Introduction

The issue: When the spindle on the CNC milling machine is dull or damaged, getting it inspected can be expensive and time consuming.

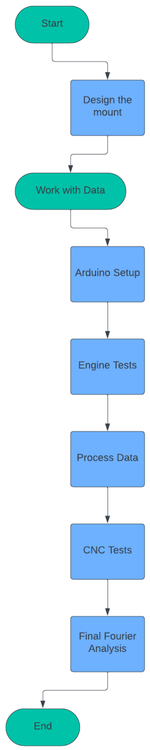
The solution: Have an AI do this job in real time, saving both time and money. This is the end goal of the project.

How it will work: The AI will compare Fourier analyses of vibration data, collected by an accelerometer inside the CNC during milling.

What we've done: Over the past six weeks, we have used various hardware and software tools to work toward this goal.

Methodology

Our time on this project splits into two chapters, each spanning a few weeks: Designing an accelerometer mounting piece and collecting/analyzing data.



Working on the mount:

- **The mount:** First we designed a waterproof accelerometer mount to hold the accelerometer in the CNC, collecting data mid-operation.
- **Tools we used:** To design this, we used Fusion 360, Bambu and Prusa 3D printers and their splicers.

Working with the data:

- **Arduino Setup:** To collect vibration data, we ran the Arduino code on our computers with the accelerometer board plugged in.
- **Engine test:** We used car engines to test run data collection.
- **Process:** The code was then processed and converted on Python and MATLAB. It was tested and fixed in this step.
- **CNC test:** The CNC was used to collect usable data during face-milling operations. Spindles in good health were tested.
- **Fourier analysis:** Finally, we ran Fourier analyses on the data. These will be given to the AI for machine learning.

Materials

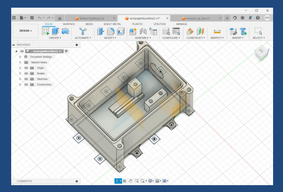


Figure 2 - Fusion 360, a computer aided design (CAD) modeling software was used to design the 3D models. Fusions' computer aided manufacturing (CAM) was used for the CNC operations.

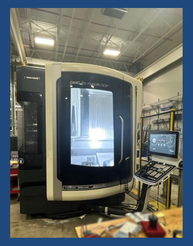


Figure 1 - The CNC machine is a DMG Mori Monoblock and was used to gather vibration data.

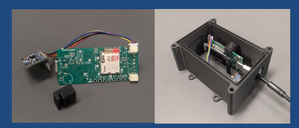


Figure 3 - The 3-axis MPU-6050 accelerometer board is shown with the printed box.

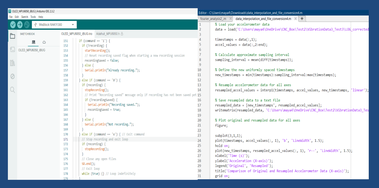
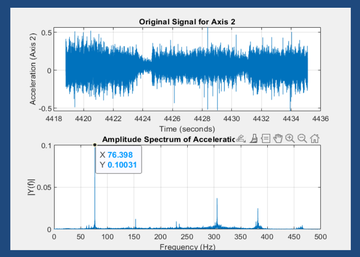


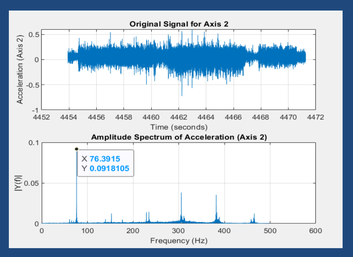
Figure 4 - Some Arduino and MATLAB code used. The MATLAB code is for the Fourier analysis. Arduino, was used to run the data collection programs.

Additional materials:

- The accelerometer mounts were printed on Bambu and Prusa 3D printers.
- Fourier analyses take data over a period and to prevalence of various frequencies. Patterns in this data can convey CNC spindle health.
- Both Python and MATLAB programs were used to process data. MATLAB also produced the Fourier analysis graphs below.

Results





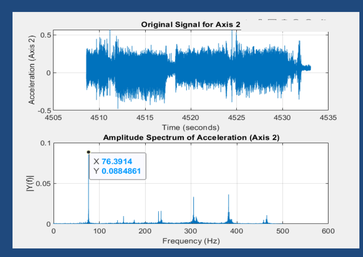


Figure 5 - Fourier analysis post-processed data from the CNC's vibrations. Patterns in the data can indicate CNC spindle health. It's the neural network's objective to extract and utilize such data features to determine spindle health.

Additional Information:

- The frequency spikes at 76.39 Hz. This corresponds to the CNC's rotations per second and is a 60th of its rpm.

Future Plans

- More data will be collected, mostly from trials with duller spindles.
- The AI neural network, which will use SVM machine learning will be completed.
- The AI system will be fed the data, trained on it, and results will be validated.

Acknowledgments

Thank you so much to all those who have helped us along the way during our time on this project, especially Zahid Fazal Shaik and Professor Se Young Yoon for being our mentors, Stephen Hale, John Roth, and the Olson Center for providing this opportunity, and the National Science Foundation for funding the NIIM internship program.