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Simulation of Multimode Radar in Fighter Aircraft

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ABSTRACT

The objective is to simulate the Radar detection by using MATLAB software. Radar systems use modulated waveforms and antennas to transmit electromagnetic energy into a specific volume in space to search for targets. Targets within a search volume will reflect portions of this energy (radar returns or echoes) back to the radar. These echoes are then processed by radar receiver to extract target information such as range, velocity, angular position, and other target identifying characteristics. Signal processing techniques are carried out for the received output signal. The reference curve studied is the ROC(Receiver Operating Characteristic) curve, which gives relation between P_D(Probability of Detection) & P_{FA} (Probability of False Alarm).Finally, after the target detection with respect to threshold limit, the comparison of the true range values and the range estimates values of the target is shown

KEYWORDS: *ROC-Receiver Operating Characteristic, P_D-Probability of Detection & P_{FA}-Probability of False Alarm.*

I. INTRODUCTION

The term radar is an acronym for the Radio Detection and Ranging, and is utilized for portraying the frameworks that uses electromagnetic energy to identify far off objects. A radar works on the principle of radiating the electromagnetic energy and distinguishing the reverberate come back from reflecting items (targets). The nature of the reflected signal gives data about the target. The range, or separation, to the target is found from the time it takes for the radiated energy to go to target and return back. Radar frameworks utilize adjusted waveforms and antenna's which are directive in nature are used to transmit electromagnetic energy into a particular volume in space to scan for targets. Objects inside a pursuit volume will reflect segments of this energy (radar returns or echoes) back to the radar. These echoes are then processed to radar recipient to concentrate target data, for example, range, velocity, angular position, and other target recognizing qualities. Most radar frameworks decide position in two dimensions: azimuth (compass bearing) and distance (radius). The radar Range equation speaks to the physical conditions of the transmit power, that is the wave spread up to the receiving of the reverberate signals. A fighter aircraft is a military aircraft designed, whose main mission is to attack ground targets.

II. LITERATURE SURVEY

The mathematical apparatus of the task solution in the redundancy conditions on the quadratic functional minimization basis is taken into account for UAV detection accuracy and coordinates calculation .Detection of the UAV are done by means of both active, and passive radar-location [1].The utilization of the antenna array Maximum Likelihood (ML) Doppler shift is examined and code delay estimator to the Global Navigation Satellite Systems (GNSS) obtaining issue, considering an unstructured channel model and Additive White Gaussian Noise (AWGN).An acquisition test function based on the ML estimator is proposed[2]. Furthermore, the work analyzes the effect of the acquisition bandwidth data transmission on the Receiver Operating Characteristic (ROC). The work which is devoted to the analysis of the performance of energy detection based spectrum sensing range detecting within the sight of advanced blurring conditions which are unmistakable for the substantial number of multipath segments is clarified. This sort of fading conditions are portrayed efficiently by the well known Nakagami-q or Hoyt appropriation and the proposed examination is completed in the context of the area under the receiver operating characteristics (ROC) curve[3].

The Two approaches such as firstly, the Theoretical Approach which is used to estimate the theoretical probability of detection for a required value of PFA. By utilizing the bistatic radar equation to an acquisition scenario, SNR is evaluated and secondly, The Numerical Approach involves Npd and Npf trials where only estimation of the detection probability is considered. The work could be the initial step towards the definition of a fair procedure for estimating the PBR performance in terms of ROC[4].

For radar frameworks with computerized target acknowledgment including some edge parameter, one would be able to plot a ROC bend demonstrating the identification rate versus the false rate over a scope of threshold values. Judgement call is preferred by operator which is a based on experience and training[5].

The Track Before Detect(TBD) algorithm[6] where in order to handle the target maneuvers, an improved DP-TBD(Dynamic Programming-DP) based algorithm is proposed, where in the algorithm involves two strategies. First is Radial Acceleration Estimation and second is CS(Current Statistical) Model. By combining the two enhanced strategies, an improved DP-TBD (CS-DP-TBD) algorithm is proposed.

FMCW(frequency-modulated continuous-wave) Doppler Radar to Detect Targets upto the Maximum Unambiguous Range is explained in [7]. FMCW radar detection for short- range targets and for a longer range target with the prominent mixing frequencies is discussed, targets that are in relatively close proximity to radar are considered, where the round- trip travel time of target's radar signature is small relative to the transmit chirp duration. Signal Detection Algorithm for Aircraft Localization and obtaining its motion parameters[8]. The algorithm is based on acoustic noise measurement & further calculation of ambiguity function, is performed using direct/inverse fast Fourier transform (FFT/IFFT), which makes calculations much faster in comparison with classic integration. The final result represents the animation of aircraft motion on XOZ- coordinate plane. The procedure involves four acoustic antennas which are located in the form of square.

The work where the primary target is test of the multistatic parasitic radar utilizing geostationary transmitters [9] is described. The range of the Astra flag is considered as a reference. In the orbital location marking 19.20 East there are four transmitting satellites sharing a typical frequency band from 10.7GHz to 12.75GHz, each owning a solitary data transmission of 26MHz. The execution which advances a moving target discovery system for space-based inactive radar is explained[10]. The fundamental downside of satellite transmitters for radar applications is the low power density on the ground level, which requires long mix times to enough build the signal to background ratio. To this point, another system is proposed depending on a hybrid coherent/non-coherent integration of the received signal, coordination of the Fractional Fourier transform (FrFT).

III. FLOWCHART & DESIGN SPECIFICATIONS

Monostatic radar is the term given to a radar in which the transmitter and receiver are collocated. The transmitter and receiver share a common antenna.

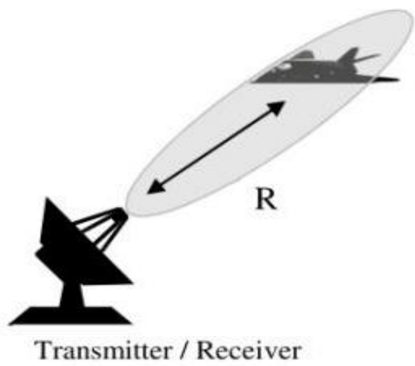

Figure 1 Monostatic Radar

Monostatic Radar equation is expressed as follows:

$P_R = (P_T.\ G^2.\ \lambda^2.\sigma_M\ )/((4\pi)^3.d^4.L_t.L_r.L_m)$

where

P_R =Total power received at the receiving antenna

G = Antenna gain

λ = Wavelength = c/frequency, where in c = 3x10^8

P_T = Peak transmitted Power
d=distance between radar and target
L_t=Transmitter losses
L_r=Receiver losses
L_m=Medium losses

A. Configuring the Parameters

• Initial step is declaring the values of probability of detection, probability of false alarm and number of pulses to be sent and SNR value calculation using Albersheim's equation.

$SNRdB = -5\log_{10}(n)+(6.2+4.54/(n+0.44))\log(A+0.12\,A\,B+1.7B)$ for n pulses,
where
$A = \log_e(0.62/P_{FA})$ and
$B = \log_e(P_D/(1-P_D))$;P_{FA} is the probability of false alarm which is in the order of 10^{-6} .

• After calculation of the required SNR, the required radar power is calculated by providing the required RCS and the wave length of the operating frequency.

• Configure the transmitter and receiver by switching the waveform and modeling the antenna by considering the isotropic antenna which radiates an energy from -180 to 180 degrees and from 90 to -90 degrees in azimuthal and elevation angles respectively.

• Model the transmitter by using proper peak transmit power.

• The receiver is modeled by specifying the noise figure and the reference temperature which is set as 0 dB and 290 K respectively.

•After all these parameters are set, the radar model is implemented as follows:

Firstly, declare the step time between the pulses, position the antenna, calculate the range and update the target position and generate the required pulse, transmit the pulse, radiate the pulse and pulse propagation should take place, propagate the echo to the antenna and collect echo and receive it at the antenna, and lastly, the power versus range is plotted so that the performance of the system is evaluated.

B. Design and Detection

The design goal is to detect the targets with at least 1m meter square RCS and 50 meters as range resolution with P_D =0.9, P_{FA} = 10-6 ,max_range = 5000.The following procedure is used:

• Calculating the maximum ambiguous range by using the important parameter called Pulse Repletion Frequency,

• Calculating the receiver noise characteristics by assuming the receiver gain as 12 dB and the noise figure as 0 dB,

•A graph which states the relationship P_{FA} and P_D called Receiver operating Curve is generated,

• Use of pulse integration technique to minimize the required SNR. When SNR is obtained, the peak power can be calculated assuming the transmitter gain 12 dB and setting the operating frequency as 10 GHz,

• Configuring the isotropic antenna for testing the radar system and specifying the channel which is required to be used between the radar system and the target.

• Simulation of the system is performed by the following steps:

Firstly, define the fast grid time and slow grid time to include them in a data matrix, update the antenna position, generate and transmit the pulse for targets, calculate the angle and radiate in the direction of the targets and the reflected echoes will be collected, and finally, receive the signal echo and form a data matrix.

• Assuming the noise as white noise and the detection is non- coherent detection,

• The threshold power is calculated and the pulses with the threshold are plotted,

Using the matched filter threshold will be increased and SNR will be improved, further improvement in the SNR by integrating the non-coherent received pulses and plot the waveform,

• Calculating the range from the peaks by referring the waveforms.

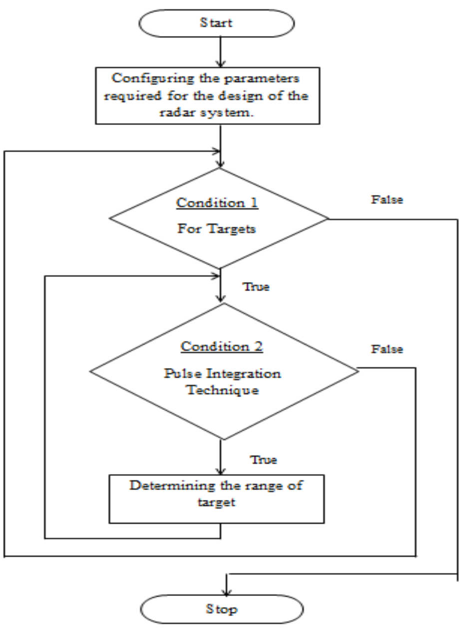

Figure 2 Flowchart

IV. RESULTS

Airborne Radar Simulation, is the real-time generation of radar displays and other radar outputs, such as data exchanges with the flight computer or other avionics subsystems, consistent with the actual radar and in response to the interaction with the operator, targets, and the environment. The application is flight simulators for man-in-the-loop training of pilots and radar operators, and engineering research simulators for designing radars, avionics systems, and cockpits. Engineering research simulators are frequently used to aid integration and so may incorporate additional aircraft hardware.

Typically, the various Radar modes require complex models for radar detection, tracking, and recognition, but processing throughput and memory requirements are modest.

The following section describes about the detection. To make the radar system more feasible, pulse integration technique is prefer000-red. After the pulse integration technique the required SNR gets to be reduced. The ROC curves in order to satisfy the design goals of P_{FA} = 1e-6 and P_D= 0.9, the received signal's SNR exceeded 13 dB though a fairly high requirement and is not really practical. If so 8 pulses are considered for pulse integration technique the curve generated is as shown below

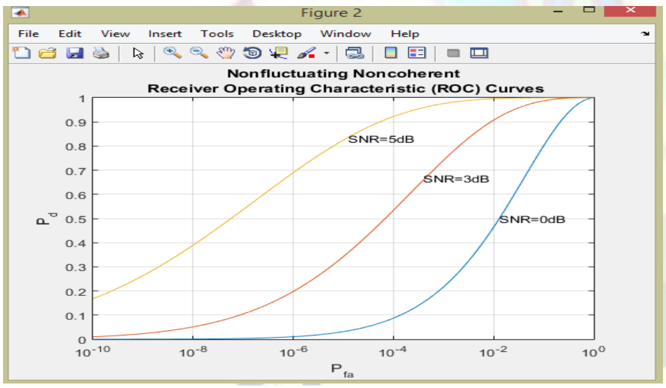

Figure 3 ROC curve for SNR(dB) at –inf,0dB, 3dB,10dB,13dB.

The following graphs explains about the detection of 5 targets which are fluctuating in nature with different positions. The concepts of Range normalization and Matched filter comes into picture. The figures which are described explains about the received pulses (2 pulses) after passing through the matched filters.

Case 1:Detection of 1st target after matched filtering above the detection threshold

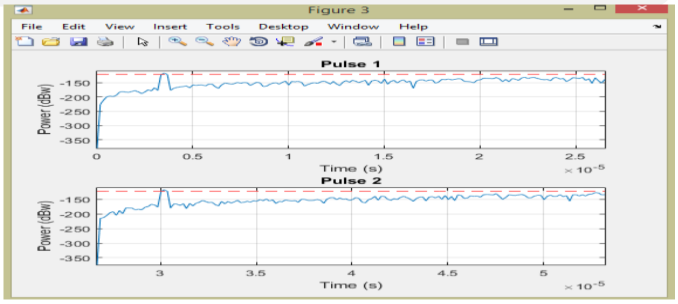

Figure 4 Received pulses indicating presence of 1st target above detection threshold

Case 2:Detection of 1st and 2nd targets after matched filtering above the detection threshold

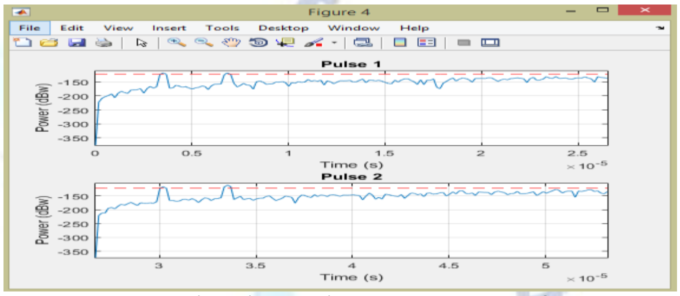

Figure 5 Received pulses indicating presence of 1st & 2nd targets above detection threshold

Case 3:Detection of 1st ,2nd and 3rd targets after matched filtering above the detection threshold

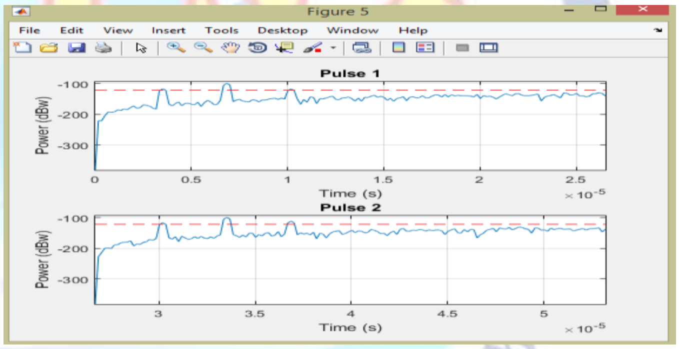

Figure 6 Received pulses indicating presence of 1st , 2nd and 3rd targets above detection threshold.

Case 4:Detection of 1st , 2nd ,3rd and 4th targets after matched filtering above the detection threshold

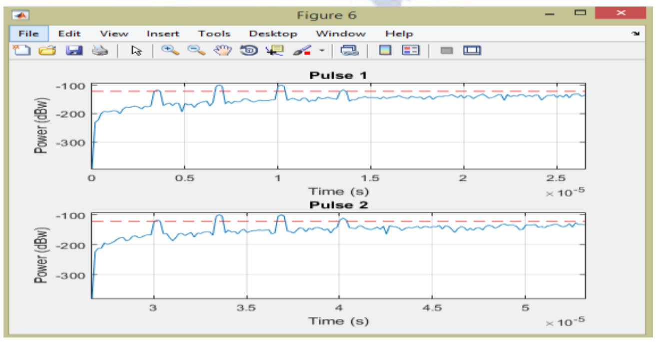

Figure 7 Received pulses indicating presence of 1st , 2nd , 3rd and 4th targets above detection threshold

Case 5:Detection of 1st , 2nd ,3rd ,4th and 5th targets after matched filtering above the detection threshold

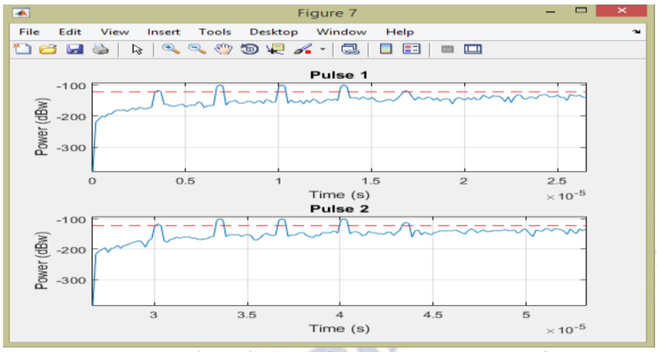

Figure 8 Received pulses indicating presence of 1st , 2nd , 3rd , 4th and 5th targets above detection threshold.

The following graph shows the indication of 5 targets which shows the detection above the detection threshold.

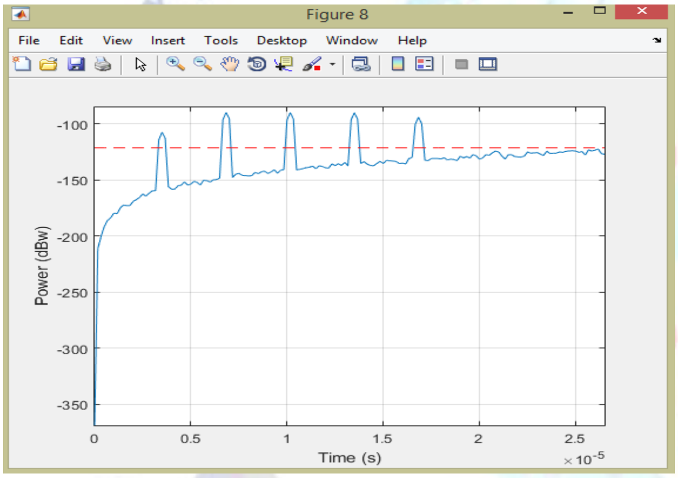

Figure 9 Detection of 5 targets with power as y axis and time as x axis.

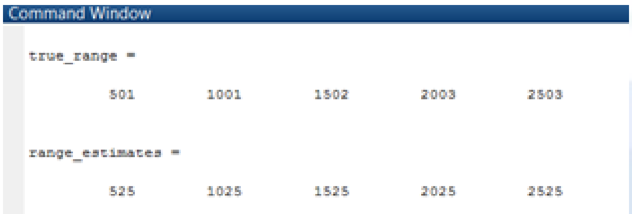

Figure 10 Calculated range and true range estimates of target

V. CONCLUSION

The simulation of the radar system is done by means of MATLAB Software. The proposed model considers present position of the own aircraft, direction of movement, environmental parameters, range of the target aircraft and the radar counter measures and generates output signal. Signal processing techniques are carried out for the received output signal. ROC (Receiver Operating Characteristic) curves are preferred along with the concepts of matched filter and Range Normalization.

The detection of the targets with respect to the detection threshold is obtained as the simulated output. The range detection of the targets are calculated whereas the true range values and the range estimates values of the target are compared which are quite similar.

REFERENCES

[1] V. M. Sineglazov, R. L.Pantyeyev " UAV detection accuracy and coordinates calculation improvement by means of the active and passive radar-location systems", IEEE International Conference Actual Problems of Unmanned Aerial Vehicles Developments (APUAVD),2015,pp 206-207.

[2] Javier Arribas, Carles Fernández-Prades Pau Closas "Reciever Operating Characteristic for array based GNSS Acquistion" Signal Processing Conference,18th European 2010,pp 1082 – 1086.

[3] Paschalis C. Sofotasios ,Mulugeta K. Fikadu , Khuong Ho-Van ,Mikko Valkama, George K Karagiannidis,"The area under ROC curveover enriched multipath fading conditions", 2014 IEEE Global Communications Conference.

[4] Michele Conti,Christian Moscardini,Amerigo Capria, Rocco Soleti "Estimation of Passive Bistatic radar detection probability: Experimental results" 11th European Radar Conference,2014,pp 145-148.

[5] T. Bechtel, L. Capineri, C. Windsor,M. Inagaki,S. Ivashov " Comparision of ROC curves for landmine detection by holographic radar with ROC data from other methods" 2015 8th International Workshop on Advanced Ground Penetrating Radar (IWAGPR),pp 1-4.

[6] Zicheng Fang, Wei Yi, Lingjiang Kong, Binbin He, Xiaoling Zhang "A multi-frame track-before-detect algorithm for maneuvering targets in radar system" 2016 IEEE Radar Conference (RadarConf),pp 1-6.

[7] Ken B. Cooper, Stephen L. Durden, Corey J. Cochrane, Raquel Rodriguez Monje,Robert J. Dengler, Chad Baldi "Using FMCW Doppler Radar to Detect Targets up to the Maximum Unambiguous Range" IEEE Geoscience and Remote Sensing Letters.,2016vol 14,pp 339-343.

[8] Yevhen Chervoniak, Rustem Sinitsyn,Felix Yanovsky "Signal detection algorithm for aircraft localization by means of passive acoustic radar" International Young Scientists Forum on Applied Physics (YSF),2016.

[9] Holger Nies, Florian Behner,Simon Reuter, Simon Meckel; Otmar Loffeld "Radar Imaging and Tracking using Geostationary Communication Satelliete systems " Proceedings of EUSAR 2017: 11th European Conference on Synthetic Aperture ,pp 1-4.

[10] ZhongyuLi,Fabrizio,Santi,DeboraPastina,Pierfrancesco Lombardo "Multiframe fractional Fourier transform technique for moving target detection with space-based passive radar"IET Radar, Sonar and Navigation,2017Vol 11 pp 822-825.