GE HealthCare

AIR™ Recon DL

Leveraging AIR™ Recon DL to support MRI-only Radiation therapy workflow for improvements in Prostate Cancer Treatment

Radiation therapy is the primary and an effective mode of treatment for many cancers. Traditionally, in preparatioon for radiation therapy patients may undergo two different, labor and time-intensive image-gathering processes. Computed Tomography (CT) allows clinicians to plan and calculate the appropriate amount of radiation dose to deliver while Magnetic Resonance Imaging (MRI) enables them to more precisely locate where to deliver it. Unfortunately, the need for two very different kinds of imaging technologies results in time and labor intensive sessions which can result in suboptimal imaging and radiation therapy planning.

Some forward-looking radiation therapy treatment centers have however found a new solution. Using the imaging technology available in GE Healthcare's SIGNA™ Architect, a 3.0T MRI scanner, along with the advanced artificial intelligence (AI) capabilities of GE HealthCare's AIR™ Recon DL, Skåne University Hospital Comprehensive Cancer Centre (SUHCCC) has streamlined typical radiation therapy planning workflows to enable improved MRI imaging that support more precise planning of radiation delivery. The SUHCCC radiation therapy center located in Lund, Sweden, is at the forefront of new developments in radiation therapy. Dr. Christian Jamtheim Gustafsson, Medical Physicist and Associate Professor at the radiation therapy center, is leading research studies on AI enhanced, MRI-only workflows that have streamlined and improved the imaging quality necessary for precise radiation delivery in the clinic.

Skåne University Hospital

A Challenge to improve the treatment planning process

The problem with conventional treatment planning workflows begins with CT and MRI modalities that are designed to deliver images to meet two very different clinical needs. For decades, the ability of CT imaging to create three-dimensional volumetric images has helped radiation oncologists to calculate radiation attenuation and optimize patient doses. CT images provide information about the electron density of tissues, measured in Hounsfield units, but the images have sub-optimal tissue contrast. Moreover, it exposes the patient to additional radiation as part of their therapy. This can be especially problematic if multiple CT scans are needed, or if the patient is of young age.

MRI, on the other hand, can provide high resolution and excellent soft tissue contrast images along with functional information which can help to improve delineation of target volume.

However, airspace and bone can look the same in an MR image due to the lack of information on electron density, thus inhibiting calculation of how radiation from the treatment will be attenuated in the tissue.

Several problems in search of one answer

To address the shortcomings of both the MRI and the CT, clinicians at SUHCCC and elsewhere have been using the two different imaging modalities in tandem. However, this dual approach requires careful integration into the workflow. First, it creates two different kinds of images that need to be co-registered[1]. Second, it adds time to the planning process and requires more clinician involvement and department resources.

Using one form of imaging for radiation dose calculation and another for precise delineation of target and other organs can introduce systematic uncertainties from image registration. Differences of 2-5 mm have been reported in the image registration for various treatment sites[1]. When delivering high dose radiation to precise targets, often with sensitive organs-at-risk nearby, discrepancies of several millimeters can be significant and should be avoided.

The handling of multiple image technologies requires additional steps in the planning process which translates to more personnel and more time spent on the whole imaging process. Using a single, integrated method for treatment planning image acquisition, target delineation and dose calculation would reduce planning uncertainties and a significant risk of error as well as reducing planning costs incurred by dual workflow comprising of two imaging modalities.

MRI-only Workflows Supported by AI

Dr. Jamtheim Gustafsson and the research team are not only aware of these problems, but also of the steps that others have taken in the past to solve them. In the late nineties radiologists began reporting on using MRI instead of CT for planning radiotherapy dose calculations[2]. In spite of their methodological ingenuity, these early attempts to mainstream an MRI-only workflow could not achieve the same quality results as those with CT scans and most clinicians were hesitant to switch over to MRI-only workflow since it meant a loss in image quality.

The recent development of synthetic Computed Tomography (sCT has tremendously enhanced the accuracy of Hounsfield units estimations which is crucial for the dosimetric integrity in MRI only radiation planning. In particular, Spectronic Medical's Deep Learning (DL) based software can map Hounsfield unit values from MR images[3]. Using GE HealthCare MR scanners and Spectronic for sCT generation allows for accurate and faster MRI-only planning.

The generation of MR images by GE HealthCare scanners, which is the basis of the sCT images, utilizes deep-learning technology to reduce both image noise and scan times. For example, GE HealthCare's AIR™ Recon DL is a deep learning-based MRI reconstruction algorithm to increase the image signal-to-noise ratio and create a crisp, clear image in less time compared to conventional MRI reconstruction technologies.

The radiation therapy center at SUHCCC uses this AIR™ Recon DL feature and it is now its standard image reconstruction method. Dr. Jamtheim Gustafsson has described it as a "quantum leap in the reconstruction pipeline" that has reduced scan times by up to 50% for some patients. For example, imaging the T2 sequence for a prostate that would have taken seven minutes now takes three minutes and forty seconds with AIR™ Recon DL. Not only is the scan time reduced, but the image quality is excellent.

AIR™ Recon DL has the potential to transform medical imaging. Its enhanced speed and image quality may help consolidate multiple MRI scans into one streamlined workflow even further and points at the possibility of relying on a single, high-quality scan for treatment planning.

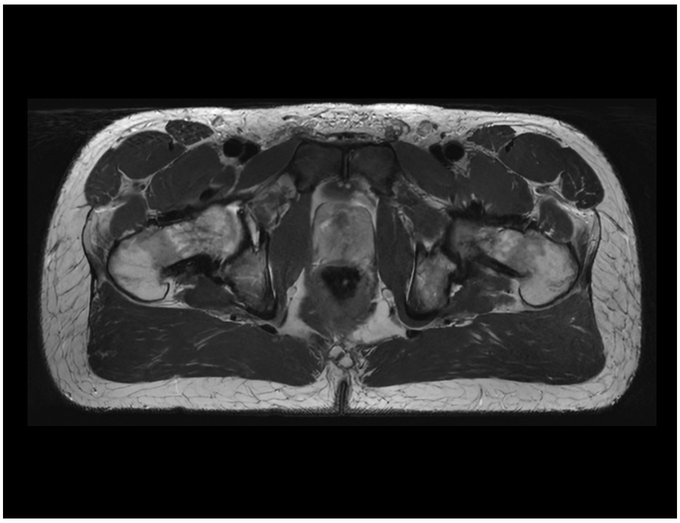
How good are the images produced using AIR™ Recon DL and can they be used for creating synthetic CT?

Dr. Jamtheim Gustafsson's team recruited twenty-four prostate cancer patients to help put AIR™ Recon DL to the test. Prostate cancer presents unique and challenging needs to the planning process in radiation therapy. High contrast MR images with low noise are required to accurately delineate the radiation target and the sensitive organs-at-risk. To this end, GE HealthCare's lightweight AIR™ Coils and SIGNA™ Architect 3.0T MRI system were used together.

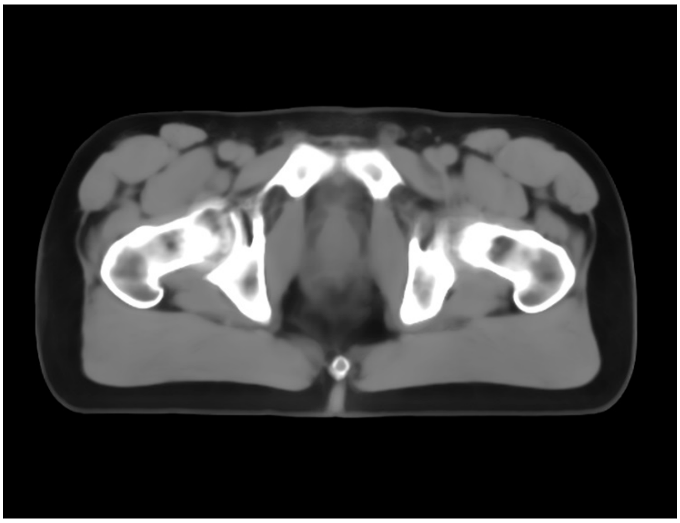
The clinical routine prescribed the patients 42.7Gy in 7 fractions to the prostate gland using an MRI-only treatment planning workflow. A large field of view (LFOV) T2 weighted MR image was reconstructed with GE HealthCare's AIR™ Recon DL product (see Figure 1) and the sCT conversion was performed with Spectronic MRI Planner v.2.4.14 (Spectronic Medical AB, Helsingborg, Sweden) creating synthetic CT images with organs-at-risk delineations. The results have been validated against CT imaging, so the SUHCCC team knew it could trust the MRI-only results. By using Spectronic Medical AI-based software, separate synthetic CT volumes could then be produced from both the conventional and AIR™ Recon DL supported MRI image.

To evaluate the accuracy of the sCT created from the AIR™ Recon DL MR image, the team analyzed Hounsfield unit differences from the two sCT versions in the tissues fat, muscle, spongy and compact bones of each patient. To assess dose differences, clinical radiation structures were copied from the original sCT and transferred to the sCT based on AIR™ Recon DL MRI to be recalculated. The new AIR™ Recon DL MRI-based sCT was then visually inspected and body volume calculated.

The team found that HU differences between the original sCT and AIR™ Recon DL sCT had a mean absolute error (with standard deviation of ±1) in fat of 1.5±0.3 HU, muscle 1.2±0.4 HU, spongy bone 4.9±1.1 HU and compact bone 7.4±2.2 HU. The mean dose calculation differences for body, femoral heads, bladder, rectum, CTV and PTV were all positive but below 0.06 Gy. The team found that an MRI-only workflow using AIR™ Recon DL MRI was suitable for generating sCT images, concluding that any differences in Hounsfield units and calculated dose were clinically negligible.



A) T2 weighted FRFSE large field of view MR image acquired on GE HealthCare SIGNA™ Architect 3.0T MR using AIR™ Recon DL. Scan time 3:40, 88 slices, 2.5 mm slice thickness.



B) Synthetic CT (sCT) derived from T2 weighted large field of view MR image to the let using Spectronic MRI Planner. Organs-at-risk delineations not shown.

AI and the Future of Radiotherapy Planning

The findings of the research team led by Dr. Jamtheim Gustafsson confirmed what the clinicians at SUHCCC had already known: MRI-only workflows can optimize the treatment planning and the MR images used can be improved when they utilize the deep-learning algorithm at work in GE HealthCare's AIR™ Recon DL. This led to more optimized MRI acquisition protocols in the hospital so scan times could be significantly decreased. For Dr. Gustafsson and team, deep learning enabled a "quantum leap" in the planning and delivery processes of radiation therapy.[4]

"Reducing the scan /me and improving the image quality is awesome!"

Dr. Christian Jamtheim Gustafsson, Medical Physicist; Associate Professor, Lund University

References
1. Persson, E., Emin, S., Scherman, J. et al. Investigation of the clinical inter-observer bias in prostate fiducial marker image registration between CT and MR images. Radiat Oncol 16, 150 (2021). hNps://doi.org/10.1186/s13014-021-01865-8
2. Edmund JM, Nyholm T. A review of substitute CT generation for MRI-only radiation therapy. Radiat Oncol. 2017;12(1):28. Published 2017 Jan 26. doi:10.1186/s13014-016-0747-y.
3. MriPlanner. medical.spectronic.se/page-2/page6/index.html.
4. Structured interview between SUAZIO outcomes research team and with Dr. Christian Jamtheim Gustafsson conducted on 5th of September 2023.

JB30463XX