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Fast estimation of kidney volumes and time courses in DCE-MRI using convolutional neural networks

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Purpose: We create a novel method for fast and accurate estimation of kidney volumes and signal intensity time courses in DCE-MRI, aiming at extracting both structural and functional quantitative information from the moving kidney.
Methods and Materials: Two repeated SPGR-DCE-MRI datasets were acquired from 20 healthy volunteers, resulting in 40 examinations, each consisting of 74 volumes recorded over ~6 min. We trained a 3D convolutional neural network (using a single standard NVIDIA GeForce 1080Ti GPU) for segmentation of left and right kidneys. The network has a dual-pathway architecture, incorporating both local and global information in the volumes. To create training data, we manually delineated 10 individual volumes from 10 different time-series, and extended the delineations to 740 volumes using image registration.
Results: Our implementation is able to segment all 74 volumes in a previously unseen, unregistered recording in less than 7 minutes. Mean segmentation accuracy (Dice) was 0.843 (SD=0.010). Mean (SD) left and right kidney volumes [ml] (incl. renal hilum) in one of the subjects (FF03) examined seven days apart (MR1 and MR2) was: MR1 L: 301.6 (15.9), R: 389.8 (16.9); MR2 L: 307.4 (17.8) R: 395.3 (23.6).
Conclusion: A CNN is able to quickly and accurately segment the moving kidneys in DCE-MRI, providing estimates of kidney volumes and mean signal intensity time courses. We are currently working to achieve sub-segmentation of the kidney (cortex, medulla, pelvis) and segmentation of the aorta (for AIF), enabling automated and fast estimation of GFR directly from the DCE-MRI.