



UNDERGRADUATE THESIS

**DESIGN OF VIRTUAL ASSISTIVE NAVIGATION
AID FOR VISUALLY IMPAIRED USERS USING
ULTRASONIC SENSORS, FIREBASE, AND
ANDROID**

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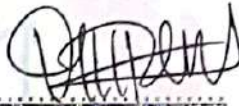
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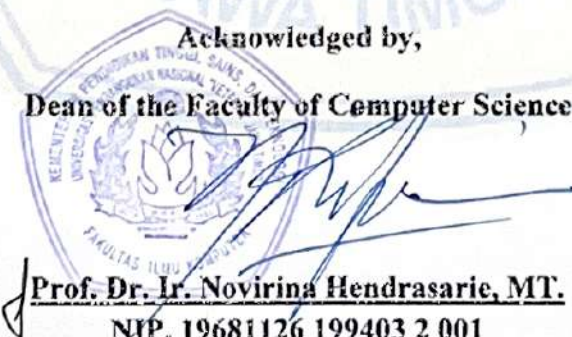
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ABSTRACT

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Thesis Title: DESIGN OF VIRTUAL ASSISTIVE NAVIGATION AID FOR VISUALLY IMPAIRED USERS USING ULTRASONIC SENSORS, FIREBASE, AND ANDROID

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This research aims to design and implement an Internet of Things (IoT)-based navigation aid for visually impaired users in the form of a wearable smart belt. The system was developed to help users detect front obstacles and potential holes on walking paths without using a handheld device. The device uses two HC-SR04 ultrasonic sensors placed at the front and bottom of the belt. The front sensor detects obstacles at a distance of ≤ 120 cm, while the bottom sensor detects potential holes when the measured distance exceeds 130 cm. An ESP32 microcontroller controls sensor readings, detection logic processing, audio and vibration alerts, and location data transmission to Firebase Realtime Database.

The development method used in this research was the prototype method, which involved requirement analysis, system design, implementation, integration, testing, and evaluation. The system was designed using a Three-Layer Architecture consisting of the device layer, cloud layer, and application layer. The device layer handles detection and local alerts through a DFPlayer Mini, speaker, and vibration motor. The cloud layer uses Firebase Realtime Database to synchronize location data in real time. The application layer is a React Native-based Android application that displays the device location based on GPS NEO-6M coordinates.

The controlled testing results showed that obstacle and hole detection achieved 100% accuracy, precision, recall, and detection success rate under the defined test scenarios. The data communication test produced an average end-to-end latency of 1 second, which was below the target of < 2 seconds. Functional alpha testing using a black-box approach achieved a 100% success rate, while User Acceptance Testing (UAT) involving five non-visually impaired respondents as simulated users achieved an acceptance score of 88.67%. However, the endurance test produced a stable session percentage of 85.71%, indicating that operational stability still needs improvement. Therefore, the system successfully achieved the main research objectives functionally, but further development is needed in power supply design, device reliability, and direct testing with visually impaired users.

Keywords: Internet of Things, Smart Belt, ESP32, Firebase Realtime Database, Ultrasonic Sensor, Visually Impaired Navigation.

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The author realizes that this thesis still has limitations and imperfections. Therefore, constructive criticism and suggestions are highly expected for future improvement. Finally, the author hopes that this thesis can provide benefits for readers, future researchers, and the development of assistive technology for visually impaired users.

Surabaya, June 8th, 2026

Kevin Ricky Pradana

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