Tidal turbine condition monitoring

Cranfield UNIVERSITY

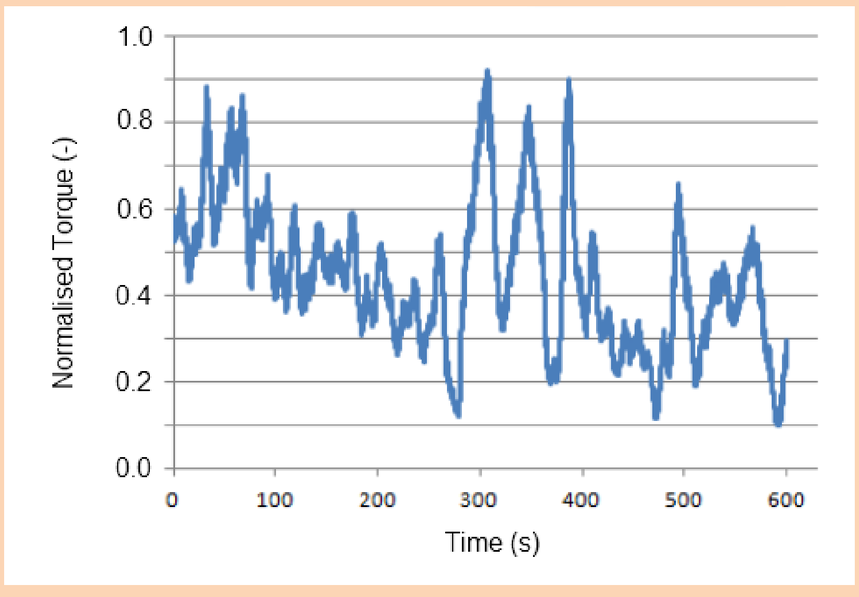
Introduction

Tidal power exploitation is relatively new. In order to ensure feasible commercial application, the appropriate design of condition monitoring systems will be crucial.

There is a considerable body of work relating to the condition monitoring of wind turbines. Some methodologies are transferrable but tidal turbines have specific characteristics, of which the medium is one, that require a specialised approach.

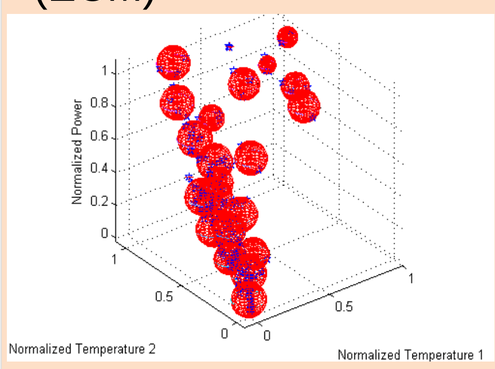
Cranfield University has a long experience in condition monitoring techniques for various mechanical components, many of which can potentially be applied to the tidal energy field.

Tidal turbine components are subject to a range of transient loadings characterized by large varying temporal and spatial scales.



The “ultimate fatigue test rig”

A promising methodology is the Evolving Clustering method (ECM)

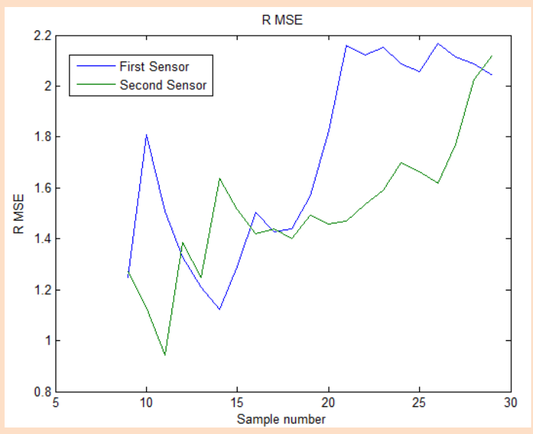


Example of cluster creation in 3-D

$$D_{im} = \left\| X_{N-training}(i) - Cc_m \right\| = \min_l \left(\left\| X_{N-training}(i) - Cc_l \right\| \right)$$

$$MSE(p) = \frac{\sum_{i=1}^{n} (X_N(i,p) - \hat{X}_N(i,p))^2}{n}$$

$$R\_MSE(j) = \sqrt{\frac{MSE_{monitoring}(j)}{MSE_{training}(j)}}$$



Relative Mean Square Error plot with 2 sensors

Methodology proposed

- Review current diagnostic and prognostic algorithms used for multivariate data analysis of machinery

- Assessment of applicability of current multivariate diagnostic and prognostic algorithm for tidal stream turbine

- Assess algorithm validity for steady as well as transient operational conditions

- Develop diagnostic and prognostic algorithms based on multivariate data input and turbine transmission design

- Use experimental data to validate and optimise algorithm developed

- Propose a control operation envelop based on diagnostic and prognostic output

Tidal turbine condition monitoring challenges

- High axial load
- Rapid torque variation
- Potentially difficult to access remote sites
- Need for planned maintenance
- Only few units deployed on-site, limited feedback

Contributions

- Selection of a robust diagnostic and prognostic methodology applicable for tidal stream turbines

- Life fatigue analysis

- Condition monitoring with transient effects taken into account