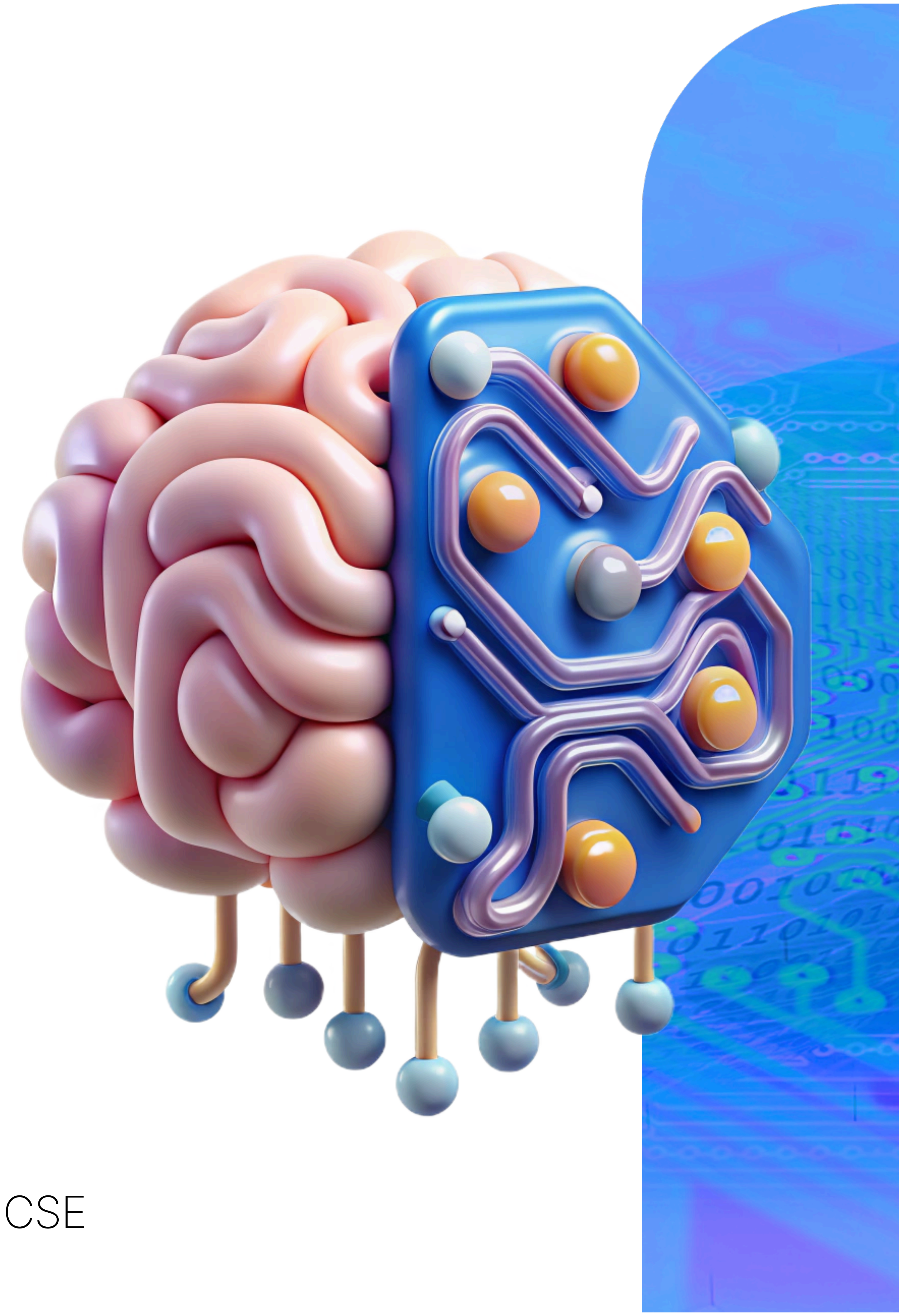
COLLEGE OF ENGINEERING KIDANGOOR
(Under CAPE , Estd by Govt.of Kerala)

Intracranial Aneurysm Detection

Minds live in bodies, and bodies move through a changing world



Presented by

Alen Sebastian : KGR22CS012
Muhammed Rayan : KGR22CS066
Subash M : KGR22CS090
Tobin Tom : KGR22CS094
Ajas Ajmal : LKGR22CS101

Mentor

Mrs. Athira S Nath
Asst. Prof Dept of CSE

Project Cordinators

Dr . Ojus Thomas Lee
Associate. Prof Dept of CSE

Mrs. Jisha C Thankappan
Asst. Prof Dept of CSE

Date : 21 OCT 2025

VISION

COLLEGE

To be a leading engineering institution in the region, providing competent professionals, who engage in lifelong learning, driven by social values.

DEPARTMENT

To become a center of excellence in Computer Science and Engineering imparting quality professional education to develop competent professionals with social values who are capable of life long learning.

MISSION

COLLEGE

To prepare engineering graduates for the development activities of the society and industry, and to prepare them for higher engineering education.

DEPARTMENT

To impart quality technical education to students at undergraduate level through constant knowledge upgradation by maintaining pace with the latest sophisticated innovations , research & development and industry interaction in the field of Computer Science and Engineering with focus on lifelong learning for the well-being of the society.

contents

1 Abstract

2 Introduction

3 Relevance

4 Problem Statement

5 Literature Survey

6 System Architecture

7 Modules And Functionality of each module

8 Design Diagrams

8.1 Use Case diagram

8.2 Sequence diagram

8.3 Activity diagram

8.4 DFD

9 Software Requirement

10 Hardware Requirement

11 Conclusion

12 Reference

13 Thank you

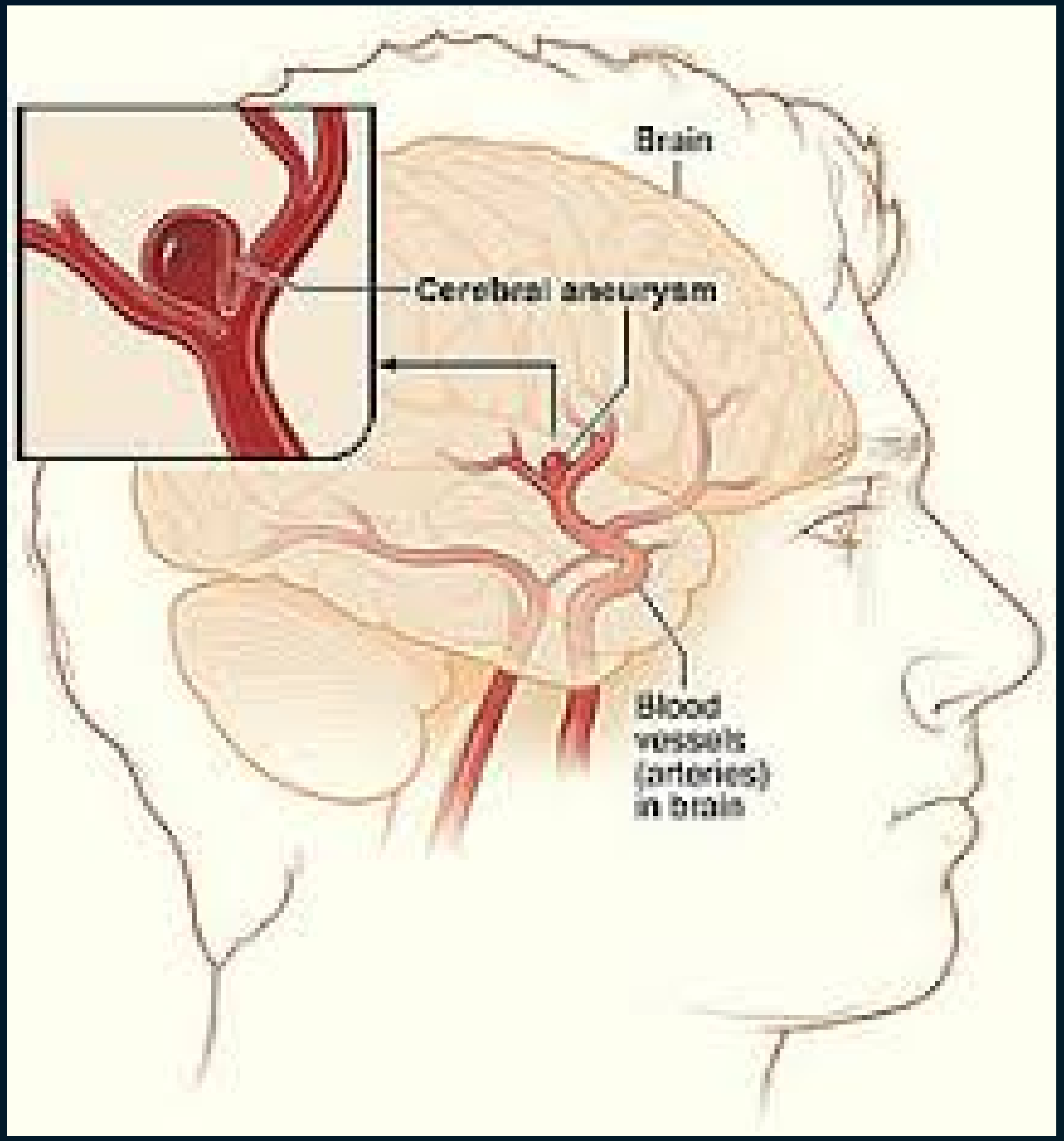
Abstract

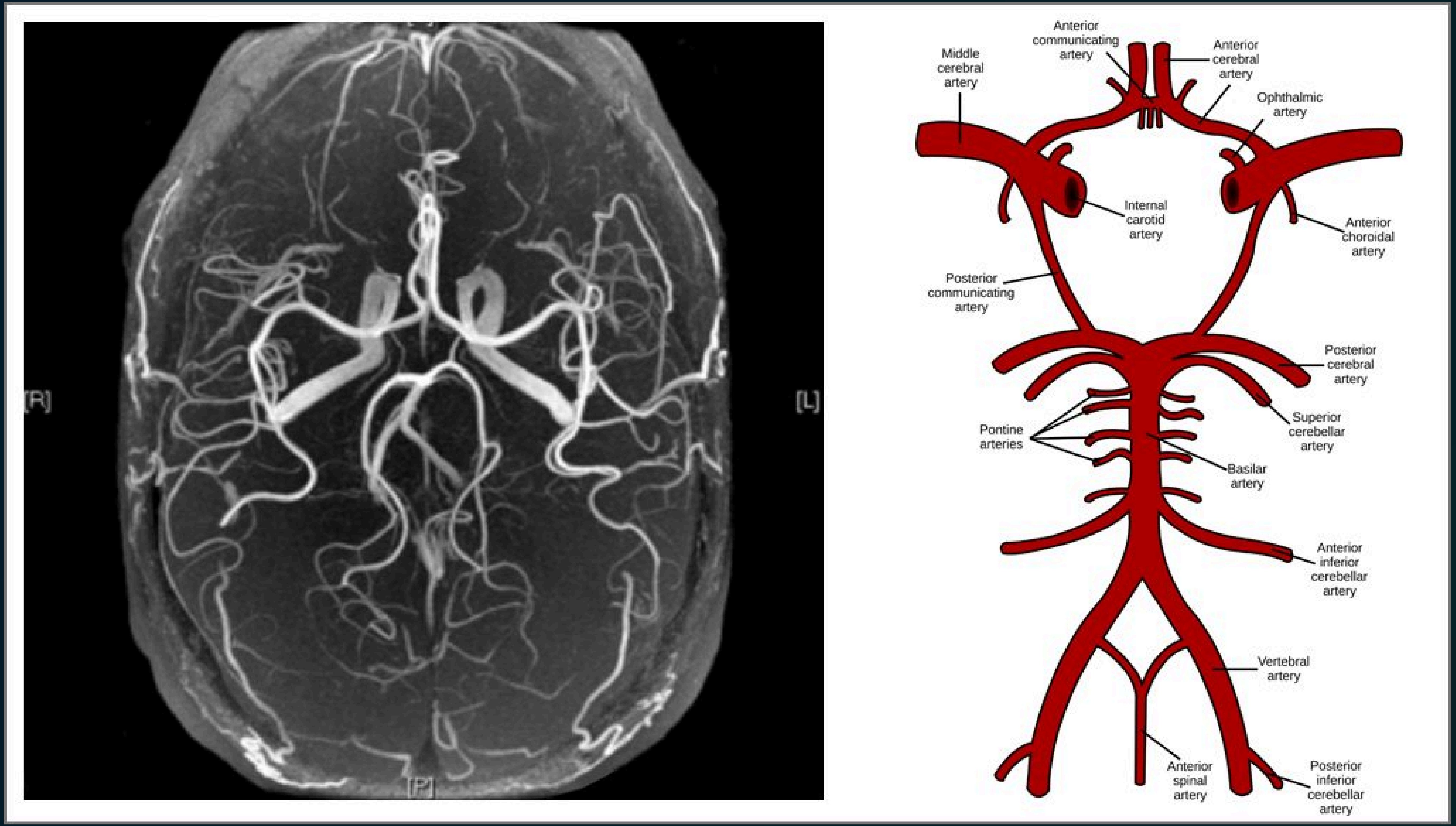
- Intracranial aneurysms are abnormal dilations of blood vessels in the brain that may rupture and cause life-threatening hemorrhage.
- Early detection and localization are critical for timely treatment and prevention of rupture.
- The dataset containing multi-modality CTA, MRA, and MRT1,T2 series with expert annotations.
- Automatically detect presence of aneurysms and localize them into 13 predefined brain locations.
- The goal is to build a generalizable tool to support radiologists in faster and more accurate aneurysm detection.

Introduction

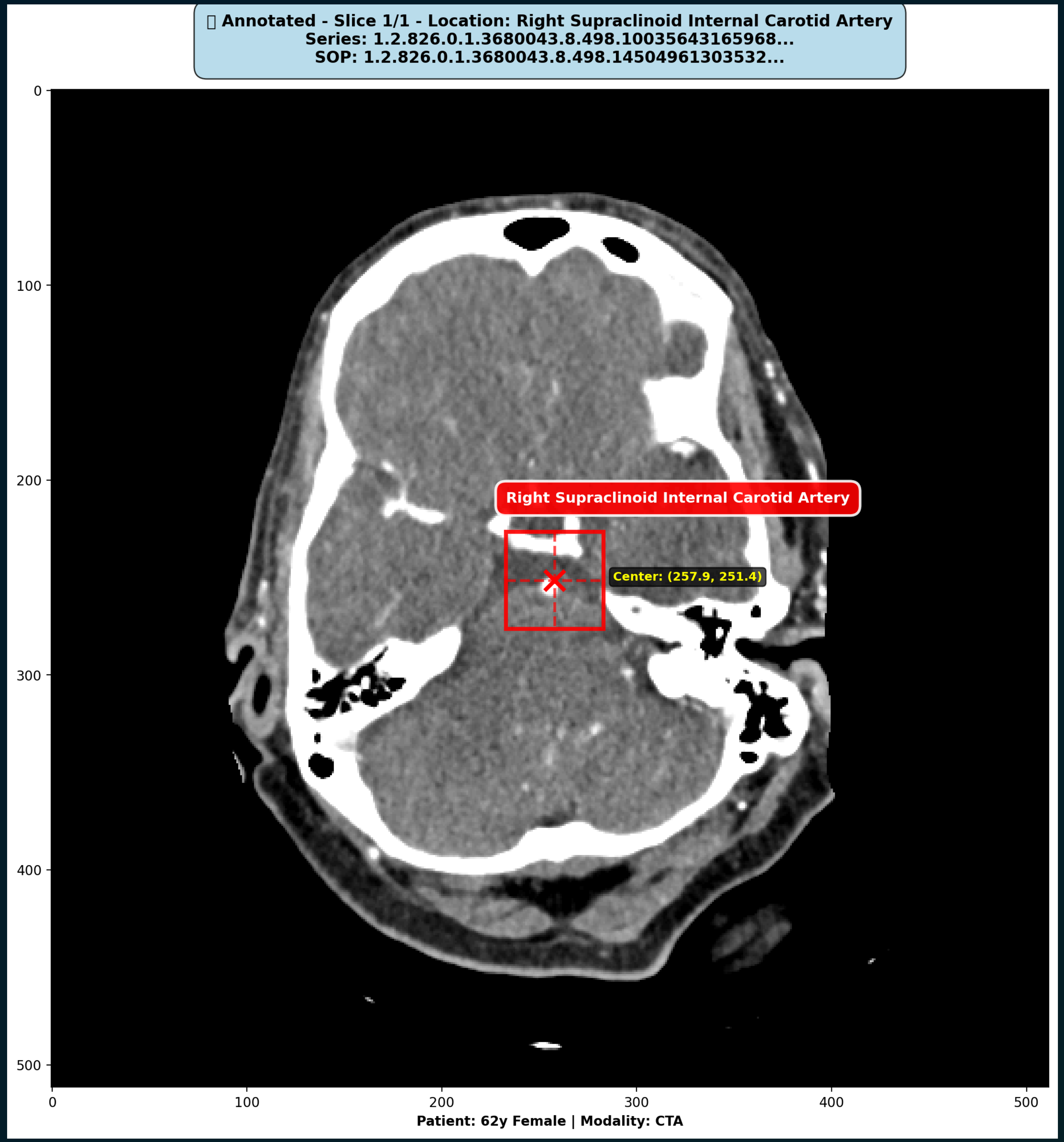
- **Problem significance :** intracranial aneurysms are common but often missed due to small size, variability, and imaging complexity.
- **Clinical challenge :** manual review of cta/mra scans is time-consuming and prone to diagnostic errors.
- **Project focus:** develop an ai-based pipeline to automatically detect and localize aneurysms in large-scale brain imaging data.
- **Dataset:** rsna provides a diverse, multi-institutional dataset with labeled aneurysm cases and localization coordinates subset for training robust models.
- **Methodology overview:** preprocessing of dicom images, training of deep learning models (2d/3d cnns, segmentation), and evaluation .

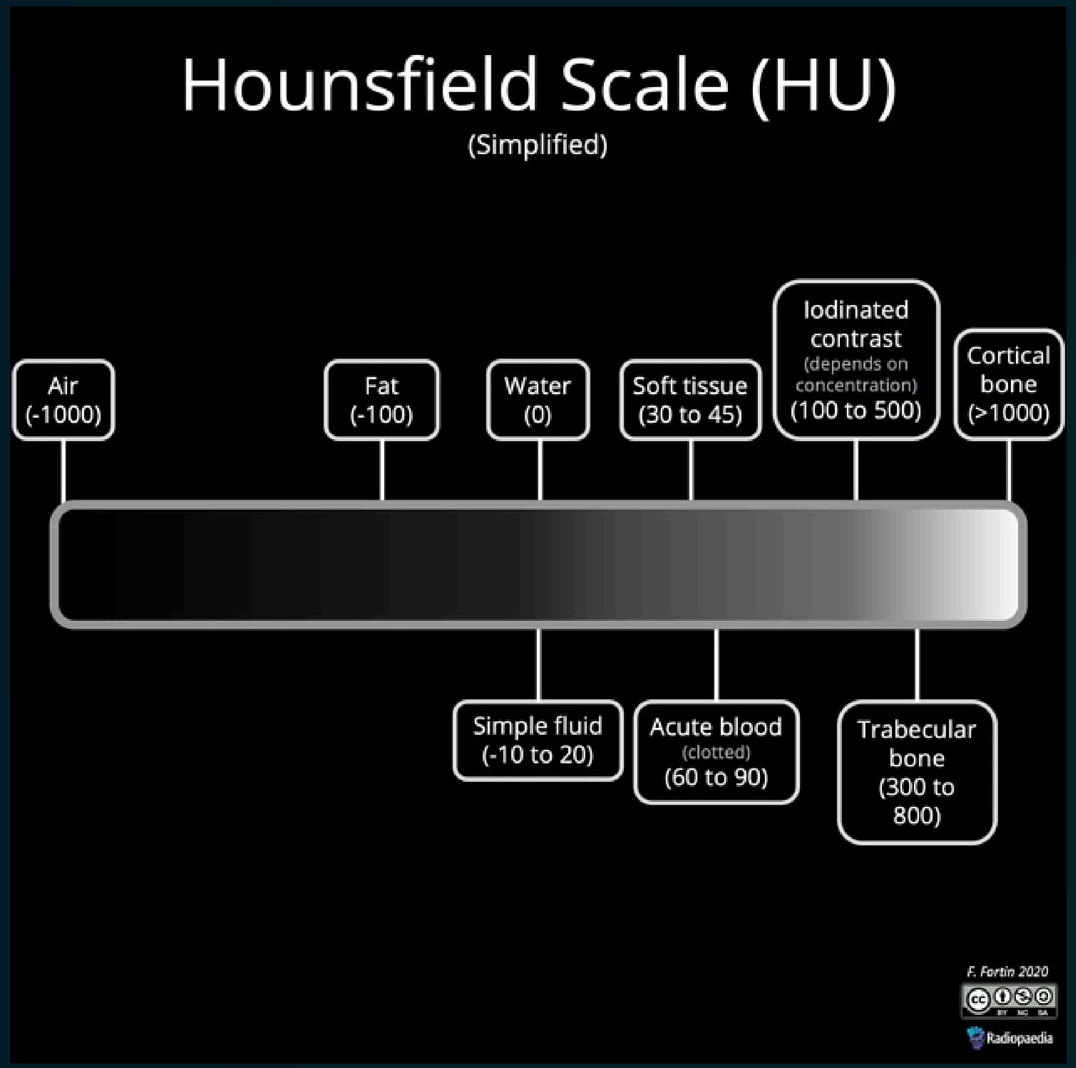
Medical Background





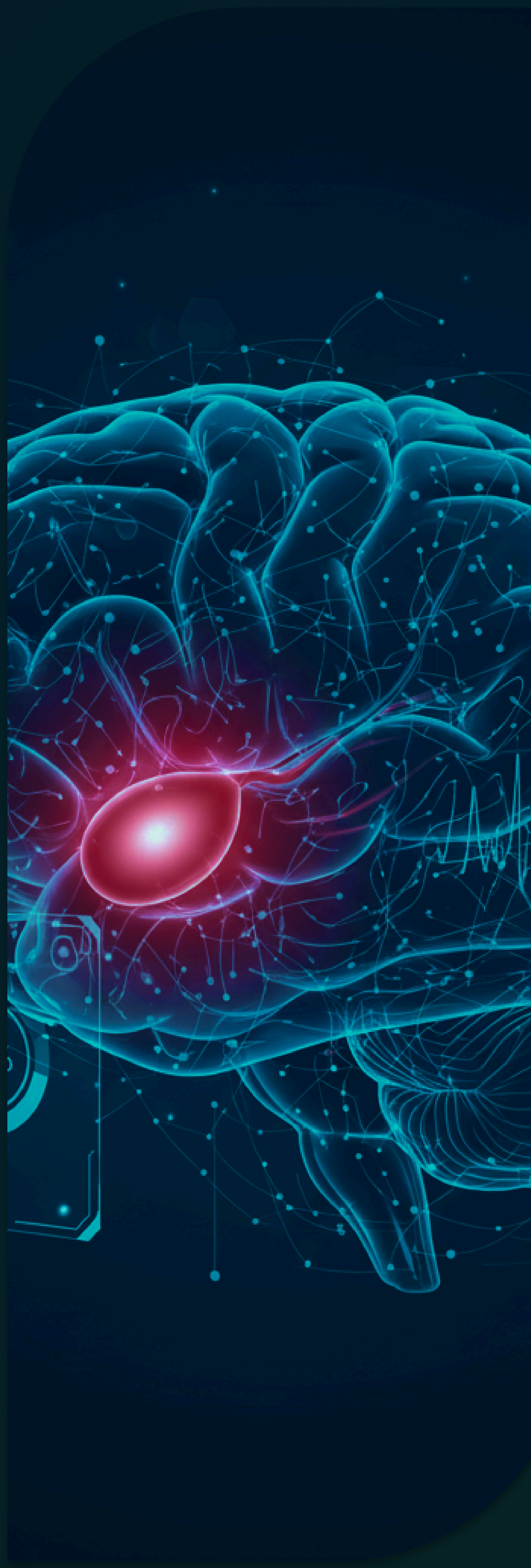

DICOM Viewer - Slice 1/1
Location: Right Supraclinoid Internal Carotid Artery | Patient: 62y Female | Modality: CTA


Annotated - Slice 1/1 - Location: Right Supraclinoid Internal Carotid Artery
Series: 1.2.826.0.1.3680043.8.498.10035643165968...
SOP: 1.2.826.0.1.3680043.8.498.14504961303532...
Right Supraclinoid Internal Carotid Artery
Center: (257.9, 251.4)
0
100
200
300
400
500
Patient: 62y Female | Modality: CTA


Hounsfield Scale (HU)
(Simplified)
Air (-1000)
Fat (-100)
Water (0)
Soft tissue (30 to 45)
Iodinated contrast (depends on concentration) (100 to 500)
Cortical bone (>1000)
Simple fluid (-10 to 20)
Acute blood (clotted) (60 to 90)
Trabecular bone (300 to 800)
F. Fortin 2020
Radiopaedia

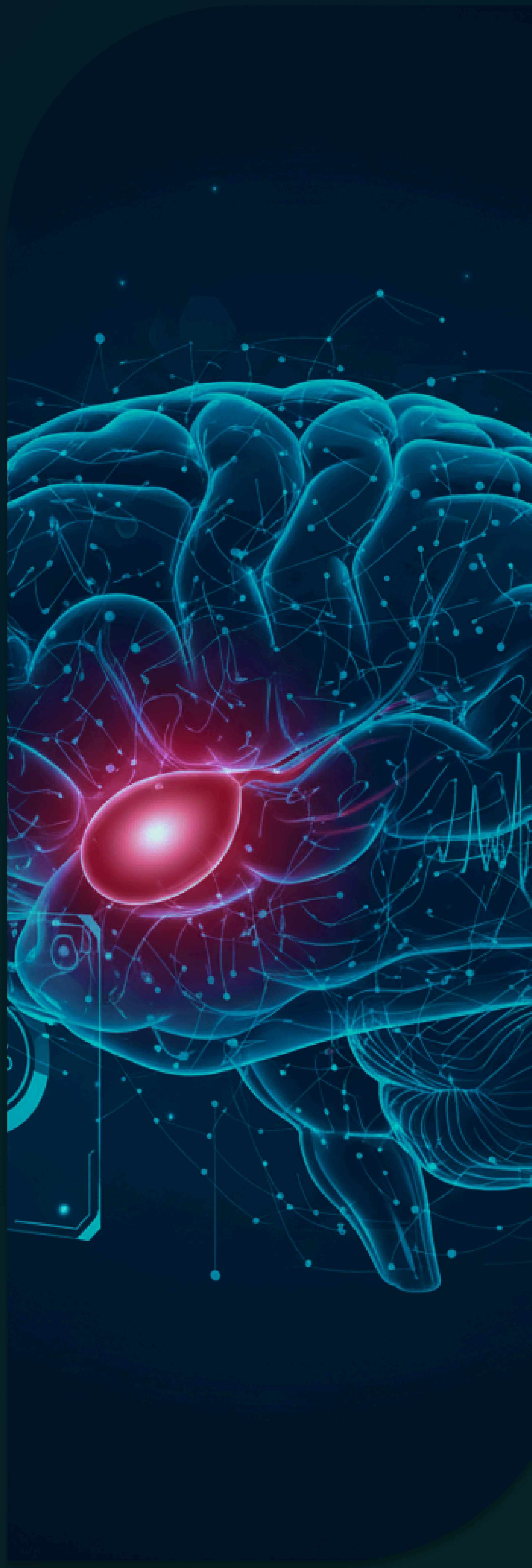
Exisitng System

- *Manual inspection of brain MRI/CT angiography images by radiologists.*
- *High dependency on human expertise and experience.*
- *No automated detection or localization mechanism.*
- *Visualization limited to 2D slices without automatic highlighting.*



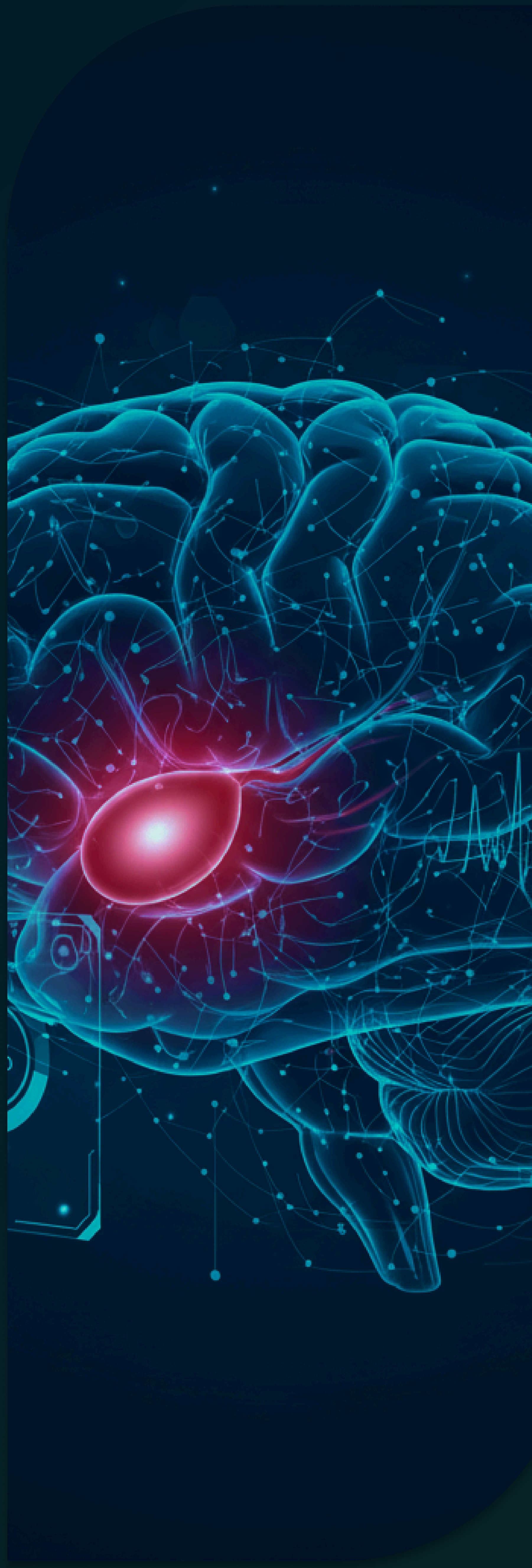
Proposed System

- *Automated aneurysm detection using an Ensemble Model*
- *Accepts and preprocesses DICOM brain scans automatically.*
- *Detection: Identifies the presence and coordinates of possible aneurysms*
- *Localize and maps each detected aneurysm to one of 13 anatomical brain locations.*



Problem Statement

Develop an AI-based system to automatically detect and localize aneurysms in brain scans, helping radiologists improve accuracy, speed, and patient outcomes.Rapid and accurate automated detection of aneurysms on routine brain imaging studies could help prevent devastating outcomes for patients.



Literature Review

Toward human intervention-free clinical diagnosis of intracranial aneurysm via deep neural network

No : 1

Authors: *Zi-Hao Bo, Hui Qiao, Chong Tian* | Publisher: *Patterns* | Year: *2021*

Purpose	Develop an AI system to automatically detect and segment brain aneurysms from CT scans without manual preprocessing, helping radiologists diagnose faster and more accurately.
Method Proposed	Two-stage approach: First, analyze the whole brain scan to find high-risk areas where aneurysms are likely. Second, zoom into small patches at full resolution to precisely segment aneurysms. Uses 3D patching strategy to handle large medical images.
Algorithms Used	3D U-Net (image segmentation), 3D CNN (to extract features from brain scans), Custom loss function (to handle small targets and uncertain boundaries)
Dataset Used	Internal: 1,338 CTA scans (1,489 IAs) from 6 institutions, 11 devices, 4 slice thicknesses (0.6-1.0mm). Train: 1,186, Test: 152 cases. External: 71 + 67 cases from 2 institutions (Philips scanners, 0.9mm thickness).
Metrics used	Sensitivity, FPR , lesion-wise DICE, normalized surface distance (0.5 mm), maximal diameter and volume differences, statistical significance : Mann–Whitney U, Kruskal–Wallis, and chi-square tests.

Multi-stage Deep Learning Model for Automated Detection of Intracranial Aneurysms in TOF-MRA Images

No : 2

Authors: *Jianping Song, Yunhua Chen, Xiaoqiang Miao , et al.* | Publisher: *Nature Scientific Reports* | Year: *2023*

Purpose	Develop deep learning model for automatic detection of intracranial aneurysms in TOF-MRA images
Method Proposed	Two-stage detection approach: candidate detection followed by false positive reduction,Train on multi-center dataset with varied imaging protocols
Algorithms Used	Faster R-CNN , ResNet-50 , Transfer learning from pre-trained ImageNet weights
Dataset Used	Training: 1,177 TOF-MRA scans from multiple centers ,Testing: 199 scans (118 with aneurysms, 81 without) Aneurysm size range: 2-25mm
Metrics used	Sensitivity, FPR , lesion-wise DICE, Free-response ROC (FROC) analysis, statistical significance : McNemar's test, Bootstrap confidence intervals

Deep Learning for Detecting Cerebral Aneurysms with CT Angiography

No : 3

Authors: Jiehua Yang, Mingfei Xie, Canpei Hu. | Publisher: Radiology | Year: *2021*

Purpose	To develop a highly sensitive deep learning–based algorithm to assist radiologists in detecting cerebral aneurysms from CT angiography (CTA) images.
Method Proposed	Developed a 3D deep learning algorithm based on ResNet-18 with Convolutional Block Attention Module (CBAM), dense atrous convolution, and residual multikernel pooling to automatically detect cerebral aneurysms from CT angiography images.
Algorithms Used	Modified ResNet-18 CNN with CBAM and dense atrous + multikernel pooling blocks, implemented in PyTorch.
Dataset Used	1068 CTA scans (1337 aneurysms) from two hospitals and divided into training (534 scans) and validation (534 scans) sets.400 additional CTA scans used for external validation.Aneurysm sizes ranged from 1.2 mm to 45.6 mm.
Metrics Used	Sensitivity: 97.5%,False-positive rate: 13.8 per case,wAFROC (AUC) improvement: +0.01 with algorithm assistance,Cross-validation: 5-fold.

A Survey of Intracranial Aneurysm Detection and Segmentation

No : 4

Authors: *Wei-Chan Hsu, Monique Meuschke, et al.* | Publisher: *Elsevier* | Year: *2025*

Purpose
Classify approaches based on input data (3D geometric, volumetric, 2D images)
Identify trends, challenges, and future directions in CAD systems for intracranial aneurysm analysis

Method Proposed
Selection criteria: semi-automated or automated methods for IA detection, isolation, or segmentation
Exclusion: aortic aneurysms, retinal microaneurysms, manual annotation methods

Algorithms Used
3D U-Net, ResNet, DeepMedic, nnU-Net, Faster R-CNN, MeshCNN, PointNet, PointNet++, Transformers

Dataset Used
@neurIST (300+ cases), AneuRisk (65 cases), CADA (109 training/22 test), ADAM (113 TOF-MRA train/141 test), IntrA (1909 vessel segments), CMHA (143 cases), OpenNeuro

Metrics Used
Detection: Sensitivity, Specificity, FP, FROC, AP, Mean Average Precision (mAP)
Segmentation: DSC Intersection over Union (IoU), Hausdorff Distance (HD)

Multi-centric AI Model for Unruptured Intracranial Aneurysm Detection and Volumetric Segmentation in 3D TOF-MRI

No : 5

Authors: *Ashraya Kumar Indrakanti, Jakob Wasserthal.* | Publisher: *Springer* | Year: *2025*

Purpose	The study focused on building an easy-to-use, open-source AI model (based on nnU-Net) that can find and measure unruptured brain aneurysms in 3D TOF-MRI scans.
Method Proposed	Researchers used past institutional and public medical data to train AI models on Aneurysm Proper, Differential Diagnoses, and ADAM datasets, comparing their detection and measurement performance.
Algorithms Used	nnU-Net, a self-configuring U-Net extension for medical image segmentation.
Dataset Used	385 internal 3D TOF-MRI scans (345 patients) and 113 ADAM
Metrics used	FP ,Sensitivity,lesion-wise DICE ,lesion-wiseNSD , Maximal diameter difference Statistical significance : Volume differenceMann-Whitney U, Kruskal–Wallis, and chi-square tests

A Deep-Learning Model for Intracranial Aneurysm Detection on CT Angiography Images in China

No : 6

Authors: *Bin Hu, Zhao Shi, Li Lu, Zhongchang Miao, Hao Wang.* | Publisher: *The Lancet Digital Health* | Year: *2024*

Purpose	To develop and validate an AI model for detecting intracranial aneurysms on CTA scans.
Method Proposed	Two-stage deep-learning system—global detection and local fine segmentation across multiple hospitals.
Algorithms Used	Cascaded deep-learning neural networks (nnU-Net–based) with 3D CTA image training and data augmentation.
Dataset Used	19,000+ CTA scans from 8 hospitals (internal, external, and real-world validation datasets).
Metrics used	AUC, wAFROC, sensitivity, specificity, F1 score, and false positives per case.

Deep Learning-Based Detection and Localization of Intracranial Aneurysms in CTA

No : 7

Authors: *Zhao, Z., Qian, H., Tian, C., Guo, Y., Li, W., et al* | Publisher: *arXiv Preprint* | Year: *2020*

Purpose

To develop an automated deep learning approach for accurate and efficient detection of intracranial aneurysms (IA) in computed tomography angiography (CTA) images, reducing manual workload and diagnostic variability.

Method Proposed

A two-stage deep learning model called CADIA (Computer-Aided Detection of Intracranial Aneurysms) was presented. A 3D Region Proposal Network (RPN) first identifies candidate aneurysm regions, followed by a 3D DenseNet-based classifier that refines detections and minimizes false positives. This framework enhances sensitivity and accuracy in IA localization.

Algorithms Used

3D Region Proposal Network (RPN), 3D DenseNet.

Dataset Used

Multi-center CTA dataset containing annotated intracranial aneurysm cases of various sizes and positions, ensuring robust model training and validation.

Metrics used

Sensitivity and FPPV. The model achieved high accuracy and low false positive rates, performing best for aneurysms larger than 3 mm.

IntrA: 3D Intracranial Aneurysm Dataset for Deep Learning

No : 8

Authors: *Xi Yang, Ding Xia, Taichi Kin, Takeo Igarashi* | Publisher: *arXiv Preprint* | Year: 2020

Purpose	To create an open-access, annotated 3D intracranial aneurysm dataset (IntrA) that supports the development, training, and benchmarking of deep learning models for diagnosis and segmentation of aneurysms using realistic 3D vessel structures.
Method Proposed	The study introduced the IntrA dataset, containing 103 3D brain vessel models reconstructed from TOF-MRA scans. Each model was cleaned, annotated, and processed with geodesic distance data to support geometric deep learning. Multiple 3D learning frameworks such as PointNet, PointNet++, SO-Net, PointCNN, and MeshCNN were benchmarked for classification and segmentation tasks.
Algorithms Used	PointNet, PointNet++, SO-Net, PointCNN, SpiderCNN, DGCNN, MeshCNN, and related geometric deep learning models.
Dataset Used	Containing 116 aneurysm segments with diverse aneurysm types (bifurcation, trunk, blister, combined).
Metrics used	F1-score, and segmentation quality.voxel-based methods performed worse than point- and mesh-based approaches.

Deep Learning–Based Cerebral Aneurysm Detection: Key Studies

No : 9

Authors: Terasaki et al.| Publisher: Frontiers in Neurology| Year: 2022

Purpose Address the high false-positive rate of CNN-based aneurysm detection on time-of-flight MRA while preserving sensitivity

Method Proposed Introduce a multidimensional CNN (MD-CNN) with two input branches: one processing a 2D maximum-intensity-projection (planar) image and the other processing 3D voxel data

Algorithms used 3D-CNN: processes volumetric patches (stereoscopic data) .
MD-CNN: a hybrid model combining the above two branches .

Dataset used TOF-MRA data from three hospitals (June 2006–Apr 2019) . 7559 patients with 732 aneurysms (mean size ~5.9 mm) were included

Metrics used Free-response ROC (FROC) analysis: plots sensitivity versus false positives per case .
Sensitivity: true positive rate (TP / total aneurysms) .

Systematic Review of Deep-Learning Methods for Intracranial Aneurysm Detection in CTA

No : 10

Authors:Bizjak & Špiclin| Publisher: Biomedicines | Year: 2023

Purpose
Conduct a systematic review and meta-analysis of deep-learning methods for detecting intracranial aneurysms on CT angiography .

Method Proposed
Selection/Quality: Followed PRISMA guidelines; applied QUADAS-2 for bias assessment .
Meta-analysis: Pooled lesion-level sensitivity (and by size), patient-level specificity, and false positives per image across studies

Algorithms used
U-Net variants (e.g. 3D-UNet, ResUNet) and other encoder–decoder models .
ResNet-based classifiers and segmentation nets (e.g. DAResUNet, ResNet, DeepMedic) .

Dataset used
1,547 CTA scans with 2,037 aneurysms , and 2,272 scans with 2,938 aneurysms . In contrast used only 20 scans .

Metrics used
Patient-level metrics: specificity and sensitivity (few studies reported specificity; patient-level sensitivity lacked a unified definition) .
False positives per image: commonly reported; included in meta-analysis to assess model precision

System Architecture

Modules and Functionality

User Interface Layer

- Upload Scans (CTA/MRA): Entry point for medical imaging files (CTA/MRA formats)
- User Interaction: Central hub for user actions and commands
- Report Generator: Automated creation of diagnostic reports
- Results Visualization: Display of analysis outcomes and detected aneurysms

DICOM Image Processing Pipeline

- Image Processor: Initial handling and quality checks of medical images
- DICOM Parser: Extracts metadata and image data from DICOM format
- Image Normalization: Standardizes image intensity and dimensions
- 3D Volume Reconstructor: Converts 2D slices into 3D volumetric representation

Ensemble Prediction Module

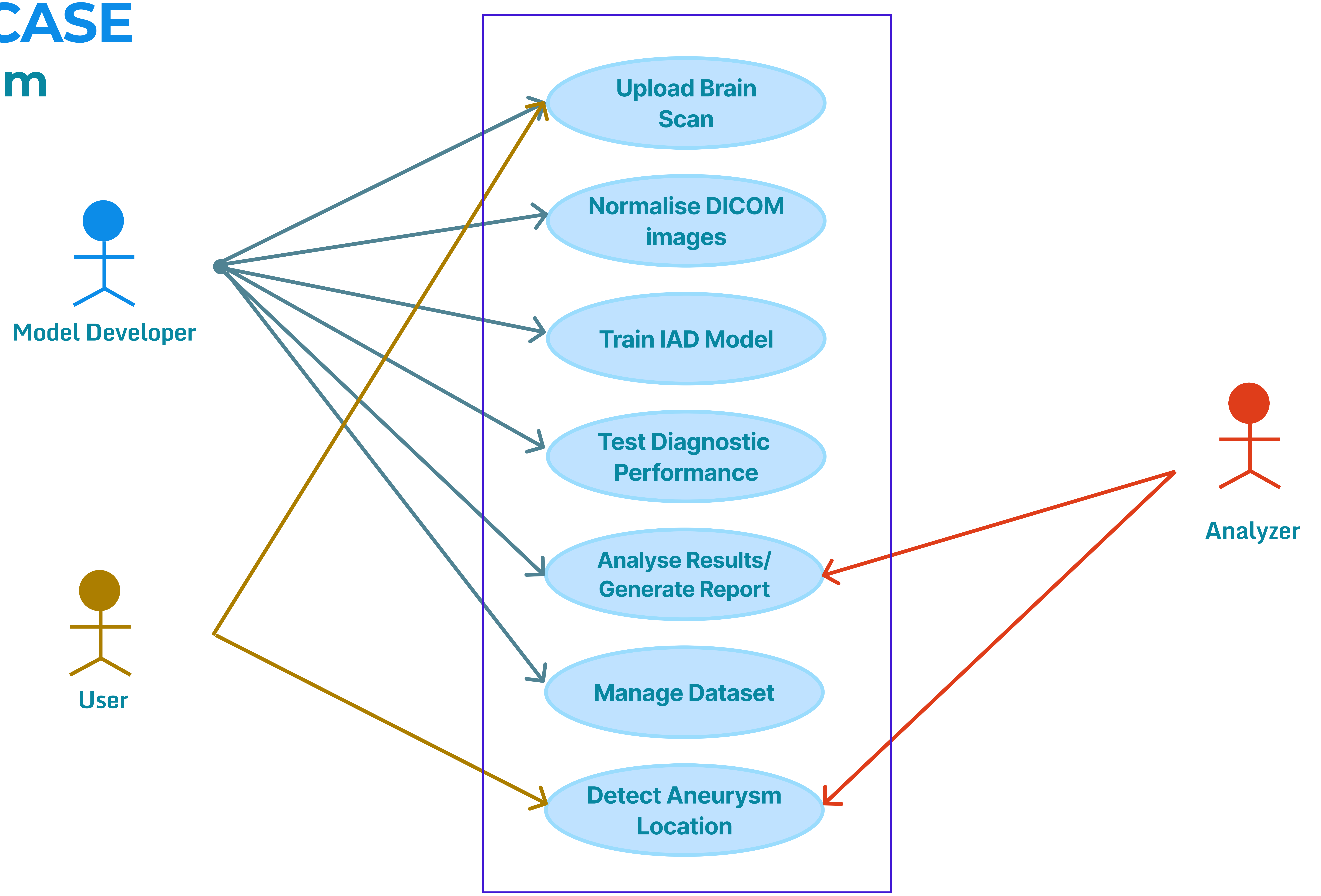
- Detection Model (3D CNN): Deep learning network for initial aneurysm detection
- Segmentation Model (Yolo V8): Precise boundary delineation of detected aneurysms
- Integration: Combines both models for enhanced accuracy and reduced false positives

Detection - Refinement Module

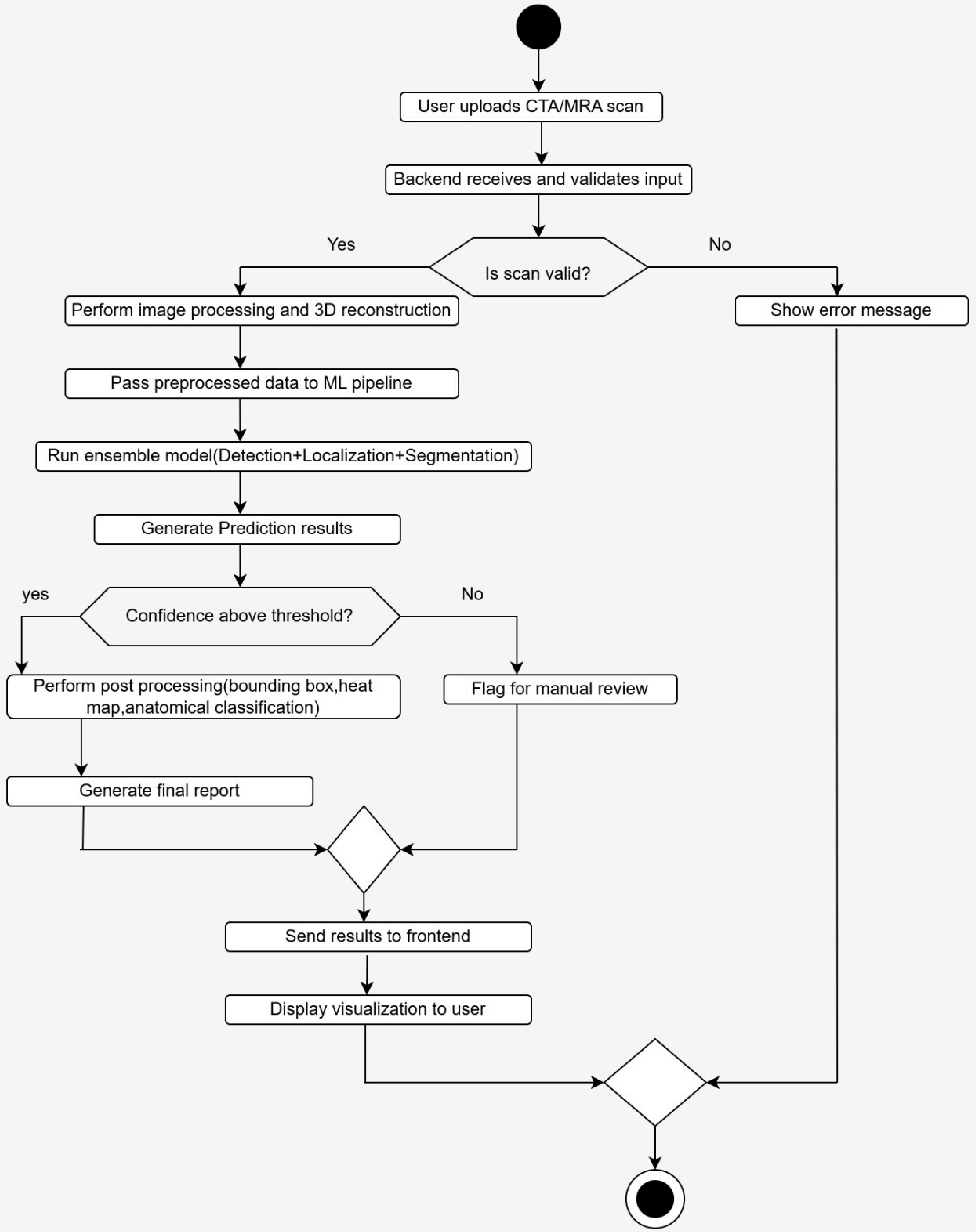
- Confidence Scoring: Assigns probability scores to detected regions
- Anatomical Location Classifier: Identifies aneurysm location (13 possible sites)
- Bounding Box: Defines precise spatial coordinates of detected aneurysms
- Heatmap: Visual representation of detection confidence areas


DESIGN
DIAGRAMS

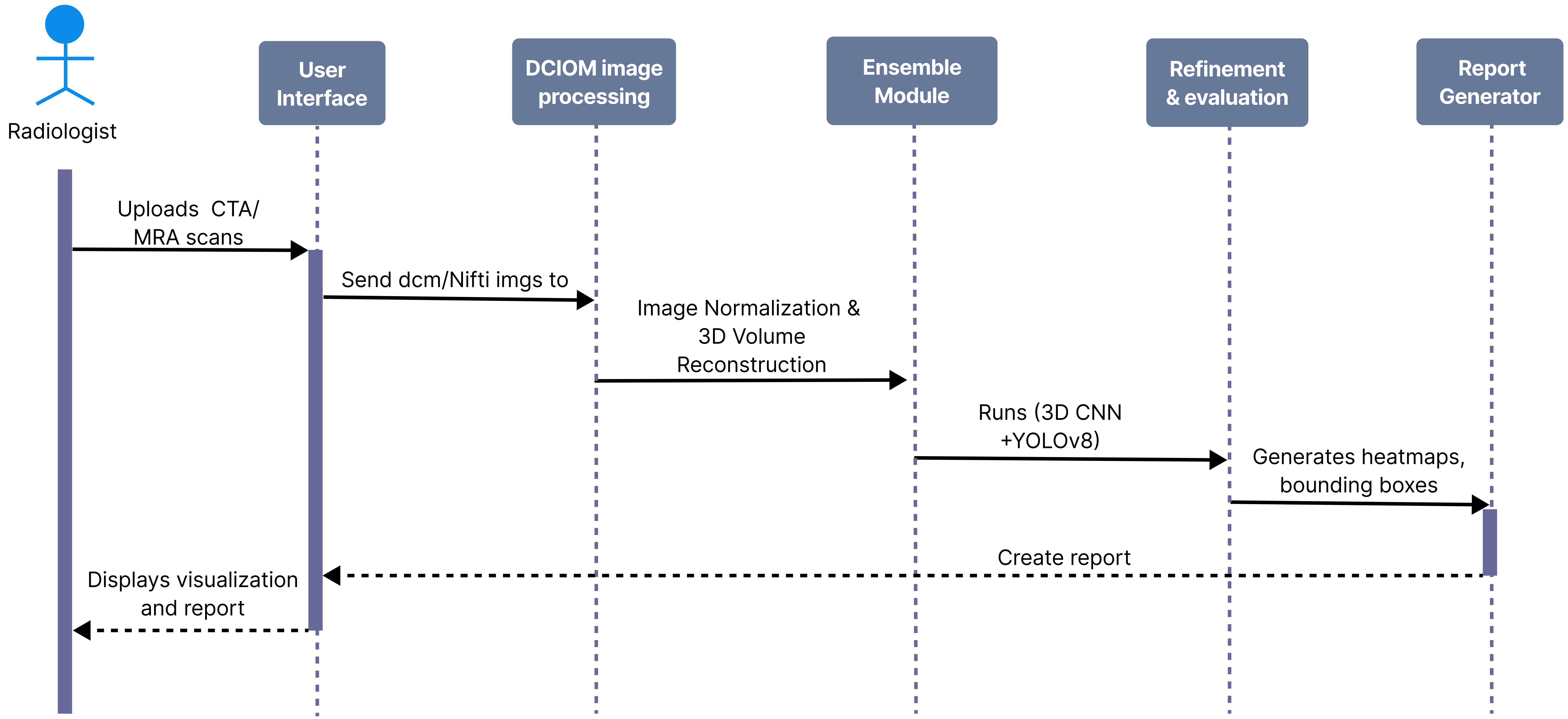
USE CASE
Diagram



Activity Diagram



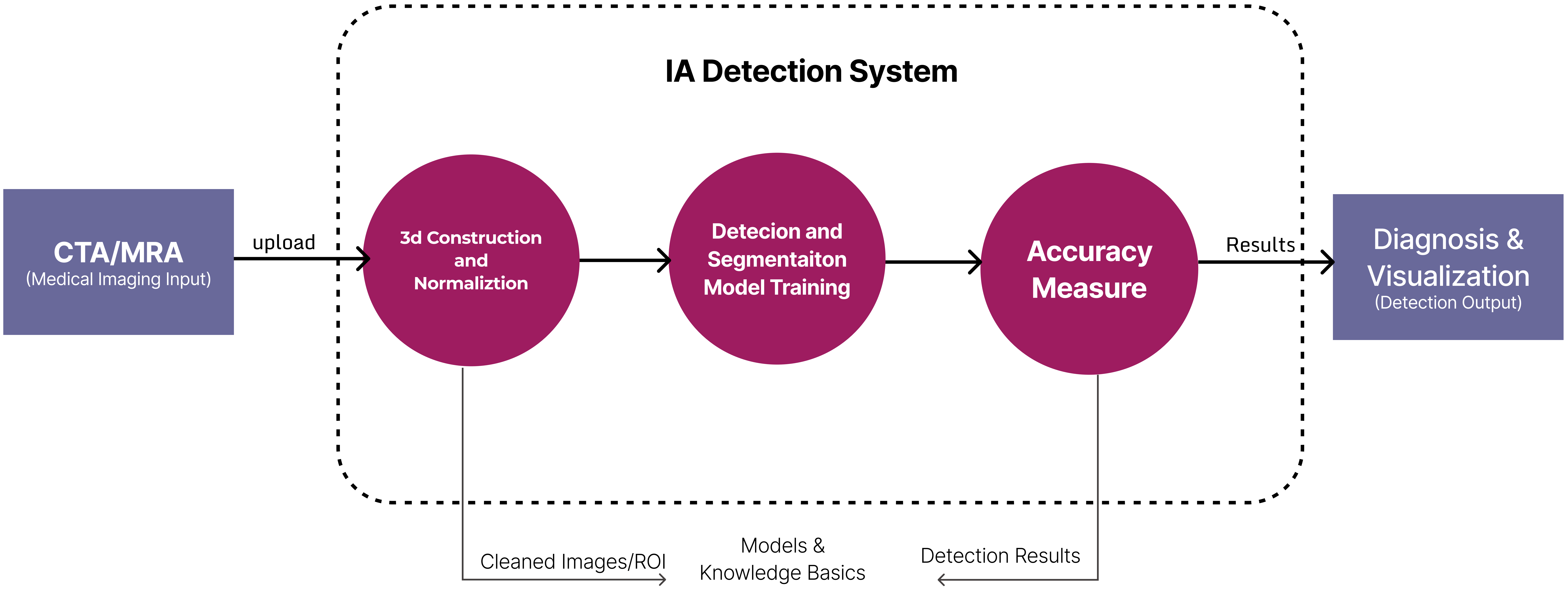
Sequence Diagram



Data Flow Diagram

Level - 0

Data Flow Diagram
Level - 1



Software Requirements

Operting System	Windows 10 / 11 (64-bit) or Ubuntu 20.04 LTS / 22.04 LTS
Programming Language	Python 3.10
Deep Learning Frameworks	TensorFlow 2.10
Data Handling Libraries	NumPy 1.24 , Pandas 2.0
Machine Learning / Evaluation	Scikit-learn 1.3 or higher
Visualization Tools	Matplotlib 3.7 , Seaborn 0.12
Medical Imaging Toolkit	pydicom 2.4
Development Environment	Jupyter Notebook
GPU Acceleration Toolkit	CUDA Toolkit 11.8 , cuDNN 8.9 (for NVIDIA GPUs)
Dataset Source	RSNA Intracranial Aneurysm Detection (Kaggle)

Hardware Requirements

Processor	Intel Core i5 / AMD Ryzen 7 or higher
RAM	16 GB
GPU	NVIDIA RTX 3060 or higher
Storage	512 GB SSD
Power Supply	550W or higher (for stable GPU operation)
Internet Connectivity	High-speed connection (for dataset download & cloud sync)

References

1. *Yang, J., Xie, M., Hu, C., Alwalid, O., Xu, Y., Liu, J., et al. (2021). Deep Learning for Detecting Cerebral Aneurysms with CT Angiography. Radiology, 298(1), 155–163. Radiological Society of North America (RSNA).*

2. *Yang, X., Xia, D., Kin, T., & Igarashi, T. (2020). IntrA: 3D Intracranial Aneurysm Dataset for Deep Learning. arXiv preprint arXiv:2003.02920.*

3. *Zhao, Z., Qian, H., Tian, C., Guo, Y., Li, W., et al. (2020). Deep Learning Based Detection and Localization of Intracranial Aneurysms in Computed Tomography Angiography. arXiv preprint arXiv:2005.11098.*

4. *Terasaki, Y., Yokota, H., Tashiro, K., Maejima, T., Takeuchi, T., Kurosawa, R., et al. (2022). Multidimensional Deep Learning Reduces False Positives in the Automated Detection of Cerebral Aneurysms on TOF-MRA: A Multi-Center Study. Frontiers in Neurology, 12, 742126.*

5. *Bizjak, Ž., & Špiclin, Ž. (2023). A Systematic Review of Deep-Learning Methods for Intracranial Aneurysm Detection in CT Angiography. Biomedicines, 11(11), 2921. MDPI.Hu, B., Shi, Z., Lu, L., Miao, Z., Wang, H., Zhou, Z., et al. (2024). A Deep-Learning Model for Intracranial Aneurysm Detection on CT Angiography Images in China: A Stepwise, Multicentre, Early-Stage Clinical Validation Study. The Lancet Digital Health, 6, e261–e271.*

References

6 *Indrakanti, A. K., Wasserthal, J., Segeroth, M., Yang, S., Nicoli, A. P., Schulze-Zachau, V., et al. (2025). Multi-centric AI Model for Unruptured Intracranial Aneurysm Detection and Volumetric Segmentation in 3D TOF-MRI. Journal of Imaging Informatics in Medicine. Springer.*

7 *RSNA Intracranial Aneurysm Detection Dataset. (2020). Kaggle Competition Platform. Available at: https://www.kaggle.com/competitions/rsna-intracranial-aneurysm-detection*

8 *Deep learning–based intracranial aneurysm detection in CTA images." Scientific Reports (Nature), 2023. Available at: https://www.nature.com/articles/s41598-023-38586-9*

9 *"Deep learning approaches for intracranial aneurysm detection: A comprehensive review." arXiv preprint arXiv:2312.17670v4, 2024. Available at: https://arxiv.org/html/2312.17670v4*

10 *Bizjak, Ž., & Špiclin, Ž. (2023). A Systematic Review of Deep-Learning Methods for Intracranial Aneurysm Detection in CT Angiography. Biomedicines, 11(11), 2921. MDPI.Hu, B., Shi, Z., Lu, L., Miao, Z., Wang, H., Zhou, Z., et al. (2024).*
Deep learning-based cerebral aneurysm detection with CT angiography." PubMed Central (PMC8968557), 2022. Available at: https:/ pmc.ncbi.nlm.nih.gov/articles/PMC8968557/

Conclusion

- Deep Learning Can Effectively Detect And Localize Intracranial Aneurysms, Helping Radiologists In Faster Diagnosis.
- Preprocessing And Proper Data Handling Are Very Important To Get Reliable Results Across Different Hospitals.
- Models Still Face Challenges With Small Aneurysms And False Positives, Which Need Improvement.

.

- With Further Validation And Clinical Testing, This Approach Can Support Doctors In Real-world Practice And Improve Patient Safety.

Thank You