

Abstract

VitaRay is a contactless fall-detection system using millimeter-wave radar to monitor human movement without wearables or cameras. Designed from the ground up with custom hardware and optimized algorithms, it delivers reliable detection while remaining low-cost, low-maintenance, and suitable for long-term use in geriatric care environments.

What is VitaRay

Why VitaRay?: Falls are a leading cause of injury and long-term disability among elderly and high-risk patients, particularly in unsupervised or home-based care settings. To address this challenge, I developed VitaRay, a non-intrusive fall-detection and vital-sign monitoring system based on millimeter-wave (mmWave) radar technology. Unlike wearable or camera-based solutions, VitaRay requires no user interaction, does not capture video, and preserves patient privacy while operating continuously in the background.

Performance testing shows that VitaRay achieves fall-detection accuracy and vital-sign monitoring performance comparable to top-tier industry benchmarks. Through custom circuit-board design and algorithm optimization, the system reduces processing requirements by approximately 60–80%, significantly lowering overall cost compared to commercial alternatives. A diversified supply chain further improves scalability and resilience.

Methodology

VitaRay was designed and built from the ground up as a fully custom, non-intrusive fall-detection system. The development process began with system-level design, defining sensing, processing, power, and communication requirements specific to geriatric care environments. A **millimeter-wave (mmWave)** radar module sourced from Texas Instruments was selected for its ability to detect human motion and vital-sign micro-movements without physical contact or visual recording.

Custom printed circuit boards (PCBs) were designed to integrate the radar module, power regulation, and control electronics, reducing reliance on expensive off-the-shelf development boards. Components were hand-soldered, tested, and iteratively refined to improve reliability and signal integrity. Enclosures and mounting components were 3D-printed, allowing rapid prototyping and optimization of radar orientation, airflow, and device footprint.

Signal-processing and detection algorithms were optimized to reduce computational load (which was limited within the compact design) while maintaining accuracy, enabling deployment on lower-cost hardware. This end-to-end design approach ensured VitaRay achieved high performance, and relatively low cost.

Market Research

Growing Global Demand: projected to grow from USD 3.8 billion in 2024 to USD 4.2 billion in 2025, with a CAGR of 11.1%.

A Strong Launch Market in Australia driven by the aging population and the increasing prevalence of chronic conditions.

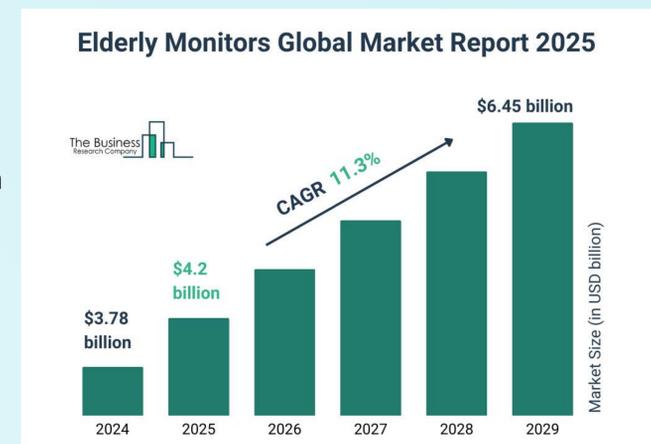


Figure 1 (above): 2024-2029 market projections

Rising demand for:

- **In-home and community-based care**
- **Passive, privacy-preserving** home monitoring systems
- Identify incidents (**falls and cardiovascular events**) and enable timely care responses

PCB Design

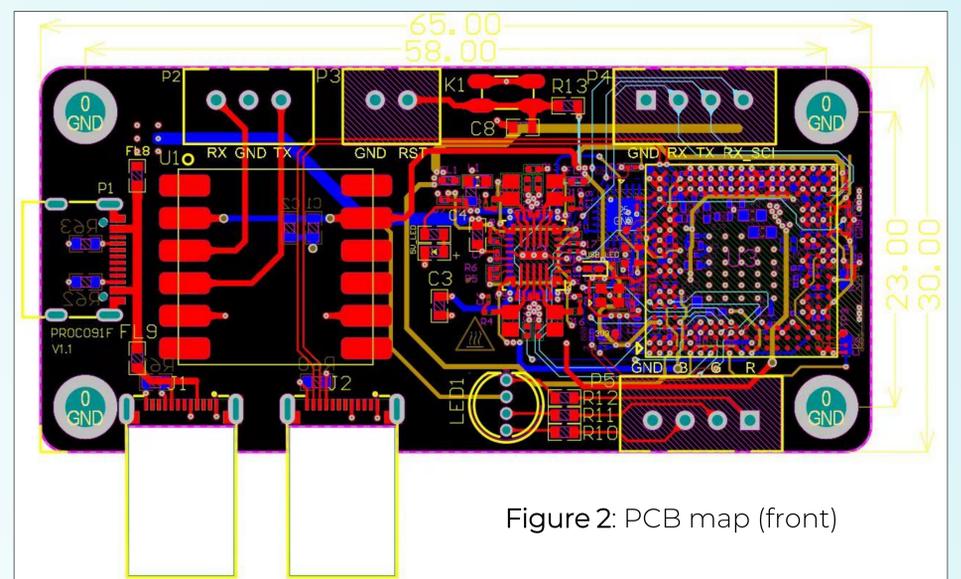


Figure 2: PCB map (front)

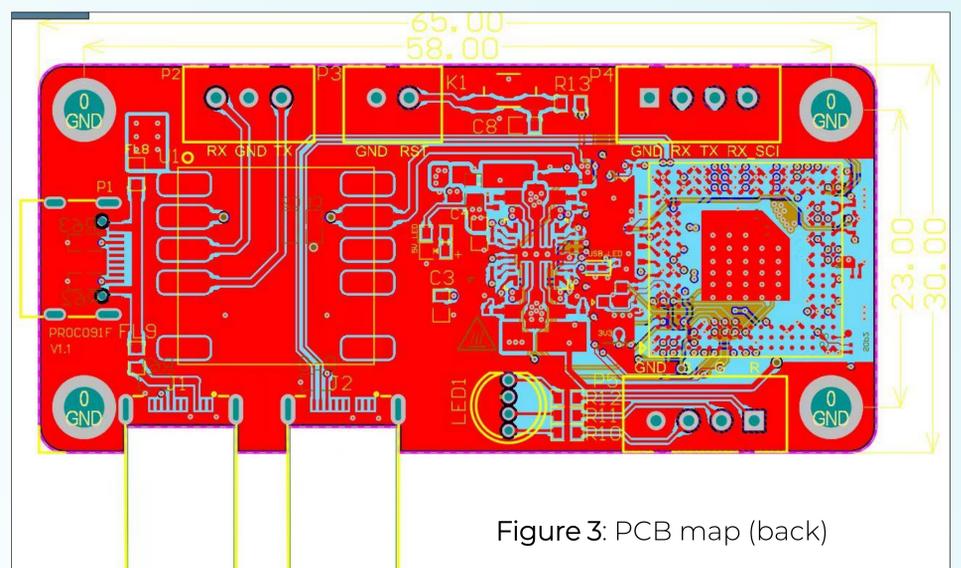


Figure 3: PCB map (back)

Benefits

VitaRay's low-maintenance, contactless, and privacy-preserving design makes it particularly well suited for geriatric care, where reliability, affordability, and patient comfort are critical. Additionally, it is also capable of monitoring vital signs like heart rate and respiratory rate through contactless means making it even more applicable in medical settings.

Capabilities/Limitations

Capabilities

- High-resolution heatmap-based point cloud generation
- Dynamic spatial filtering to eliminate background noise Intelligent User Tracking
- Continuously tracks user posture, movement, and location
- Optimized for complex environments (e.g. sitting, resting, multiple people)
- Range: 8X8 square meters
- Capable of penetrating most thin surfaces, i.e glass, rubber (shower curtains), plastics...
- Capable of TWS (track while search) of up to 2 targets
- Water resistant
- Low maintenance
- Capable of monitoring heart and respiratory rate

Limitations

- Cannot be used underwater
- Requires continuous internet connection
- Low accuracy when used in outdoors settings

Me!

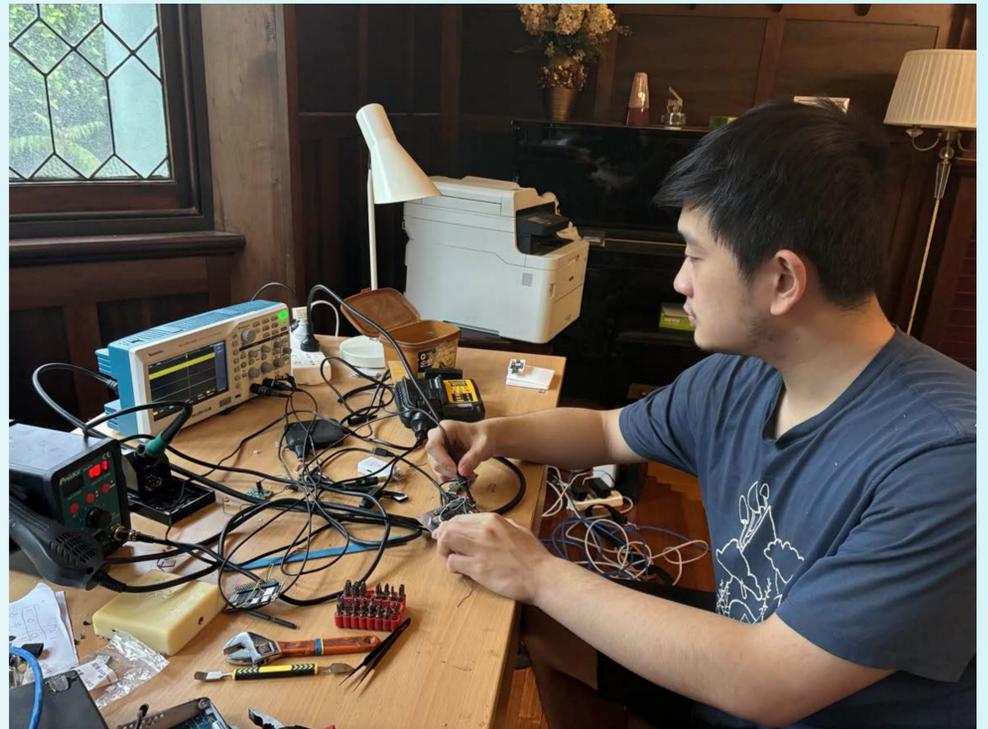
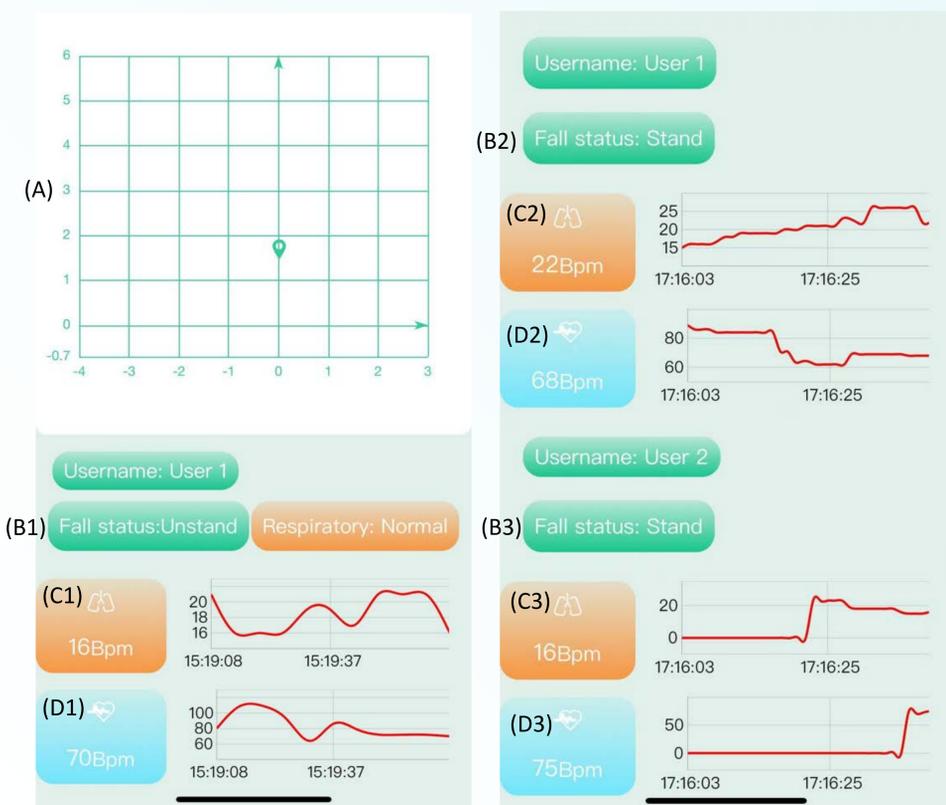


Figure 6 (above): Me working on the first prototype ©

App User Interface



Figures 4 & 5 (above): App interface (A) graph displays location of target within room using coordinates, (B1), (B2), (B3) displays the falls status of tracked target, (B2), (B3) displays simultaneous tracking of 2 targets (C1), (C2), (C3) orange box displays the respiratory rate of tracked targets, graph (right) displays respiratory rate over time (D1), (D2), (D3) blue box displays heart rate of tracked targets, graph (right) displays heart rate over time

Final Design

Figure 7 (right): First completed and functional prototype. Outer shell was 3D printed using ABS plastic



Figure 8 (right): Internals of first prototype, created using TI mm wave radar. PCB board with WiFi card and Cdtech processing unit

