Toufiq Musah

toufiqmusah.github.io

Education ...

KNUST
KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

BSc. Biomedical Engineering (2021-2024)

Penn
UNIVERSITY of PENNSYLVANIA

MSE. Data Science (2025-2026*)

Research ...

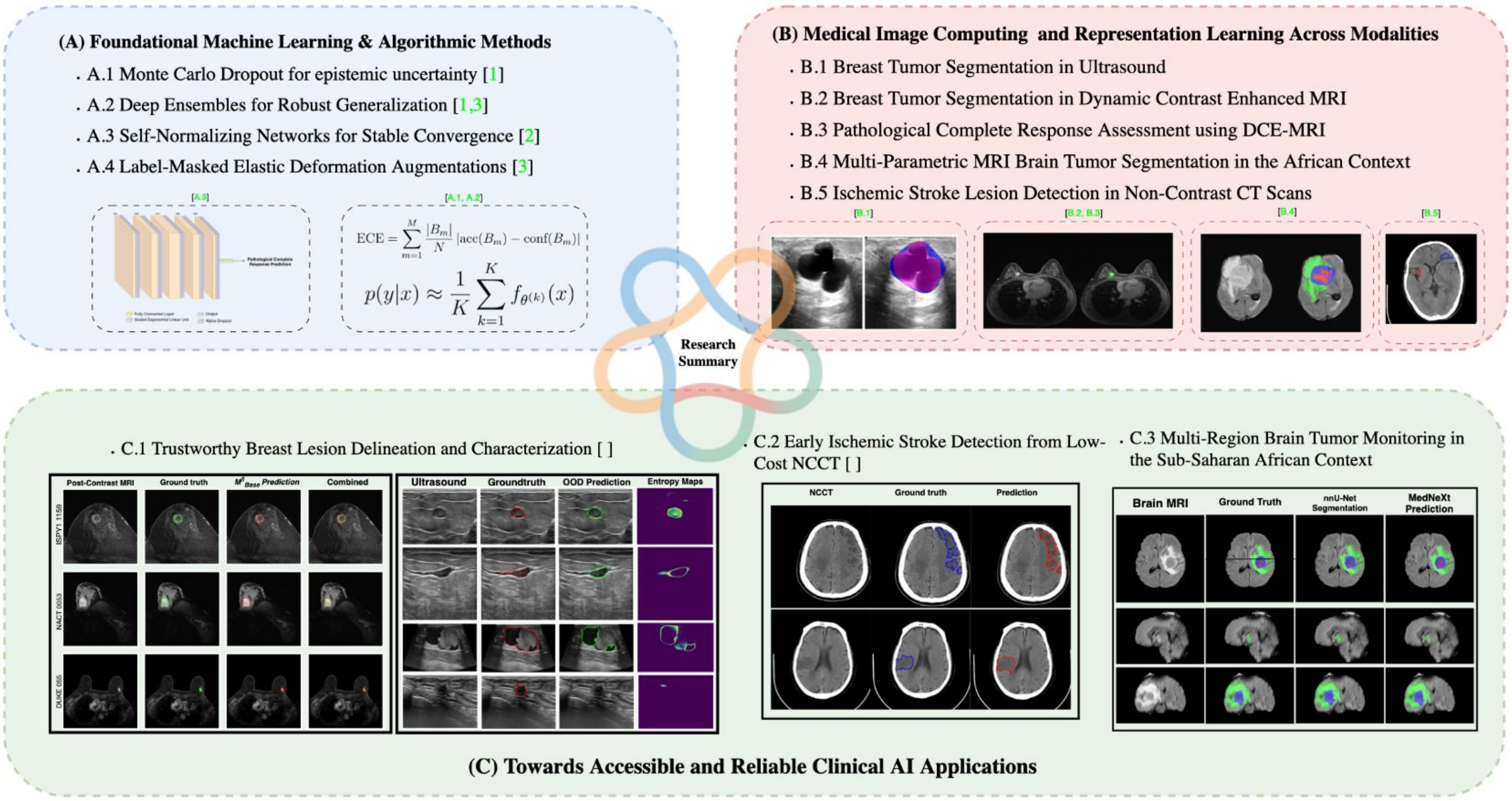
KCCR
Global Health and Infectious Diseases Research Group

Kumasi Centre for Collaborative Research in Tropical Medicine (2024-2025)

RESPONSIBLE ARTIFICIAL INTELLIGENCE LAB

Responsible Artificial Intelligence Lab (2023-2024)

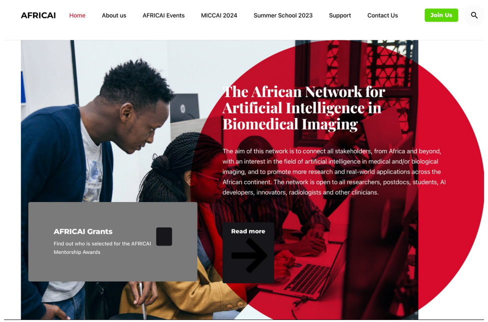
Research Summary



Current Work – ULF-BrainGen: Physics-Guided Generative Synthesis and Super-Resolution of Ultra Low-Field MRI

Funded By:

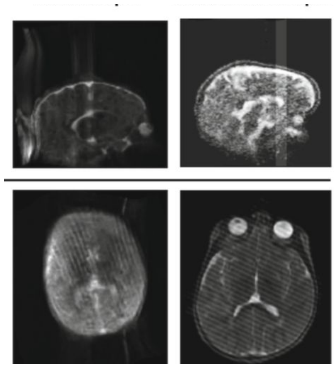
The African Network for Artificial Intelligence in Biomedical Imaging



Problem:

Ultra low-field MRI presents a great opportunity for expanding access to MRI procedures in underserved regions of the world.

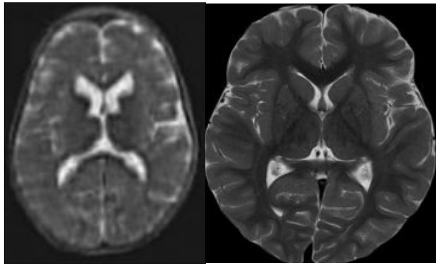
The imaging quality due to inherent noise and low magnetic strength sometimes leads to poor imaging quality.



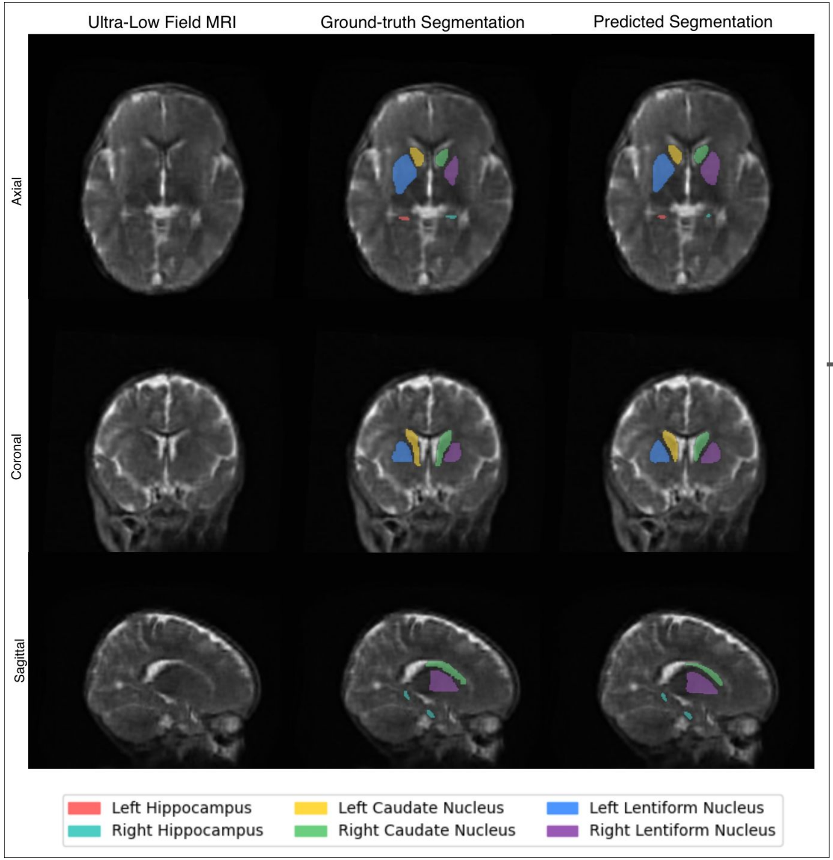
Proposal:

ULF-BrainGEN is a physics-guided generative modeling framework designed to synthesize ULF-MRI scans into diagnostically faithful, high-quality images comparable to conventional 1.5 T MRI systems.

By quantifying ULF degradation patterns and making use of state-of-the-art generative architectures guided by MRI physics.



Automated Segmentation of Pediatric Hippocampal and Basal Ganglia Structures in Ultra-Low-Field Magnetic Resonance Images



Problem:

Automated segmentation of brain structures such as the hippocampus and basal ganglia from ultra-low field (0.064T) neonatal MRI (ULF-MRI) is important for neurodevelopmental research and diagnosis . Manual segmentation is time-consuming and inconsistent, while the low signal-to-noise ratio and spatial resolution in ultra-low-field MRI make it challenging

Method & Solution:

We used the Low-Field Pediatric Brain Magnetic Resonance Image Segmentation and Quality Assurance Challenge (LISA) 2025 dataset comprising 79 training and 12 validation neonatal MRI scans. A medium variant MedNeXt was trained using a composite Focal-Dice-CE loss function to prioritize small-structure segmentation.

Hippocampal segmentation achieved an average DSC of 0.69 ± 0.18 outperforming the uLF nnU-Net baseline score of 0.61 ± 0.27. Basal ganglia segmentation achieved a mean DSC of 0.85 ± 0.06 across caudate and lentiform nuclei.

Automated Segmentation of Ischemic Stroke Lesions in Non-Contrast Computed Tomography Scans

MICCAI'24 – Workshop Paper

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Automated Segmentation of Ischemic Stroke Lesions in Non-contrast Computed Tomography Images for Enhanced Treatment and Prognosis

Conference paper | First Online: 09 February 2025
pp 73–80 | Cite this conference paper

Toufiq Musah, Prince Ebenezer Adjei & Kojo Obed Otoo

Part of the book series: Communications in Computer and Information Science ((CCIS,volume 2240))

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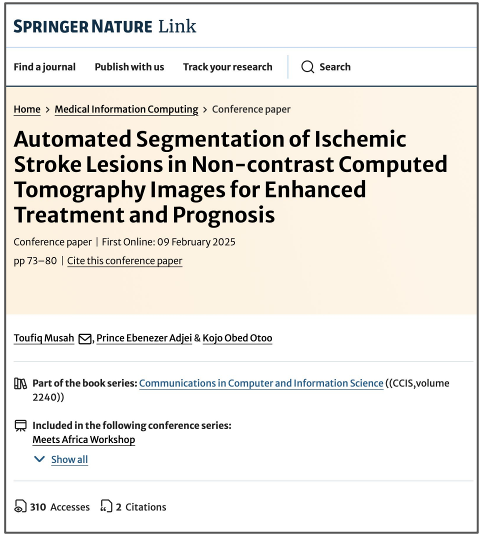

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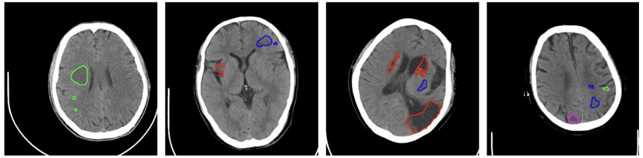
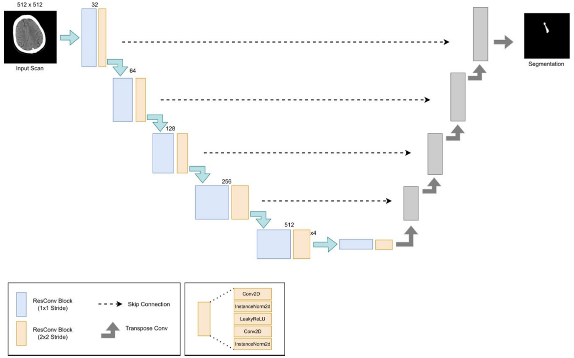
Problem:
Early Ischemic Stroke detection via neuroimaging is usually done using **DWI MRI**. MRI is not a widely accessible neuroimaging modality in underserved region.

Can we perform IS detection using NCCTs (More widely available and accessible)

1. NCCT Dataset of Different Infarct Types



2. Residual-Encoder U-Net in nnU-Net Framework



Method:
NCCTs are labeled using DWI pairs.
Preprocess NCCTs into relevant slices.

Using a well-validated biomedical image segmentation framework (nnU-Net), with a **Residual-Encoder U-Net**, we perform segmentation of acute infarcts in NCCTs.

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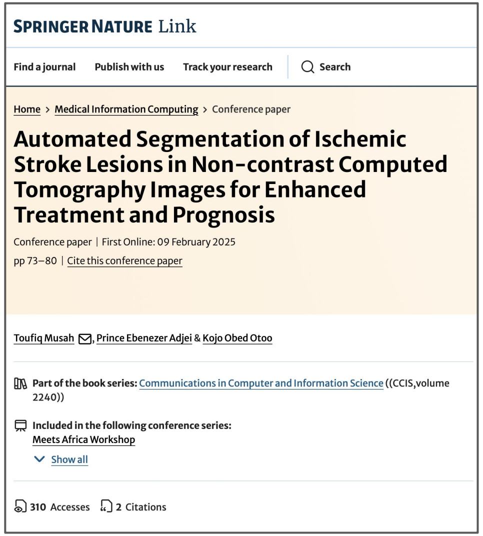
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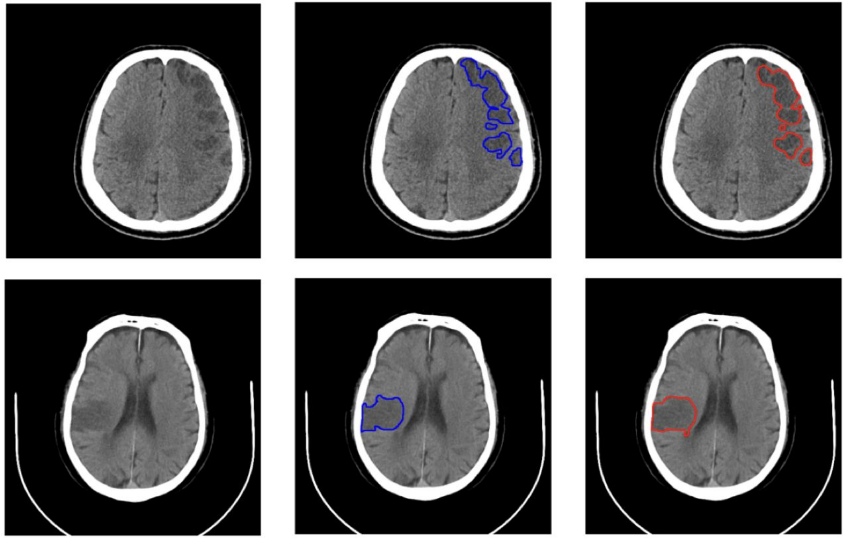
Result:

Achieved 0.752 Dice in the best when adjusting for outliers.

Comparative works achieved 0.578 Dice.

3. Results from Segmenting Acute Infarcts (0.75 Dice – Benchmark 0.57)



Tumor Segmentation in Dynamic Contrast MRI | Radiomics-Based Pathological Complete Response Assessment

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Large Kernel MedNeXt for Breast Tumor Segmentation and Self-normalizing Network for pCR Classification in Magnetic Resonance Images

Conference paper | First Online: 21 September 2025
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Toufiq Musah

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Tumor Segmentation in Dynamic Contrast MRI | Radiomics-Based Pathological Complete Response Assessment

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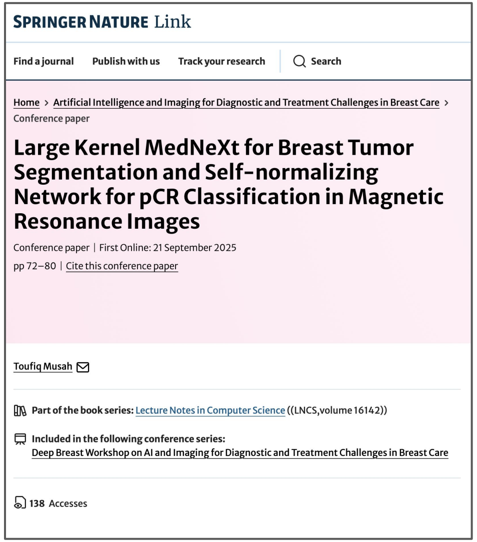
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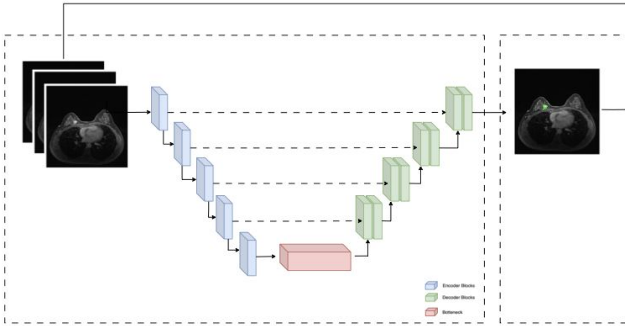
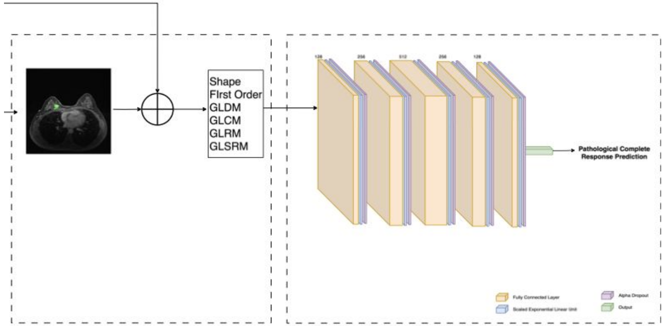
Problem:
Accurate breast tumor segmentation in DCE-MRI is important for downstream tasks.

There is a need to capture both the subtle enhancement patterns of tumors across contrast time points and the broader breast tissue context, which larger receptive fields naturally accommodate.

1. Segmenting Tumors w/ Large Kernel Network



2. Assessing pCR w/ Radiomics-Based SNN



Method:
A large-kernel MedNeXt architecture with a two-stage training strategy that expands the receptive field from 3^3 to 5^3 kernel sizes using the UpKern algorithm.

This allowed for stable transfer of learned features to larger kernels, improving segmentation performance

Tumor Segmentation in Dynamic Contrast MRI | Radiomics-Based Pathological Complete Response Assessment

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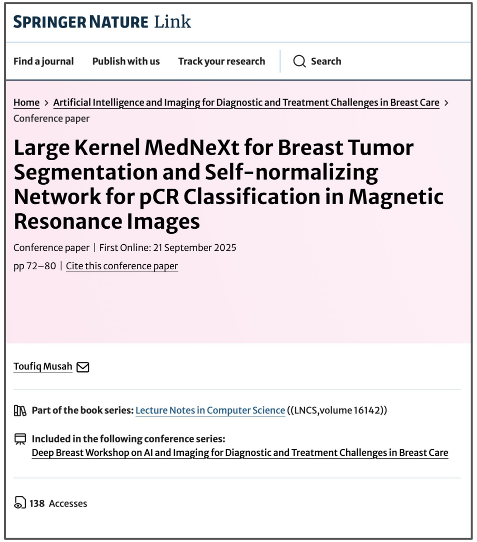
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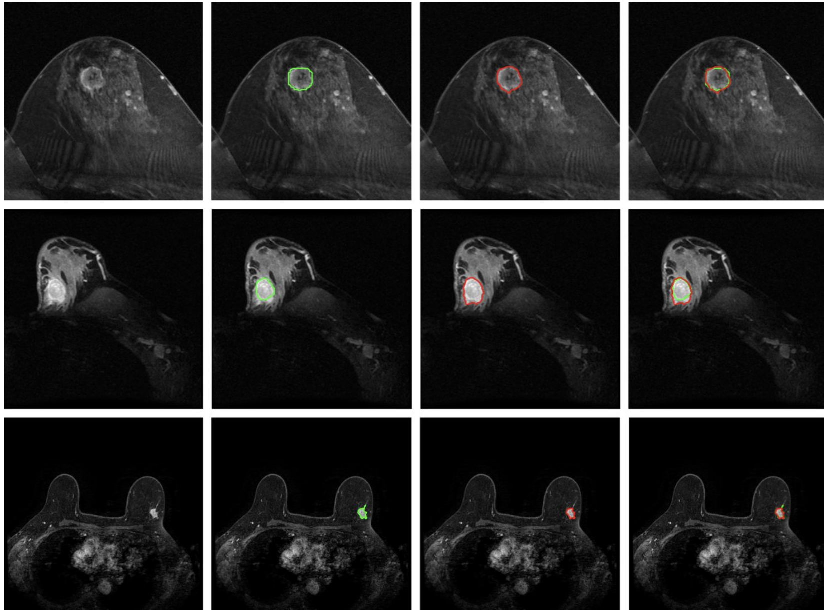
Result:

Ensemble of large-kernel networks achieved a **Dice of 0.67** and a **NormHD of 0.24**.
For pCR classification, a self-normalizing network (SNN) on radiomic features achieved an accuracy of **57%**, and up to **75%** in some subgroups.

3. 0.67 Dice | 64M Parameters – vs – 0.65 | 700M Benchmark



Other Works

First Place Submission: Brain Tumor Segmentation Challenge (2025)

Performed segmentation-aware data augmentation with controlled rigorous elastic deformations, and model deep-ensembling for **SOTA** segmentation performance ..

arXiv > eess > arXiv:2510.03568

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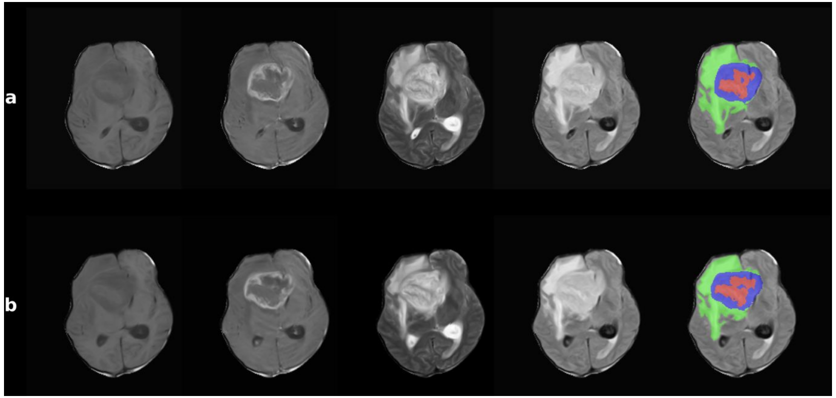
Electrical Engineering and Systems Science > Image and Video Processing

[Submitted on 3 Oct 2025 (v1), last revised 9 Oct 2025 (this version, v2)]

How We Won BraTS-SSA 2025: Brain Tumor Segmentation in the Sub-Saharan African Population Using Segmentation-Aware Data Augmentation and Model Ensembling



Oral presentation at MICCAI MIRASOL Workshop on trustworthy segmentation in ultrasound.

Performed epistemic uncertainty estimation in segmentation using Deep Ensembling and Monte Carlo dropout .

arXiv > eess > arXiv:2508.17768

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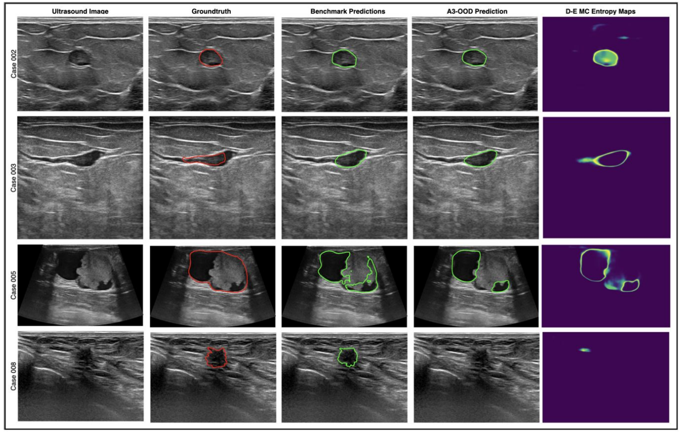
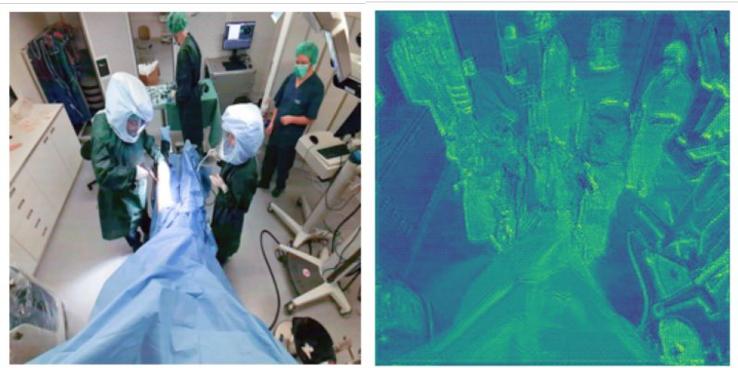
[Submitted on 25 Aug 2025]

Towards Trustworthy Breast Tumor Segmentation in Ultrasound using Monte Carlo Dropout and Deep Ensembles for Epistemic Uncertainty Estimation



Projects

Surgical Video Scene Understanding & Panoptic Segmentation

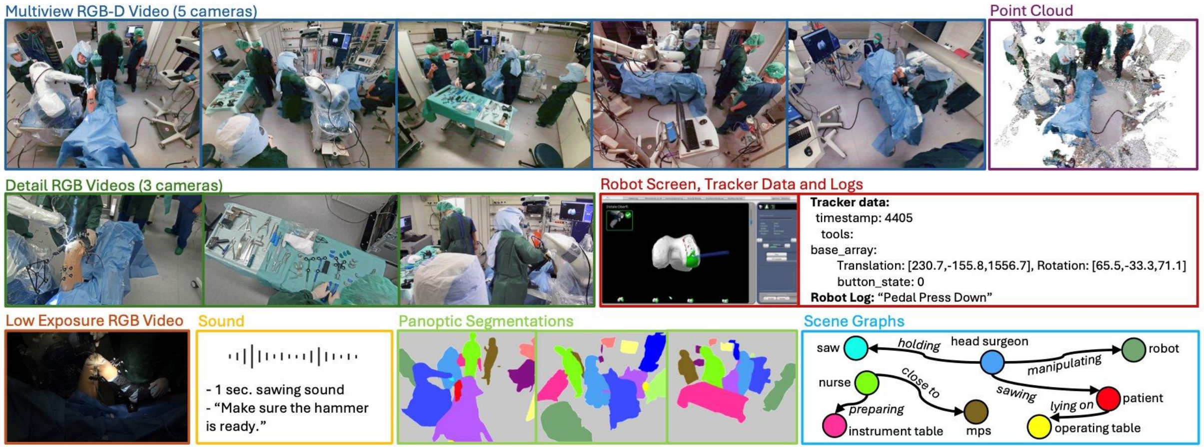


Problem:
Surgical Operating Rooms are a complex, high-risk environment …

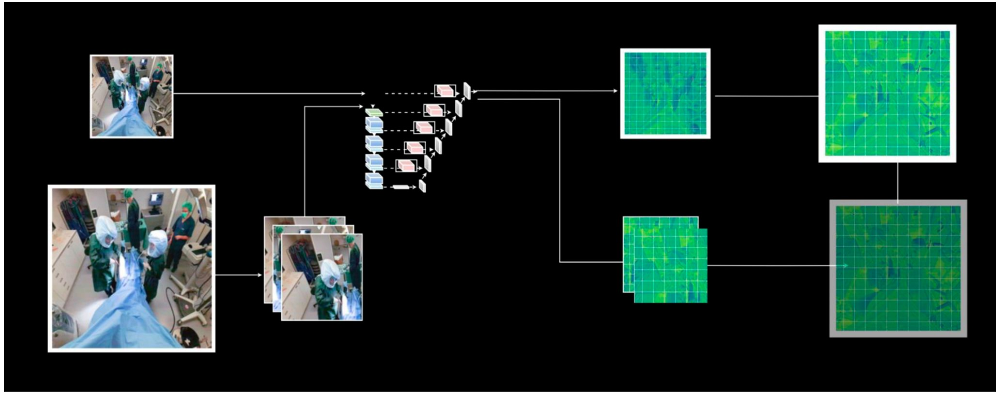
Precise understanding of interactions among staff, tools, and equipment can enhance surgical assistance and situational awareness

Dataset:
MM-OR dataset including a rich set of synchronized data sources:

- Multi-view RGB-D Video
- Detail RGB Cameras (3 cameras)
- Low-exposure RGB Video
- Audio + Speech Transcripts



Surgical Video Scene Understanding & Panoptic Segmentation



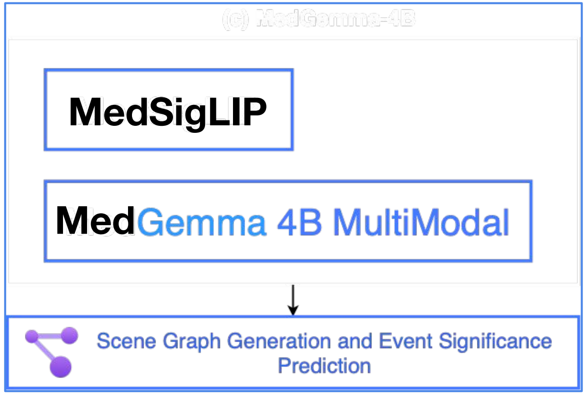
Methods – Panoptic Scene Segmentation:
Applied S2-Scaling to SwinUNETR to enable better feature extraction for high precision segmentation.

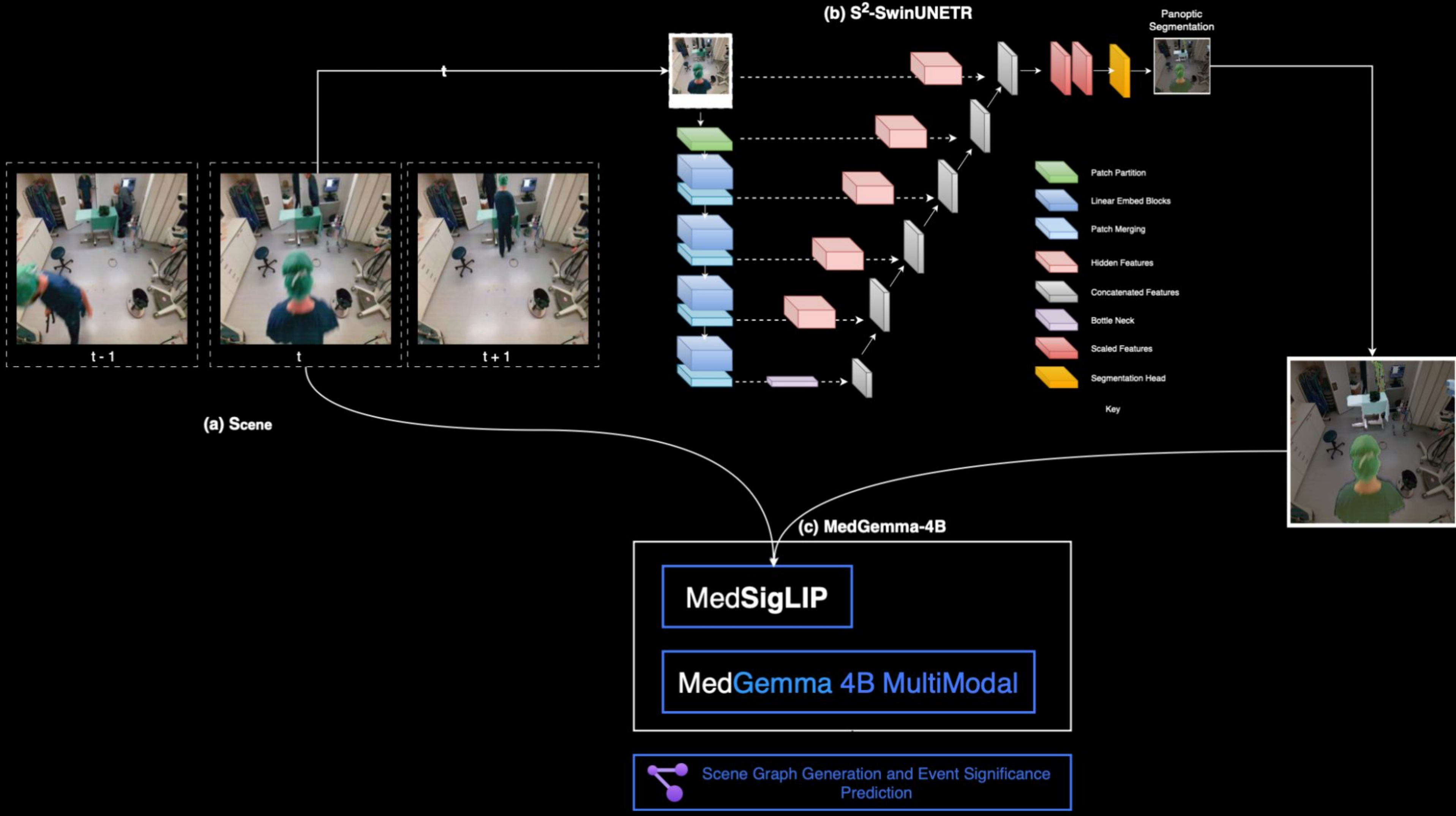
Segmented for 21 classes, including personnel and tools.

Method – Vision Language Finetuning:
MedGemma Vision Language model for Scene Graph Generation and Event Significance Classification.

Model trained on 3 FPS surgical video + panoptic segmentations.

Trained with Quantized Low-Rank Adaptation.



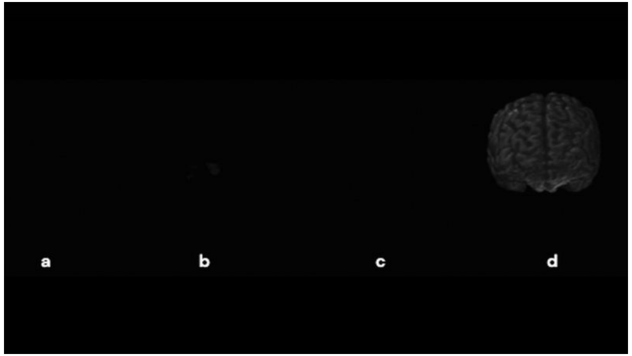


(b) S²-SwinUNETR
t
Panoptic Segmentation
Patch Partition
Linear Embed Blocks
Patch Merging
Hidden Features
Concatenated Features
Bottle Neck
Scaled Features
Segmentation Head
Key
t - 1
t
t + 1
(a) Scene
(c) MedGemma-4B
MedSigLIP
MedGemma 4B MultiModal
Scene Graph Generation and Event Significance Prediction

Tutorial Articles on 3D Medical Image Computing

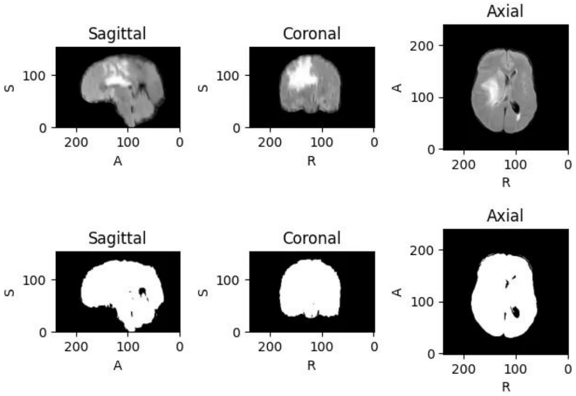
A Hitchhiker's Guide to 3D Medical Image Processing (Preprocessing, Augmentations & DataLoaders)

Toufiq Musah 10 min read · Aug 17, 2025



Introduction to TorchIO for 3D MRI Processing: Preprocessing Transforms (Part 1)

Toufiq Musah 7 min read · Feb 2, 2025



Introduction to TorchIO for 3D MRI Processing: Augmentation Transforms & DataLoaders (Part 2)

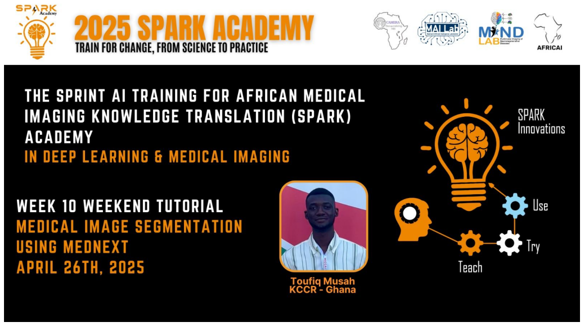
Toufiq Musah 6 min read · May 11, 2025

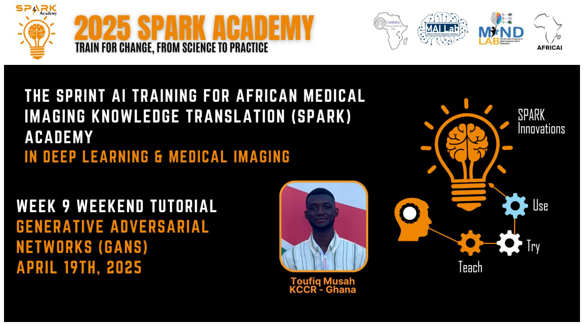
70 4

SPARK ACADEMY

Train the trainer strategy

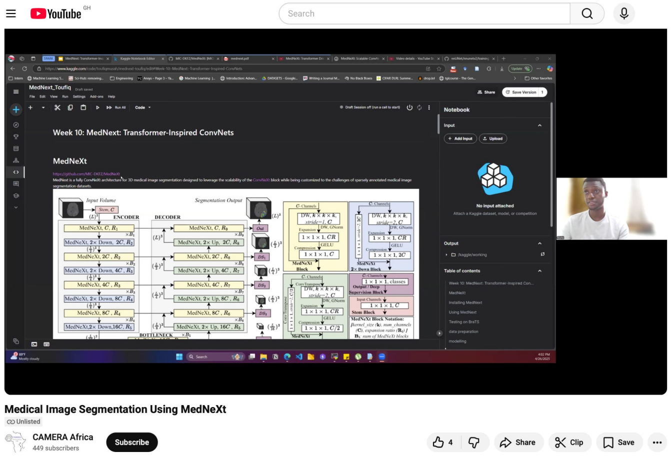
SPARK ACADEMY – Coordination

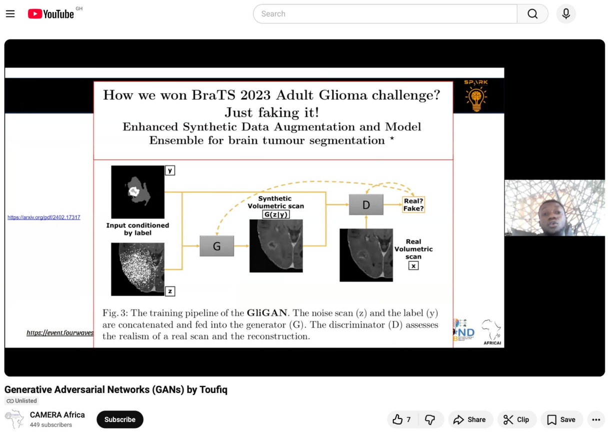




https://youtu.be/g2NCLfWrzrc?si=r4dijOqU-coF313Y

https://youtu.be/QNdNNjhe3A?si=mZwpMaJWF_biXnw9





Other Ongoing Works …

MedSegMNIST – A Python Library for Easy Access to 2D/3D Medical Image Segmentation Datasets for Benchmarking and Learning Purposes.

MED-RAE – Representational AutoEncoders for Medical Image Synthesis …

SSC-UNet – State-Space ConvNeXt UNet for 3D Biomedical Image Segmentation

Topology-Based Network Optimization for Neuro Tracing/Segmentation

Imaging-Biomarkers, Radiomics …