Generating Healthy Aortic Root Geometries from Ultrasound Images of the Individual Pathological Morphology using Deep Convolutional Autoencoders

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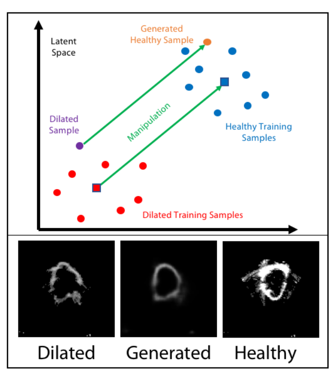
Aim: During valve-sparing aortic root reconstruction, the pathologically dilated aortic root is replaced by a prosthesis mimicking its healthy shape. One challenge is the estimation of this unknown, individual healthy shape based on the assessible, pathologically dilated one. To assist the surgeon, we propose the manipulation of an ultrasound image of the dilated root in the latent space of an auto-encoder to generate an image of the healthy shape. **Methods:** We worked with a dataset of 48 2D ultrasound images of the commissure plane of porcine aortic roots where the dilated state as well as the healthy ground truth was known. We trained a fully-convolutional deep autoencoder (10 layers) to encode the images into a latent space description. In this description, we calculated the class centers as the mean over all healthy and all dilated valve samples, respectively. We assume that a translation along the vector that points from the dilated class center to the healthy class center is a sufficient manipulation of a dilated valve to reconstruct its healthy state. Hence, a dilated valve can be encoded, manipulated by adding the vector and from this new point, an image of the estimated healthy state can be generated using the decoder. We applied the pipeline to the dilated images and compared the generated images to the corresponding healthy ones using 5-fold Cross Validation. **Results:** Qualitatively, the method provides realistic images of healthy root shapes, including individual geometries. The average MSE (pixel-wise) between generated and healthy images was 29.2% lower than between dilated and the healthy ones, while the average structural similarity was increased by 3.4% on between these image pairs. This indicates that representation learning makes the generation of images of healthy geometries based on images of the pathological morphology possible and presents an important step towards planning reconstructive surgeries.



Method sketch and example results