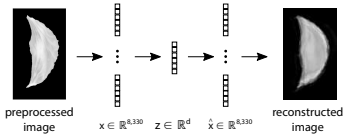
Towards personalized aortic valve prostheses - A sparse representation of the individual leaflet shape

Jannis Hagenah, Michael Scharfschwerdt, Floris Ernst

Institute for Robotics and Cognitice Systems, Universitiy of Lübeck
Lübeck, Germany

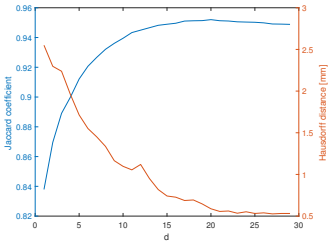
Aim: Promising results in the field of tissue engineering move the goal of the fabrication of personalized aortic valve prostheses within reach. However, there is no study on the degree of personalization that is needed to find a trade-off between the patient's outcome and economical and logistical issues. A pattern analysis study could reveil generic valve types using clustering techniques. One problem in performing such a study is the lack of a sparse, unified representation of the individual aortic valve shape to perform clustering without facing the curse of dimensionality. We present such a description which is derived model-free and directly from experimental data.

Methods: We set up a suitable data base, consiting of photographs of the leaflets of 10 porcine aortic valves (i.e. 30 leaflet images). We segmented the leaflets and used principal component analysis on these images for dimensionality reduction. Furthermore, we analyzed the minimal number of values in the representation preserving all relevant information to reconstruct the leaflet shape. The Jaccard coefficient and the Hausdorff distance served as evaluation metrics to compare the reconstructed images with their ground truth.



Sketch of dimensionality reduction and reconstruction.

Results: The shape reconstruction accuracy saturates at 13 incorporated principal components with acceptable error values (Jaccard above 0.94, Hausdorff below 1 mm). Hence, we could show that an accurate representation of the shape of one aortic valve leaflet is possible with no more than 13 values, resulting in 39 parameters for one complete valve. This relatively low-dimensional representation makes the search for geometrical patterns possible and has the potential to present the basis for economical valve prostheses personalization.



Reconstruction accuracy (blue: Jaccard, red: Hausdorff) for increasing number of components d.