LINEAR OPTIMIZATION ALGORITHM FOR 1D HEMODYNAMICS PARAMETER ESTIMATION

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An algorithm for estimating the parameters of 1D blood flow modelling [1] is proposed. The following parameters are identified based on the blood pressure measurements at certain points: elasticity of arteries, hydraulic resistances of peripheral regions and cardiac output. These parameters are rarely available in the patient-specific cases.

The algorithm consists of two steps. In the first step, parameters $\vec{p} = \{p_1, p_2, .., p_n\}^T$ are changed individually, and the changes in target values $\vec{u} = \{u_1, u_2, .., u_m\}^T$ are stored

$$p_i \to p_i + \Delta p_{i,j},\ i = 1,..n,\ j = 1,..L_i \ \Rightarrow\ \vec{u} \to \vec{u} + \Delta\vec{u}_k,\ k = 1..K,\ K = \sum L_i.$$

In the second step, the target value $\vec{u}^*, \Delta\vec{u}^* = \vec{u}^* - \vec{u}$ is used to estimate unknown parameters $\vec{p}^* = \{p_1^*, p_2^*, .., p_n^*\}^T$. The estimation method is based on the algorithm of linear optimisation [2]

$$\vec{x} = \{x_1, .., x_K\}^T :\ \sum_{k=1}^{K} x_k \Delta\vec{u}_k = \Delta\vec{u}^*,\quad x_k \ge 0,\quad x_k^{\min} \le x_k \le x_k^{\max},\quad \sum_{k=1}^{K} x_k \to \min,$$

where $\vec{x}$ will be used to calculate vector $\vec{p}^* = \{p_1^*, p_2^*, .., p_n^*\}^T : p_i^* = p_i + \sum_j x_j \Delta p_{i,j}$. Boundaries $x_k^{\min}$ and $x_k^{\max}$ can be defined based on the physiological range of parameters $\vec{p}$.

This algorithm was tested by estimating the elasticity of a single blood vessel and parameters of blood flow at the inlet of the blood vessel. Parameters were determined from the blood flow velocity in the middle of the vessel. The target value of the blood pressure was calculated with a relative error smaller than 14%. Root-mean-square error is less than 2%.

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