The openGTN project is funded by the European Union in the Marie Curie ITN-EID program (project 764465)

# A Multipurpose Numerical Simulation Tool for Late Gadolinium Enhancement Cardiac MR Imaging

**Sina Amirrajab[1], Cristian Lorenz[2], Juergen Weese[2], Marcel Breeuwer[1,3]**

[1]Biomedical Engineering Department, Eindhoven University of Technology, Eindhoven, The Netherlands. [2]Philips Research Laboratories, Hamburg, Germany. [3]Philips Healthcare, MR R&D - Clinical Science, Best, The Netherlands

**Abstract ID: A-1233, Presentation Number: L01.35**

## INTRODUCTION

- The MRXCAT[1] approach grounded on the XCAT[2] anatomical phantom has shown remarkable utility for simulating cine and perfusion images.
- We extend the MRXCAT tool for cardiac LGE image simulation by implementing two clinical sequences, defining relevant imaging parameters, contrast agent dynamics, and incorporating two patterns of myocardial infarctions (MI).

## METHODS

- As shown in Figure 1, two virtual patients with transmural and subendocardial MI patterns are created using our modified version of the XCAT phantom[3].
- IR-SSFP and IR-GRE MR sequences for bright blood imaging[4] are implemented in MRXCAT pipeline.
- The change in relaxation times due to the contrast agent concentration and its relativity are considered.

## RESULTS

- As shown in Figure 2, simulated images with variable inversion times demonstrate that MI visibility is sensitive to the inversion time and the scar-to-myocardium contrast is maximized when the signal of normal myocardium is nulled.
- The inversion time could be optimized to obtain adequate contrast between the blood pool and subendocardial MIs. Blood pool to normal myocardium contrast is higher in the IR-SSFP sequence compare to the IR-SPGR which is considered as one of the advantages of using a steady state sequence in clinical routine.
- The sensitivity of the MI signal to the inversion time is lower in gradient echo sequence, which suggests robustness in detecting of MIs.

## CONCLUSION

- The multipurpose simulation tool provides a unified framework to compare, estimate, and optimize sequences to achieve high contrast between the infarct region, normal myocardium, and blood pool. Moreover, a population of images with variable scar geometry, location, and size can be generated to aid the development of deep learning-based cardiac disease classification, myocardium and infarct segmentation algorithms.

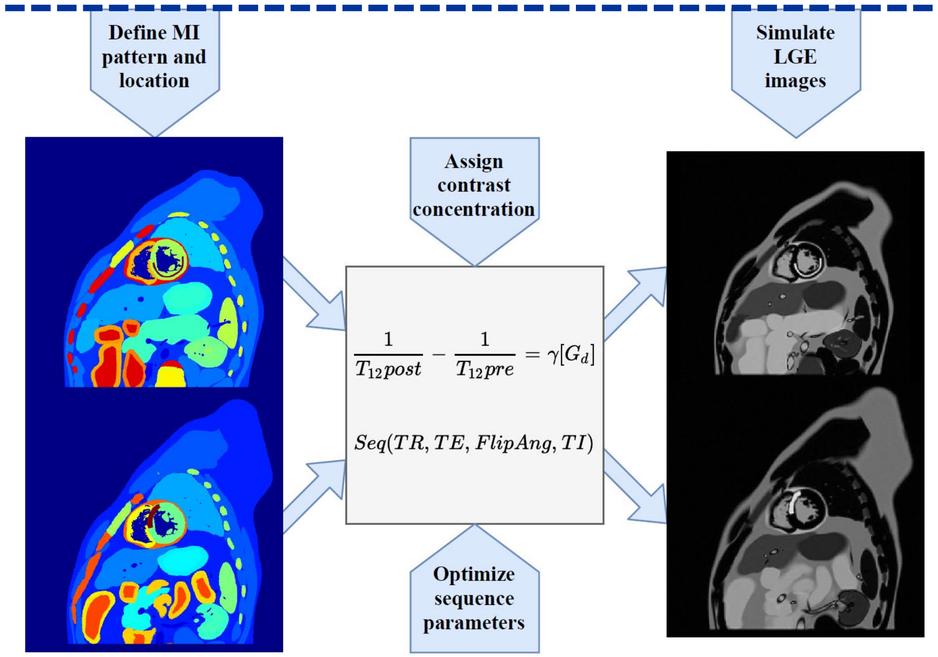


*Figure 1 LGE image simulation overview for two myocardial infraction patterns incorporated into the left ventricular myocardium (left). Parameterized tissue and sequence parameters to optimize the contrast (middle) and late gadolinium enhancement simulated images (right).*

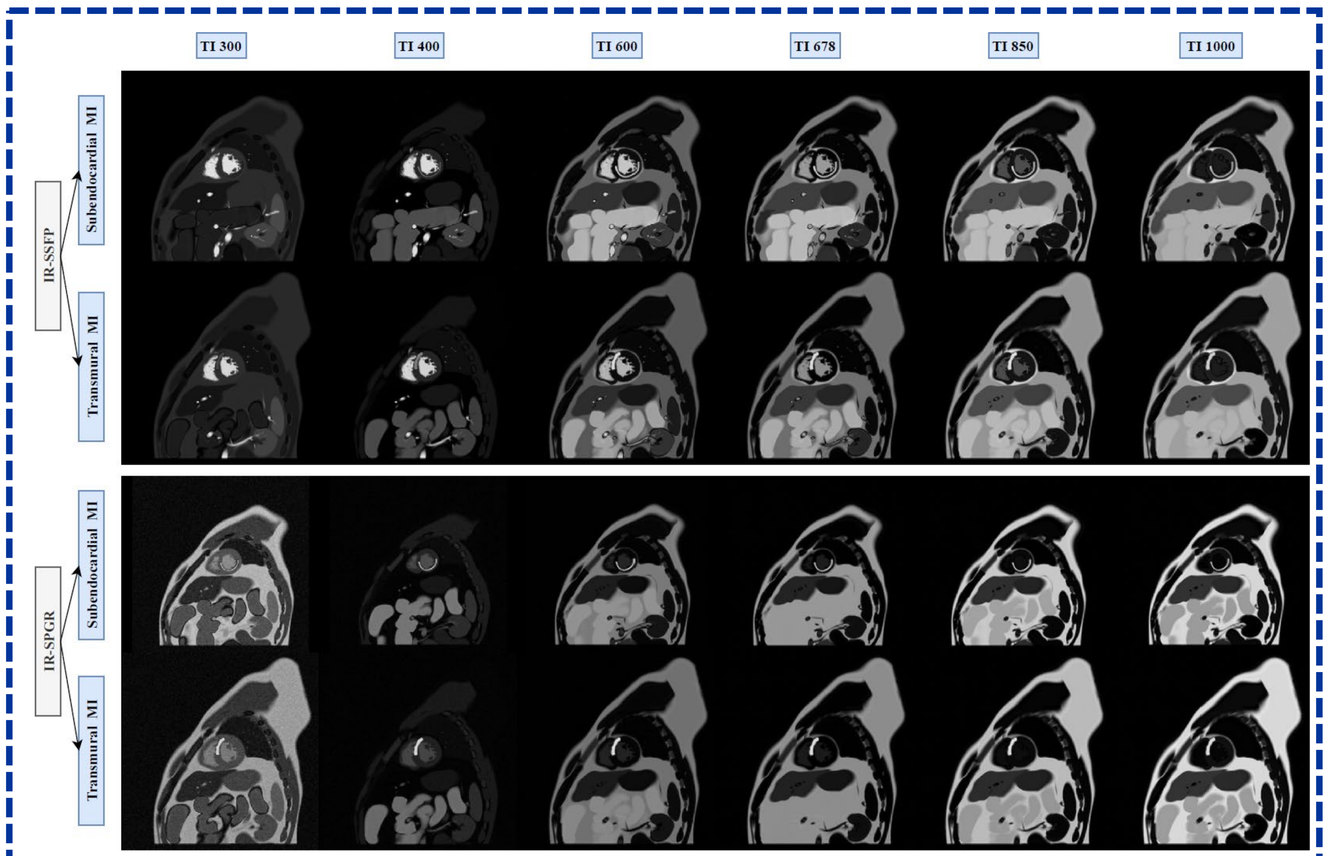


*Figure 2 inversion recovery steady state (IR-SSFP) and gradient echo (IR-SPGR) sequences with variable inversion time for subendocardial (1st and 2nd rows) and transmural (3rd and 4th rows) myocardial infarctions. Given the chosen T1 relaxation time for the myocardium, the inversion time to null the myocardium signal is around 678ms.*

[1] L. Wissmann et al. *JCMR* 2014 [2] W. P. Segars et al. *Med. Phys* 2010. [3] S. Amirrajab et al. *ISMRM* 2020 [4] P. Kellman et al. JMRI 2012.