Shuaiwen CUI (Shaun)

Mr | Sep, 1995 | Shandong, CHN | Ph.D. Candidate, NTU, SG

Personal Website: http://www.cuishuaiwen.com/ cswoffice@163.com
Linkedin: www.linkedin.com/in/shaun-shuaiwen-cui +86 182-0192-3138 (CHN)
Github: https://github.com/Shuaiwen-Cui +65 83071903 (SG)

EXPERTISES & INTERESTS - IoT-based Digitalization, Automation and Intelligentization

- **Distributed Computing & Intelligence:** Edge Intelligence Framework, Federated Learning, Graph Neural Networks, Reinforcement Learning, Multi Agent System, Game Theory
- **Sensing, Processing, Control, Optimization:** Real-time Signal Processing, Data Analytics, Digital Twins, Control Theory, Single/Multiple Objective Optimization
- **IoT System & Embedded Intelligence:** Edge–fog–cloud Architectures, Resource-efficient Embedded AI
- **Structural Health Monitoring:** System Identification, Vibration Analytics, Condition Assessment
- **Embodied Personal AI Agent Products:** Context-aware Interaction, Multimodal Reasoning, On-device AI Deployment, Privacy-preserving and Energy-efficient Optimization
- **Intelligent Built Environment & Smart Living Spaces:** AI-enabled Spatial Digitalization, User Intent Modeling, Personalized Service Orchestration and Content Delivery

EDUCATION – Graduation Date (Expected): Jul 2026 - Thesis Submission; Dec 2026 – Defense; Feb 2027 - Graduation

Nanyang Technological University **Singapore, SG**
Ph.D. Candidate - Civil Engineering 08/2022-**02/2027** (Expected)
- Embedded System
- Signal Processing
- Internet of Things
- Digital Twin
- Edge/Cloud Computing
- Distributed AI
- Structural Health Monitoring

Tongji University **Shanghai, CHN**
M.Eng. - Architectural and Civil Engineering 09/2018-06/2021

Tongji University **Shanghai, CHN**
B.Eng. - Major in Civil Engineering, Minor in Mathematics and Applied Mathematics 09/2014-07/2018
- Mathematics
- Physics and Mechanics
- Engineering
- Computer Science

SKILL SETS

- **Languages:** Chinese (native); English (skilled); Japanese (beginner)
- **Programming:** C/C++; Python; Matlab
- **AI Framework:** Tensorflow, Pytorch
- **Embedded System:** STM32/ HAL/ STM32CUBE; ESP32/ESP_IDF; Keil, PlatformIO; FreeRTOS; Linux
- **Edge Intelligence:** CMSIS-DSP/NN; X-Cube-AI; ESP-DSP/DL; Tensorflow Lite; Edge Impulse
- **Internet of Things:** MQTT; EMQX; Home Assistant
- **Computer Aided Design:** Auto CAD; Rhinoceros/Grasshopper; Sketchup; Revit; EasyEDA
- **Mechanical Analysis:** Ansys; OpenSees; Particle Flow Code
- **Digital Twin and Platforms:** Autodesk Forge; BIMFace

SELECTED PUBLICATIONS & PATENTS (FIRST/CORRESPONDING AUTHOR)

- **Journal Article: Cui, S.**, Fu, H., Shen, W. & Fu, Y. (2026) **Edge-to-Cloud Computing and Intelligence in IoT-based Structural Health Monitoring: A Comprehensive Review.** *Advanced Engineering Informatics, 71, 104300.* https://doi.org/10.1016/j.aei.2025.104300 [Core: Ubiquitous/Ambient Computing and Intelligence in IoT SHM systems]
- **Journal Article: Cui, S.,** Fu, Y.*, Xia, Y., Zhang Q., & Li, S. (2026) **A Class-Lab-Field Pedagogical Framework for Structural Health Monitoring using Ultra-Low-Cost Wireless IoT Prototypes.** *IEEE Transactions on Education.* (Under Review) [Core: Ultra-Low-Cost Wireless AIoT Node and Network, SHM Application]

- **Journal Article:** Xu, J., **Cui, S.***, Cai, W., Zhang, J., Zhu, M., & Cai, E. (2026) Stratigraphic Modelling and Probabilistic Parameter Estimation from Sparse Borehole Data via Bayesian Inference and LightGBM. *Georisk*. (Under Review) [Core: Sparse Data Field Modelling based on Bayesian Inference, Regression/Prediction based on Decision Tree]
- **Patent (No. 10202502426R, SG):** Adaptive Triggering Mechanism for Time-Series Data Sensing on Edge Devices. [Core: Hardware-Software Join Design, Time Series Data Trigger Sensing Parameter Optimization]
- **Journal Article: Cui, S.,** Fu, Y. *, Fu, H., Yu, X. & Shen, W. (2025) **Smart Adaptive Trigger Sensing Powered by Edge Intelligence and Digital Twin for Energy-Efficient Wireless Structural Health Monitoring.** *Mechanical System and Signal Processing, Volume 241, 2025, 113537.* https://doi.org/10.1016/j.ymssp.2025.113537 [Core: Bayesian Optimization, Edge NN, Feedback Control, Trigger Parameter Optimization, Energy Efficiency Optimization]
- **Conference Paper: Cui, S.,** Yu, X., & Fu, Y.* (2025). **Smart adaptive triggering strategy for edge intelligence enabled energy-efficient sensing.** In *Proceedings of the 13th International Conference on Structural Health Monitoring of Intelligent Infrastructure (SHMII-13)*, pp. 609–616. Graz, Austria: Verlag der TU Graz. (**Best Conference Paper Award** 1st/202) [Core: Bayesian Optimization, Edge NN, Feedback Control, Trigger Parameter Optimization, Energy Efficiency Optimization]
- **Journal Article: Cui, S.,** Hoang, T., Mechitov, K., Fu, Y. * & Spencer, B. (2025). **Adaptive Edge Intelligence for Rapid Structural Condition Assessment using a Wireless Smart Sensor Network.** *Engineering Structures, 326, 119520.* https://doi.org/10.1016/j.engstruct.2024.119520 [Core: Gaussian Process Regression, Stochastic Process Control, Edge Intelligence, Data-driven Real-time Anomaly Detection]
- **Journal Article: Cui, S.,** Tan, Y. *, & Lu, Y. (2020). **Algorithm for generation of 3D polyhedrons for simulation of rock particles by DEM and its application to tunneling in boulder-soil matrix.** *Tunnelling and Underground Space Technology, 106, 103588.* https://doi.org/10.1016/j.tust.2020.103588 [Core: GJK Geometry Collision Detection]
- **Patent (No. 202011585928.2, China):** Random 3D Polyhedron Generator Based on a Hybrid Extension Method. [Core: GJK Geometry Collision Detection]

WORK & INTERNSHIP EXPERIENCE

Arcplus Group - ArcTron Data & Innovation Technology Co., Ltd. **Shanghai, CHN**
Product Manager, R&D 08/2021-07/2022

- Led the prototype development of ArcOS (building operating system) GUI for interactive project configuration.
- Spearheaded the modulization of the ArcOS workflow for project configuration.
- Engaged in ArcOS-API design for data importation (from IoT & IBMS) and exportation (for applications).
- Engaged in algorithm development for ArcOS, e.g., energy conservation, invasion detection.

SYSTEM ENGINEERING & PROTOTYPING

I - AIoT MCU Node Prototyping - Interface between the Physical and Cyber Worlds **Singapore**
Uses: IoT System Frontend – Perception, Computation, Storage, Communication, Actuation. 08/2023-Now
Features: Low Cost, Energy Efficient, General Purpose / Domain Specific, Edge AI Enabled.

- **Project A – Arduino IoT Wireless Sensor Network** – Pedagogical Uses & Idea Verification
  - Arch: MCU (Uno R4 WiFi) + IMU (MPU6050) + Storage + RF Communication (nRF24L01)
  - Features: Phone + MQTT Control; High Precision Time Synchronization (FTSP)
- **Project B – NexNode** – General Purpose MCU AIoT Node & Network
  - Architecture: Main Control + Perception + Actuation + Communication + Power; Base Board + Extension Board
  - Tools: STM32/HAL/STM32CUBE; ESP32/ESP-IDF/ESP-DL; FreeRTOS
  - Sensing: T. & H. (DHT11), Acc. (ADXL367&355)
  - Communication.: Bluetooth, WIFI, 4G, ESPNOW; MQTT
  - Software: Physical / Driver / Middleware / Application Layer
- **Project C – LiftNode** – Structural Health Monitoring Specific MCU AIoT Node & Network
  - Based on NexNode, Structural Health Monitoring Specific
  - ADXL355, 20-bit low noise low power high resolution accelerometer
  - Built-in Online/Offline Sensing and System Identification Functions

II - AIoT Cloud Server Development – Coordination for the IoT Nodes **Singapore**
Uses: IoT System Backend - Coordination, Storage, Computation, Analysis, Interfacing. 08/2023-Now
Features: Light-weight, General Purpose / Domain Specific, Cloud AI Enabled.

- **Project A – NexHub** – General Purpose IoT Cloud Platform for NexNodes
- Tech Stack: Web - Nginx, MQTT – EMQX, Database – MongoDB & InfluxDB
- Coordination: Orchestrating IoT nodes to ensure efficient and reliable system operation.
- Broker and Interface: facilitating communication between heterogeneous IoT nodes and providing standardized access for applications.
- Storage, Computation and Analysis: supporting long-term data management, complex computational tasks, and insight extraction for decision-making.

- **Project B – LiftHub** – Structural Health Monitoring Oriented Cloud Platform for LiftNodes
- Based on NexHub.
- High Performance Measurement: capturing and synchronizing sensing data.
- Accurate System Identification: modeling and characterizing structural dynamics.
- Effective Damage Assessment: detecting anomalies and evaluating conditions.

III – Distributed Computing and Intelligence Framework – for Edge Intelligence on MCU **Singapore**
Uses: Enabling Efficient Computation and AI on Resource-constrained Edge Devices. 08/2023-Now
Features: Resource-aware, Cross-platform, lightweight, efficient, modularized & layered.

- **Project A – TinyAuton** – General Purpose Edge Intelligence Enabling Framework
- TinyToolbox: Platform-related Functions, Configurations, Time Management, Evaluation
- TinyMath: Mathematic Operations, including Vector and Matrix Operations
- TinyDSP: Digital Signal Processing Algorithms & Functions
- TinyAI: AI Components for Onboard AI Deployment

- **Project B – TinySHM** – SHM Oriented Edge Intelligence Enabling Framework
- High Performance Measurement: capturing and synchronizing sensing data.
- Accurate System Identification: modeling and characterizing structural dynamics.
- Effective Damage Assessment: detecting anomalies and evaluating conditions.

ALGORITHM RESEARCH & INNOVATION

Agentic AIoT Networks with Collective Intelligence: From Passive Execution to Network-Level Autonomy **Singapore**
08/2025-now

- **Problem:** Conventional AIoT sensing networks are typically designed for passive execution, where nodes follow user commands and centralized scheduling for data acquisition and upload. Limited task awareness and cross-node collaboration make network-level autonomy and closed-loop execution difficult under dynamic environments and resource constraints, leading to frequent manual intervention, delayed responses, and high operational overhead.
- **Solution:** Built an edge–cloud collaborative collective intelligence framework by modeling application objectives and task constraints, and integrating federated learning, reinforcement learning, and multi-agent collaboration. This enables multi-node networks to shift from passive execution to proactive cooperative decision-making, with autonomous planning, adaptive resource allocation, and policy optimization.
- **Implementation:** Delivered an end-to-end perception–reasoning–decision–action loop using NexNode (AIoT hardware), TinyAuton (low-power edge runtime), and NexHub (cloud services) for network-level coordination. In TinyAuton, node capabilities were packaged into composable service modules (Lego-like building blocks); on top of this, we developed agents that invoke these services on demand—covering sensing, compute, communication, and alerting—based on their decisions to execute tasks autonomously. Federated learning enabled privacy-friendly collaborative modeling, reinforcement learning optimized triggering and resource scheduling policies, and multi-agent mechanisms supported orchestration, fault tolerance, and self-recovery.
- **Results:** Enabled autonomous task execution and collaborative operation across multi-node AIoT networks, significantly reducing manual configuration and on-site intervention. Demonstrated real-time monitoring and event response in structural monitoring deployments, providing a practical pathway from sensor networks to agentic networks.

Real-time Multivariate Time-Series Classification, Forecasting, and Control – TBM Tunneling Parameters as an Application Scenario **Singapore**
04/2025-12/2025

- **Problem:** TBM operations generate high-frequency, high-dimensional, and strongly coupled multivariate time-series data, with frequent regime transitions and diverse operational needs (varying input/output horizons and different latency–accuracy requirements). Conventional offline analytics or single-model pipelines struggle to support a closed-loop workflow for real-time monitoring, classification, forecasting, alerting, and parameter adjustment.
- **Solution:** Developed a multi-model time-series intelligence engine with an adaptive inference framework, systematically benchmarking and integrating ARIMA, LSTM, GRU, CNN, Transformer, and MAMBA models. The system dynamically selects suitable models based on task requirements to enable an integrated pipeline of real-time monitoring → classification → forecasting → alerting → adjustment, while supporting continual model updates and adaptive fine-tuning.
- **Implementation:** Built a real-time monitoring system with an interactive UI dashboard, allowing flexible configurations of input window length and prediction horizon. Established a unified training and evaluation workflow across multiple models, and designed a model selection strategy balancing accuracy, latency, and stability. Integrated online data streaming and model iteration interfaces to support continuous evolution under varying working conditions and data drift.
- **Results:** The system has been tested and deployed in the Suzhou Metro Digital Twin platform, enabling real-time classification and short-horizon forecasting of key tunneling parameters, and providing interpretable alerts and adjustment suggestions. It delivers an engineering-ready time-series intelligence module for intelligent TBM tunneling operations.

Smart Adaptive Trigger Sensing with Edge Intelligence and Digital Twin for Energy-Efficient Wireless Structural Health Monitoring **Singapore** 04/2024-04/2025

- **Problem:** Event-triggered sensing in wireless SHM commonly relies on fixed thresholds and durations, lacking adaptivity to dynamic environments and leading to an inherent trade-off between missed events, false triggers, and energy efficiency on resource-constrained edge devices.
- **Solution:** Proposed a Smart Adaptive Triggering Mechanism (SATM) based on a feedback control framework, integrating Bayesian Optimization for adaptive parameter tuning, lightweight neural networks for onboard inference, and Digital Twin technology to accelerate optimization.

- **Execution:** Designed a two-stage deployment strategy with digital-twin-based pre-optimization and onboard fine-tuning; developed and deployed lightweight CNN and DNN models on MCU-level sensor nodes; integrated the framework into low-power wireless platforms (LiftNode) for real-time edge execution.
- **Outcome:** Achieved approximately a 30% improvement in trigger detection performance (F-beta) compared with conservative manual settings, while reducing computational overhead by 2–3 orders of magnitude, enabling reliable and energy-efficient wireless SHM deployments. This work led to a granted patent (SG Patent No. 10202502426R) titled "Adaptive Triggering Mechanism for Time-Series Data Sensing on Edge Devices". The results were presented at SHMII-13 (Graz, Austria), where the conference paper received the Best Paper Award (1st out of 202 submissions).

Adaptive Edge Intelligence for Rapid Structural Condition Assessment Using a Wireless Smart Sensor Network **Singapore** 03/2023-06/2024

- **Problem:** Conventional wireless SHM systems rely on centralized processing and offline analysis, resulting in delayed structural condition assessment and limited adaptability under resource-constrained sensing environments.
- **Solution:** Proposed an adaptive edge intelligence framework that integrates Gaussian Process Regression (GPR) for structural response modeling and Statistical Process Control (SPC) for condition monitoring, enabling rapid and data-driven structural condition assessment at the sensor-network level.

- **Execution:** Designed a wireless smart sensor network with onboard computing capability; implemented GPR models for local structural behavior estimation and SPC-based decision rules for condition assessment; deployed the framework on edge sensor nodes and validated it using experimental structural response data.

- **Outcome:** Demonstrated that the proposed edge-intelligent system enables timely and reliable structural condition assessment while significantly reducing communication overhead, offering a scalable and efficient alternative to conventional centralized SHM architectures. The results were presented at EMI 2023, Atlanta, USA.

Algorithm for Generation of 3D Random Morphology of Granules and Its Application in TBM Tunneling **Shanghai, CHN** 09/2018-06/2021

- **Problem:** Realistic simulation of TBM tunneling in boulder–soil strata is limited by the lack of efficient methods to represent irregular, non-convex boulder geometries and their interactions with surrounding ground.
- **Approach:** Proposed a 3D random polyhedron generation framework based on a hybrid extension method, incorporating a two-step convexity control strategy and an improved GJK (Gilbert–Johnson–Keerthi) algorithm for non-convex collision detection, enabling reliable geometric modeling for DEM simulations.
- **Execution:** Implemented the algorithms in a GUI-based application for automatic polyhedron generation; designed and fabricated a scaled TBM physical model using 3D printing and servo motors; conducted DEM-based parametric studies using the generated polyhedrons to simulate boulder and ground motion.
- **Outcome:** Demonstrated that ground motion magnitude is mainly governed by boulder size, while boulder motion is strongly influenced by morphology, position, and orientation; showed that advance boulder blasting and grouting can mitigate potential geohazards. Results were presented at an international tunneling conference (CTTU202, Melbourne).

AWARDS & COMPETITIONS

Best Conference Paper Award (1st/202), SHMII-13, Graz, Austria.	09/2025
First Place, 3-Minute Thesis Competition, School of CEE, NTU	03/2025
Excellent Graduate & Excellent Dissertation of Tongji University	06/2021
Shimao-Jiangxin-China Scholarship for Academic Excellent (Top 3% in China)	11/2020
Third Prize in the 15th China Post-Graduate Mathematical Modelling Contest (Top 30%)	12/2018
Honorable Mention in the Interdisciplinary Contest in Modelling (Top 20%)	2016&2017
Third Prize of Tongji Scholarship of Excellence (Top 20% of the school)	2015&2017
Second Prize in the 5th Future Aircraft Designing Contest of Tongji University (3rd/22)	11/2016
First Prize in the 6th Applied Mechanics Innovation Contest of Tongji University	04/2016
Third Prize in the 7th China Undergraduate Mathematical Contest (Top 15%)	11/2015