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PRESENTATION TITLE

Implementation of a software framework for automated offline MR image reconstructions

AUTHOR(S)

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ABSTRACT

Purpose: Many novel MRI techniques generate large amounts of data and require computational intensive reconstructions. Examples for MRI-guided radiotherapy include 4D-MRI with compressed sensing, deep learning image reconstructions and post-processing steps such as synthetic-CT generation and motion modelling. These operations generally cannot be performed on the regular MRI reconstructor, due to limited computational resources and in-accessibility to proprietary reconstruction software. As a result data is often exported manually for offline reconstructions on research PCs, which is cumbersome and limits clinical implementation. An external reconstruction server would overcome many of these issues. Although server queuing systems exist, the connectivity between MRI scanner and server is often lacking.
In this work, we have developed the tools required to implement such a framework and enable for the automatic export of data from the MRI system to a reconstruction server, which performs the reconstruction and exports DICOM to a clinical image database.

Materials & Methods: The reconstruction pipeline was developed for the MR-Linac system (Elekta Unity, Elekta, Sweden) and Philips MRI systems (Ingenia, Philips, The Netherlands). It consists of a client, running on the MRI/Unity system, and an external server, running on the hospital network (Figure 1). The scanner client was developed in collaboration with MRcode and facilitates the automatic export of raw k-space data of individual acquisitions, along with accompanying reference scans and DICOM header information. Using the Philips PRIDE environment, this could be done without user interaction.
The open source Yarra framework (https://yarra.rocks) runs on the server, which acts as a queuing system and allows custom reconstruction modules in many languages, such as Matlab, C(++) and Python. In this work, the ReconFrame Matlab toolbox (GyroTools, Switzerland) was used as a demonstrator. A custom DICOM export option allows generation of DICOM images and export to a DICOM database. Additionally, stand-alone clients were developed to send locally stored data from

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other workstations than the scanner (i.e. PCs) to the reconstruction server.
As a proof-of-concept simple phantom scans were acquired, which were reconstructed both on the scanner and reconstruction server. Additionally, 4D-MRI data were acquired and automatically reconstructed using a Matlab-based compressed sensing reconstruction module.

Results: The reconstruction pipeline was tested on 1.5T and 3T MR systems and on the 1.5T Unity MR-Linac on phantoms and healthy volunteers. Data could automatically be exported and reconstructed for all systems. All appropriate tags were set in the generated DICOM images, which allowed for export to a clinical database where they were available for viewing. A qualitative comparison between phantom data reconstructed by the scanner and the reconstruction pipeline (Figure 2) showed a correct geometrical representation. Furthermore, 4D-MRI data showed good image quality and could readily be used for viewing or post-processing (Figure 3).

Conclusions: A data export pipeline was developed to automatically send and reconstruct raw MRI data. This enables the implementation of novel, but computationally intensive reconstructions and facilitates clinical introduction of these new methods in the workflow.

Disclaimer: B. Stemkens is partly employed by MRCode. R.H.N. Tijssen, C.A.T. vd Berg are minority shareholders of MRCode.

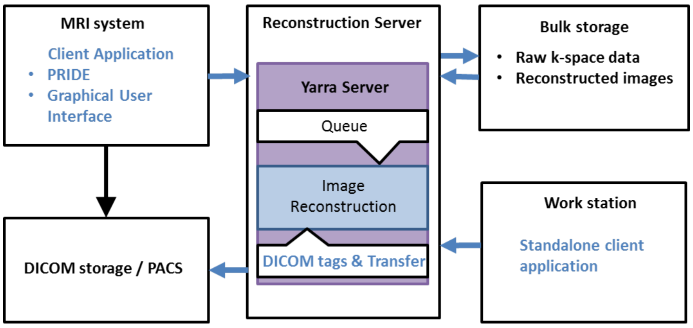

Figure 1 Graphical overview of the infrastructure. The arrows indicate the data flows. Black is the standard flow, while blue indicates the proposed offline workflow.

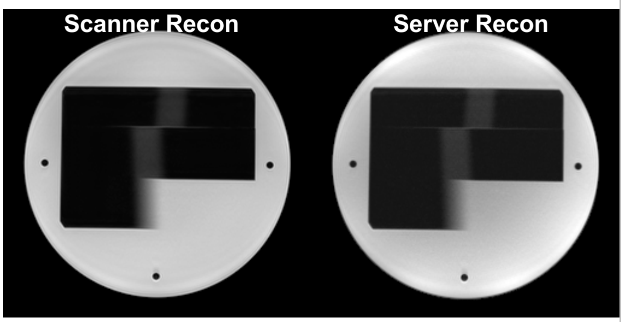

Figure 2 Comparison of the scanner and offline reconstruction using the proposed pipeline. For the scanner reconstruction, some additional image processing is performed, showing reduced noise.

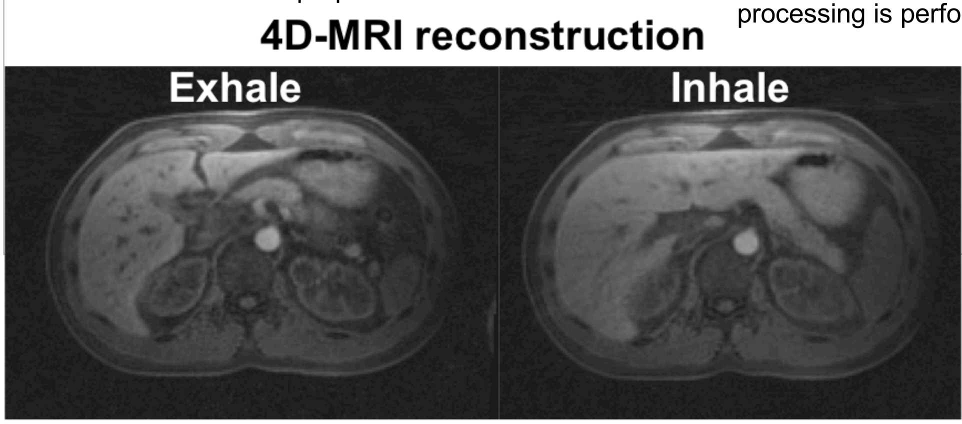

Figure 3 Example of a 4D-MRI, reconstructed through the proposed pipeline. The exhale and inhale volumes are shown. The scanner was not able to reconstruct these 4D-MRI data.