KARTHOS: An AI-Integrated Robotic Assistant for Early Breast Cancer Detection via Mammogram Classification, Heatmap Segmentation, and Guided Self-Examination

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Breast cancer is the most commonly diagnosed cancer worldwide, yet 2.3 billion women lack access to screening due to the prohibitive cost of commercial computer-aided detection systems (~$50,000). This project engineered KARTHOS, a portable, multilingual AI screening device built on a Raspberry Pi 4B in a custom 3D-printed enclosure with an integrated touchscreen, speakers, and rechargeable battery, costing under $220. KARTHOS employs a dual-model deep learning architecture trained on the CBIS-DDSM dataset (3,567 mammographic ROIs, patient-grouped split). The classification model, an EfficientNetV2S backbone with squeeze-and-excitation attention, performs simultaneous malignancy detection and BI-RADS categorization; with 5-view test-time augmentation it achieved 90.66% accuracy, an AUC-ROC of 0.9754, and malignant recall of 0.908 on 1,006 held-out test images. The heatmap model, an Attention U-Net with deep supervision and Focal Tversky loss, generates interpretable visualizations localizing suspicious regions while penalizing missed lesions over false alarms. Beyond imaging, KARTHOS integrates a guided six-zone breast self-examination with multilingual audio prompts in eight languages and a risk-stratification algorithm using 12 evidence-based clinical factors to classify findings into four tiers with physician-ready referral reports. The system operates fully offline with no internet dependency. Expert review by an oncologist, mammographer, and computer scientist confirmed clinical relevance, and breast cancer survivors rated usability 4.5/5. KARTHOS demonstrates that clinically meaningful screening can be delivered on hardware costing less than 0.5% of commercial systems, offering a scalable pathway to early detection in underserved communities.

Awards Won: