CS 401 / Phys 511

Procter & Gamble — Servo Motor Anomaly Detection Project Proposal

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Abstract

The problem proposed by Procter & Gamble is to model the failure of a diaper manufacturing process focusing specifically on the process steps controlled by servo motors. The failure of servo motors disrupts the process steps and can damage the product. Many models of failure predictions methods have been proposed based on time series data from mechanical components. We will specifically look at models using a long short term memory framework (LSTM) as this has proven to be a successful and flexible framework for time series event prediction [1, 2].

1 Introduction

Factory machine failure prediction is important because machine failure interrupts factory processes and reduces the quality of the products produced by the factory. Planned maintenance prevents these problems. This motivates the need for failure predictions of machines to know when to fix them [1].

2 Background

One of the key problems in predictive maintenance is the prediction of equipment failures early enough so that the proper maintenance can be scheduled before the failure happens. This problem is posed in two ways: (i) Remaining Useful Life (RUL) estimation which estimates how much time is left in the useful life of the equipment, and (ii) Failure Prediction (FP) which estimates the probability that a failure is going to happen within a typically short time horizon. From a maintenance process perspective, RUL estimation is very useful for long-term planning of spare parts supply and maintenance scheduling. On the other hand, failure prediction is more useful for handling unexpected failures that might happen in a short time-span. In the literature, a number of techniques have been used for the RUL estimation and failure prediction, mostly utilizing the temporal models using time-series analysis, explicit degradation modeling, hidden Markov models, and deep learning methods recently [1].

3 Project Description

Given time series of servo motor performance data and other tags from several diaper converting lines for 100 servo motors/line and associated quality tags and/or reject events over a given time frame, create an algorithm that will alert machine operators which servo motors are most likely to fail next and when. The time series data may be high frequency data (sampled every several milliseconds over seconds or minutes) and/or low frequency data (samples collected on a one-minute frequency over months). The number of tags will be in the range of 500-1000. If motor failure frequency is too low to be detectable, an alternative approach may be to correlate position variability of diaper features (position of fastening tabs, absorbent core, taping panel, etc. in the finished product) to motor variables. Other unique insights gained by students from analyzing the data, for example if certain servo motors tend to be more variable, or certain lines have a greater number of poor-performing servo motors compared with other lines, would be of interest.

3.1 Project Deliverable

The end deliverable of the project will consist of a LSTM model which successfully predicts when a component will fail within a reasonable time to replace the soon-to-fail component (reasonable time would be determined by P&G). A prediction metric that we would consider successful would be having an overall accuracy of 75% (This could be revised upon familiarization with the data). Another potential deliverable, should we have time to implement it, would consist of another LSTM which predicts the remaining lifetime of each component. A good success metric would be to predict remaining useful lifetime of a component with an accuracy of 70%. Prediction or remaining useful lifetime is a more difficult problem than simple failure classification, hence the lower accuracy expectation.

3.1.1 Proposed Technology

- Python Language, Pytorch, Jupyter Notebook
- BYU Super Computer

3.2 Tasks and Time Plan

Given this is semester project, the time scale and items may change

- Week 1 - Data Cleaning / Building Framework for LSTM
- Week 2 - Building Framework for LSTM
- Week 3 - Train model on supercomputer
- Week 4 - Train model on supercomputer
- Week 5 - Tune Hyperparameters
- Week 6 - Tune Hyperparameters
- Week 7 - Make poster and final write up

4 References

References

[1] K. Aggarwal, O. Atan, A. K. Farahat, C. Zhang, K. Ristovski, and C. Gupta, "Two birds with one network: Unifying failure event prediction and time-to-failure modeling," *CoRR*, vol. abs/1812.07142, 2018. [Online]. Available: http://arxiv.org/abs/1812.07142

[2] M. Hajiaghayi and E. Vahedi, "Code failure prediction and pattern extraction using LSTM networks," *CoRR*, vol. abs/1812.05237, 2018. [Online]. Available: http://arxiv.org/abs/1812.05237