Development of a new Python-based cardiac phantom for myocardial SPECT imaging

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ECE/SSE 591

What is SPECT?

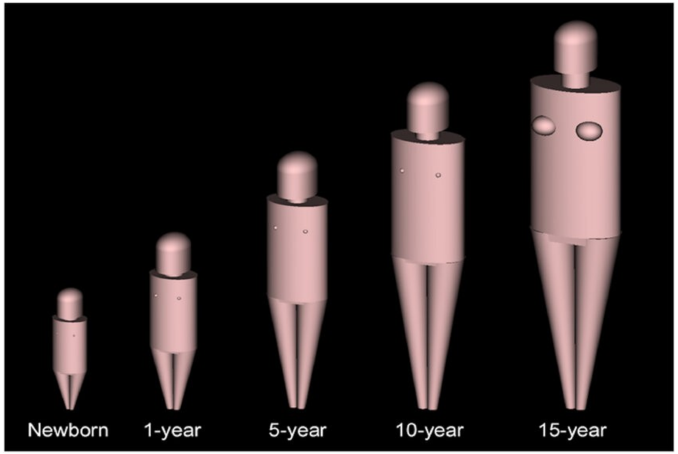
- Single Photon Emission Computed Topography
- Nuclear Imaging
- Shows blood flow to tissues and organs
- Myocardial Perfusion SPECT
  - Evaluates blood flow to the heart muscle

Anthropomorphic Human Phantoms

- Objects that simulate human tissues and organs to test and calibrate imaging devices
- Used in nuclear medicine
  - Image acquisition
  - Reconstruction
  - Data analysis
  - Calibration, etc

Types of Phantoms

- Numerical Phantoms
  - Stylized Phantoms: Use mathematical equations to represent human anatomy
    - Analytical geometries
  - Voxel Phantoms: Use 3D imaging techniques like MRI or CT scans
    - More realistic, derived from human patients
- Non-numerical phantoms
  - Physical models



Quantitative Measurements

- End Diastolic Volume(EDV)
  - Volume of blood in the left ventricle at the end of filling
- End-Systolic Volume (ESV)
  - Volume of blood in the left ventricle after contraction
- Ejection Fraction(EF)
  - Percentage of blood pumped out of the left ventricle during each heartbeat
- Phase Analysis, Wall Thickening Motion, Perfusion Parameters
  - Various measures of heart function and blood flow
- Defect Extent and Severity, Stress and Rest Scores, Total Perfusion Deficit(TPD)
  - Assessment of areas with poor blood flow and overall heart health

The Problem

- Current Cardiac Phantoms limited in realism and flexibility
- Stylized Phantoms lack detail of anatomical model
- Voxel Phantoms are rigid and less flexible

Study Aim

- Design a computational cardiac phantom
  - Simulate interfering Parameters
  - Accurate phantom for validating and improving the quantitative analysis software
- Computational Phantom
  - Versatile and easily modifiable
  - Enhances imaging accuracy and diagnosis

Why use Python?

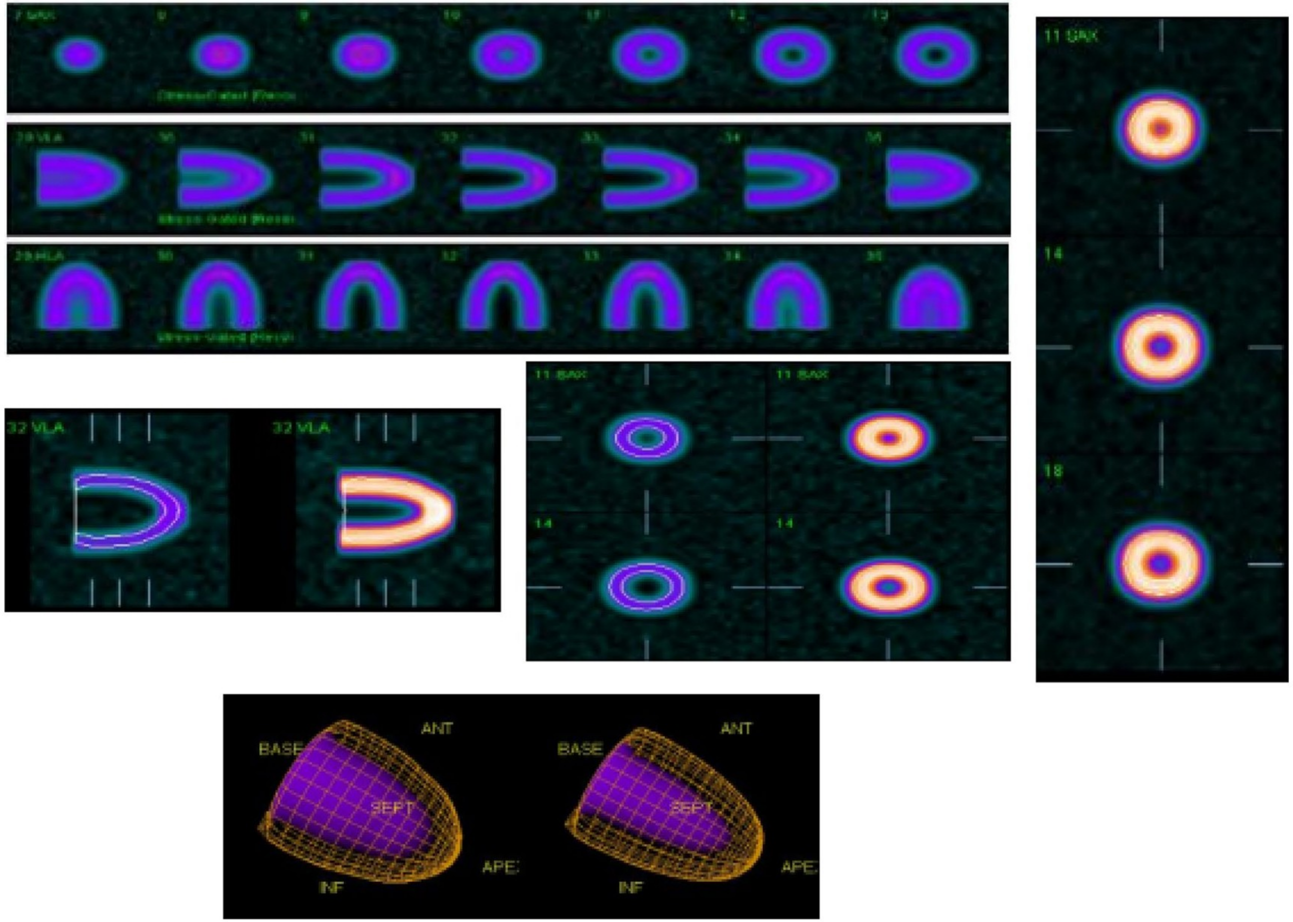
- High-Level programming language
- Easy Syntaxes
- Flexibility
- More advantages over other languages

Python Libraries Used

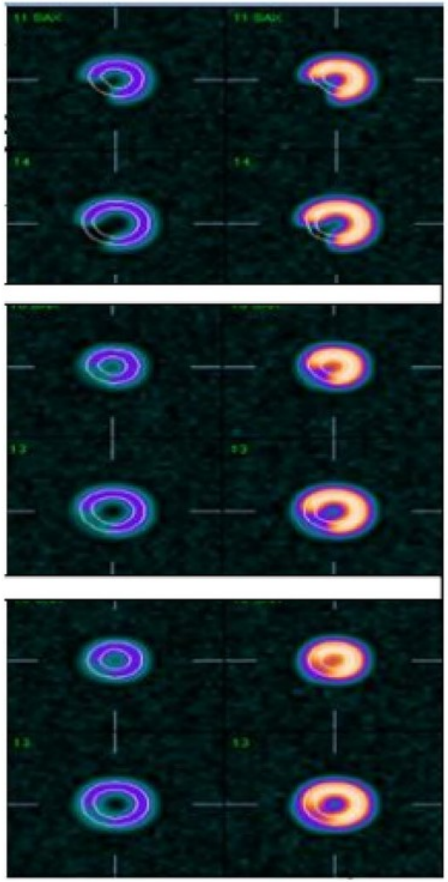
- **NumPy**: numerical operations and matrix handling
- **SciPy:** scientific computing, including optimization and interpolation

Results

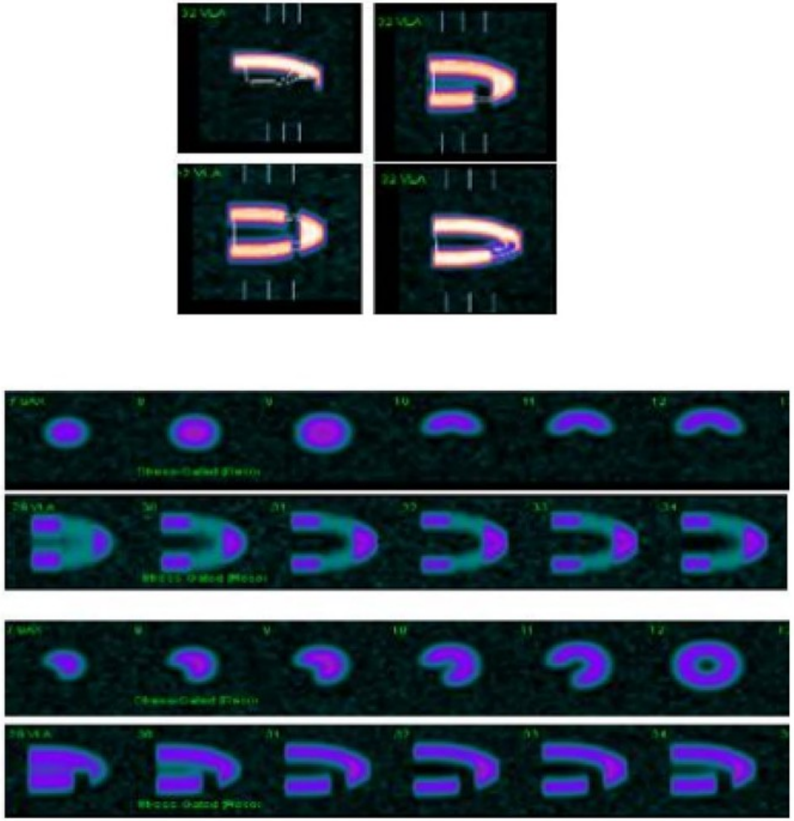
Accurate myocardial slices consistent with SPECT images



Various defect severities simulated

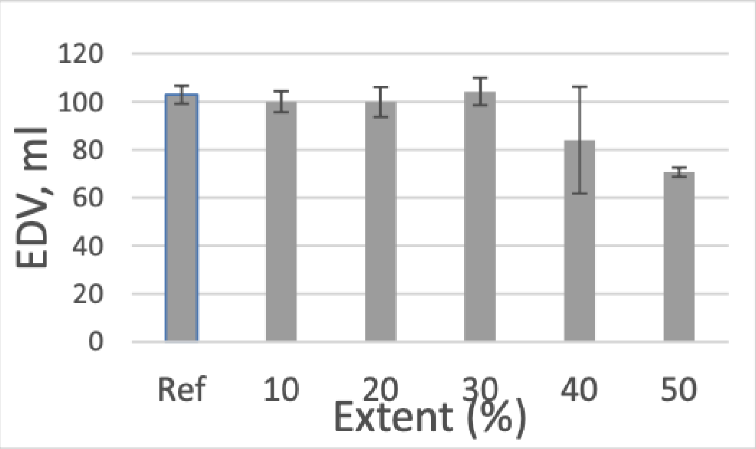


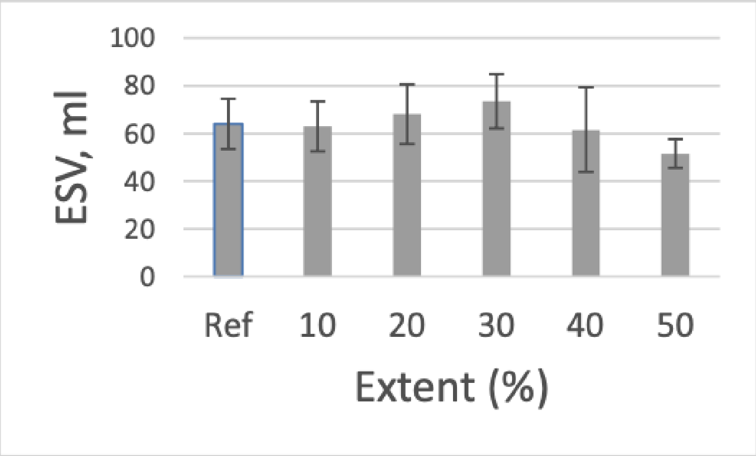
(A)

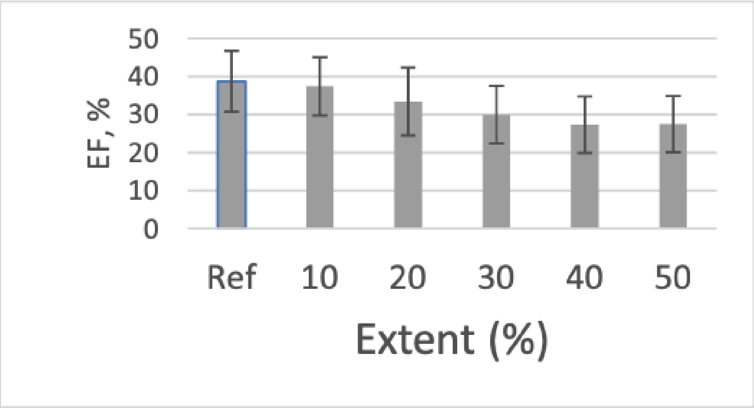


(B)

Accurate EDV, ESV, EF parameters







	% Difference				
Extent	10%	20%	30%	40%	50%
EDV	2.8	2.9	-1.2	18.4	31.5
ESV	1.6	-6.5	-14.8	3.9	19.4
EF	1.3	5.3	8.8	11.4	11.2

My Thoughts

References

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Questions?