An alternative approach to conventional methods of belt wear modelling and forecasting

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Virtual - Researchers Catch-up

Unplanned failure of the belt on a critical conveyor can have catastrophic repercussions for production. Even a planned belt change requires a large amount of time and resources. Therefore, understanding how a belt is wearing is critical.

Maintainers use ultrasonic thickness (UT) measurements across the width of the belt to monitor its thickness and then forecast when the minimum belt thickness reaches a threshold that indicates a soft failure. This information informs maintenance decisions about when the belt should be replaced.

Many UT measurements are taken across the width of the belt at a given measurement time. Current approaches for predicting soft failures rely on summary statistics such as the mean or minimum of the UT samples at each time. However, summarising the data in such a way discards important spatial information that describes the wear patterns of the belt. In addition, disregarding the spatial structure in the data can lead to a loss in the detail and preciseness of the forecast.

In this work, we consider an alternative approach to conventional methods of belt wear modelling and forecasting. We assume that all UT measurements come from an underlying smooth curve that describes the wear profile across the width of the belt at a given time. Such an approach is known as functional data analysis (FDA). FDA reduces the dimensionality of the data but preserves the spatial structure of the UT measurements. We then model how the underlying latent function, the wear profile, evolves through time to produce a forecast. The functional interpretation of the UT measurements lends itself well to a Bayesian hierarchical modelling framework, similar to what is seen in spatio-temporal statistics. To model the evolution of the wear profile over time, we use spatially correlated Gamma processes. The Gamma process has a principled grounding in degradation modelling and a convenient interpretation for belt wear. Furthermore, a random spatial effect within the Gamma processes accounts for the spatial dependence structure in the UT measurements.

The posited Bayesian hierarchical model provides a far more interpretable and information-rich forecast on which to base maintenance decisions. Furthermore, since the prediction correctly quantifies uncertainty at all points along the width of the belt, it explicitly decomposes the uncertainty therefore making the forecast more informative and usable.