Modelling three-dimensional surfaces in *R*

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Flexible methods of regression, such as those offered by splines, provide invaluable tools for the exploration and modelling of data (Eilers and Marx (1996), Wood (2006)). Covariate terms involving two or three variables simultaneously arise naturally in a wide variety of contexts, with spatiotemporal data a particular example. While the construction of estimates is relatively straightforward, it is also important to be able to explore the nature of the covariate effect, the evidence for its presence in the model and the dependence on model complexity (expressed in smoothing parameters). Some computational and visualisation tools for doing this, based on p-splines and on interactive three-dimensional graphics, will be described.

However, flexible surfaces can arise in other settings such as imaging, where techniques such as stereo-photogrammetry create high-resolution representations of object surfaces. A particular application to the analysis of human facial data will be described. Here the medical and biological questions of interest, such as the effects of facial surgery or the differences between cases and controls, require the analysis of surface shape. A variety of issues arise, such as how to identify key anatomical features from high-resolution point-cloud data, how to represent facial shape in a standardised, anatomically meaningful form, and how to analyse these representations in a statistical model. The ideas of statistical shape analysis (Dryden and Mardia (1998)) are central but there are many issues to be addressed in extending standard tools for point data to curve and surface data.

A final form of three-dimensional surface data returns to the regression setting, where measurements of electrical signal from the brain are recorded on the surface of the head, particularly through MEG (magnetoencephalography) equipment. Flexible forms of regression, plus informative visualisation, are again able to give considerable insight into the patterns of brain response to stimulus.

These topics and applications will all be discussed in the context of *R* software. In particular for visualisation, the **rpanel** (Bowman et al. (2007), Bowman et al. (2010)) package provides a very simple route to the addition of interactive controls while the **rgl** (Murdoch (2001), Adler and Murdoch (2011)) package provides invaluable tools for three-dimensional visualisation.

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