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POD-RBF network approximation for identification of material coefficients of human pelvic bone tissues

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ABSTRACT

Pelvic joint is one of most important human supporting element. Knowledge of stress and strain distribution within such structures can significantly improve the process of diagnosis and/or result of future surgery. However, as *in vivo* strain and stress measurements cannot, so far be executed, the idea of numerical modeling arises in natural way.

To use this option, reliable data concerning the applied loads, material properties and geometry are required. Using specialized software the geometry of the bone can be retrieved from *in vivo* CT examinations [1]. The load cases to be analyzed depend on the specific situation [2]. Assuming linear elastic behavior of the bones, strain and stress distribution can be determined when Young modulus and Poisson's ratio are known.

Papers [3-6] deal with a problem of material properties identification for human pelvic bone based on genetic algorithms using the principle of best fit between the FEM model and measured displacements. This kind of problem belong to the wide class of inverse analysis, and as such is by nature ill conditioned. The aim of the present work is to apply the POD-RBF network model [7-9] to the solution of the same problem. The advantage of the POD-RBF approach lies in its strong regularizing property, which is desired feature of any inverse problem solver.

PD-RBF network model. The idea behind this approach is to detect the correlations between the response of an object excited by a sequence of input data vectors (here material coefficients and loads). The result is an expansion of the output into a generalized Fourier series with empirically evaluated eigenfunctions. Optimal approximation properties of the eigenfunctions allow to truncate the expansion after first few terms. As result an accurate model of reduced dimensionality is build.

Model and geometry of bone tissue. The FEM model of analyzed bone tissue was build. The geometrical data were obtained by scanning of the human pelvic bone by coordinate measuring machine.

Resulting geometrical measurements were then translated into MSC Patran/Nastran environment by means of in-house code and discretized using standard numerical mesher. Layer structure of bone tissue has been accounted for in both cortical and trabecular bone tissue. For a set of material properties structural FEM analysis was performed. The resulting displacement vectors were then used to train the POD-RBF model of the analyzed pelvic bone.

Inverse analysis. The identification of sought for coefficients was performed resorting to the minimization of discrepancy between the measured and computed displacements at a predefined set of points. Electronic Speckle Pattern Interferometry (ESPI) was used to measure the displacements resulting from known applied loads. POD-RBF technique was applied to evaluate the displacements.

Results. Several test cases are presented. The retrieved coefficients (Young modulus and Poisson number) are compared with the experimental data. Good accuracy is observed.

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