## MULTIDIMENSIONAL P-SPLINE MIXED MODELS: A COMPUTATIONAL EFFICIENT METHOD

 $\underline{M}$  Durbán<sup>†1</sup>, I. Currie<sup>2</sup>, P.H.C. Eilers<sup>3</sup>

<sup>1</sup>Universidad Carlos III de Madrid, Spain; <sup>2</sup>Heriot-Watt University, Edinburgh, UK; <sup>3</sup>Leiden University Medical Center, Leiden, The Nederlands

<sup>†</sup>E-mail: *mdurban@est-econ.uc3m.es* 

We present a mixed model representation of multidimensional P-splines with B-spline basis for data with an array structure. The method is based on the singular value decomposition of the penalty which allow us to split the penalty into a null penalty (the fixed part) and a diagonal penalty (the random part). This decomposition results in a new basis which enables us to decompose a surface into a an additive plus a non-additive (interaction) component. This method allows us to have a different penalty in each direction of the array, avoiding the restrictions imposed by smoothing methods that require an isotropic penalty. We have developed an arithmetic of arrays which leads to low storage, high speed computation of the residual maximum likelihood for estimation of variance parameters and the estimates of fixed and random effects as a sequence of nested operations. The method extends easily to the generalized linear mixed model context. We illustrate our methods with examples of mortality data indexed by age and year of deaths and a particular application on multivariate density estimation.