Aravind Karthik R

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Research Interests

- **Primary Research Areas**: Design and development of embedded biomedical sensing systems, with emphasis on hardware–signal co-design for wearable and minimally In-Vivo applications. Interested in physiological signal acquisition (EEG, EMG, optical sensing) and integrating real-time inference within resource-constrained embedded platforms.

Education

- **Vellore Institute of Technology** Chennai, India
  M. Tech - Embedded Systems *July 2025 - Present*

  Relevant Coursework: *Real-Time Operating Systems, Advanced Embedded Programming, In-Vehicle Networking, Machine Learning, Micro-controller Architecture*

- **Vellore Institute of Technology** Chennai, India
  B. Tech - Electronics and Computer Engineering *July 2021 - Sept 2025*

  Relevant Coursework: *Signal Processing, Embedded System Design, Computer Networks, Artificial Intelligence, Operating Systems*

Research Experience

- **Indian Institute of Science (IISc)** Bangalore, India
  Project Associate (Research Intern) *June 2024 – June 2025*
  - Designed and deployed real-time embedded inference pipelines for biomedical sensing under strict latency and memory constraints.
  - **Near-Infrared Hand Vein Segmentation System**
    * Collected and curated ∼600 NIR hand images (initial 200 images with documented consent; additional 150+ participants during IISc Open Day 2025, capturing both left and right hands).
    * Performed manual pixel-wise annotation to construct supervised segmentation dataset.
    * Addressed dataset variability including illumination differences, skin tone variation, and contrast inconsistency through preprocessing and augmentation strategies.
    * Implemented and trained DeepLabV3+ (MobileNet backbone) for subcutaneous hand vein segmentation.
    * Designed distributed Raspberry Pi–GPU inference architecture using TCP-based streaming, enabling offloaded execution on RTX 3050.
    * Achieved ∼23 FPS real-time visualization with measured end-to-end latency profiling.
    * Evaluated trade-offs between edge-only inference and distributed processing for compute-constrained biomedical imaging systems.
  - **Embedded IV Fluid Monitoring and Safety System**
    * Developed capacitive sensing-based fluid estimation using PSoC4 CapSense.
    * Integrated AS7341 optical sensing for reverse blood-flow detection.
    * Implemented deterministic embedded control logic for safety-triggered actuation.
  - Curated and validated large-scale biomedical datasets (150+ participants) for improving model generalization and robustness.

Research Projects

- **EEG-Based Neurodevelopmental Disorder Classification**: Analyzed clinically collected EEG recordings from 23 children (12 ASD, 11 typically developing; age ¡ 10 years) during controlled visual stimulus exposure. Extracted temporal statistical features (mean, variance, skewness, kurtosis) and spectral features including LFCC from T3, T5, F4, and F8 channels. Trained and evaluated KNN and ensemble models using cross-validation and confusion matrix analysis. Deployed trained model on Raspberry Pi to assess embedded inference feasibility.
- **fNIRS-Based Embedded Signal Classification**: Analyzed frontal-lobe fNIRS dataset (Shixian Liu, 2020; 18 subjects, stroke and healthy controls performing left/right hand movements). Implemented dual-wavelength optical acquisition prototype using photodiodes and ESP32-based ADC sampling. Applied digital filtering and feature extraction prior to ML classification. Streamed processed signals via TCP to Raspberry Pi, achieving end-to-end inference latency of ∼250 ms.
- **Wearable Assistive Vision System for Reading Impairments**: Developed Raspberry Pi-based wearable prototype integrating camera capture, OCR processing, and text-to-speech synthesis. Measured acquisition-to-speech latency to analyze real-time constraints in assistive embedded AI systems.

Technical Skills

- **Programming**: Python, C/C++, Embedded C, ARM Assembly (Thumb, Interrupt handling)
- **Embedded Systems**: ESP32, STM32, Nvidia Jetson, Raspberry Pi, PSoC4, RTOS fundamentals, Embedded Linux
- **Signal Processing**: EEG feature extraction, MFCC, LFCC, Statistical modeling, Digital filtering
- **Machine Learning**: KNN, Random Forest, XGBoost, model optimization for edge deployment
- **Systems Engineering**: Latency profiling, distributed inference design, TCP-based streaming architectures