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MULTISCALE SIMULTATIONS OF TRANSPORT PROCESSES IN HUMAN ORGANISM

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One of the primary global processes in human organism is matter transport including tissue perfusion with oxygen and nutrients, carbon dioxide excretion, drugs propagation and absorbtion/excretion. Partial pressure analysis in the presence of different pathologies like atherosclerosis, loss of blood, anatomical features, changes in acid-base balance and others is significant issue in physiological and medical applications. Global scale impact of these processes is of special interest as it includes feedbacks and interdependencies between different regions of the organism. The two important transport main-lines are cardiovascular and respiratory systems.

In this work we summarizing multiscale multimodelling approach combining the models of respiratory system, 1D haemodynamics in large vessels closed by the 0D four-chamber dynamical model of the heart and extended with 2D model of peripheral circulation. Blood flow in large vessels and air flow in trachea-bronchial tree are modelled in terms of incompressible viscous fluid flow in the network of collapsible tubes. Computational domain for the vascular network is represented as composition of four vascular networks corresponding to the arterial and venous parts of systemic and pulmonary circulation. The 0D dynamical linear oscillator model is the basis for the four-chamber dynamical model of the heart and alveolar compartments model. Than these models are combined with 1D network flow models. The 2D porous filtration model is used to describe blood flow in small vessels and capillary network providing matter distribution in the tissues. All models are validated by anatomical and physiological data from general well-known literature and fitted with patient-specific observations.

We demonstrate application of our approach by modelling drug injection and O_2 and CO_2 transport during laparoscopic procedures and vibrating environmental impacts.

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