

Designed experiments for semi-parametric models and functional data with a case-study in Tribology

David C. Woods^{†*}, Christopher J. Marley and Susan M. Lewis
University of Southampton, Southampton, UK
[†]D.Woods@southampton.ac.uk

Experiments with functional data are becoming ubiquitous in science and engineering with the increasing use of online monitoring and measurement. Each run of the experiment results in the observation of data points that are realised from a smooth curve. Although large quantities of data may be collected from each run, it may still only be possible to perform small experiments with a limited number of runs. We describe statistical methodology for an example from Tribology, concerning the wear-testing of automotive lubricants. Here, we investigated how lubricant properties and process variables affected the shape of a functional response measuring wear. Novel techniques were developed for the initial design of a screening study where the levels of some of the factors could not be set directly. A two-stage semi-parametric modelling approach was applied, using a varying coefficient model and principal components. New methods for the design of follow-up experiments for such models were also developed and applied. In addition to the new methodology, we present conclusions from the case study about which factors had substantial effects, and how they influenced the shape of the wear curves.

Key Words: Hierarchical modelling, optimal design, principal components, screening experiments.