

Y.A.N.K.I.

Yield Analysis & Networked Kinetic Intelligence

Yapısal Akustik Nesneler ve Kritik İzleme

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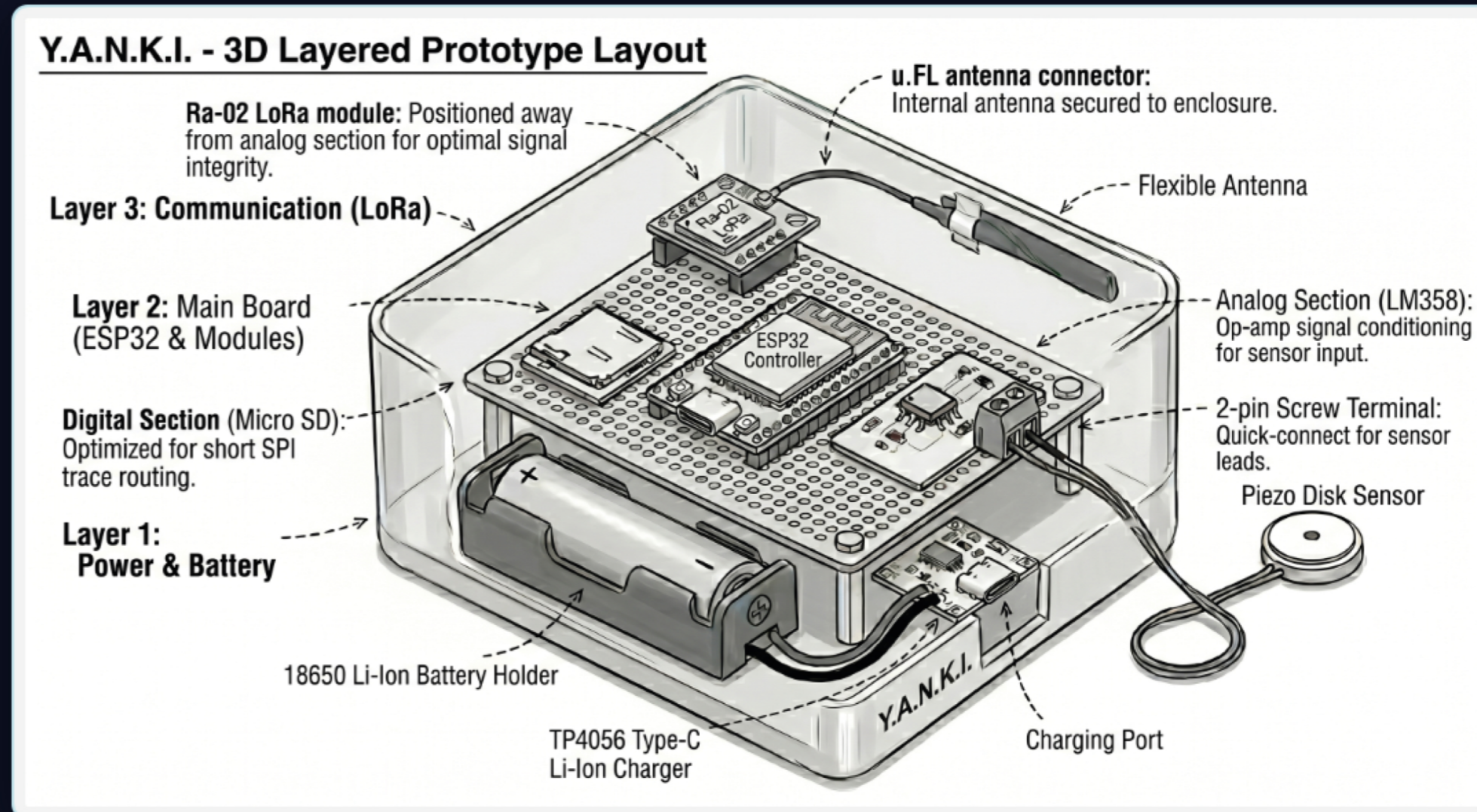
ABSTRACT

Y.A.N.K.I. is a low-cost, edge AI-powered Structural Health Monitoring (SHM) system designed to detect micro-vibrations, structural fatigue, and early damage indicators in critical infrastructure. The system captures kHz-band acoustic signatures using a 15mm piezoelectric disk sensor, conditions the signal through an LM358 op-amp circuit, and digitizes it via the ESP32's internal 12-bit ADC. Real-time anomaly classification is performed on-device using a quantized 8-bit 1D Convolutional Neural Network (TinyML), completing inference in under 50 milliseconds — with zero cloud dependency. Anomaly alerts are transmitted via LoRa (SX1278) long-range radio at 868 MHz, enabling operation in environments without internet connectivity. The event-driven deep-sleep architecture allows months of autonomous operation on a single 18650 Li-Ion cell, while maintaining a per-node cost below \$25 — democratizing structural safety monitoring for mining, heritage preservation, and residential applications.

METHODOLOGY

- Piezo Detection** — 15mm piezoelectric disk converts surface micro-vibrations into millivolt-level electrical signals at kHz frequencies.
- Signal Conditioning** — LM358 op-amp amplifies signal to ESP32-readable range. RC low-pass filter suppresses environmental noise.
- ADC Digitization** — ESP32's 12-bit ADC samples the conditioned analog signal at high frequency for digital processing.
- Dataset Creation** — Raw waveforms logged to SD card, labeled into categories (crack / normal / impact / noise) for supervised training.
- TinyML Inference** — Quantized 1D-CNN (Float32→Int8) runs on ESP32 flash. Real-time structural classification in <50ms latency.
- LoRa Alert** — On anomaly detection, a minimal 9-byte alarm packet is transmitted via SX1278 at 868 MHz. Zero idle data traffic.

SYSTEM ARCHITECTURE



KEY RESULTS & METRICS

< \$25

Per sensor node cost
(vs. \$5,000+ industrial AE)

< 50ms

On-device inference
(1D-CNN, 8-bit quantized)

9 bytes

LoRa alarm packet
(ultra-low data overhead)

Months

Battery autonomy
(3000 mAh, 18650 cell)

3 Markets

Mining · Heritage · Smart Home
(B2B · B2G · B2C)

TBDY 2018

Turkish Earthquake Code
(Article 13.8 compliant)

KEY INNOVATIONS

Edge AI (TinyML)

All ML inference on-device. Zero cloud dependency, zero latency. Float32→Int8 quantization reduces model size by 4x, enabling deployment on resource-constrained MCUs.

LoRa Communication

Operates in unlicensed 868 MHz spectrum with kilometer-range penetration. Functions underground, indoors, and in remote areas — ideal for mines and heritage sites.

Event-Based Sampling

Deep sleep by default; MCU wakes only on piezo threshold crossing. Achieves 75% energy reduction while maintaining continuous structural vigilance.

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