Defining identifiability for improved flexibility of input data in the cardiovascular functional avatar

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Background: We have recently developed an integrated imaging-modelling framework for assessment of the overall cardiovascular health status of individuals called “Cardiovascular functional avatar” (Figure 1). The avatar consists of a lumped parameter model, in which the parameters are adjusted for every specific patient. By using the input from a brachial pressure cuff measurement, anatomy, and dynamic flow data from 4D Flow MRI measurements, the majority of the model elements can be individualized (Casas, 2017). In addition to quantifying the functional characteristic of every element, the avatar allows the investigation of important cardiovascular parameters that are otherwise unavailable from non-invasive data, e.g., the pressure-volume curves of the heart.

While many cardiac patients will undergo advanced imaging at some point, subsequent follow-up is often performed using diagnostic approaches that are less advanced than the original ones. Consequently, once defined using a full dataset, the avatar could potentially be updated using new blood pressure and heart rate measurements and/or limited imaging information from e.g., ultrasound. However, in this case, the confidence of the cardiovascular functional avatars will vary on both parameter-to-parameter and patient-to-patient bases. By adding an identifiability analysis, the degree to which the amount and quality of experimental data influence the confidence of the model parameters can be estimated.

Aim: To perform an identifiability analysis on the avatar model parameters.

Implementation. The confidence of the input measurements will be estimated based on imaging modality. Based on this input confidence, the confidence of every derived avatar parameter will be computed using a practical identifiability analysis (Pironet 2018). The use of other imaging data to derive the avatars will be evaluated on data from the Doppler-cip study (Rademakers 2013), in which 4D flow MRI, as well as advanced ultrasound data are available for heart failure patients.

References
Pironet, ..., Desaive (2018) Practical identifiability analysis of a minimal cardiovascular system model, Computer Methods and Programs in Biomedicine, Early view