Project summary

For the proper product design optimal material selection is very significant, whereby special attention should be paid to the behavior of materials under actual conditions of use.
In order to enhance and improve product features, increasing attention is paid to enhancing the properties of conventional and, especially the development of innovative materials and creating conditions for their technical applications. Although the materials research is still to a large extent focused on metallic, polymeric materials, glass, ceramics, composites, etc.., increasing interest is devoted to the study of the biological and the like materials with excellent properties and behavior under different conditions and loads. Many biological systems have mechanical characteristics that are greatly above those that can be achieved using conventional and synthetic materials, so mechanical properties and behavior of materials present in, for example, clams, mussels, bone, spider silk, the muscles and the like are intensely studied.
The behavior of the biological material is very complex, but, as well as modeling of the conventional material it is based on the knowledge of their mechanical properties, such as the interdependence between the stress and strain of the material. Some of these characteristics may be determined by experimental methods such as tensile loading of samples to their cracking.
In addition to knowledge of mathematical and material model which can be well described by the aforementioned interdependence, a basic prerequisite for modeling the behavior of biological materials, is certainly the identification of their parameters, based on physical laws that apply to them.
Due to the complexity of the model of biological materials and a large number of material parameters that appear in them, conventional calculation methods are not sufficient for their determination. In preliminary studies, it was found that for the identification of parameters of biological materials needed for modeling and simulation of their behavior, it is advisable to apply the evolutionary methods, especially genetic algorithm.

Within the project, for the characterization and modeling of biological materials, the data obtained through experimental testing of samples of cervical ligaments of the human spine will be used. Hyperelastic material model that can be used for both compressible and incompressible materials was selected as appropriate. In order to more efficiently obtain the precise values of the parameters for the proposed nonlinear hyperelastic material model techniques for determining the parameters of material behavior based on genetic algorithm will be developed. In order to develop the best genetic algorithm and to optimize it for the given material or group of materials, and to achieve desired solutions as soon as possible, complex genetic algorithm procedures and its operators, will be developed applying the appropriate objective function for the optimization procedure. The procedure will be automated by using the appropriate mathematical and numerical methods.

The proposed methodology of material characterization, has so far proved to be very applicable for parameters identification of material with different microstructure and mechanical properties. It is expected that because of its flexibility and robustness, besides for the modeling of the biological material it can be applied to characterize the behavior and other non-conventional and innovative materials of complex behavior. For this purpose, collection and systematization of relevant results of experimental tests of advanced types of materials and information on the methodology and material models is foreseen and planned. This will create the basis and foundation for the further improvement of the developed solutions and the creation of a unified methodology for the characterization of a large number of innovative materials and facilitate their application in engineering practice.

This project proposes setting innovative foundations in the interdisciplinary field of engineering sciences and biomedicine, allows the connection of members of the proposed scientific groups and ensures their international visibility and contributes to the overall development of the field of material research in Croatia.