A Technology of Information Data Fusion between Radar and ELINT System

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ABSTRACT

This paper presents a technology of information data fusion between radar and ELINT electronic intelligence system. adar get the information of the range, direction and velocity of targets, and ELINT system get the information of the direction and angular velocity of the same targets at the same place and at the same time. Since we have some common information data of targets from radar and ELINT system, we can find the target on radar is same or not on ELINT system using the information data fusions. If the target on the radar is verified with the same target on ELINT system, we get more information of the target. e can analysis and identify the target exactly and reduce an ambiguity error of unknown targets.

Keywords: *radar, direction finding, ELINT, information, data fusion, display, array.*

1. INTRODUCTION

The radar which is the most representative target detecting system can obtain the direction, distance and velocity of targets, but can not obtain the target's electric parameters. The ELINT system is the only sensor which can get the target's direction, angular velocity and electric parameters together, but have no distance information of targets.

If we can find the target on radar is same on ELINT system using the information data fusions, we are able to know the target's direction, distance, speed and electric parameters together and identify the target exactly and reduce an ambiguity error of unknown targets..[1]

The information helps aircraft or ship to move safely, especially in military use it is able to be aware of any symptoms of war and allows to set up the most suitable plan in case of enemy's attacks by knowing the enemy's movement.

World countries are developing and operating the radar and the ELINT system separately. If we combine the information from radar, ELINT system and electro-optic systems, we can obtain much more information of a target. [2, 3]

Today, a few data collected by the ELINT system is transmitted to the radar and linked with the information that the radar collected.

2. PARAMETER ANAL SIS OF INFORMATION FUSION

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To combine the information collected from each device, we have to know the information of each device and the relationship between the information of each device. The information parameters of the radar and ELINT system are presented in table 1 by experience.

The azimuth angle of target into two systems is the most important parameter compared to see the tracking target of two systems is same or not. Secondly the angular velocity of target is compared. If the azimuth angle and angular velocity of a target is same into two systems, the target shall be the same target, and we can add the information of target from two systems.

Table 1 Information Parameter of two systems

system	Information Parameters
ELINT	Azimuth angle Angular velocity Electric parameter (PRI, frequency, PW, Scan pattern)
Radar	Azimuth angle Angular velocity Distance(range)

Fig.1 is a block diagram of the information fusion device showing the information data flow. The information fusion device is made of Information Comparing Module, Information Fusion Module, Electronic Information Library and Information Display.

The input signals from the ELINT system and the radar system come into the Information Comparing Module and

compare the azimuth angle, angular velocity of the targets. IF the tracking target from radar is verified with the same into ELINT system, the information of target go to the Information Fusion Module and fuse the data with library data. The display show the target position and parameters such as direction(azimuth angle), distance(range), angular velocity and electric parameters.

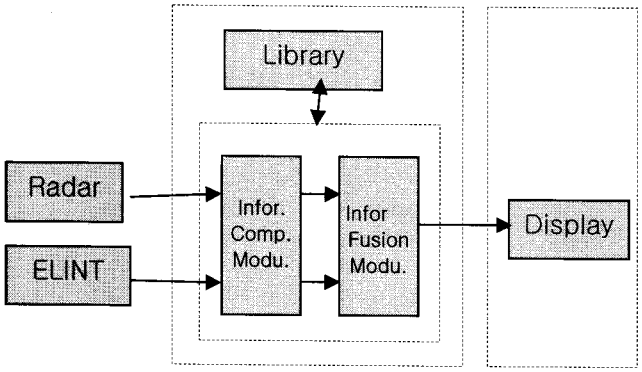

Fig. 1. Block diagram of the information fusion device

3. TARGET DETECTION TECHNOLOG OF ELINT S STEM

The ELINT system receive the radio frequency from targets, then analysis the target's direction and electric parameters such as radio frequency, pulse width and pulse amplitude using the received electromagnetic waves. Especially because the ELINT system can measure the target's direction accurately within 1 degree error, it is very reasonable to match the target and to interleave the electric information.

After the 1990's, by using the array antenna technology a new method is developed that is able to measure all signals from 360 degrees without rotating the antenna. Generally we use an amplitude-comparison method and phase-comparison method to find the direction of target antenna and to increase the signal detection probability.

3.1. Amplitude comparison direction finding

The principle of the amplitude-measurement is shown in Fig. 1. antenna #1 is set on $-\alpha$ azimuth angle and antenna #2 is set on $+\alpha$ azimuth angle. G1(θ) is the antenna beam pattern of antenna #1, and G2(θ) is the antenna beam pattern of antenna #2. When a RF signal comes from 0 degree in Fig. 2, the received signal amplitude of antenna #1 is same to that of antenna #2. But when a RF signal comes from $-\alpha$ azimuth angle, the received signal amplitude of antenna 1 is larger than that of antenna 2. When a RF signal comes from α azimuth angle, the received signal amplitude of antenna 1 is smaller than that of antenna 2. If we know the beam pattern of two antennas, we can calculate the incident angle to measure the amplitude of incident RF signal.[4].

3.2. Phase comparison direction finding

The interferometer method is a way to find out the direction of incident RF signal by setting up the antennas at different positions and measuring the phase differences of same coming signals. When the interval of two antennas is D and the signal incidence direction is θ, λ is the wavelength of the incidence signal. ϕ is the phase difference of RF signals measured at the two antennas with the interval of D in Fig.3. We can calculate the signal incidence direction (θ) with Eq. 1[4]

$$\phi = \frac{2\pi}{\lambda} D.\sin\theta \tag{1}$$

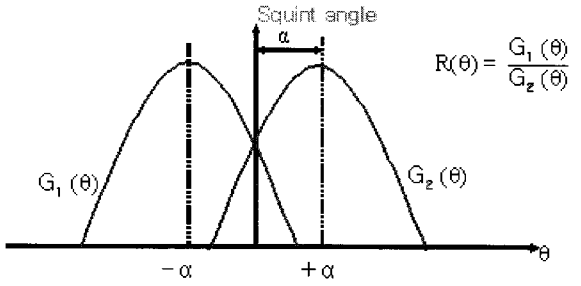

Fig. 2. Principle of amplitude-comparison DF.

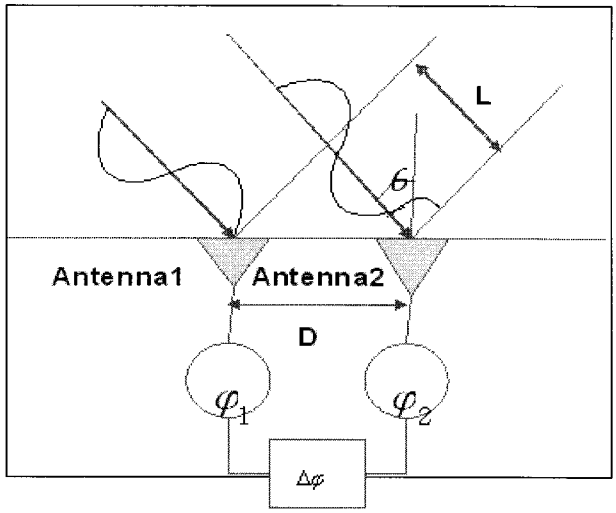

Fig.3. Principle of interferometer DF technology.

3.3. The display of ELINT

The two most general display forms of ELINT system is a method showing the target's information by diagram and also another using the standard symbols formed by PPI graphic to mark friend, enemy and unknown.

The table display screen shows the target's tracking number, direction, radio frequency, PRF, PW, scan type, scan-cycle like Fig. 4.

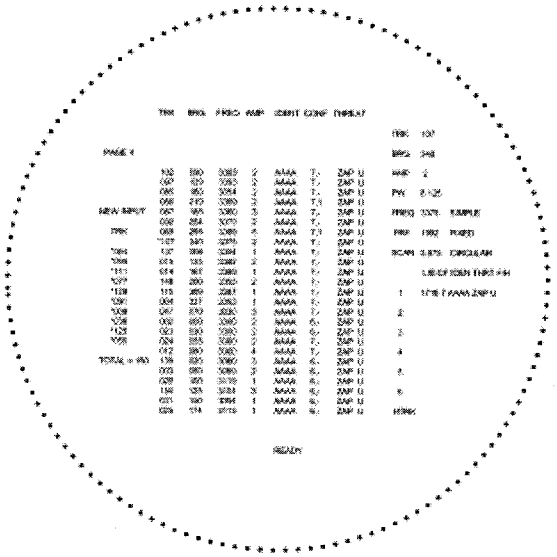

Fig.4. ELINT display with digital table

4. TARGET DETECTION TECHNOLOGY OF RADAR

The radar is an electrical device to detect the target's location and direction. This is a device that uses the wave to radiate energy to an object and receive the echo signal reflected from the object. The radar is made as antenna, transmitter, receiver and display.

A radar receives the electric wave occurred by the transmitter via antenna and measures the target's distance and direction using the received signal reflected from the object. The distance of the target is more accurate when the Pulse width is small and the direction of the target is accurate when the antenna half beam width is small. [5]

The power of the signal entered to the radar receiver is as Eq. 2.

$$P_r = \frac{P_t G_t G_r \lambda^2 \sigma}{(4\pi)^3 R^4} \tag{2}$$

Where, P_t is transmitting power, G_r is antenna gain, λ is wave length, and R is distance.

Also the time of the pulse transmitted and received from the object is inverse proportion of the speed and is comparison to the distance from the target to the radar and is able to figure out the distance of the target from the radar.

$$T = \frac{2 * R}{C} \tag{3}$$

Where, T is a delayed time between transmitting and receiving pulse.

Through various processes such as Pulse compression, Doppler filter bank, the detection signal obtains the target's speed and distance. It is important to find out moving targets and fixed targets. To distinguish fixed targets, delay-line and MTI technology using weighting multiplexer are used. This technology exclude fixed targets without the Doppler effect and climate clutter which is influenced by the wind such as Eq. 4.

$$y(t) = W_1 X_1(t) + W_2 X_2(t+T) + . \\ ..W_n X_{n1}(t+(n-1)T) \tag{4}$$

Clutter signals which are reflected from fixed objects such as the ground are powerful but have little change between pulses. Reflected signals from flying objects have less power but there is a small difference in pulses due to factors such as flying speed. So the reflect signal by the fixed object becomes 0 when subtracting the distance between the N pulse and N-1 pulse.

Most detecting radars use PPI or sector PPI display forms with Fig. 5. PPI(pulse position indicator) could be raw video or synthetic video. The PPI scope shows information of direction and distance into the polar form and shows all targets within 360 degrees. Sector PPI scopes displays direction and distance information on all targets in a certain sector, the location of the radar could be out of the scope due to the movement of the standard location.[6][7]

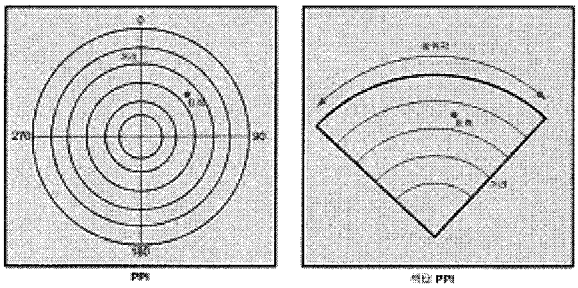

Fig.5. Radar PPI Scope and Sector Scope.

5. DATA FUSION AND DISPLAY TECHNOLOGY

The output of the radar shows the target's distance, direction and speed. But the output of the ELINT system occurs a pulse description word(PDW) formed of 128 bits on each radar reflected pulse. The PDW include many parameters such as waves direction, frequency, power, receiving time of the target pulse.

We make a display screen which is efficient to show the location and information of the target from the information fusion device.

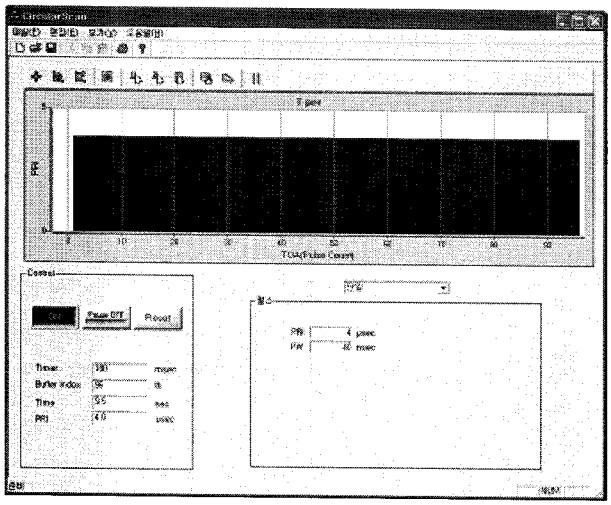

Fig.6. PDW generator

We can make a fusion display in which targets and all information of targets is shown on PPI scope with a digital parameter table such as Fig. 7.

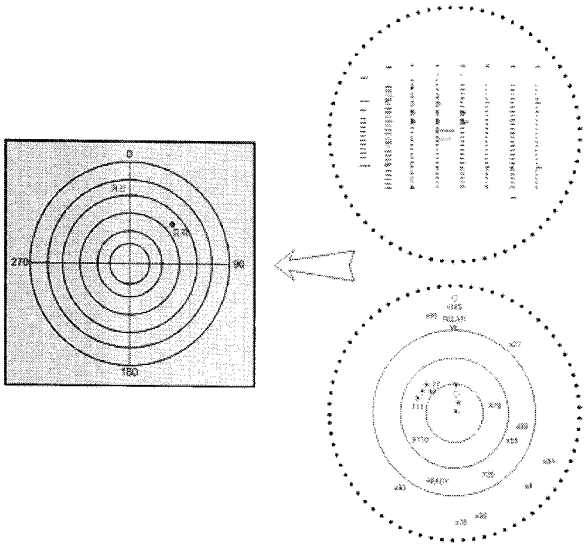

Fig.7. PPI scope with digital information table

6. CONCLUSIONS

This paper suggests a method to fuse the information data between radar and ELINT system. Comparing the azimuth angle and angular velocity of targets between in radar and in ELINT system, we can fuse the information, find the target accurately. These data fusion is able to increase the probability of detection of target, to reduce the error rate of misdetection, and specially detect the targets early in space or ocean.

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He received the B.S., M.S. in electrical Engineering from Kyung-book university, Choong-Nam University, Korea in 1978, 1987 and also received Ph.D. in electrical engineering from Auburn university, USA in 1994. He worked at Agency for Defense Development from 1994 to 2002 as principal researcher. Since then, he has worked for Baekseok university as professor, Korea. His main research interests include numerical analysis, direction finding, Data fusion, EW and RF system design.