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INVESTMENTS IN EDUCATION DEVELOPMENT

Mathematical modeling of intraorgan circulation

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Mathematical modeling of blood circulation in the intraorgan vasculatures is important for better understanding the role of hemodynamical factors in development of the vascular pathology and diagnostics of severity of aneurisms/stenoses and other impairments. Due to complexity of the system (>1000 vessels) direct numerical computations on the whole tree are time consuming. Recently several approaches based on combination of patient-specific 3D model of larger vessels with 1D/0D models of smaller vessels have been proposed, but they also do not allow real-time computations. Here the results of numerical simulations on a combination of viscoelastic 3D geometry with axisymmetric wave propagation model in the branching system of smaller arteries are presented. It is shown the structured tree approach describes correctly wave propagation and reflection in the vasculature. Theoretical results are compared to in vivo measurements on human kidneys with/without stenoses of renal arteries. A possibility of non-invasive in silico assessment of severity of renal artery stenosis is substantiated.

Linear and nonlinear models for diagnostic analysis of postural sway in human

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Posturography remains one of the simplest and informative tools for examination of human biomechanics and early diagnostics of skeletal, muscular, neural, visual and other pathology. The results of the posturographic tests are time series of the center of pressure coordinates {X(t),Y(t)} oscillations. The linearized 3-link inverted pendulum model of human body is usually used for data analysis and interpretation. Here the non-linear n-link model with feedback control over displacement of its links due to nervous regulation is presented. Validation of the model is done on the posturographic data measured on a group of young healthy volunteers and patients with different locomotory and nervous diseases. Characteristic patterns of Y(X) curves at different 2-leg and 1-leg postures with open/closed eyes proper to osteochondrosis, arthrosis, injury and pain are revealed. Transition from regular to chaotic dynamics while disease is progressing has been detected by the largest Lyapunov exponent and fractal dimension technique. It is shown the time delay in the control function corresponds to severity of neural disease (Parkinson's, stroke, age-related sclerosis).

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