Enhancing Machining Quality and Productivity Using Deep Learning

Team Name: Industrial Revolutionists 4.0

Team Members: Hitvarth Diwanji (190100057), Gyandev Gupta (190100051), Sai Gangadhar (190100080)

1. Background and Motivation

Manufacturing processes involve a lot of tunable parameters like the feed rate, depth of cut, spindle speed, tool materials, and so on. Most of the time we rely on mathematical models or the prevalent empirical theories to find out an approximate cost function and then optimize it to obtain sensible parameters. But this cost function generally involves a lot of approximations and the actual function might be very complicated and difficult to optimize. This is where we can leverage the power of deep learning.

The amount of data available today in manufacturing has practically reached big data and is of varying forms and from different sources. Very useful insights can be brought from the application of deep learning models on these data sets. The deep models can be fed more than thousands of features and hence we can consider a lot of parameters while optimizing our process. The AI industry has also achieved significant success in training networks on various contrasting modalities (like image, text, audio, etc). This is ideal for its applicability in the manufacturing industry.

2. Objectives

We aim to explore and analyse various deep learning based methods for topics like tool condition monitoring, machining and optimization while gaining deeper understanding of the manufacturing concepts involved.

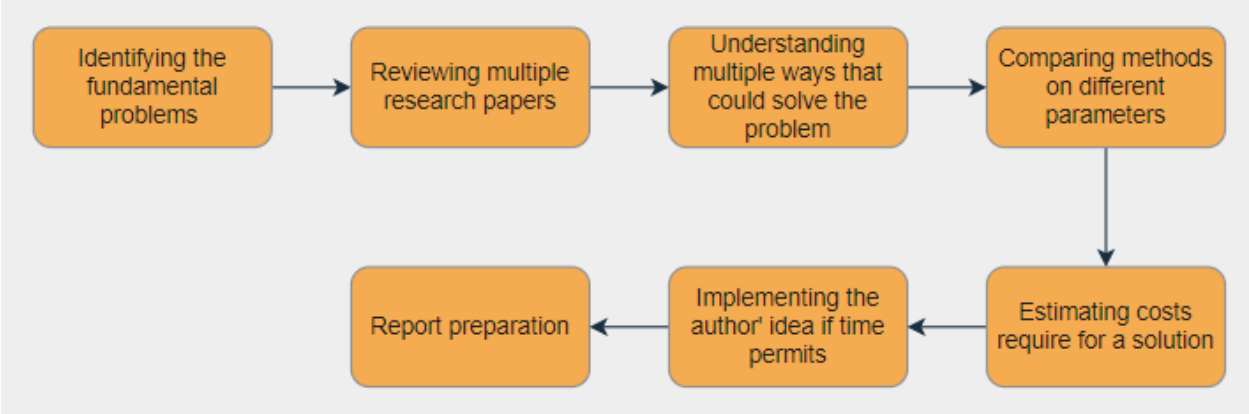
- Understand the various key parameters in machining process
- Review the methods and strategies used to model the network which are based on the machining concepts and analyse how these are more sophisticated for manufacturing field over traditional networks
- Gain insights into how the machining parameters can be tuned for optimal machining productivity
- Evaluate the results from various papers on dependance of machining parameters with that of our understanding of the subject
- Become familiar with the advancements happening in Industry 4.0

Among the available methods, we intend to suggest the best among them based on proper reasoning. Furthermore, we will attempt to point out the possible improvements in the existing methods.

3. Tasks/Plan

- Identify the problems to be solved / can be solved
- Review and understand the methods that can solve the problem
- Review and understand papers
- **Compare the methods (on the basis of effectiveness, accuracy and cost).**
- **Ideate possible improvements or new solutions**
- **Estimate the additional costs required to setup the solution**
- Can implement the novel ideas if time permits
- Preparing a detailed report on the basis of analysis

4. **Chart**



5. **Paper Collection**
   - Review of tool condition monitoring in machining and opportunities for deep learning
   - Remaining Useful Life Prediction using Deep Learning Approaches: A Review
   - A novel transformer-based neural network model for tool wear estimation (iop.org)
   - A Deep Learning Approach for High-Speed Machining Tool Wear Monitoring
   - Optimization of selective laser melting process parameters for Ti-6Al-4V alloy manufacturing using deep learning - ScienceDirect
   - https://link.springer.com/content/pdf/10.1007/s40684-018-0057-y.pdf

Possibly Important content

TCM systems can be divided into hardware and software components. Hardware parts consist of various sensors that collect data such as temperature, vibration, acoustic emissions, and

cutting force. In the software part of a TCM system, several processes such as signal preprocessing, feature extraction, feature selection, and decision-making are applied, as shown in Fig. 1. In a consistent and reliable TCM system, the software and hardware parts must be compatible and interact seamlessly. Hence, the tool life can be maximized, and machine tool failures can be avoided. Therefore, a reliable TCM system plays a crucial role in Industry 4.0

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The amount of data available today in manufacturing has practically reached big data and is of varying forms and from different sources. Very useful insights can be brought from the application of deep learning models on these data sets. These deep models can be fed more than thousands of features and hence we can consider a lot of parameters while optimizing our process. The AI industry has also achieved significant success in training networks on various contrasting modalities (like image, text, audio, etc). This is ideal for its applicability in the manufacturing industry.

2. Objectives

We aim to explore and analyse various deep learning based methods for topics like tool condition monitoring, machining and optimization while gaining deeper understanding of the manufacturing concepts involved.

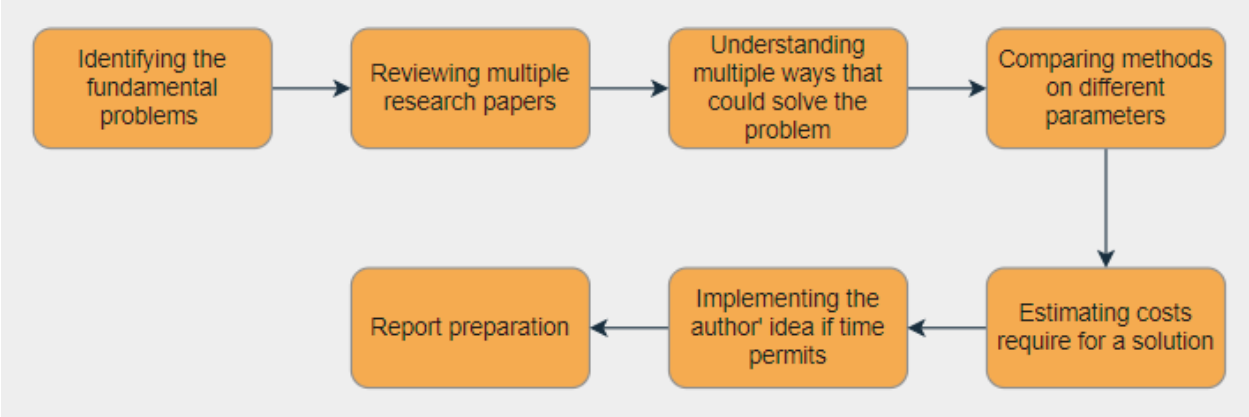
- Understand the various key parameters in the addressed machining processes
- Review the deep learning methods and strategies used for tool condition monitoring, machining and optimization.
- Understand the additional requirements of an architecture for integrating it with the manufacturing pipeline.
- Take note of the hardware setup required for setting up the solutions.
- Among the available methods, we intend to suggest the best among them based on proper reasoning
- Gain insights into how the machining parameters can be tuned for optimal machining productivity
- Evaluate the results from various papers on dependance of machining parameters with that of our understanding of the subject
- Become familiar with the advancements happening in Industry 4.0

3. Tasks/Plan

- Refine/formulate the specific manufacturing problems to be addressed
- Critically analyse and understand the methods that can solve the problem
- Compare the available methods
- Estimate the additional costs required to setup the solutions
- Ideate possible improvements

- Can implement a prototype of the suggested improvements if time permits
- Preparing a detailed report on the basis of analysis

4. Chart



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- *More papers will be added as we read these..*