

RESEARCH & SYSTEMS**TinyAuton - MCU-Native Edge Intelligence Framework****09/2023- Present***Core Ph.D. contribution: numerics, DSP, neural networks and on-device learning on microcontrollers.*

- Framework Architecture: Open-source MCU-native C/C++ framework - 52,000 lines, 150+ public APIs across linear algebra, DSP, neural networks, system identification and quantization; ESP-IDF components with a platform-abstracted dispatch layer, portable C fallback, and on-target tests against vendor DSP references.
- On-Device Learning: Backpropagation runs in firmware, not just inference - dense, convolution, normalization and attention layers with SGD/Adam, gradients derived by hand rather than traced. A 4-16-8-3 MLP trains one 150-sample epoch in 18.8 ms and infers in 300 us; FP8 quantization compressed weights 4:1.
- Heavy Numerics in 8 KB: Reworked six output-only modal identification methods for the MCU, within 0.6% of the workstation reference; pairwise decomposition cut peak RAM 83% (47 KB to 8 KB) and ran 13% faster.

NexNode + NexHub - Wireless Edge AI Node, Schematic to Cloud**09/2023- Present***Sole designer across hardware, firmware, radio and backend - all on a 240 MHz MCU with 512 KB on-chip SRAM.*

- Hardware Design: Designed a two-board node end to end over two PCB revisions - ESP32-S3 core, swappable sensing board, 3D-printed enclosure, microSD storage, MPPT solar and 18650 power.
- Always-On Sensing: A 0.89 uA sentinel accelerometer watches continuously and wakes a 20-bit, 22.5 ug/rtHz acquisition sensor only on motion, holding quiescent draw under 10 uA.
- Real-Time Firmware: Four-layer FreeRTOS stack with three interchangeable acquisition architectures (producer-consumer, DMA double-buffering, dual-core split) and microsecond timestamping.
- Connectivity & Backend: Wi-Fi/MQTT uplink and ESP-NOW peer-to-peer sync over one 2.4 GHz radio, custom chunked transport at three QoS levels; NexHub backend on EMQX, MongoDB and InfluxDB.

Smart Adaptive Triggering - Learning When a Battery Node Should Record**04/2024-04/2025***Fixed thresholds miss events or waste power; MSSP, 2025; SHMII-13 Best Conference Paper, 1 of 202.*

- Self-Tuning Loop: The node tunes its own trigger threshold and record length - Bayesian optimization against a digital twin, then on-device fine-tuning on live ambient data.
- On-MCU Learning: CNN and DNN labelers running on the node, trained on 4,000 synthesized clips and validated on 300 held-out field segments across four excitation types.
- Fewer Wasted Recordings: Raised precision from 50% to 90.8% at 94.4% recall, using 1.3% of exhaustive-search computation and transmitting zero raw data, against 15 MB for the batch baseline.

Multi-Node Edge Cooperation - Only Condition Scalars Cross the Radio**03/2023-06/2024***Rapid structural condition assessment on Embodior's Xnode platform; Engineering Structures, 2025; with UIUC (B.F. Spencer Jr.), funded by the U.S. Federal Railroad Administration.*

- Confirmed Detections from Field Data: Replayed field records from 11 railroad bridges, 2-8 nodes each, on Xnode hardware; flagged two anomalies confirmed by inspection as member section loss and displaced rail hardware.
- On-Node Optimization: Cut reference-free displacement estimation on 600,000 samples from 3,353 s to under 30 ms on the Xnode target - decimation, CMSIS-DSP kernels, precomputed coefficients, binary I/O, and processing concurrent with acquisition.
- Distributed Estimation: Node-side estimation feeding gateway-side Gaussian process regression and SPC - only compact indicators cross the radio, cutting end-to-end assessment from 4.5 s to 0.07 s.

Manifold Dynamics - One Latent State, Many Readouts**12/2025- Present***Healthy-data-only state learned across structures and machines; manuscript in preparation.*

- Learned State-Space Dynamics: Formulated multi-node data as one latent state with a learned transition operator - deviation from the learned flow scores damage, the state-estimation and forward-dynamics structure of a world model. On Z24 monitoring dataset, flow direction reaches AUROC 0.810 against 0.683 for static baselines.

- Edge Deployment: 128-dimension encoder in 15.8 ms per window, end-to-end scoring in 34.5 ms, int8 inference in 0.345 ms within 4.4 KB, matching PC float32 to $1e^{-6}$; windows compressed 48:1.
- Cross-Domain Validation: The same healthy-data-only state, validated on a four-storey lab frame, the Z24 bridge and FEMTO run-to-failure bearings (IEEE PHM 2012) - transferring from civil structures to rotating machinery, with degradation tracking at 0.355 against 0.21 for standard novelty detectors.

Real-Time Multivariate Forecasting - Linear-Time Sequence Models in Production 08/2025- Present

Running in production on a metro shield tunnelling project; first-author manuscript on the Mamba forecaster.

- Linear-Time Sequence Modelling: Replaced the Transformer forecaster with a selective state-space (Mamba) model on 167,690 samples of 16 tunnelling parameters - same task at 11% of the parameters and 80% less inference time, with R^2 up from 0.965 to 0.982.
- Production Deployment: Reduced 1,500+ raw sensor channels to 32 engineered parameters and shipped a joint 32-parameter forecaster now running on site - time-ordered splits, early stopping, ONNX export.

PUBLICATIONS

Research Scope: on-device AI, model compression, energy-efficient sensing, distributed inference, multivariate time-series learning.

Selected First-Author Papers:

- Edge-to-Cloud Computing and Intelligence for IoT-based Structural Health Monitoring: A Review. Adv. Eng. Informatics, 2026.
- Smart Adaptive Trigger Sensing Powered by Edge Intelligence and Digital Twin. MSSP, 2025.
- Adaptive Edge Intelligence for Rapid Structural Condition Assessment Using a Wireless Smart Sensor Network. Eng. Structures, 2025.
- Algorithm for Generation of 3D Polyhedrons for Simulation of Rock Particles by DEM. TUST, 2020.

Record: 12 papers, 6 first-author, 102 citations - also IEEE TII, IEEE IoT-J, Structural Health Monitoring, Measurement, Applied Soft Computing.

Recognition: Best Conference Paper Award, 1 of 202, SHMII-13, 2025.

Service: Reviewer for 6 journals including IEEE Sensors J. and MSSP; teaching assistant, CAD & BIM (NTU).

INDUSTRY EXPERIENCE

Arcplus Group - ArcTron Data & Innovation Technology Co., Ltd. **Shanghai, CHN**

Product R&D - ArcOS, an IoT & Digital-Twin Platform for Smart Buildings 08/2021-06/2022

- **Data & Product:** BIM ingestion and IoT device binding - one model fed by geometry and live sensor data; asset management and 3D visualization on Unreal Engine and WebGL for clients; 4 projects, 50,000+ sqm.
- **On-Platform Intelligence:** Neural-network energy forecasting; anomaly detection from prediction residuals.

EXPERTISE & SKILLS

Embedded Systems: PCB design, BSP development (sensors, storage, radios), SPI/I2C/UART, real-time processing, ultra-low-power design; C/C++, ARM Cortex-M, STM32/HAL, ESP32/ESP-IDF, FreeRTOS, Linux

Onboard Intelligence: math/DSP/NN operator kernels, TinyML, MCU-native DL framework, on-device training & inference, quantization & memory-constrained design; CMSIS-DSP/NN, ESP-DSP/ESP-DL

Distributed Learning: time-series modeling (Transformer, Mamba), system identification & feedback control, Gaussian processes & Bayesian optimization, collision detection (GJK), latent state-space & dynamics learning; Python, PyTorch, TensorFlow

EDUCATION

Ph.D., Civil Engineering **Nanyang Technological University, SG**
Edge-AI Hardware, On-Device Learning, Distributed Intelligence 08/2022-02/2027(Expected)

M.Eng., Architectural and Civil Engineering **Tongji University, Shanghai, CHN**
3D Geometry, GJK Collision Detection, DEM Simulation, Mechatronic Prototype 09/2018-06/2021

B.Eng., Civil Engineering | Mathematics (Minor) **Tongji University, Shanghai, CHN**
Mathematics, Physics, Mechanics, Computing; Modelling and Mechanics Awards 09/2014-07/2018