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Real time furnace froth state detection using Hidden Markov Models

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ABSTRACT

In this dissertation the feasibility of developing a soft sensor utilising Hidden Markov Models (HMM) was evaluated. Specifically, this methodology was tested for use as a soft sensor to detect furnace froths in a real time environment.

Initially, a review of Hidden Markov Models was undertaken to gain an understanding of the mathematics and algorithms associated with HMM's. A simple HMM example was constructed to highlight practical problems associated with HMM's. One such problem identified was that HMM's are unsuitable for real time use without modification.

Potential modifications were then researched to improve the real time performance of the HMM. This research yielded a real time variant of the HMM Viterbi algorithm, labelled Real Time Viterbi (RTV), as a potential modification. In addition a new hybrid algorithm, labelled the Hidden Markov Model Fixed State Test (HMM FST), was developed by the Author.
Comparative studies of the respective real time performances of the RTV and HMM FST algorithms concluded that the HMM FST algorithm was the most suitable for use in the real world application.

A final HMM FST real time algorithm was developed which incorporated the use of K-Means Clustering techniques. Data files, consisting of electrode positions from real furnace froths, were then replayed into the HMM FST algorithm to evaluate its performance. Four scenarios, incorporating different HMM FST tuning parameters, were then executed to determine the impact of the model parameters on its froth detection ability and false positive response. A final tuning set was recommended for the HMM FST Furnace Froth Detector.

This research proved that this approach can be used as a practical soft sensor to detect furnace froths in electric arc furnaces with any structural or electrode configuration. The HMM FST model could be tuned to various levels of sensitivity and was found to generate low false positives due to its treatment of plant sensors as a collective.