CHAPTER 6

FUTURE WORK

In this work, it has been described how an automatic condition monitoring system could be implemented. However, there are still interesting aspects, which have not been investigated. This chapter considers these aspects, and how they might be investigated in future work.

6.1 Threshold for DMD algorithm decision functions

In appendix C, the DMD algorithm is applied on all feature signals from all experiments. In the DMD plots, a threshold for the decision function is plotted. This threshold is equal to 20 times a_{sub}. The change detection system seems to be reliable with this threshold, i.e. when a change is present, the DMD algorithm detects the change, and when no change is present, the DMD algorithm does not detect a change. However, some optimization of the threshold is needed. It could be interesting to investigate whether a proportionality factor different from 20 exists that improves the reliability of the DMD algorithm. Knowledge about the relation between a_{sub} and the threshold will also make it easier to implement an adaptive threshold update method by means of the off-line hypothesis test.

6.2 Other re-sampling methods

As mentioned in chapter 2, the re-sampling methods investigated in this work do not produce adequate signals. Since a single test on the test engine is very time consuming, it could be interesting to develop other re-sampling methods. One of the new methods could be a modification of method no. 5, where the mixer-function is replaced by another mixer function. Another method is to mix the four sensor signals, by normalizing them and then mixing them with a specific “mixer rule”. In this method it might be a good idea to collect the sensors in two groups, sensor no. 1 and no. 3, and sensor no. 2 and no. 4, since these two groups are quite different from each other.

6.3 Gradient based change point 2 detection

In this work the detection of the second change point by the DMD algorithm has not been prioritized. It has been mentioned that the peak of the decision function, to some length, corresponds to the second change point. Therefore, it could be interesting to implement a gradient based detection of the second change point, since the gradient of the decision function is zero at the peak maximum value of the decision function. This might not be an easy task, since the decision function usually contains points different from the peak maximum value, where the gradient also is zero

6.4 Optimization of DMD parameters

The DMD algorithm must be fast in this work according to the project specification. The speed of the algorithm depends on the algorithm parameters, and the smaller they are, the faster the algorithm is, but if they are too small, then the performance of the algorithm will decrease. Therefore, optimization of the parameters is needed. Also the boost function

parameters must be investigated further, to get a better understanding of their influence on the DMD algorithm.

6.5 Improvement of the off-line hypothesis test

Only a single re-sampled experiment has been tested, and here it was confirmed that a critical value for the log-likelihood ratios in the two change cases could be determined by means of ROC curves. But is this also the case with the other experiments, and can the same critical values be applied? This must also be investigated.

It could also be interesting to perform the off-line hypothesis test on the sub-feature signals, since they are cleaner than the real feature signals.

At this point the off-line hypothesis test states whether or not the feature signal has changed condition. The off-line hypothesis test assumes that the feature signal, which has to be tested, consists of a normal condition and a new condition. If the feature signal changes abrupt and thereafter goes back to its normal condition, then the change will quite probably not be confirmed by the off-line hypothesis test. Therefore, it is necessary to improve the off-line hypothesis test so it can handle these - and similar situations.

6.6 Improvement of the performance of the off-line change point estimation

Two maximum likelihood methods have been implemented, but neither of them works adequate. However, if they are combined, they are getting better to estimate both change points. But still, it is not good enough, and therefore the methods must be modified. The main problem might be the assumptions, which in several cases are not correct.

6.7 Implementation of a panel of experts

In this work a panel of experts has not been implemented. But this is necessary in order to compress the multiple statements on the engine condition down to a single statement. Unfortunately, the risk of fitting the expert panel too much to this data set is high, since the number of changes and sensors are relatively low.

6.8 Selection of cycle areas

It must also be investigated how hand tuned cycle areas influence the system performance. Perhaps the feature signals will be cleaner, but it might not be possible to detect the unstable region. This must be investigated together with the choice of areas. If more knowledge is gained about the engine, then it might be easier to select the areas.

6.9 Interface the modules

Finally, the modules described in the work must be interfaced as described in chapter 5 in order to prepare it for real application.