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ECE 4007-L03
Collision Detectors
Technical Review Paper

Introduction

Modern RADAR detection systems are an effective engineering solution when incorporated into distance detection systems for a variety of industries. The current generation of RADAR range finders finds a home in several commercial applications. Dating back to World War I, the radar system and its underlying technology have received global adoption across many industries that use the technology on a daily basis [1]. Its ability to detect objects within a given field of view and report back real-time location and speed information is a common method for accurate kinematical measurement. Using different frequencies of light causes radar to detect objects of various densities, made popular by every news channel's nightly weather report.

Though radar technology has reached maturity, new applications are being developed at the transistor level. Several researchers are working on a single-chip transceiver in the millimeter-wave range for radar imaging. These rely on Silicon chips to reproduce Doppler radar imaging via HBT (hetero-bipolar transistors) amplification in the tens-of-GHz ranges [2].

Commercial Applications of the Technology

Radar range finders have the unique ability to determine distances and speeds by careful emission and detection of electromagnetic waves at particular frequencies [1]. In the aeronautical industry, many range finders are used to detect the location of airplanes in the skies above, how fast they are moving, and what trajectory they are taking. Another common use is to apply a range finder to determine the size of the airborne object empirically.

Other uses include probing and mapping space in the sky or subterranean regions [4], avoiding speeding tickets and missile targeting systems [3, 6]. These are sold at a variety of prices from manufacturers including Northrop Grumman, K40, and NASA.

Physics of the Technology

According to [3], radar (short for radio detection and ranging) involves the emission of electromagnetic waves at a variety of different frequencies chosen specifically for the application. These waves have a penetration depth in some substances and a coefficient of reflection from others which do not absorb a particular frequency. What is interesting is the objects which reflect this "light", and are subsequently redirected back towards the emission point. These waves are detected by a sensor (usually a parabolic antenna tuned to a particular frequency) which times how long the waves were in flight and uses this information to calculate distance, given the speed of the e-m waves (300,000,000 meters per second). Subsequent findings can be processed to determine more information such as the object's trajectory, acceleration, and velocity. Further, due to the Doppler Effect, a slight shift in frequency of returning waves delivers additional information on the target's speed. Systems of this nature are most popular and are called "pulsed" radar systems. Other systems emphasize the Doppler Effect as a means of gaining information, and are referred to as "continuous wavelength[1,3,7]".

Using processing, the emissions coming from the antenna are activated by an emitting source and are transmitted or propagated away from the source using the antenna. Afterwards, to allow for the very sensitive and low-power receiver to detect collisions and reflections, software disengages the emitting device abruptly after the last pulse. This prevents the high-powered emitting source from blinding or blowing out the receiver. The receiver then detects signals as peaks from the noise floor, calculating each spike's registration in software and marking the time at which each was received [3,7].

Building Blocks for Implementation

Radar requires three main building blocks, as specified in [3]: The emission system, the detection system, and the processing system. Due to advances in technology, the processing systems are currently advanced enough to combine the emission system and detection system into the same antenna. To design the antenna, it must be made known what frequency of operation the radar is expected to maintain, and in what way the signal will be reflected back. For example, an antenna that actively scans for reflections in all directions would be best designed as a dipole, servo-mounted device that spins at a rate of speed that satisfies the refresh demands of the system, as in Doppler Radar weather detection [6].

Other systems require acute directionality and implement directional antennae, often referred to as parabolic antennae [6]. These contain particular emission patterns resembling a stretched ellipse or bubble, the width of which characterizes the field of view of the device. The field of view must be kept in mind when determining the correct antenna for the application.

Lastly, the device requires a type of human interface to present information determined by the system. Often, a screen or display with a set refresh rate is used, which matches the refresh rate of the device and ensures the user has real-time information. Often, complete systems are distributed with emitter, detector, and matching processing software. An example of this is [5].

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