

Range-finding Sensors

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Range-finding sensors are used to measure distances to a target. Measuring distances accurately is important in navigation, land surveying, building development, targeting weapons, and even sports. Distances define locations and boundaries: where a place is at, how far it is from other places, and where one place ends and the next one starts. Mapping takes these distances and converts them into a graphical format to easily display distance data and relationships between places. Modern infrastructure of world commerce requires a fast and versatile transportation network; distances from location to location must be exact for the most efficient network. This paper focuses on range-finding sensors to identify commercial applications, explain the underlying technology, and describe the building blocks to implement them.

Commercial Applications

Commercial rangefinders are sold to consumers for outdoor hunting, targeting practice, and even golf [3]. Laser range-finding sensors are used in LIDAR (light, detection and ranging) systems to scan buildings and are even mounted on airplanes to help navigation. Scientific applications include fault detection, terrain modeling, glacial monitoring, Doppler systems, and lunar laser ranging. LIDAR systems are used as an alternative to radar guns for traffic speed law enforcement. 3D laser scanners are used to gather record 3-dimensional data of entire landscapes [1]. Laser range-finding sensors in LADAR (or laser radar) systems are used in military applications for target acquisition. LADAR systems can be incorporated into many military vehicles including tanks [6] and unmanned air vehicles (UAVs) [5]. Sound Navigation and Ranging (SONAR) systems are essential for underwater travel, where distances for submarines can be hard to determine by sight. Radio Navigation and Ranging (RADAR) systems are used to determine distances on modern airplanes.

Underlying Technology

Modern rangefinders use a variety of active methods to measure distance – sending out sound, light, or radio waves and listening to the receiving waves. Generally these are known as sonar, laser, or radar systems.

Sonar systems use sound propagation through the medium to determine distances. Active sonar creates a pulse of sound (a ping) and listens for its reflections (echoes). The time of the transmission of the pulse to its reception is measured and converted to distance by knowing the speed of sound; this is a time-of-flight measurement [2]. The speed of sound waves is dependent on the bulk modulus and mass density of its medium. It can be affected by absorption through the medium and noise from waves and ships. Normal frequencies vary from infrasonic (below the range of human hearing) to ultrasonic (above the range of human hearing).

Laser (Light Amplification by Stimulated Emission of Radiation) systems can use a variety of techniques to measure distances: triangulation, time-of-flight measurements, interferometers, and the phase shift method [9]. Laser beams are tightly focused compared to other radio or sound waves, providing highly accurate measurements. Lasers can be made in the visible spectrum; however common are infrared lasers, ultraviolet lasers, and X-ray lasers.

Radar systems used electromagnetic waves to measure distances. Techniques for measuring distances include time-of-flight measures, frequency modulation, and phased array method. Radio waves travel at the speed of light for quick and accurate measurements. Radar allows detection at ranges where sound or visible light are weak. Solid objects reflect radio waves in air or space, especially on electrically conductive material. Radar can be jammed by sending radio waves on the radar's frequency. Radar systems uses a specific pulse repetition frequency (PRF) – changing their range by changing their PRF.

Building Blocks to Implement

Building a range-finding sensor using time-of-flight measurements requires knowledge of the specific wave characteristics and effects of the medium it travels. To send out a wave, a transmitter and receiver is necessary. Modern systems may use several receivers to listen for feedback and amplify the returning signals. Computer software may be used to automate signals being sent out and process received signals to map out a wide range of distances.

Sonar systems need equipment to determine the environmental conditions for the passing sound waves. Pressure, temperature, depth, and sound absorption of water all affect the reflecting sound waves. Sound waves are created electronically using a Sonar Projector: a signal generator, a power amplifier, and an electro-acoustic transducer.

Laser systems can be built with a variety of materials depending on the wavelength to generate: gases, chemicals, solid-state, semiconductors, and fiber.

Radar systems consist of a transmitter, a waveguide, an antenna, and a receiver. The antenna design is critical to targeting and mapping. Radio signals broadcast in all directions; a parabolic reflector may be necessary to create a directional beam of radio waves.

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