PERSONALISING POPULATION-BASED RESPIRATORY MOTION MODELS OF THE HEART USING ANATOMICAL FEATURES

Peressutti D., Penney G., Kolbitsch C., King A.
Division of Imaging Sciences and Biomedical Engineering, King's College London
devis.peressutti@kcl.ac.uk

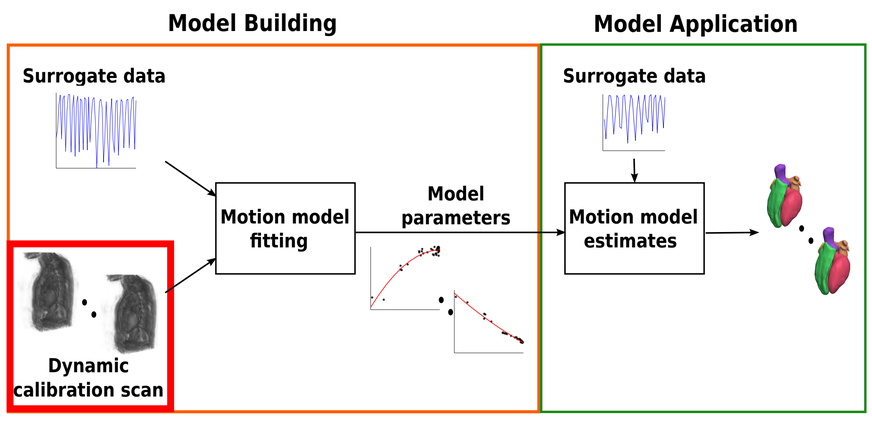
1. Abstract

Respiratory motion models have been proposed to compensate for respiratory motion of the heart in image acquisition and image-guided interventions [1]. We present a novel population-based respiratory motion model which overcomes the limitations of current techniques by learning the relationship between the anatomy of the heart and its respiratory motion using a neighbourhood approximation technique. For the first time, correlation between the anatomy and respiratory motion of the heart is analysed.

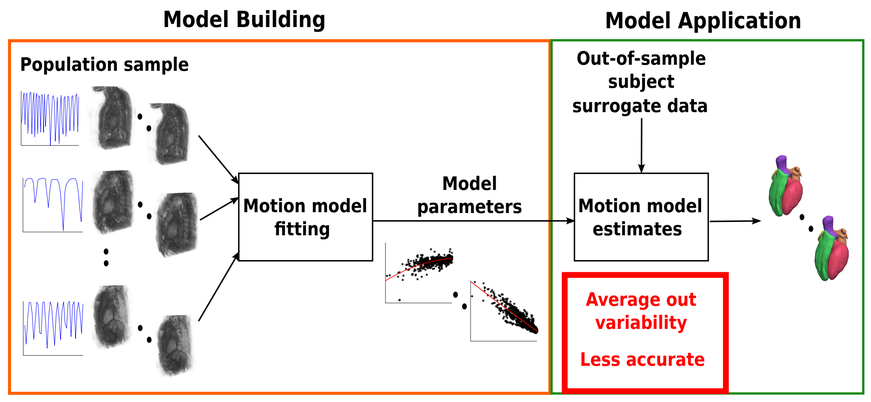


2. Respiratory motion models

Subject-specific motion models [1]

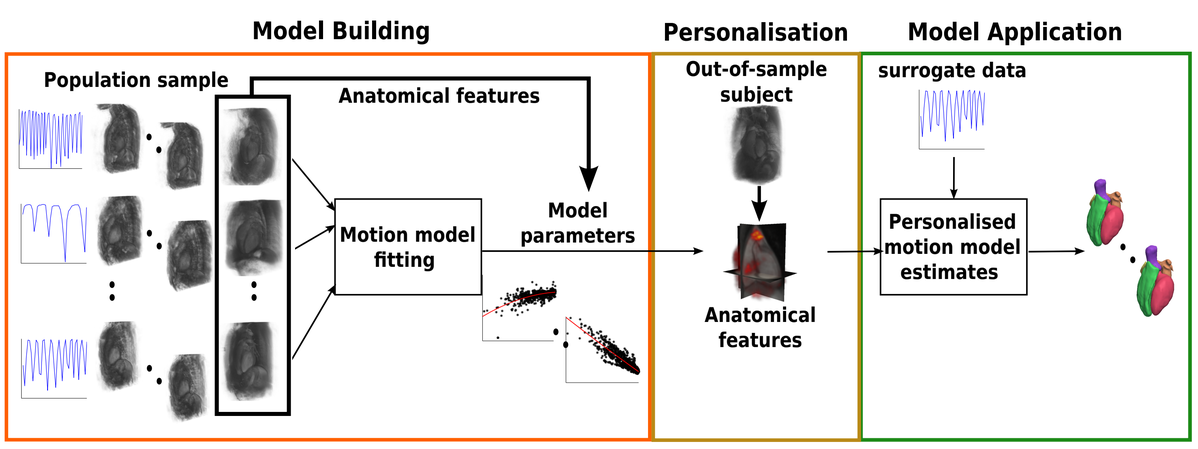


Population-based motion models [1]



3. Proposed personalisation framework

Aims at overcoming the limitations of current respiratory motion models by learning the relationship between some anatomical features and the respiratory motion of the heart. Based on anatomical features derived from a static image, the framework selects a subset of the population more likely to model the respiratory motion of the out-of-sample subject.

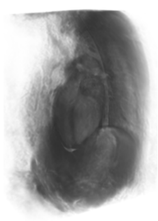


4. Materials

Population sample of 28 volunteer datasets.



- Dynamic calibration scan of 40 ECG-gated 3D MRI images acquired during normal breathing.
- 3D high resolution anatomical image at end-exhale.



Superior-Inferior displacement of the left hemi-diaphragm is employed as respiratory surrogate.

5. Method

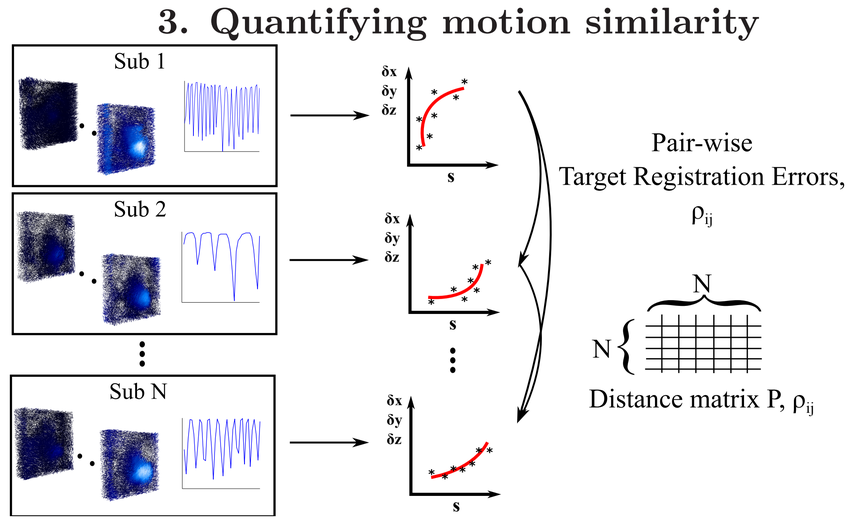
1. Average shape atlas of the heart

An atlas of the heart in its natural coordinate system is generated [2].

2. Motion estimates in atlas space

The affine respiratory motion estimates are warped from the subject-specific to the atlas coordinate system [3].

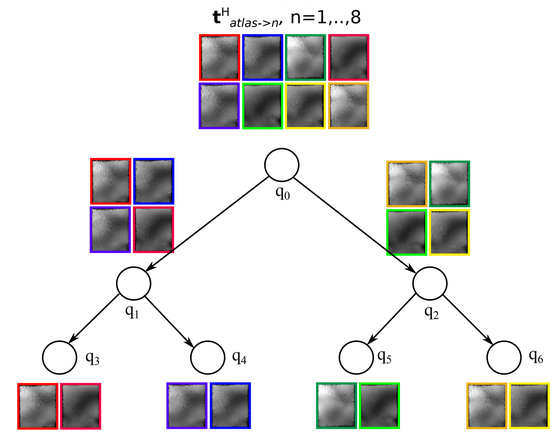
3. Quantifying motion similarity



4. Neighbourhood approximation [4]

Anatomical features





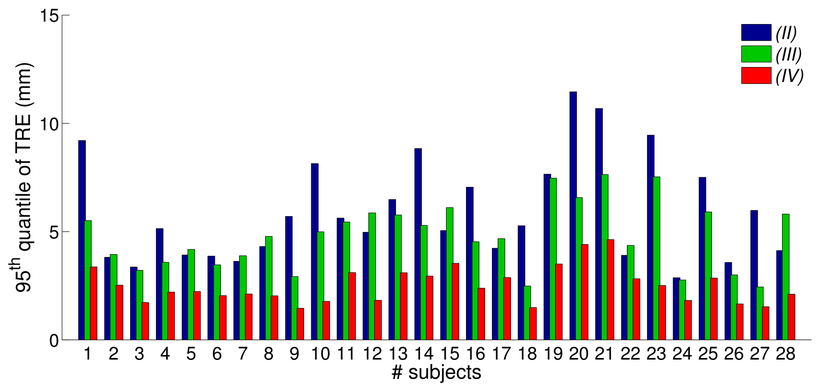
5. Personalisation

Provided with the anatomical features of the out-of-sample subject, the trained forest returns a subset of the population which is more likely to represent the respiratory motion of the subject. The motion model is built using the subset of the population.

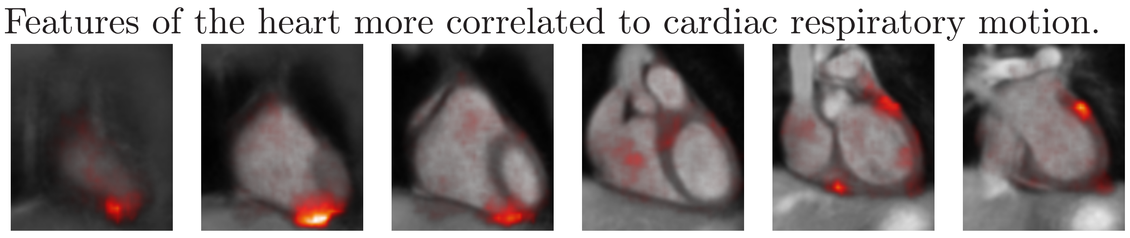
5. Results

A leave-one-out validation and gold-standard respiratory deformation fields were used for accuracy evaluation. The proposed framework (III) was compared to no motion estimation (I), average population-based motion model (II) and subject-specific motion model (IV).

	Mean/standard deviation of TRE (mm)				Impr. in mean (%)
	(I)	(II)	(III)	(IV)	wrt (II)
Median	3.5/2.0	2.0/1.1	1.6/0.6	0.9/0.3	20.0
95^{th} quantile	11.3/4.4	5.9/2.4	4.7/1.5	2.5/0.8	20.3



Features of the heart more correlated to cardiac respiratory motion.



6. References

[1] J. McClelland, *et al* : *Respiratory motion models: A review*, Med Image Anal, vol. 17, pp. 19-42, 2013.

[2] A. Frangi, *et al.* : *Automatic construction of multiple-object 3D statistical shape models*. IEEE Trans on Med Imag, vol. 21, pp. 1151-1166, 2002.

[3] A. Rao, *et al.* : *Spatial transformation of motion and deformation fields using nonrigid registration*. IEEE Trans on Med Imag, vol. 23, pp. 1065-1076, 2004.

[4] E. Konukoglu, *et al.* : *Neighbourhood approximation using randomized forests*. Med Image Anal, vol. 17, pp. 790-804, 2013.