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METHOD FOR USING SERVO DATA TO ANTICIPATE COMPONENT FAILURE IN MECHANICAL DRIVE SYSTEMS

HP INC

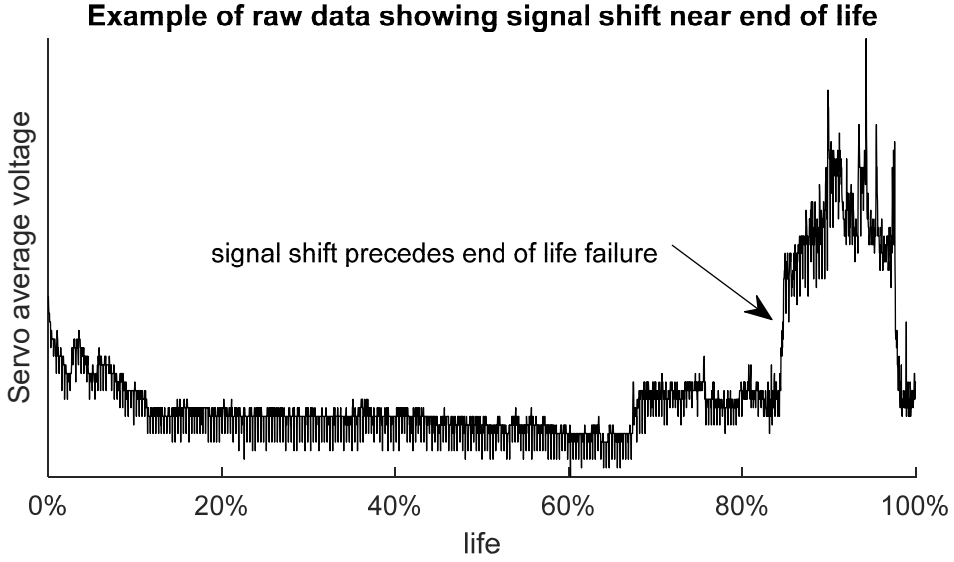
Method for using servo data to anticipate component failure in mechanical drive systems

Abstract

Performance data from a servo controller can be monitored over time to detect possible component wear out. Changes in the servo performance can indicate that performance of a component in the system has changed and may be nearing the end of its life. Algorithms can be created to detect these signals in the data.

When servo feedback is used to control a mechanism, the servo controller can report data about servo performance, such as statistics based on required voltage (i.e. control effort) like average and variance, ability to achieve commanded position and velocities, and system backlash. In a system like a printer where the operating conditions do not change significantly over time, these data can be monitored for anomalies. Anomalies, or shifts in the data trends, can indicate that performance of a component in the system has changed and may be nearing the end of its life. In some cases, this information can be used for prediction and provide advanced warning before a component fails.

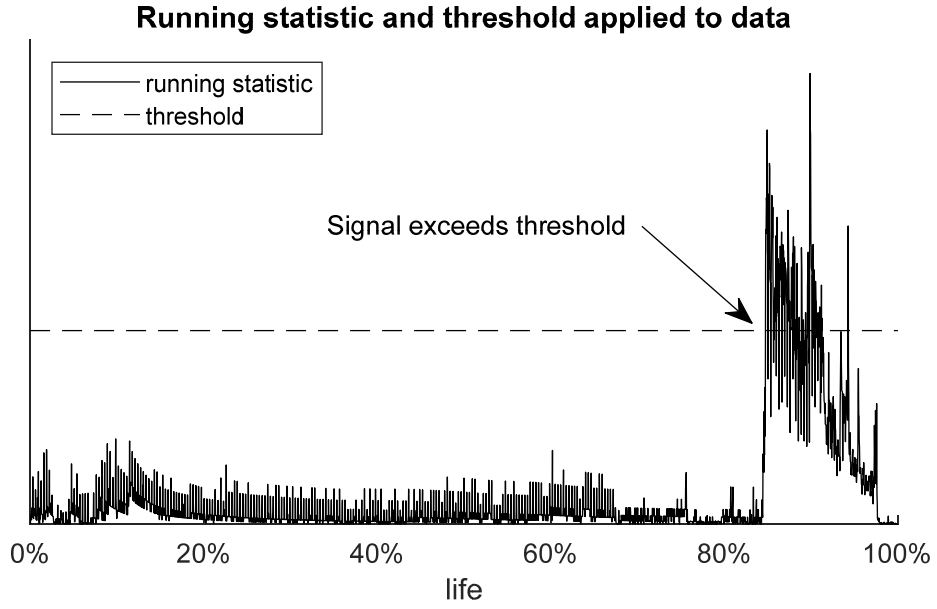
The graph below shows an example of average voltage required to maintain a servo velocity (controlled with pulse width modulation) on a test unit that was run to failure. The data show a visible change at about 85% of life preceding component failure. In this case, the signal shift corresponded to brush wear out in the motor, but other wear components such as bearings, belts, and gears can show similar signals.



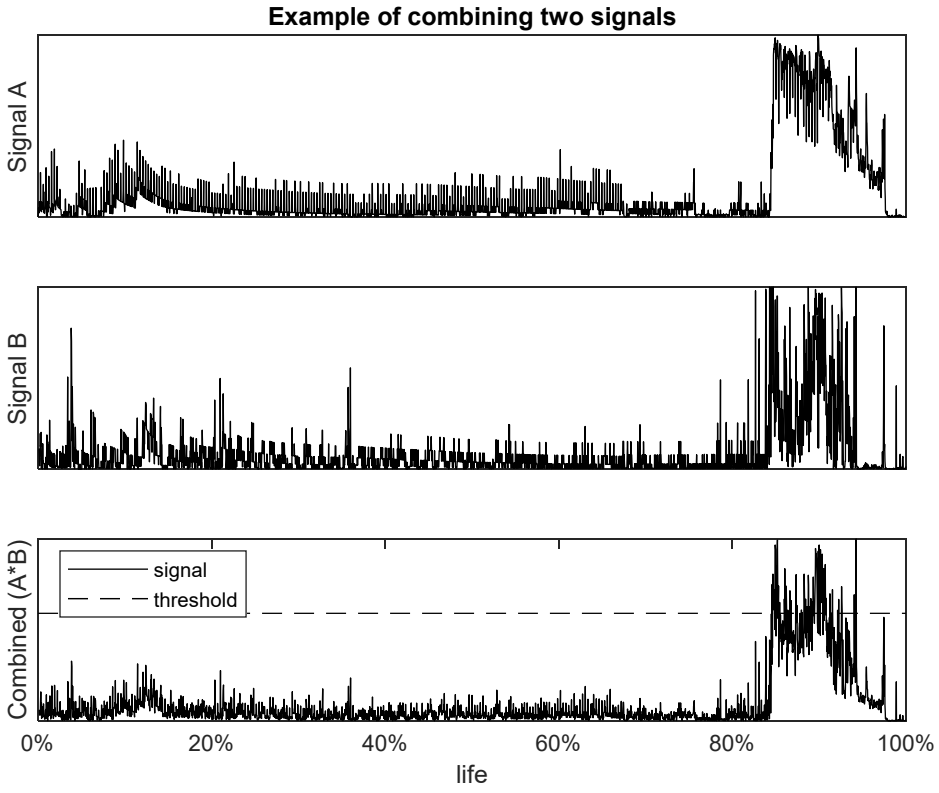
There are a variety of possible algorithms that can be used to identify a signal shift. One simple option is to compute a running statistic that is a comparison of each new data point to the mean and variance of all the data up to that point:

$$running\ statistic = \left(\frac{x - \bar{x}}{\sigma}\right)^2$$

This type of running statistic can then be compared to some predetermined threshold, and if the threshold is exceeded then the data may signal that a failure will occur soon. Below is an example of applying this technique to the data from above:



This analysis can be done on different types of servo data (average voltage, position error, measured backlash, etc.), and the results can be combined to create an indicator that responds to multiple signals that might come from different failure modes. The graph below shows an example of one way to combine such signals.



In this case, Signal A is derived from the average servo voltage and Signal B is from the standard deviation. Combining the two signals with multiplication produces a resulting signal that more cleanly identifies the shift near end of life.

Disclosed by Devin Scott Uehling, HP Inc.