Myocardial strain generation from cine MR images by deep learning

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Background
CMR cine and tagging sequences are typically used for quantifying global and regional cardiac functions, respectively. Nevertheless, the need for acquiring additional tagged images and using special software packages for tagged images analysis contributes to longer and more expensive CMR exam. The CMR feature tracking technique has been proposed to generate regional cardiac function measures from cine images, although the lack of intramyocardial markers poses a limitation of the technique compared to conventional CMR tagging. In this study, we developed a deep neural network algorithm for extracting regional cardiac function parameters from the cine images after the network is trained on corresponding gold-standard tagged images.

Methods
The developed algorithm (Figure 1) is based on image-to-image translation using generative adversarial network (GAN) to generate the myocardial displacement fields from cine images. During the training phase, the inputs of the network are: 1) cine difference images, generated by subtracting consecutive cine images using a fine-tuned segmentation Unet; and 2) corresponding tagged images acquired of the same slice and cardiac phases. The target image of the network is the corresponding gold-standard myocardial displacement field generated by analyzing the tagged image using the SinMod method. We used a dataset of 1134 images acquired from rats scanned on a 9.4T Bruker MRI scanner, where 1114 images were used for training and 20 were used for testing. Bland-Altman plots, students t-test, and correlation analysis were conducted to compare the generated displacement fields, on a segmental basis, against the gold-standard measurements generated from the tagged images.

Results
• The generated output displacement fields (Figure 2) showed myocardial shape similar to that in the input images as well as regional bright and dark areas (representing tissue displacements) at corresponding locations to those in the gold-standard displacement fields generated from the tagged images.
• Bland-Altman analysis (Figure 3) showed good agreement between the output measurements and corresponding gold-standard displacement fields, where almost all the measurement differences lied within the ±2SD agreement level.
• Student t-test showed insignificant differences between all paired measurements (p>0.05).
• Lin's concordance correlation coefficients (CCC) were 0.96 and 0.89 for x- and y-displacement fields, respectively.
• The calculated radial and circumferential strains by displacement fields are insignificant differences (p>0.05) in Table 1.
• Myocardial strain curves (Figure 4) have similar patterns between generated and gold-standard measurements.
• The developed method reduced the time required for generating the displacement field by two orders of magnitude to < one second.

Conclusions
The developed deep-learning based method allows for ultrafast and accurate generation of myocardial tissue displacement fields from conventional CMR cine images without the need for acquiring additional tagged images or using special tagging analysis software, which would help reduce scan time and data analysis time and improve CMR value imaging.

References