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Miniature Radar System

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ABSTRACT: During recent years, low-cost sensing and embedded platforms have enabled the development of compact radar-like systems for short-range object detection. Conventional radar systems based on RF transmission are expensive, power-hungry, and complex, making them unsuitable for educational and small-scale surveillance applications. This paper presents the design and implementation of a Miniature Radar System using an Arduino Nano microcontroller, ultrasonic sensor, servo motor, 16×2 LCD display, and an audible buzzer. The proposed system performs real-time angular scanning and distance measurement of objects within a 180° field of view. Ultrasonic time-of-flight measurements are combined with servo-controlled angular positioning to emulate radar functionality. Experimental evaluation demonstrates reliable detection in the range of 2–400 cm with an angular resolution of 1°. The system also provides an audible alert when an object is detected within a predefined threshold distance. The complete prototype is implemented on a custom PCB using off-the-shelf components, making it economical, portable, and highly suitable for student projects and academic research prototyping.

I. INTRODUCTION

Radar systems play a vital role in object detection, navigation, and surveillance across civilian and defense applications. Traditional radar systems operate using radio-frequency (RF) waves and require complex signal processing, high-frequency circuitry, and significant power resources. These constraints limit their adoption in low-cost educational and short-range sensing scenarios.

With the growth of embedded systems and low-cost sensors, simplified radar-like systems can be developed using ultrasonic sensing techniques. Although ultrasonic sensors do not operate on RF principles, they provide accurate distance measurement based on time-of-flight, enabling radar-style scanning when combined with angular motion control.

II. LITERATURE SURVEY

Miniature radar systems are compact, low-power radar devices designed for short-range detection, tracking, and sensing applications, enabled by advances in CMOS/MMIC integration and millimeter-wave technology. Most modern miniature radars operate in high-frequency bands such as 24 GHz and 77–81 GHz, allowing smaller antenna sizes and improved resolution while maintaining reduced form factor and cost. A significant portion of the literature focuses on FMCW (Frequency Modulated Continuous Wave) techniques, which provide accurate range and velocity estimation with relatively simple hardware architecture.

III. METHODOLOGY

The system integrates hardware and software components to achieve voice-controlled wheelchair movement. Voice commands are captured using a voice recognition device and transmitted wirelessly. The Arduino Nano processes the received signals and controls the motor driver to drive DC motors accordingly.

- └ Generate high-frequency radar signals using the radar module
- └ Transmit electromagnetic waves through the antenna
- └ Reflect radar waves from the target object
- └ Receive the reflected (echo) signals
- └ Amplify and filter the received signals
- └ Process signals using a microcontroller

Block Diagram

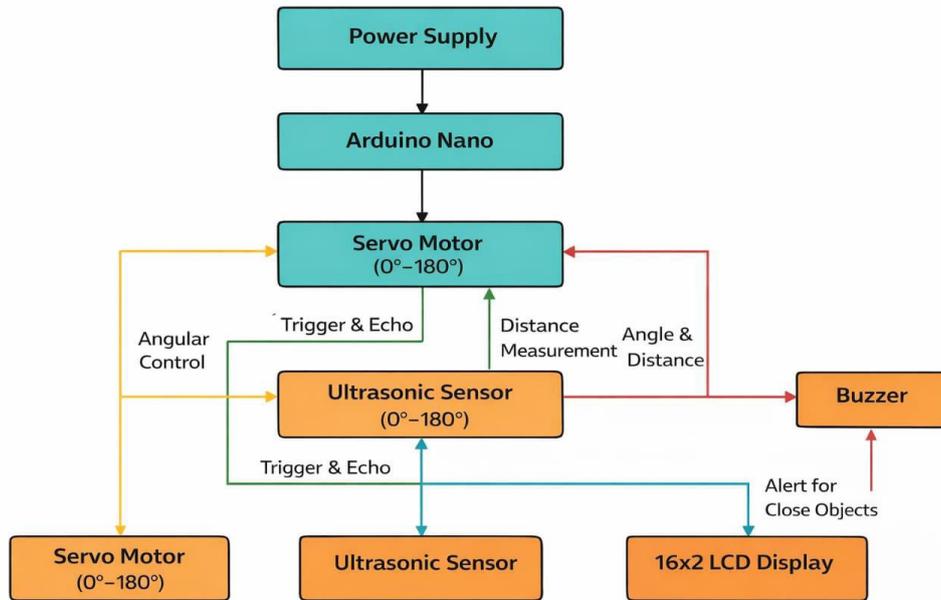


Fig. miniature radar system

Receiver Section

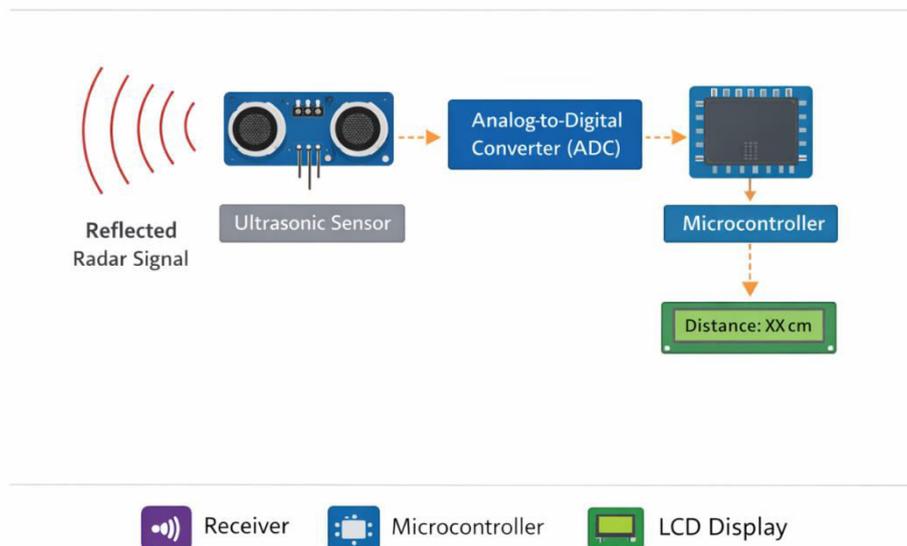
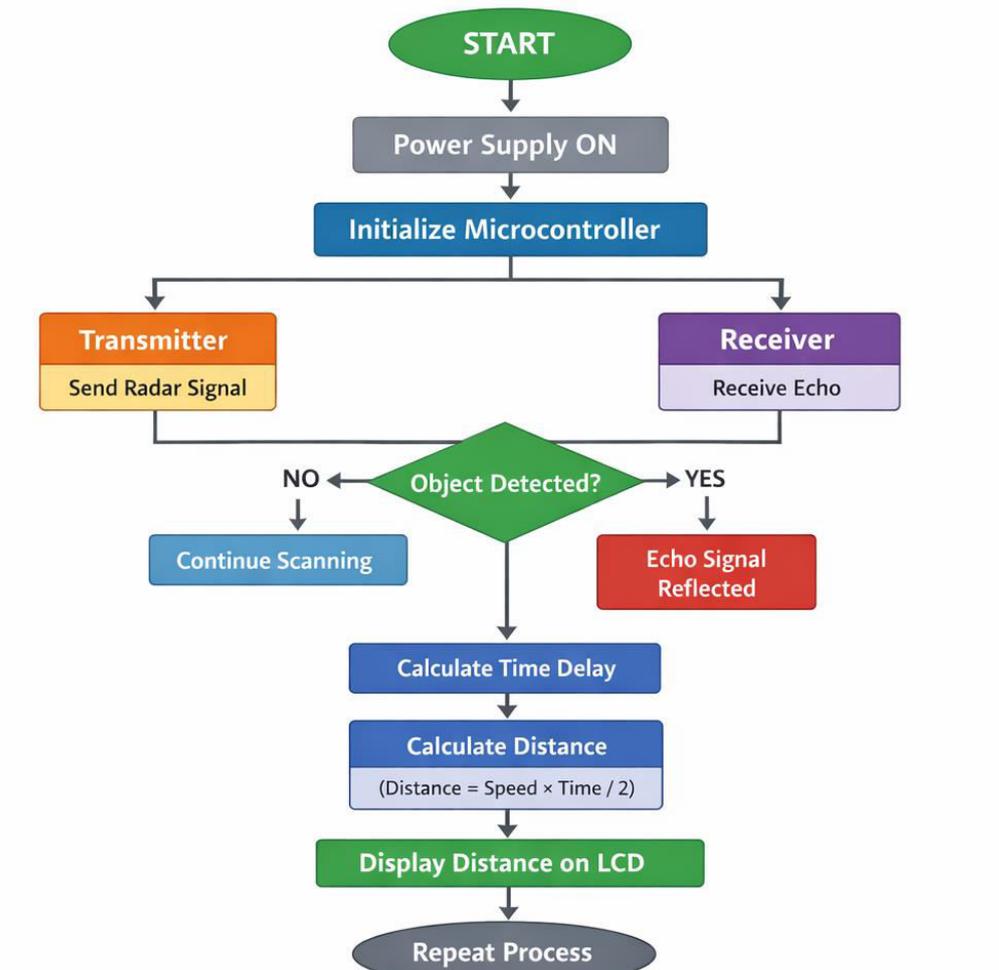


Fig. Receiver section

Flowchart

Miniature Radar System



IV. EXPERIMENTAL RESULTS

The miniature radar system successfully detected objects within its operating range and measured distance with an average accuracy of about $\pm 1-3$ cm. The system displayed real-time results on the LCD and showed reliable performance under normal indoor conditions, with minor variations due to surface type and environmental factors.



V. CONCLUSION

The miniature radar system was successfully designed and tested, demonstrating reliable performance for short-range target detection. Experimental results show good accuracy at lower distances with a near-linear relationship between actual and measured values. Although measurement error increases at higher distances due to environmental and sensor limitations, the overall performance remains acceptable. The compact design, low power consumption, and stable operation make the system suitable for applications such as obstacle detection and proximity sensing.

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