An Automatic Data Processing Pipeline to Reconstruct Coherent 3D Image Volumes From Cardiac Cine MRI Data

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Abstract   Computational fluid dynamics (CFD) simulations of left ventricle (LV) flow require geometric models of the heart constructed from patient-specific cardiac image scans. Cine magnetic resonance imaging (MRI) produces several time-series 2D image slices from different locations of the heart which must be reconstructed into a 3D image volume before a deep learning model for constructing CFD-ready LV models can utilize it. Thus, we are creating a data processing pipeline that can automatically take in all 2D image slices for a patient and align them to produce a 3D image volume.
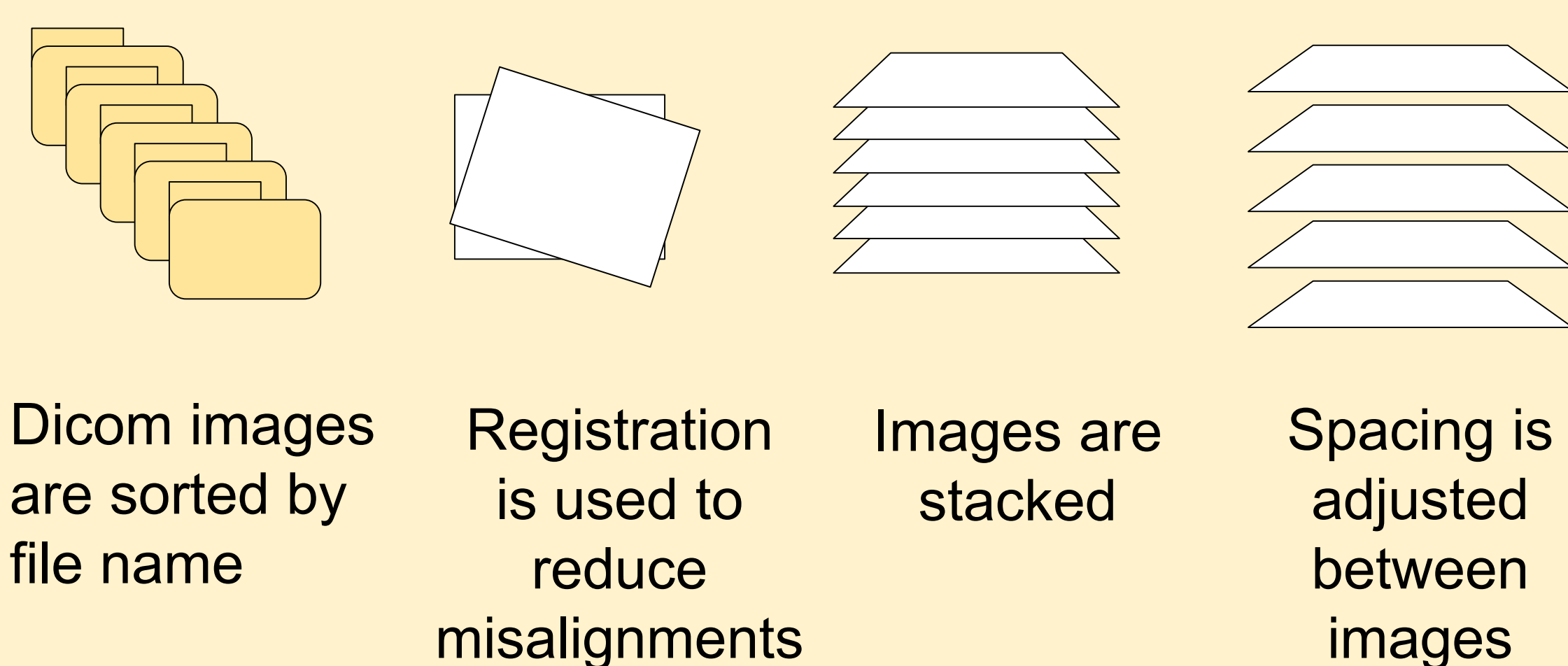
Background

Cardiovascular disease is the leading cause of death worldwide [1]. Computational fluid dynamics (CFD) simulations of left ventricle (LV) flow combined with patient medical imaging data may facilitate a better understanding of cardiovascular diseases so patients can have improved diagnosis and treatments.
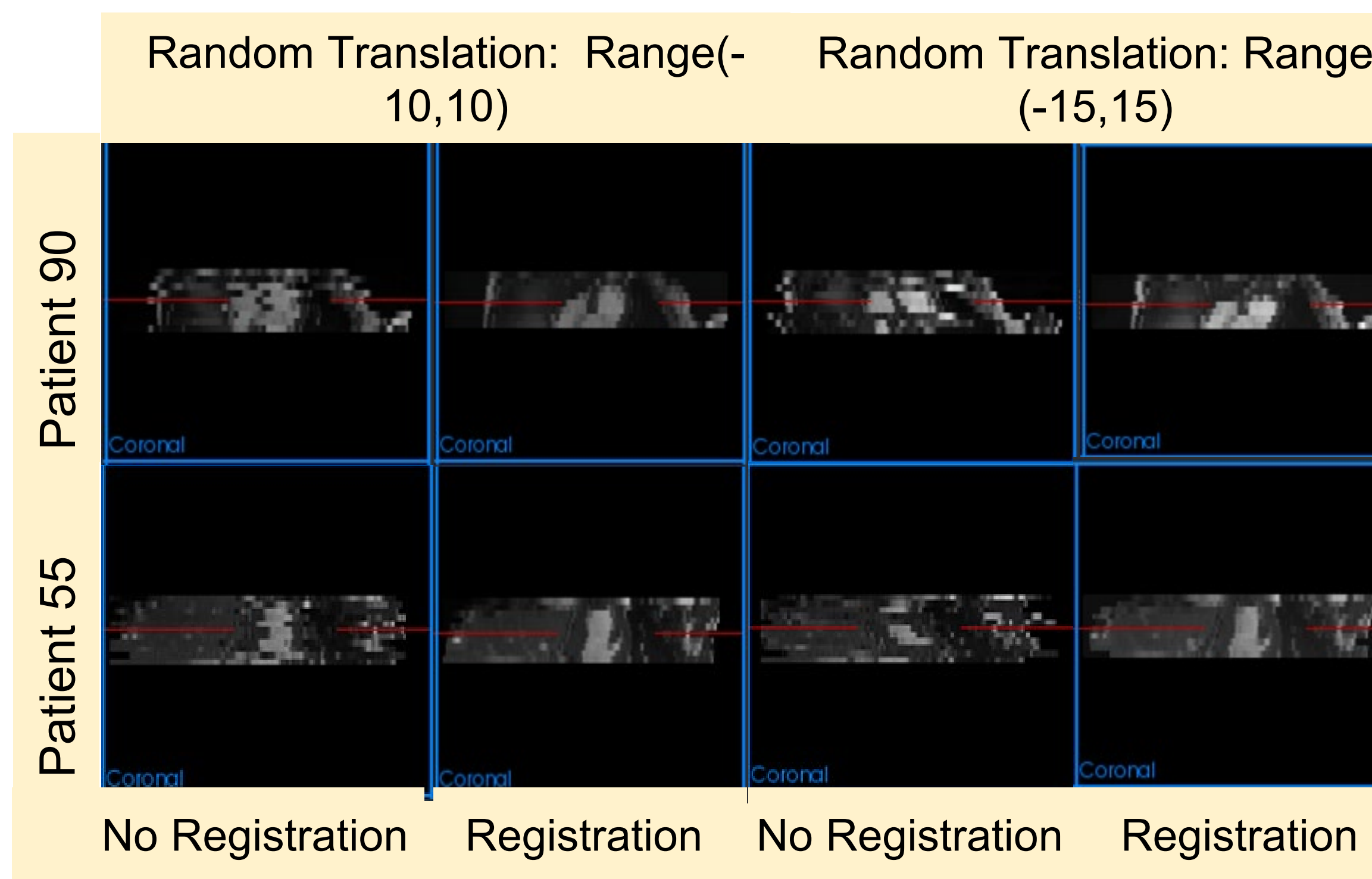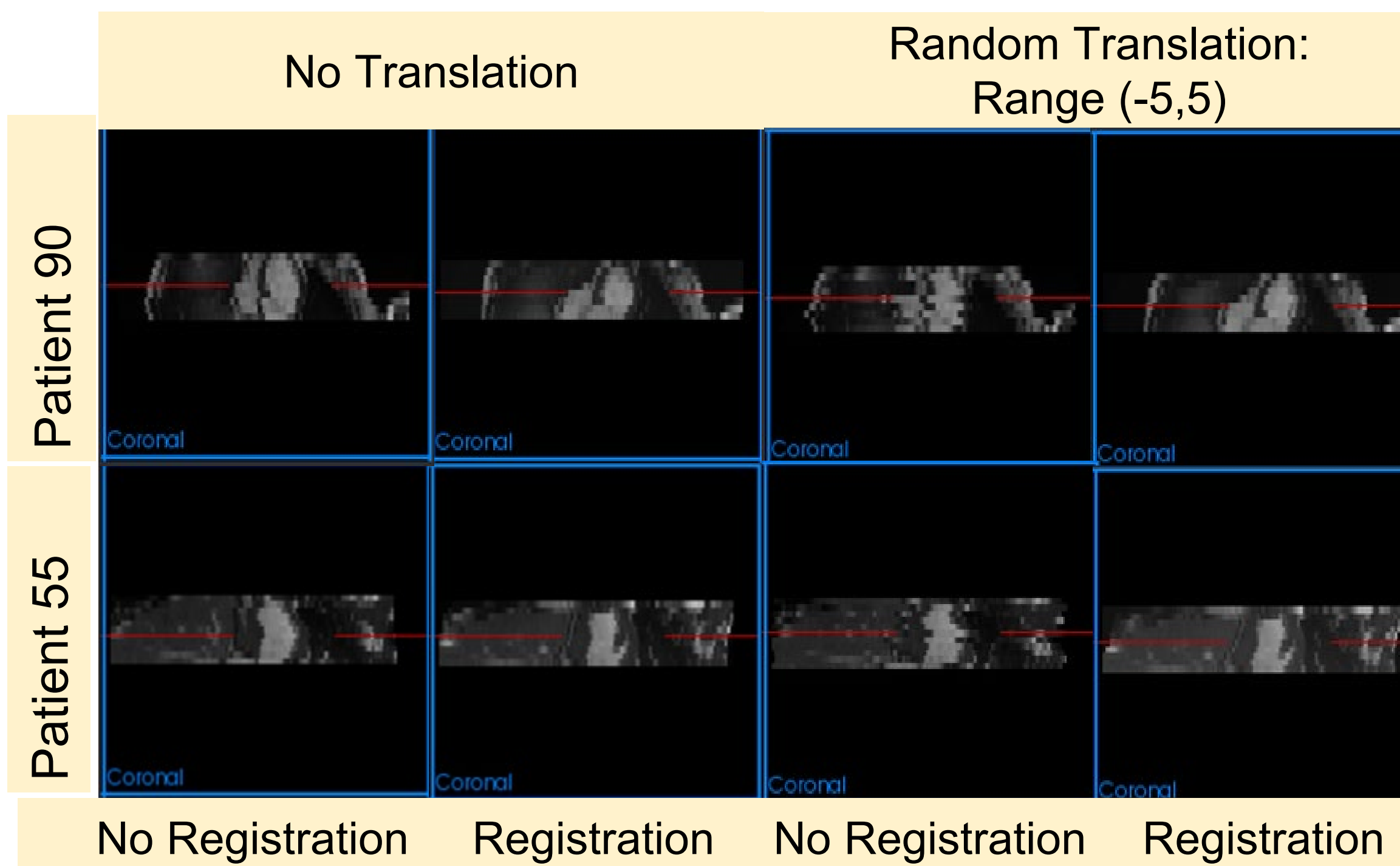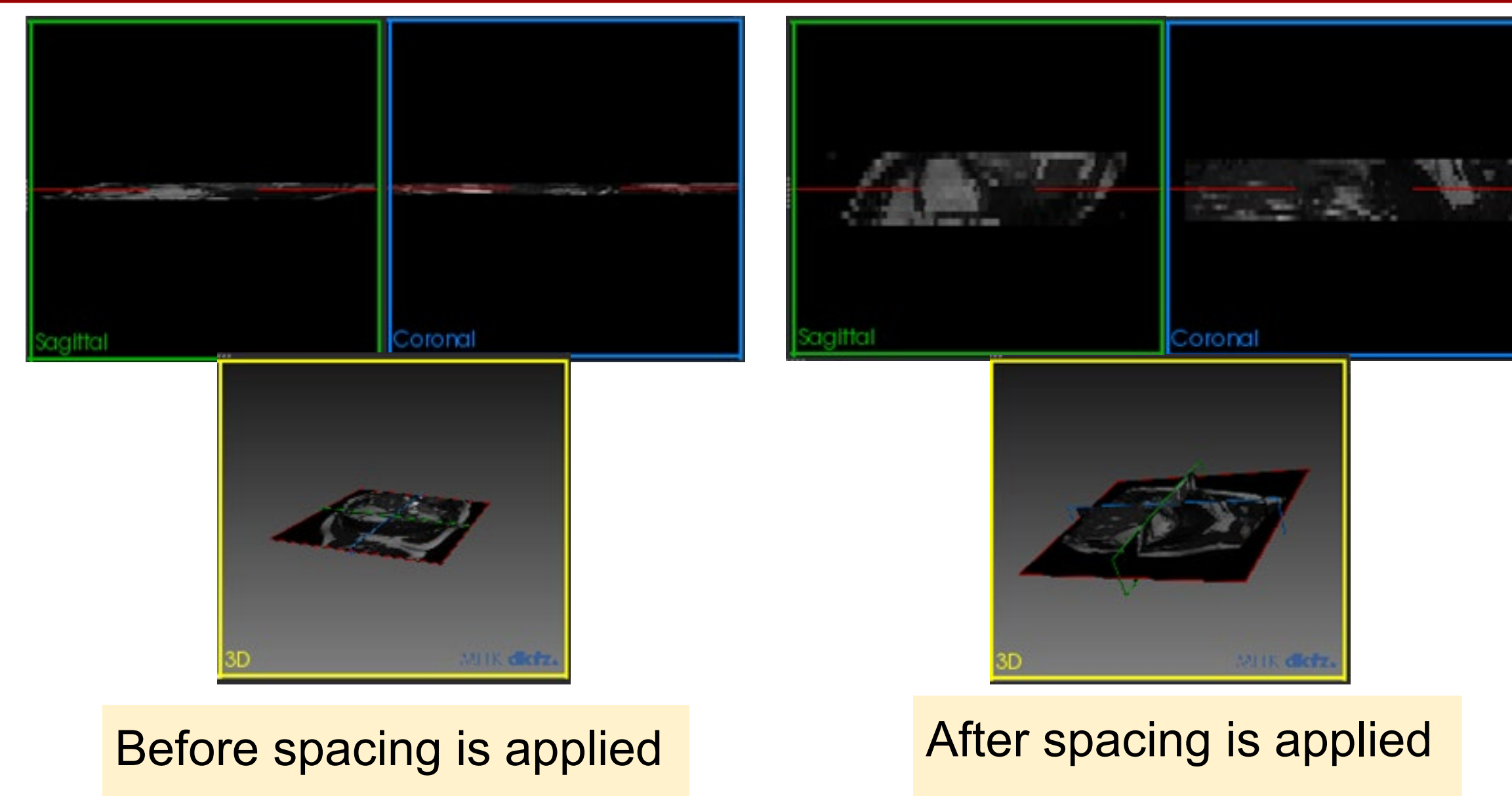
2D Cine MRI Images

3D CT Images and Segmentation

3D CT Model

CFD Simulation
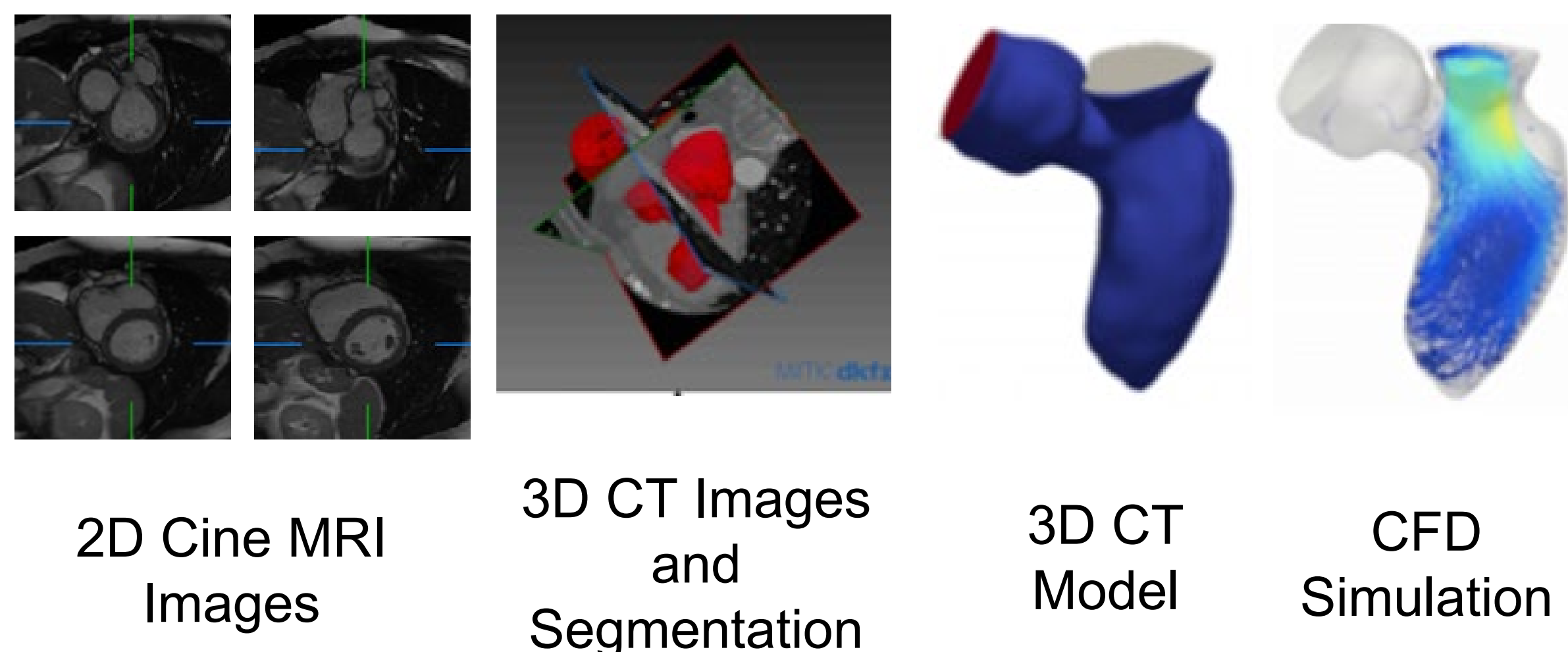
Data and Software

- This study used the "Data Science Bowl Cardiac Challenge Data" which consists of images of over 1000 patients of varying ages and cardiac function. These 2D cine images are in DICOM (Digital Imaging and Communications in Medicine) format.
- We used SimpleElastix and SimpleITK for alignment and registration and Medical Imaging Interaction Toolkit (MITK) for visualization which are free, open source software.

Data Processing Pipeline

Dicom images are sorted by file name

Registration is used to reduce misalignments

Images are stacked

Spacing is adjusted between images

Image Results

Before spacing is applied

After spacing is applied

No Translation | Random Translation: Range (-5,5)

Patient 90

Patient 55

No Registration | Registration | No Registration | Registration

Random Translation: Range(-10,10) | Random Translation: Range (-15,15)

Patient 90

Patient 55

No Registration | Registration | No Registration | Registration

Quantification Of Registration Error

- We artificially corrupted the volume and cause more misalignments to better view registration being applied. We used translation to randomly shifted center of images which used parameters that correspond to the x and y direction.
- There is a consistently larger number in the y direction. A larger translation range means a larger amount of error.

Translation Range	Total Mean of Patient Translation Parameters	Standard Deviation
(-5,5)	(3.84, 4.84)	(.298, .382)
(-10,10)	(5.06, 7.02)	(.149, .384)
(-15,15)	(7.71, 8.843)	(.193, .241)

References

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