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EE · ICS · CIE · ME · 4
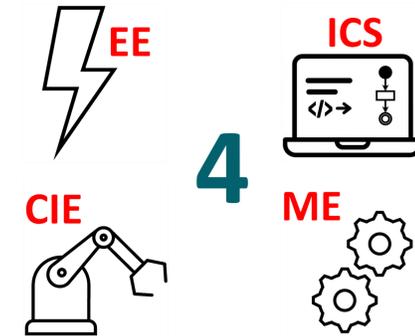
## Introduction

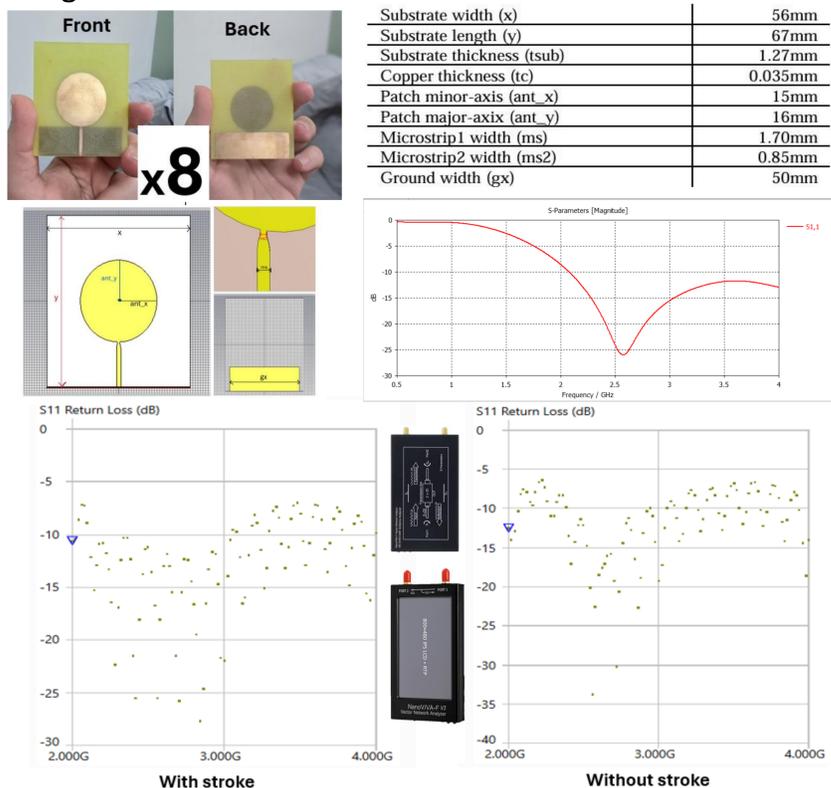- Brain stroke is the **4th** worldwide cause of death.
- The **1st** common illness among elderly people.
- There is a pressing need to search for a **portable**, **more accessible**, **cost-effective**, and **safer** diagnostic solutions.
- **8** Antennas, **2-3**kg, **10**mins
- Freq. Range: **2.1- 4** GHz
- Total Cost: < **6000** SAR



Fig. 1 (a) Hemorrhagic stroke, (b) ischemic stroke [3].
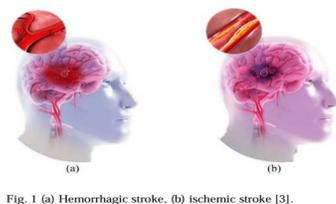
## Antenna Fabrication & Sensing

The MWI system utilizes a novel, research-based antenna design (**Developed by our TEAM!**) for stroke sensing & detection. A commercial, low-cost Vector Network Analyzer (**VNA**) provides the signals to the **8** antennas via the RF cables. Then the **S11** parameters are *measured*, *preprocessed*, and *analyzed* to generate a diagnostic image.

Front | Back | x8

| | |
|---|---|
| Substrate width (x) | 56mm |
| Substrate length (y) | 67mm |
| Substrate thickness (tsub) | 1.27mm |
| Copper thickness (tc) | 0.035mm |
| Patch minor-axis (ant_x) | 15mm |
| Patch major-axix (ant_y) | 16mm |
| Microstrip1 width (ms) | 1.70mm |
| Microstrip2 width (ms2) | 0.85mm |
| Ground width (gx) | 50mm |

S11 Return Loss (dB) — With stroke

S11 Return Loss (dB) — Without stroke

## Helmet Design with Automated Sizing

**Four** linear actuator systems, consisting of servo motors, gears, and shafts, were used to perform dilation and narrowing operations for various head sizes. The helmet, with a **90** cm circumference and **45°** antenna positioning, can expand up to **21** cm in length and **17** cm in width, ensuring proper antenna positioning on the least curved areas of the head.



Part of the helmet · The Actuator x4 · Sensor
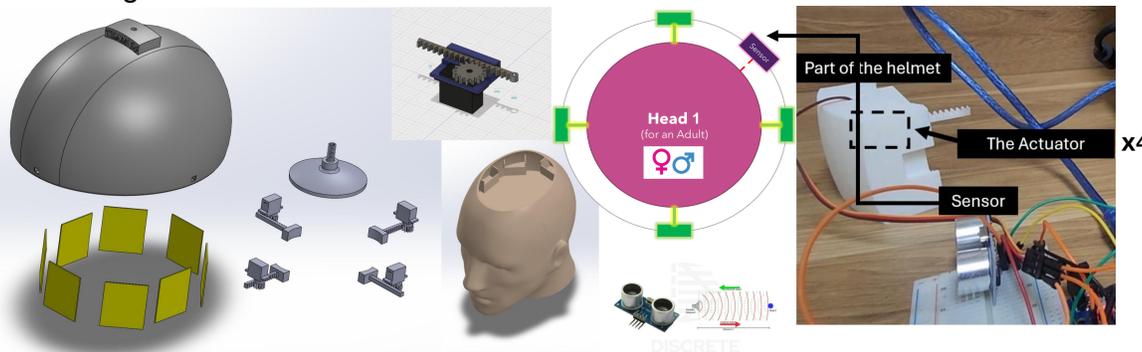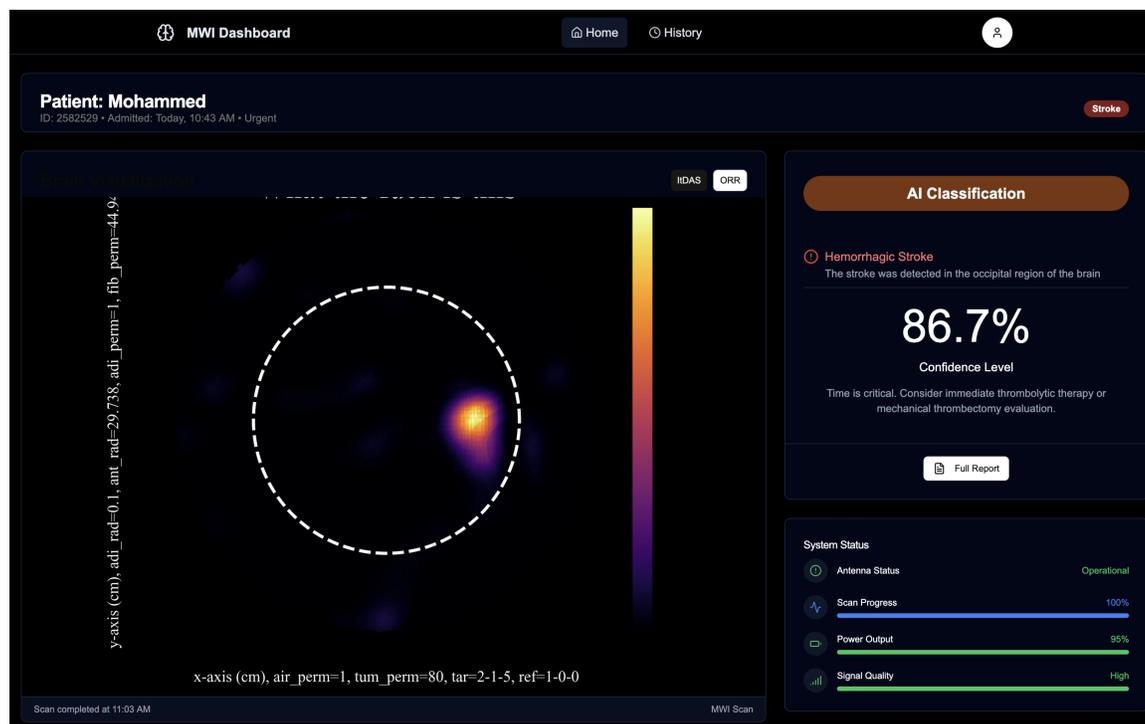
Head 1 (for an Adult) ♀♂

DISCRETE

## Image Reconstruction & AI Detection

The system utilizes two image reconstruction methods, **iterative delay-multiply-sum (itDMAS)** and **Optimization-Based Radar Reconstruction (ORR).** The AI model used was a combination of **Support Vector Machine (SVM)** and **3D Convolutional Neural Network (3D-CNN). Model achieved ≥ 85% F1-score**.



MWI Dashboard · Home · History

**Patient: Mohammed**
ID: 2582529 • Admitted: Today, 10:43 AM • Urgent — Stroke

itDAS · ORR

**AI Classification**

Hemorrhagic Stroke
The stroke was detected in the occipital region of the brain

**86.7%**
Confidence Level

Time is critical. Consider immediate thrombolytic therapy or mechanical thrombectomy evaluation.

Full Report

System Status
Antenna Status — Operational
Scan Progress — 100%
Power Output — 95%
Signal Quality — High

Scan completed at 11:03 AM · MWI Scan

y-axis (cm), adi_rad=0.1, ant_rad=29.738, adi_perm=1, fib_perm=44.9;
x-axis (cm), air_perm=1, tum_perm=80, tar=2-1-5, ref=1-0-0

## Final Prototype Product



## Testing / Validation

The testing involved multiple scans of a 3D-printed brain phantom with a water-glycerin mixture, revealing clear S11 differences for accurate stroke detection.
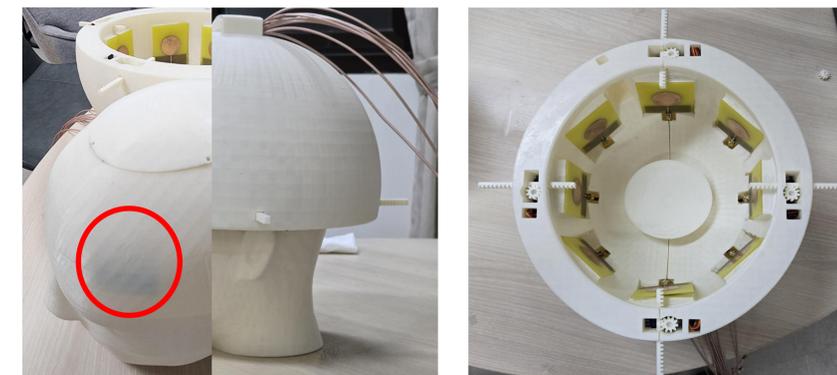


## Conclusion

We developed a portable microwave imaging system using 8 UWB antennas **(2.1–4 GHz)**, a 3D-printed helmet **(2–3 kg)**, and a NanoVNA-F V3. With real-time signal processing and a 3D CNN model **(F1 score: 0.88)**, stroke detection is achieved in under **10 minutes**. The adjustable helmet, powered by linear actuators and ultrasonic sensors **(±3 mm)**, ensures comfort and accurate antenna alignment. The total system cost is below 6000 SAR. Future work includes clinical validation and expanding to **24** antennas for higher resolution.