VISUALIZATION OF CARDIAC MOVEMENT WITH EDGE DETECTION TECHNIQUES

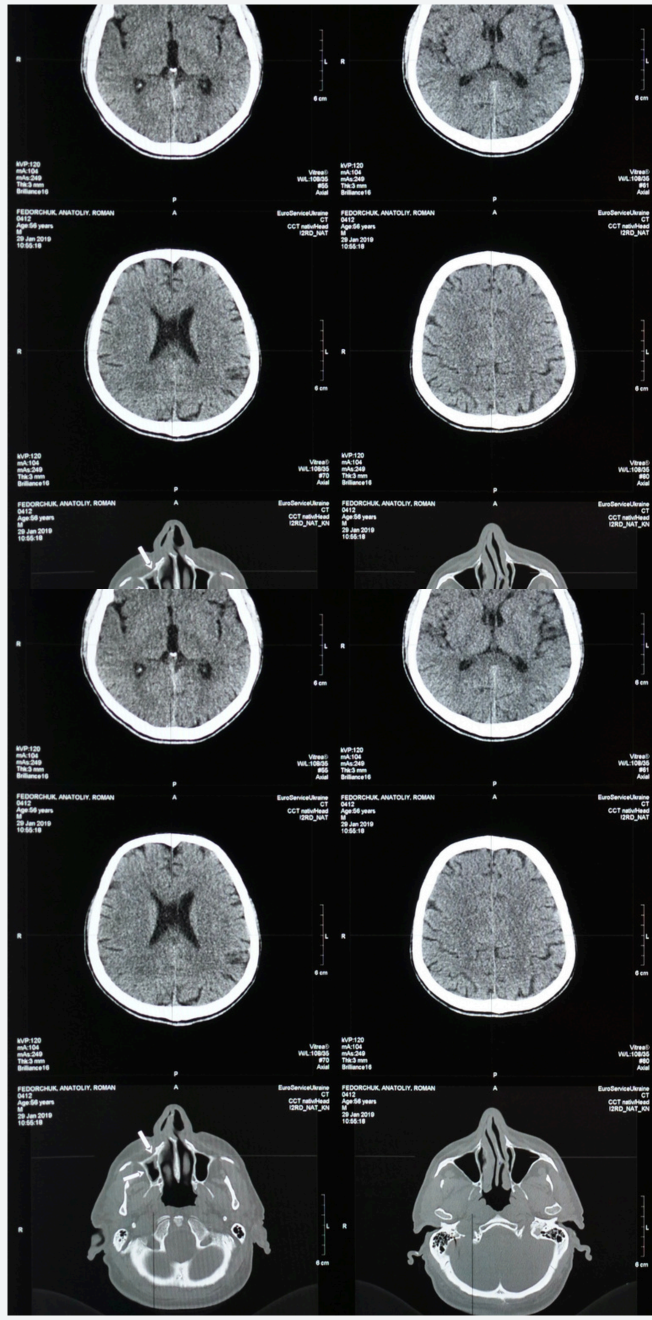
MPCS 56430 - SONIA SHARAPOVA

CONTENT

INTRODUCTION

Medical imaging, particularly MRI (Magnetic Resonance Imaging), is invaluable for diagnosing various diseases, especially those affecting brain and tissue structures.

This project aims to utilize edge detection and other computer vision techniques to automate the identification of structural changes in MRI scans, assisting in the diagnosis of various diseases.



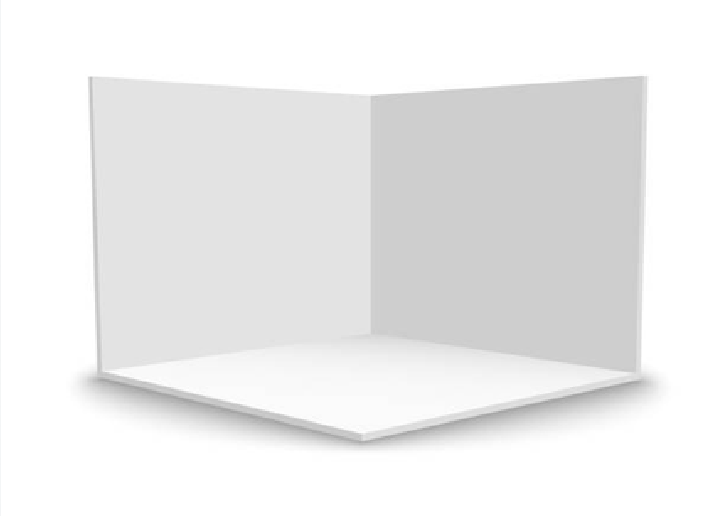
Strategy

Use Edge Detection Techniques to analyze cine MRI Scans .

Idealy: Differentiate between healthy and diseased patients.

BACKGROUND

Corners!



Shi-Tomasi Corner Detection:

- Shi-Tomasi is a corner detection algorithm used to identify points of interest in an image that have significant variations in intensity. These points, known as corners, are useful for tracking and image matching.

Lucas-Kanade Optical Flow:

- Lucas-Kanade is an optical flow estimation method used to track the motion of objects or features between two consecutive frames of a video or image sequence.

Movement!

Ski-Tomasi: geeks-4-geeks
Lucas-Kanade: CMU School

METHODOLOGY

PREPROCESS IMAGES

Process and visualize cine-MRI cardiac data.

FEATURE DETECTION

For each frame, detect keypoints on heart wall using Shi-Tomasi corner detection

MOTION ANALYSIS

Analyze motion using Lucas-Kanade optical flow.

PARALLELIZATION

Speed up execution by parallelizing the exection.

MACHINE LEARNING

CNN to look at motion over time to produce higher accuracy results.

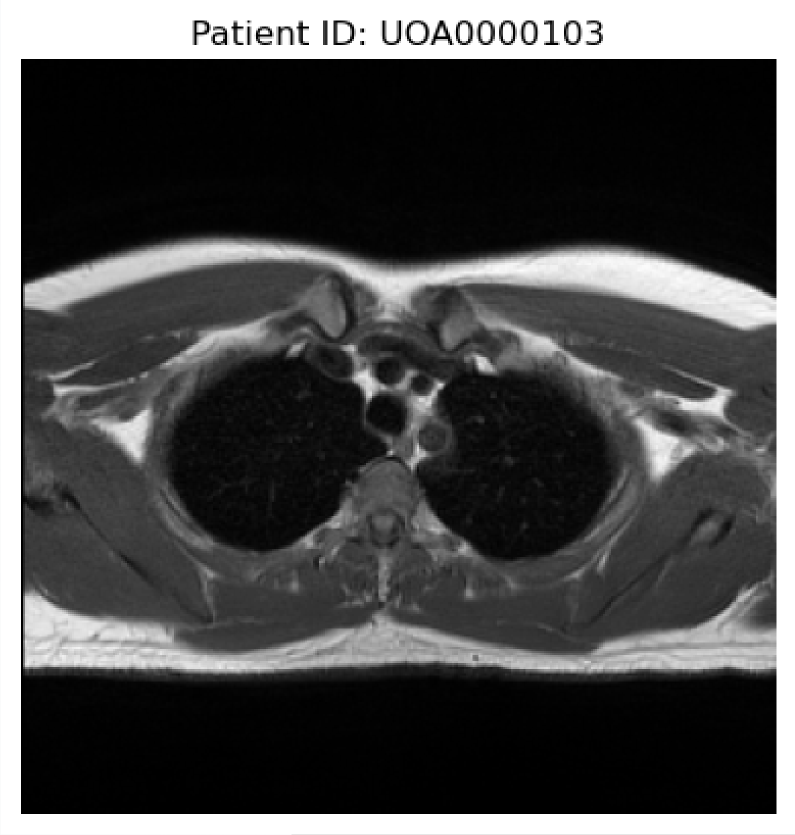
DATA

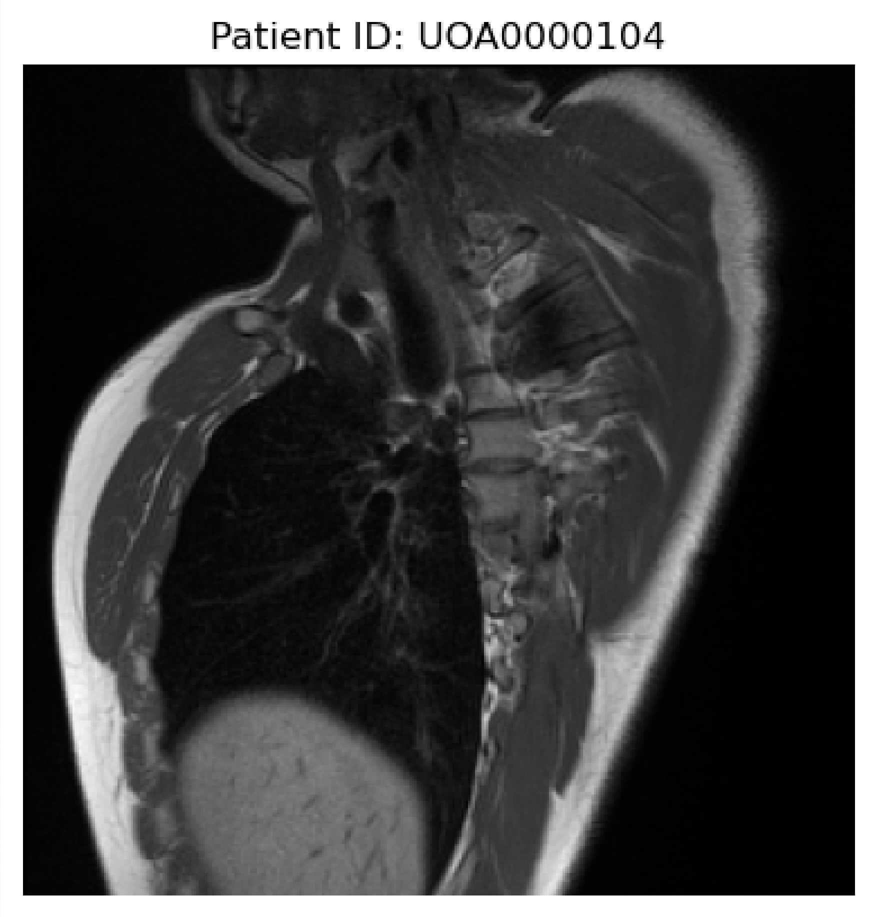
Series of horizontal cross section MRI images of the heart stored as DICOM files.

Cine-MRI: uses real-time imaging to create a 3D video of the inside of the body.

Data obtained from:

- Sunnybrook Cardiac Data - 45 images from a mix of patients and pathologies
- AMRG Cardiac MRA Atlas - complete labelled MRI image set of a normal patient’s heart.





Images from AMRG set

TOOLS

PYTHON LIBRARIES

pydicom:
Storage and transfer of medical image datasets.

openCV:
Computer vision library

Image (from PIL):
Python imaging library

ProcessPoolExecutor (from concurrent.futures)
Parallelization in Python. Allows for concurent processes.

OPTICAL FLOW TECHNIQUES

Shi-Tomasi Corner Detection:

Identifies key points for tracking.

FEATURE DETECTION

Lucas-Kanade Optical Flow:

- Tracks feature points between consecutive frames.
- Computes motion vectors based on neighborhood intensity changes.

MOTION TRACKING

Overlay motion vectors as arrows on the heart region to show direction.

VISUALIZATION

CHALLENGES

Data Quality

- Missing or corrupted DICOM metadata.
- Frame dimension mismatches causing computation errors.

Handling Skipped Frames

Frames with invalid data or missing features were logged and excluded.

File Sizes

The file sizes were very large so execution time and file transfering took a while. Hopefully this can be eased with parallelization

RESULTS

Key Observations:

- Motion vectors illustrate heart contractions and expansions across frames.
- Skipped frames had minimal impact on final results due to consistent preprocessing.

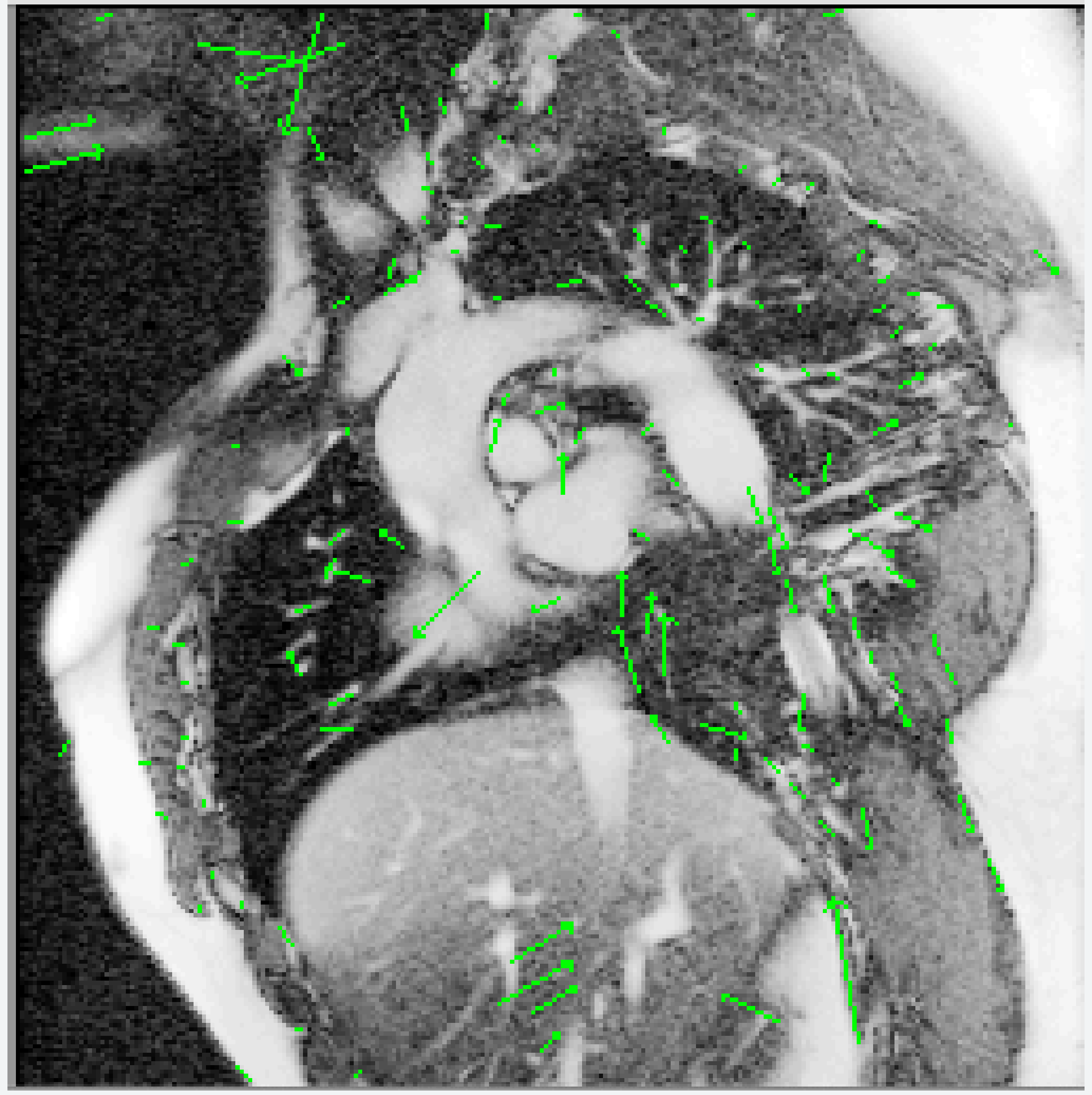
Output:
GIFs generated for each folder of cardiac MRI data, visualizing heart motion.

AMRG

RESULTS

SCD_01

SCD_02



SCD_03

INTERPRETATION

Arrows:

- The direction of the arrows represents the direction of motion between two consecutive frames.
- The length of the arrow corresponds to the magnitude of motion.

- Longer arrows = more movement
- Smaller arrow = less movements

- Base of each arrow marks a detected feature
- motion calculated over tracking consecutive frames

Patterns:

Uniform arrow directions and lengths over a region suggest coherent motion.
(like heart beat)

Variations can indicate different motion patterns
(like deformation)

INTERPRETATION

In my analysis, there was a lot of variation between detected motion, so I need to find what causes these changes.

Noise vs. Deformation

NEXT STEP: ANALYZE DIFFERENCES

As a practical application of this implementation, the differences between healthy and diseased patients can be assessed to see if noticeable patterns can be detected.

See if there are noticeable differences between healthy and diseased patients

PATIENT TYPE

Find key features that play. a role in motion pattern differences.

KEY FEATURES

See if there are noticeable differences between healthy and diseased patients

PYTHON EASE

NEXT STEP: PARALLELIZATION

Since processing each subfolder or frame pair is independent, we can parallelize the code to improve performance, especially for batch processing of datasets.

Pythons multiprocessing module:

Each subfolder is processed in parallel by a separate process since these are independent tasks.

PYTHON EASE

Using our class server which has multiple cores,, we can significantly reduce processing time for the large datasets.

IMPROVED EFFICIENCY

GIFs are saved separately for each subfolder, which can be maintained with parallelization.

OUTPUTS

CONCLUSION

Key Takeaways:

- Optical flow is a powerful tool for visualizing cardiac motion.
- Proper preprocessing ensures robust feature detection and motion analysis.

Next Steps:

- Incorporate advanced techniques like CNN-based motion tracking (e.g., MotionNet).
- Expand analysis to larger datasets with varied heart conditions.

THANK YOU!

ACKNOWLEDGMENTS

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- Jiamao Zheng
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REFERENCES

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- **Lucas-Kanade:**
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- **Datasets:**
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