**Procter & Gamble/BYU Data Science Capstone Project Proposal**

**Servo Motor Anomaly Detection**

**September 19, 2019**

**Background**

A diaper manufacturing process is comprised of several sequential process steps and associated equipment components each of which are controlled based on several factors. The setpoints for these factors and their variation have effects on the reliability of the process and the quality of the product produced by it.

One set of components common to several process steps are **servo motors** that are used to control the speed of rollers and other process equipment. These motors are used to control the position and velocity of mechanical equipment such as rollers or rotary knives.

When motors wear out, or the mechanical drive systems connected to the motors fail due to wear or damage, diaper defects can be generated when product components shift from target position and machine stops due to motors exceeding control limits occur. Performance data of these motors as well as in-process product quality measures are collected and stored. These data can be used to detect abnormal performance early enough to prevent machine stops, quality degradation or scrap from rejected defective products. Intelligent prognostics and condition-based maintenance are research fields related to this goal.1,2 In fiscal year 2018/19, P&G Baby Care spent 3.14 million dollars on drive-related maintenance and repair. Of this, 1.2 million dollars was related to servo motors, with the remainder related to gearboxes, pulleys, couplings, bearings, belts, and shafts. There were 580 motor replacements during the year.

Additionally, 6 million dollars were spent on conveyor maintenance and repair, of which the majority was related to conveyor belts. In total some % of 9 million dollars annually could be saved through preventing premature failures and there would be other savings associated with downtime and quality-related defects from part failures.

**Problem Statement**

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.

The main goal is to discover patterns in data that predict failures and reduce these failures by at least 50%, i.e. to develop one or more anomaly detection algorithms for servo motors that could be used to predict in advance issues and to prescribe actions that would prevent the failure.

How we will measure progress will include:

1. Defining which servo motors are the most variable in terms of torque, position error, position, encoder temperature, and velocity.
2. Finding and characterizing time series patterns that are abnormal in the context of the total time series for any of the five tags for each servo motor.
3. If motor failure frequency is too low to be detectable, an alternative approach will be to correlate position variability of diaper features (position of fastening tabs, absorbent core, taping panel, etc. in the finished product) to motor variables.
4. The dataset may include data from multiple manufacturing lines. Another lead measure for this dataset would be to define which lines are more variable or have more anomalous events and which are the most stable.

**Principal Investigator:** Steve Lange

**References**

1Jay Lee, Jun Ni, Dragan Djurdjanovic, Hai Qiu, Haitao Liao

Intelligent prognostics tools and e-maintenance, Computers in Industry, Volume 57, Issue 6, 2006,

Pages 476-489, ISSN 0166-3615, <https://doi.org/10.1016/j.compind.2006.02.014>.

2Yam, RCM; Tse, PW; Li, L; Tu, P

Intelligent predictive decision support system for condition-based maintenance

INTERNATIONAL JOURNAL OF ADVANCED MANUFACTURING TECHNOLOGY Volume: 17 Issue: 5, Pages: 383-391, DOI: 10.1007/s001700170173, Published: 2001