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A Comparative study on various anti-collision mechanisms for correlation radar

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ABSTRACT:- Radars are general devices for defense, survey & vehicle guidance systems however the sophisticated design & requirements of costly devices makes it out of reach to the daily applications. we proposed an approach to making the device simpler, cheaper & to make the device much compatible for automobiles so that it can be used for automated vehicle driving system as well as collision avoidance system although many other features can be added to it like vehicle signature reading can be used to find out the type of vehicle such as lifesaving or emergency vehicles.

KEYWORDS:- Anti-collision, Correlation Radar, PRBS

I. INTRODUCTION

The RADAR is the basic requirement of anti-collision system hence many type of RADAR has been already proposed according to its property and requirement of system .Anti-collision system use RADAR detection to measure distance to obstacles and obstacles relative speed. Many RADAR antennas were developed but correlation radar is the most recent radar used in Anti-collision system. It’s a bad and erroneous estimation of the safety distance from the driver that cause car accidents on the road. The safety distance is the minimum distance required to stop a braking vehicle.

The distance estimation is worsened because of bad visibility condition due to whether (rain, fog, snow).Hence, driver need assistance to perform an efficient estimation of distance on road under bad vision condition. The radar is not limited by whether condition.

We focused on its application on automotive RADARs which is used for road anti-collision system, although recent developments in chip manufacturing technology provides as capability to make it multi-function device such that it can be used for automatic driving system but this is another goal, presently we discuss aspect when a large number of vehicles will use this technology then the interference produced by their signals can totally jam the radar hence it become totally unusable to avoid this problem we analyzed the performance of correlation radar for different PN sequences under interference & noisy condition so that the best PN sequence which can properly work on such conditions can be found.

Correlation Radar

A new method for generating the binary sequences used in ranging systems, based on correlation techniques, is proposed in order to improve and simplify the processing of the received signal. Radar systems can be based on single pulse transmissions, frequency modulation or the correlation between the transmitted and received binary sequences. The distance between units is deduced from the time difference between the correlation peaks of the transmitted signal and those of the echo produced by the signal being reflected back from the obstacle. The radar sensors in many automotive applications work either in the 24 or 77 GHz frequency band, and since the maximum range does not exceed several hundred meters, the antenna radiation pattern’s beam width is very narrow in order to avoid incorrect measurements. In other non-automotive applications, such as the railway transportation industry, the desired range is much higher, between 1 and 5 km.

This radar emits a signal modulated with a pseudo random binary sequence: PRBS forming the references codes. The pseudo random binary sequences have codes interesting correlation and inter correlation properties. This code is recognized in the echo signal by a calculation of correlation that provides the time of flight .Thus, we can easily deduce the distance to obstacle and its relative speed.

The classical correlation is the sum of sample products *x* and y, with *y* being only shifted in time. Zeros replace gaps in the shifted sequence. We don't use a classical correlation function but a cyclic one. Instead of a simple time shift the cyclic correlation performs a circular permutation of the second sequence.

One of the applications of correlation is finding the time it takes for a known signal to pass through a system, if the signal is not grossly distorted during the transient. The lag of time at the maximum value of the cross correlation is the time shift caused by the system. This principle is used in developing a correlation radar system. Another form of correlation called cyclic correlation consists of rotating one of the signals rather than shifting it. In case of radar applications, cyclic correlation produces far better results than linear correlation.

The general principle of correlation radar is to continually transmit a Pseudo Random Binary Sequence (PRBS) towards a potential target. The signal received back after reflection from the target determines its distance and relative speed.

Pseudo random sequence

PRBS or Pseudo Random Binary Sequence is essentially a random sequence of binary numbers. It is random in a sense that the value of an element of the sequence is independent of the values of any of the other elements .It is 'pseudo' because it is deterministic and after N elements it starts to repeat itself, unlike real random sequences

1. The relative frequency of 0′s and 1′s are each ½
2. The run lengths of 0′s and 1′s are: ½ of all run lengths are of length 1; ¼ are of length 2; 1/8 are of length 3; and so on.
3. If a PN sequence is shifted by any non zero number of elements, the resulting sequence will have an equal number of agreements and disagreements with respect to the original sequence.

RADAR

Radar is an object-detection system that detects the presence of objects by using reflected electromagnetic energy-specifically radio waves. Under some conditions a radar system can identify the range, altitude, direction, or speed of both moving and fixed objects such as aircraft, ships, spacecraft, guided missiles, motor vehicles. The radar dish, or antenna, transmits pulses of radio waves or microwaves which bounce off any object in their path. The object returns a tiny part of the wave's energy to a dish or antenna which is usually located at the same site as the transmitter. The frequency of electromagnetic energy used for radar is unaffected by darkness and also penetrates fog and clouds. This permits radar systems to determine the position of airplanes, ships, or other obstacles that are invisible to the naked eye because of distance, darkness, or weather. Modern radar can extract widely more information from a target's echo signal than its range.

Block Diagram of RADAR

All targets produce a diffuse reflection i.e. it is reflected in a wide number of directions. The reflected signal is also called scattering. Backscatter is the term given to reflections in the opposite direction to the incident rays. Radar signals can be displayed on the traditional plan position indicator (PPI) or other more advanced radar display systems. A PPI has a rotating vector with the radar at the origin, which indicates the pointing direction of the antenna and hence the bearing of targets.

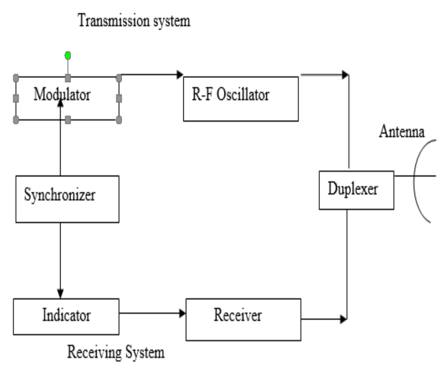

Figure 1.1 Block Diagram of RADAR

Basic Principle of Operation

The basic principle of operation of primary radar is simple to understand. The implementation and operation of primary radars systems involve a wide range of disciplines such as building works, heavy mechanical and electrical engineering, high power microwave engineering, and advanced high speed signal and data processing techniques. A radar system has a transmitter that emits radio waves called radar signals in predetermined directions. When these come into contact with an object they are usually reflected and/or scattered in many directions. The radar signals that are reflected back towards the transmitter are the desirable ones that make radar work. If the object is moving either closer or farther away, there is a slight change in the frequency of the radio waves, due to the Doppler effect.

Distance determination

The distance is determined from the running time of the high-frequency transmitted signal and the propagation. The actual range of a target from the radar is known as slant range. Slant range is the line of sight distance between the radar and the object illuminated. While ground range is the horizontal distance between the emitter and its target and its calculation requires knowledge of the target's elevation. Therefore the following formula arises for the slant range:

$$R = \frac{c_0 t}{2}$$

Where C0= speed of light= measured running time, R=slant range antenna.

Distance Measurement Principle

The distance measurement shows the result of a simulate decorrelation measurement. From top to bottom, the first graphic shows a 1023 length PRBS, (for clarity concerns, we only show the first 127 chips of the whole sequence), this sequence is the reference code. The second graphic depicts a simulated received sequence (time delay and Gaussian noise were added). The last graphic shows the result of the correlation between the reference code and the simulated received sequence. On the last graphic we can see a peak of correlation.

The position of the peak corresponds to the delay that we introduced. Result of correlation between a 1023 chips PRBS and a simulated received sequence To perform obstacle detection with this radar, we only need to localize the correlation peaks, between the emitted code and its echo. Thus, a peak in the correlation graphic denotes a detected obstacle whose distance d to the sensor is given by
d = v л/2

Where v is the wave speed and л/2 is the time delay.

On the correlation radar block diagram, the correlator unit is connected to a signal processing unit.

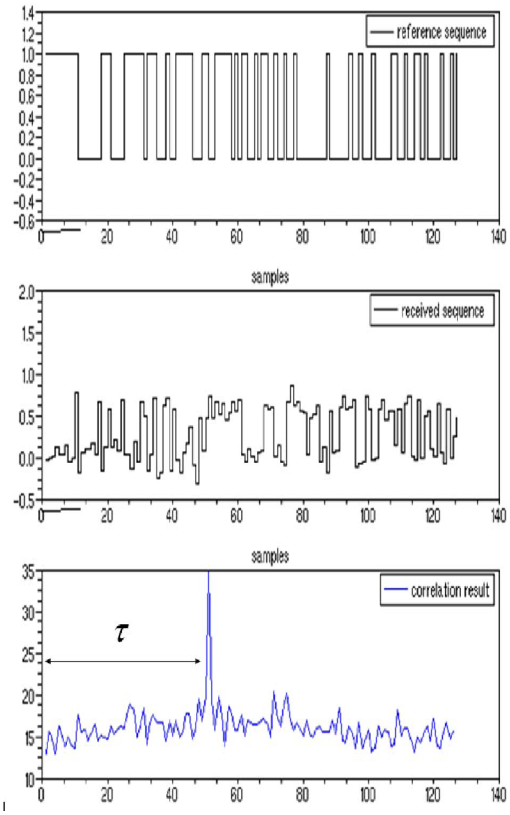

Figure 1.2 Result of correlation between a 1023 chips PRBS and simulated received sequence.

The correlator provides real time values of correlation result to the signal processing unit. The latter performs obstacle detection and provides the distance to the obstacle in real time.

Radar Reflections from Flat Ground

The trigonometric representation shows the influence of the Earth's surface. The Earth plane surrounding a radar antenna has a significant impact on the vertical polar diagram. The combination of the direct and re-reflected ground echo changes the transmitting and receiving patterns of the antenna. This is substantial in the VHF range and decreases with increasing frequency. For the detection of targets at low heights, a reflection at the Earth's surface is necessary. This is possible only if the ripples of the area within the first Fresnel zone do not exceed the value 0.001 R (i.e.: Within a radius of 1000 m no obstacle may be larger than 1 m)

Classification of RADAR Pulse RADAR

Pulse radar transmits a sequence of short pulses of RF energy. By measuring the time for echoes of these pulses scattered off a target to return to the radar, the range to the target can be estimated by the pulse radar. The measure components of pulse radar are transmitter, consisting of an oscillator and a pulse modulator. The antenna system, which passes electromagnetic energy from the transmitter to the transmission medium, and receives reflection from the target. The receiver, which amplifies the signal received by the pulse radar and detects returns from target and Interfaces, including displays and interfaces to other electronic systems shown in Figure 4.4.Continuous Radar as opposed to pulsed radar systems, continuous wave (CW) radar systems emit electromagnetic radiation at all times. Conventional CW radar cannot measure range because there is no basis for the measurement of the time delay. Recall that the basic radar system created pulses and used the time interval between transmission and reception to determine the target's range. If the energy is transmitted continuously then this will not be possible. TCW radar can measure the instantaneous rate-of-change in the target's range. his is accomplished by a direct measurement of the *Doppler shift* of the returned signal. The Doppler shift is a change in the frequency of the electromagnetic wave caused by motion of the transmitter, target or both. For example, if the transmitter is moving, the wavelength is reduced by a fraction proportional to the speed it is moving in the direction of propagation. Since the speed of propagation is a constant, the frequency must increase as the wavelength shortens. The net result is an upwards shift in the transmitted frequency, called the Doppler shift.

RADAR sets transmit a high-frequency signal continuously. The echo signal is received and processed permanently.

Doppler Radar

Doppler radar is specialized radar that makes use of the Doppler Effect to produce velocity and data about objects at a distance. It does this by beaming a microwave signal towards a desired target and listening for its reflection, then analyzing how the frequency of the returned signal has been altered by the object's motion. This variation gives direct and highly accurate measurements of the radial component of a target's velocity relative to the radar. Doppler radars are used in aviation, sounding satellites, police speed gun, and radiology. The specific term "Doppler Radar".

Doppler Effect

The emitted signal toward the car is reflected back with a variation of frequency that depends on the speed away/toward the radar (160 km/h). This is only a component of the real speed (170 km/h).The Doppler effect (or Doppler shift), is the change in frequency of a wave for an observer moving relative to the source of the waves. It is commonly heard when a vehicle sounding a siren approaches, passes and recedes from an observer. The received frequency is increased (compared to the emitted frequency) during the approach, it is identical at the instant of passing by, and it is decreased during the recession. This variation of frequency also depends on the direction the wave source is moving with respect to the observer; it is maximum when the source is moving directly toward or away from the observer, and diminishes with increasing angle between the direction of motion and the direction of the waves, until when the source is moving at right angles to the observer, there is no shift. Since with electromagnetic radiation like microwaves frequency is inversely proportional to wavelength, the wavelength of the waves is also affected. Thus, the relative difference in velocity between a source and an observer is what gives rise to the Doppler Effect.

Correlation Radar

The most important radar used in this project is correlation RADAR whose function is to provide the matching between transmitted and received signal and the matched signal is send to comparator for comparing the data Digital intercorrelation function is given above .The classical correlation is the sum of sample product X and Y, with Y being only shifted in time. Zeros replace gaps in the shifted sequence.
We don't used classical correlation function but a cyclic one is used. Instead of a simple time shift the cyclic correlation perform a circular permutation of the second sequence.
Pseudo random sequence can be unipolar or bipolar. For unipolar sequence, chips can take the value 0 and 1 when a bipolar sequence can have values -1 or 1.we used unipolar sequences and this sequence is generated by using shift register. Pseudo random binary sequences are generated using some specific outputs of the register's flip flops are fed-back via a XOR gate. This feedback is done so that the register plays its (2n-1) possible states, such as *n* is the number of flip-flops forming the shift register. Thus, we get what is called a maximum length sequence.

$$C_{xy}(k) = \sum_{i=0}^{N} x(i)\, y\,(k+i)$$

Where Cxy is the correlation, *N* is the number of samples and *k* is the time shift.

PRBS

PRBS or Pseudo Random Binary Sequence is essentially a random sequence of binary numbers. It is random in a sense that the value of an element of the sequence is independent of the values of any of the other elements. It is 'pseudo' because it is deterministic and after N elements it starts to repeat itself, unlike real random sequences.

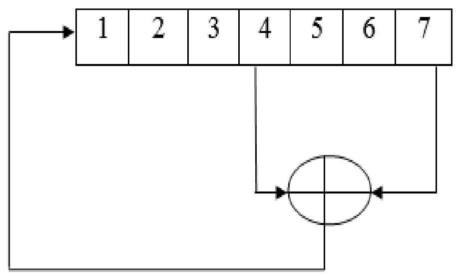

Figure 1.4.Binary Pseudo Random Sequence Generator

Examples of random sequences are radioactive decay and white noise**.** A binary sequence (BS) is a sequence of N bits, a j for j = 0, 1... N − 1,i.e. m ones and Nm zeros. A binary sequence is pseudo-random(PRBS) if its autocorrelation function, has only two values.

PRBS is implemented using **LFSR** or Linear Feedback Shift Register. LFSR is an *n*-bit shift register which pseudo-randomly scrolls between 2^n-1 values, but does it very quickly because there is minimal combinational logic involved. Once it reaches its final state, it will traverse the sequence exactly as before.

Previous Work

FPGA based Avoidance Support System(VCASS) based on Inter –Vehicle Communications (IVC) proposed by Yuki NAKANISHI, Ryohta YAMAGUCHI[1] in order to prevent a vehicular collision beforehand. The system grasps the relative locations of vehicles by exchanging the GPS information in each vehicle. Then the system warns drivers if it detects a danger of collision. VCASS can drastically reduce the potential accidents of vehicular collisions, VCASS cannot avoid collisions between vehicles and pedestrians, but avoid collisions just between vehicles. They propose a new collision judgment algorithm for Pedestrian-Vehicular Collision Avoidance System (P-VCASS) which extends VCASS which avoid collision.

Pravin P Ashtankar, Sanjay S. Dorle [2] presented a anti-collision mechanism between vehicles foe improving safety in Intelligent Vehicular Transportation system. This method is based on correlative and cooperative wireless networking concept. For determining location two techniques: a Global Positioning System (GPS) receiver aided with dead-reckoning sensors and RADAR based measurement system. Using these inputs, vehicles determine whether or not they are on a collision course with each another.

FPGA Based is Given By Chika Sugimoto, Yasuhisa Nakamura, and Takuya Hashimoto [3] a prototype pedestrian-to-vehicle communication system which uses a cellular phone and wireless communication to improve the safety of pedestrians. A pedestrian-to-vehicle communication system was developed by using a cellular phone and a car navigation system equipped. With GPS and wireless communication function basically the give the idea about it the exchange of information between a cellular phone and a car navigation system and make each of a pedestrian and a driver find the other from out of sight.

Ken Teo, Kai Wei Ong and Hoe Chee Lai [4] suggest a new algorithm based on implementation of an obstacle detection, obstacle avoidance and anti-collision system using a COTS multi-beam forward looking sonar. The purpose is to equip our in-house built MEREDITH autonomous underwater vehicle the capability to navigate around obstacles that arise in its programmed path. For a system, the ability to identify unknown obstacles and discards false returns and noise is an important issue and extremely challenging. To remove this problem, image processing technique is employed to extract potential obstacles from the sonar image. This is follow by the employment of a real-time multi-frame filter to confirm the presence of obstacles.

Lounis DOUADI, Pascal DELOOF [5] proposed a Car anti-collision systems. The principle of this system is to avoid collision between the equipped vehicle and the one in front, or other kind of obstacles (pedestrians, animals, etc.). As a consequence, this will reduce accidents and enhance road safety. Correlation radar is the most recent radar used for anti-collision system. He also give idea about the principle of distance measurement using this sensor as well as the implementation of the correlation function on an FPGA.

Chika Sugimoto, Yasuhisa Nakamura, [6] and Takuya Hashimoto propose a prototype pedestrian-to-vehicle communication system which uses a cellular phone and wireless communication to improve the safety of pedestrians. A pedestrian-to-vehicle communication system was developed by using a cellular phone and a car navigation system equipped. with GPS and wireless communication function basically the give the idea about it the exchange of information between a cellular phone and a car navigation system and make each of a pedestrian and a driver find the other from out of sight.

L. Sakkila [7] P. Deloof et all proposed a technique real time processing unit used for an anti-collision road radar system. This radar based on a numerical correlation between the transmitted signal and the received signal. The signal uses orthogonal codes to ensure a multiple access communication between all vehicles in near area. This system used the pseudo-random sequences and a correlation receiver is very useful to detect signal buried in noise in the anti-collision radar field. The pseudo-random sequences are preferable due to the simpler modulation of the radar waveform they involve and their robustness. This confirm that the proposed receiver is efficient and simple to implement C.

Tatkeu, P. Deloof,[8] proposed a method for improve reliability, security on roads .In this technique cooperative been developed to facilitate the exploitation of automatic collision avoidance radar which uses a transponder inside targets.

Conclusion

We have described the principle of a distance measurement with correlation radar and gave our contributions on real time implementation of this radar. Many improvements were performed on the correlator architecture. This concerns optimized multipliers and improvements on adder layers. A particular attention was paid to our correlator generator. The major interest of the latter is that it is able to generate the VHDL code of the correlator including allits components, in an automatic way.

REFERENCES

[1]. Yuki NAKANISHI, Ryohta YANAGUCHI "A New Collision Judgment Algorithm for Pedestrian –Vehicular Collision Avoidance Support System in Advanced ITS" information Network laboratory", 2010.

[2]. Pravin P Ashtankar, Sanjay S .dorle, "Design Apporch For Anti-Collision Mechanism between vechicle to Vechicle for improving Safety operation in Intelligent transportation system", 2009.

[3]. Hung Youpeng, Zhang Haibo, "Radar Infrared sensor Track Correlation Algorithm Using Gray Correlative Analysis", 2009.

[4]. Ken Teo, Kai Wei Ong and Hoe Chee Lai, "Obstacle detection, obstacle avoidance and anti-collision system using a COTS multi-beam forward looking sonar", 2009.

[5]. Lounis DOUADI*, Pascal DELOOF*, Yassin ELHILLALI "Real time implementation of reconfigurable correlation radar for road anti-collisionsystem", Institute National de Recherche sur les Transports et leur Sécurité, Laboratoire Électronique Ondes et Signaux pour les, 2011.

[6]. Chika Sugimoto, Yasuhisa Nakamura, Takuya Hashimoto, "Development of pedestrian-to-vehicle communication system prototype for pedestrian safety using both wide-area and direct communication", 2008.

[7]. L. Sakkila ,P. Deloof. "Real time processing unit used for an anti-collision road radar system", 2006.

[8]. C.Tatkeu, P.deloof, Y.Elhillai "A Cooperative radar system for collision avoidance and communication between vehicles", 2006.

[9]. Shalabh Gupta and E. R. Brown, "Retro-directive Noise Correlation Radar with Extremely Low Acquisition Time", Fellow, *IEEE* University of California at Los Angeles, **CA** 90095, 2003.

[10].M.Lienardand, P.Degauque "CORRELATION RADAR: An optimization of code generator architecture", 2003.

[11]. Pascal Deloof, jean-pierre GHYS " Radar system studied at INRETS to the road and Railway field", 2002.