Research Proposal

Data Science Final Project 2023

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1. [The title of the research proposal]

Lathe Slideway Failure Predicting Mechanism By Analyzing Lathe Slideway Sensor Data Using Apriori Algorithm

2. [Introduction]

A crucial aspect of mechanical manufacturing is metalworking, which relies on machine tools, among which lathes play an important role. One of the key components of lathes is the slideway. Proper functioning of the slideway is essential, as its failure can lead to defective products or, in worse cases, unexpected machine downtime for repairs (Pham Van et al., 2022).

Current maintenance practices are mainly periodical downtime maintenance. However the time period is difficult to determine. Long time period could increase risk of failure and a period too short would waste time and manpower. Unexpected failures leading to capacity loss are costly.

Modern lathes are equipped with various sensors that monitor the slideway, collecting data on temperature, vibration, displacement and so on. The proposal aims to use the Apriori algorithm to analyze these data, identify patterns predictive of slideway failures to prompt the maintenance team to perform timely repairs and maintenance. Implementing the predictive mechanism proposed herein for slideway failure will significantly reduce unexpected failure and the lathe maintenance time and labor costs, thus enhancing productivity.

3. [Literature review]

Maintenance of mechanical equipment requires time, money, and manpower. Unexpected failure can result in even higher costs and risks of delayed product delivery. Therefore, regular maintenance is common practice, but determining the optimal schedule is challenging. Too long intervals increase failure risk, while too short intervals waste resources. This context has led to discussions on Predictive Maintenance (PdM)(Esteban et al., 2022).

In various industries, there are researchers focused on PdM, with data mining being a key component(Chemweno et al., 2016).

For instance, Dong et al. collecting historical gas turbine data and establishing a data mining model based on K-means clustering and discretization for Apriori correlation analysis, it is possible to analyze the internal relationship of variables related to gas turbine vibration values and avoid certain specific working conditions in daily use. In addition, early warning of gas turbine failures can be carried out during operation, and preventive measures can be taken in advance, which has important reference significance in the actual work of a certain type of gas turbine (Dong et al., 2022).

Another study surveyed methods for using lubricant condition monitoring as a basis for maintenance decisions(Wakiru et al., 2019).

This paper, drawing on the above literature, focuses on lathe slideways, using Apriori algorithm to analyze temperature, vibration, and displacement data to establish a predictive mechanism for failures, thus achieving PdM.

4. Research methodology

Current lathe sensors provide data on temperature, vibration, and displacement (*Iot Monitoring Lathe Machine Performance - ScienceDirect*, n.d.) (Bhagat & Nalbalwar, 2016). This study will collect data from factory lathes, using Apriori analysis to correlate these metrics with various types of failures. The aim is to identify specific patterns associated with failures. Upon detection of such patterns in the monitoring data, maintenance staff will be alerted to schedule checks and maintenance promptly.

5. Reference

Bhagat, S. N., & Nalbalwar, S. L. (2016). LabVIEW based tool condition monitoring and control for CNC lathe based on parameter analysis. *2016 IEEE International*

Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT), 1386–1388. https://doi.org/10.1109/RTEICT.2016.7808058

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Dong, X., Yu, Y., & Li, Y. (2022). Gas turbine vibration monitoring based on K-means clustering and apriori correlation analysis. *12th International Conference on Quality, Reliability, Risk, Maintenance, and Safety Engineering (QR2MSE 2022)*, *2022*, 1670–1675. https://doi.org/10.1049/icp.2022.3107

Esteban, A., Zafra, A., & Ventura, S. (2022). Data mining in predictive maintenance systems: A taxonomy and systematic review. *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery*, *12*. https://doi.org/10.1002/widm.1471

Iot monitoring lathe machine performance—ScienceDirect. (n.d.). Retrieved December 30, 2023, from https://www.sciencedirect.com/science/article/pii/S2214785321051592?casa_token=sN_b5FQGGxQAAAAA:FBBEa6IxEnS3NwhuJjZTBEXQlmuwpxZSpUK1oX23qkRsD4wRssfESNYQioYVqMqydrOsI-xMZhh1

Pham Van, H., Nguyen Van, C., & Nguyen Thuy, D. (2022). A Method of Determination of the Remaining Geometrical Accuracy of Lathe Machine Based on the Wear of Slideway. In A.-T. Le, V.-S. Pham, M.-Q. Le, & H.-L. Pham (Eds.), *The AUN/SEED-Net Joint Regional Conference in Transportation, Energy, and Mechanical Manufacturing Engineering* (pp. 851–859). Springer Nature. https://doi.org/10.1007/978-981-19-1968-8_71

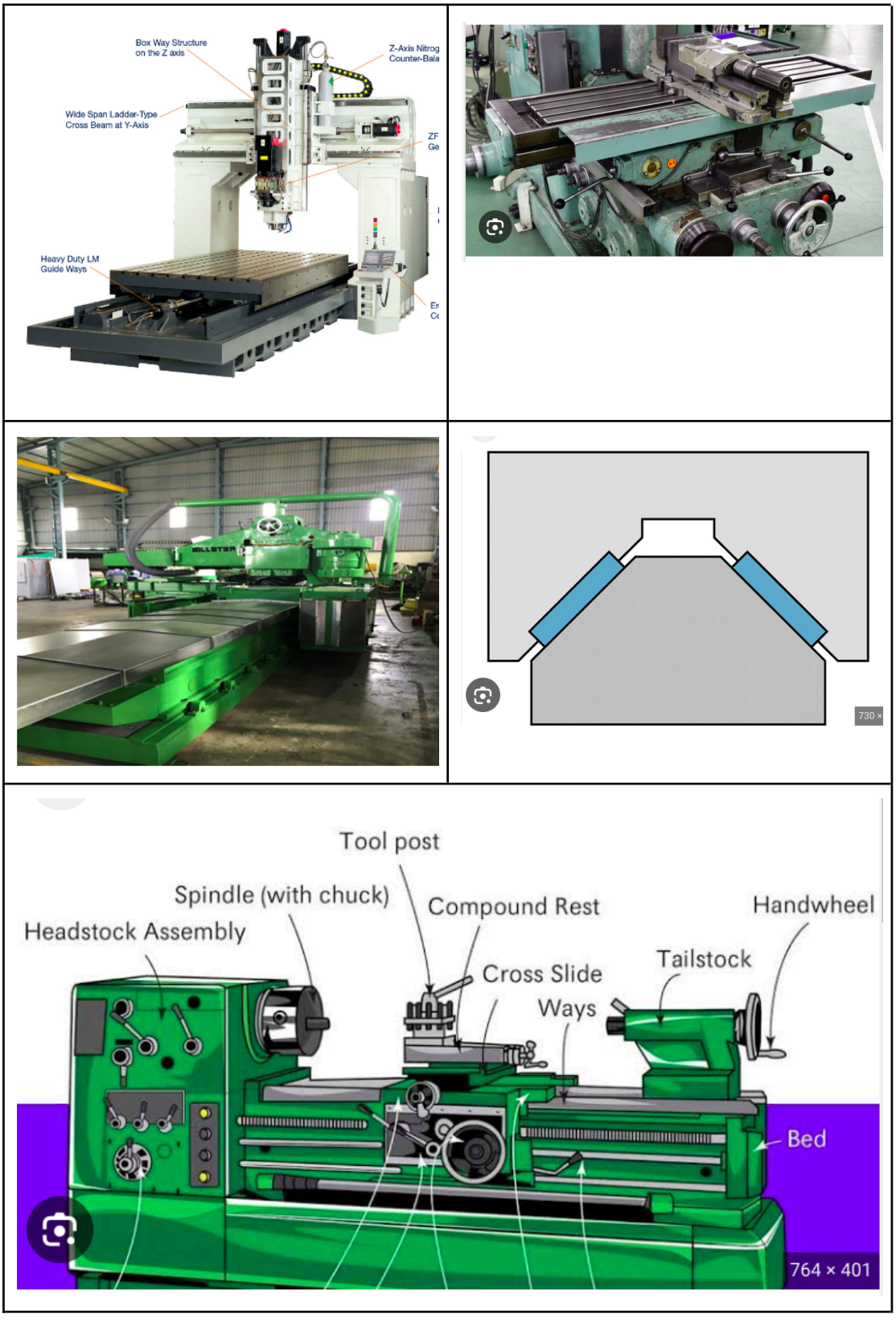
Wakiru, J. M., Pintelon, L., Muchiri, P. N., & Chemweno, P. K. (2019). A review on lubricant condition monitoring information analysis for maintenance decision support. *Mechanical Systems and Signal Processing*, *118*, 108–132. https://doi.org/10.1016/j.ymssp.2018.08.039

Backup Data

Dr. Lee introduced The Application Power by AI-Data Mining and DATA types used in: Smart Healthcare: Smart Manufacturing, FINTECH (Financial Technology)
Inside the 'Smart Manufacturing' there is Smart Maintenance.
used to diagnose prognosis for the failure of machines.

1)(PdM)(Esteban et al., 2022).Tin predictive maintenance systems: A taxonomy and systematic review 評論2015-2021年間在高影響力期刊的132篇文章，驗證了PdM Predictive maintenance是個新興且非常活躍的領域，由於工業4.0範式帶來的監控進步以及預測模型和計算的進步，許多出版物呈指數級增長。 Review of 132 articles in high-impact journals between 2015 and 2021, verifying that PdM Predictive maintenance is an emerging and very active field, with many publications exponentially due to advances in monitoring brought about by the Industry 4.0 paradigm and advances in predictive models and calculations level growth. 問**Ray: 3.3 | Article selection** **提到的criteria C3 and C4 或(C2 criterion). 是什麼樣的內容？**
2)(Chemweno et al., 2016). Chemweno, i-RCAM: Intelligent expert system for root cause analysis in maintenance decision making. 3 years of Thermal Polwer Plans operational Data which follow: 用了兩種關聯規則挖掘算法-Apriori和Predictive Apriori。此外，包含了一個數據標準化的步驟，採用了 ISO 14224 的標準術語和詞彙，用於標準化設備故障描述。然後，將標準化的描述作為輸入，應用於關聯規則挖掘框架，從中提取重要的故障關聯性，並由專家進行相關性驗證。之後，利用提取的故障關聯性生成因果圖，並從圖中識別設備故障的關鍵根本原因。 Two association rule mining algorithms are used - Apriori and Predictive Apriori. The data standardization: adopting the standard terminology and vocabulary of ISO 14224 for standardizing equipment fault descriptions. Then, standardized descriptions are taken as input and applied to an association rule mining framework, Important fault correlations are extracted and correlation verified by experts. The extracted fault correlations are then used to generate a cause-and-effect diagram and identify key root causes of equipment failures from the diagram.
3) gas turbine (Dong et al., 2022).Gas turbine vibration monitoring based on K-means clustering and apriori correlation analysis
4) (Wakiru et al., 2019).

(2019). A review on lubricant condition monitoring information analysis for maintenance decision support.



Signal: temperature, vibration, and displacement

	Predictive apriori rules (Number of rules = 100)
1	If {Component = Lubricant piping} => {Failure mode = ELU ⋂ Component = Turbocharger} (acc: 0.9667)
2	If {Failure Mode = ELU ⋂ Component = Turbocharger} => {Failure mode = ELU} (acc: 0.9462)
3	If {Failure mode = ELU} => {Component = Turbocharger } (acc: 0.92)
4	If {Failure mode = ELU ⋂ Component = Turbocharger} => {Failure mode = ELU} (acc: 0.89)
5	If {Component = Fuel piping} => {Failure mode = ELF ⋂ Component = Turbocharger} (acc:0.86)