Functional data analysis of three-dimensional surface data

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Abstract

The advent of high-resolution imaging has made surface shape data widespread. Methods for the analysis of shapes based on points (landmarks) are well established, but high-resolution data require a functional approach.

First, a systematic and consistent description of each surface shape (using landmarks, curves (semi-landmarks), and surface patches (semi-landmarks)) and a method of automatic identification of this using penalised regression models with constraints and conditions are described. Second, the registration of curves and surfaces in functional form is discussed. Then the functional principal component (PC) analysis of curves and surfaces and PC subspaces where interesting behaviour, such as population differences, is exhibited (rather than on individual PCs), are presented. Finally, functional regression models of curves and surfaces are defined.

All these ideas are developed and illustrated in the important context of the human facial shape of healthy individuals, patients before and after orthognathic surgery, or patients with psychotic or other disorders and controls, with a strong emphasis on effective visual communication of effects of interest. All the methods presented here are implemented in R as part of the development of the face3d package.

Keywords

Curves, Surfaces, Automatic identification, Penalised regression models, Functional registration, Functional principal component analysis, Functional regression, Human face.

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