RESEARCH ON PERFORMANCE ANALYSIS OF COOPERATIVE MIMO RADAR-COMMUNICATION SYSTEM

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In this paper, a cooperative multiple-input multiple-output (MIMO) radar and communication systems is studied, where the two systems work cooperatively on the basis of coexistence. The knowledge of communication system is shared with the radar system, so that the communication signals can be accurately decoded at radar receivers. Then target returns contributed from both the radar transmitters and communication transmitters are employed to complete the radar task. The cooperative systems can be equivalent to a hybrid active-passive MIMO radar network, which helps to improve the radar performance. With the information shared by the radar system, the communication system can estimate the parameters of the radar target. Thus, the communication signals bounced off from the target are exploited to complete the communication task on the basis of the traditional communication, which helps to improve the communication performance. The target detection probability and mutual information are derived for the radar-communication systems respectively. It is shown that there is a performance gain due to the cooperation between the radar and communication systems.

Key Words : *cooperative radar-communication system, MIMO , detection, mutual information*

1. INTRODUCTION

With the development of electronic technology, the integration of radar communication will be an inevitable trend in both military and civil fields[1)].

In an integrated system, it is difficult for a single antenna to meet the requirements because of the complex environment to be monitored and the heavy communication task. MIMO technology has shown advantages in both radar system and communication system, and has also attracted the attention of researchers in the research of integration[2)].This paper studies the performance of MIMO radar and MIMO communication integrated system.

The cooperation between the two systems mainly refers to information sharing[3)]. For example, the antenna positions of the two systems are shared with the other system, and the radar transmitting signals are shared with the communication system. Using the information shared by the communication system, the radar receiver can accurately decode and reconstruct the communication signals[4)].The cooperative integrated system can not only use the target echoes of traditional radar, but also use the target echoes carried by communication signals to accomplish radar tasks.Therefore, thanks to information sharing, the cooperative integrated system can be equivalent to a hybrid system of active and passive MIMO radar, referred to as active and passive hybrid MIMO radar system. On the other hand, because the transmitting signal and antenna position of the cooperative integrated system are shared with the communication terminal, the use of shared information, communication receiver can get radar target parameters accurately, and then on the basis of the traditional communication information extraction, use after radar target reflecting signal to further improve the quality of communication.

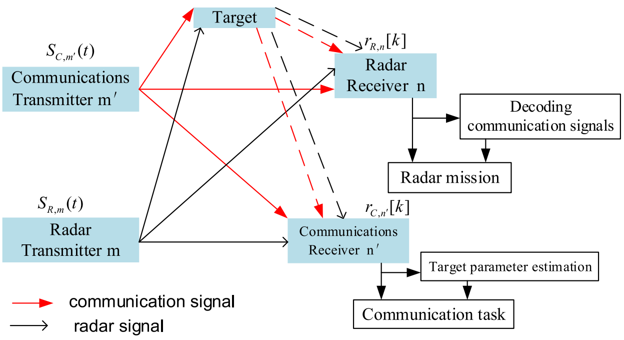

Fig.1 Cooperative MIMO radar-communication systems

In this paper, target detection is considered in the radar task[5], and the radar target detection probability of cooperative MIMO integrated system is derived as a performance measurement criterion. Taking mutual information as a criterion to measure communication performance[6], the communication mutual information expression of cooperative MIMO integrated system is derived. The analysis shows that the radar target detection probability and communication mutual information of the integrated system can be improved by the cooperation between the radar terminal and the communication terminal.

2. SIGNAL MODEL

Assumed the radar terminal has M_R transmitters and N_R receivers, and the communication terminal has M_C transmitters and N_C receivers. All transmitters and receivers are defined as single antennas. The transmitting signals of the $m(m=1,...,M_C)$ radar transmitter and the $m'(m'=1,...,M_C)$ communication transmitter respectively $\sqrt{E_{R,m}}S_{R,m}(kT_s)$, $\sqrt{E_{C,m'}}S_{C,m'}(kT_s)$ .Among them, $E_{R,m}$ and $E_{C,m'}$ denotes that the transmitted power, T_s denotes sampling period, T denotes the observation time, k(k=1,…,K) denotes the time serial number, $K=\lceil T/T_S \rceil$, $\lceil \cdot \rceil$ means round up. The detection unit determining whether the target exists is located at (x,y) in the coordinates. The schematic diagram of the cooperative MIMO radar-communication integrated system is shown in Figure 1.

(1) Radar receiving signal model

The received signal of the radar receiver $n(n=1,...,N_r)$ at the moment kT_S is modeled as:

$$\begin{aligned} r_{R,n}[k]=&\sum_{m=1}^{M_R}\sqrt{E_{R,m}}\zeta_{Rt,nm}S_{R,m}(kT_s-\tau_{Rt,nm})+\\ &\sum_{m=1}^{M_R}\sqrt{E_{R,m}}S_{R,m}(kT_s-\tau_{R,nm})+\\ &\sum_{m'=1}^{M_C}\sqrt{E_{C,m'}}\zeta_{Ct,nm'}S_{C,m'}(kT_s-\tau_{Ct,nm'})+\\ &\sum_{m'=1}^{M_C}\sqrt{E_{C,m'}}S_{C,m'}(kT_s-\tau_{C,nm'})+\omega_{R,n}[k] \end{aligned} \quad (1)$$

The first four items respectively represent the target reflection path and direct path corresponding to the radar transmitting signal, the target reflection path and direct path corresponding to the communication transmitting signal. $\tau_{Rt,nm},\tau_{R,nm},\tau_{Ct,nm'},\tau_{Ct,nm'}$ represents the delay of the corresponding path, and $\zeta_{Rt,nm},\zeta_{Ct,nm'}$ denotes the corresponding target reflection coefficient, $\omega_{R,n}[k]$ denotes clutter and noise component at time k. Total radar received signal vector can be written as:

$$\begin{aligned} r_R&=[r_{R,1}^T,\cdots,r_{R,N_R}^T]^T\\ &=U_{Rt}S_{Rt}+U_RS_R+U_{Ct}S_{Ct}+U_CS_C+\omega_R \end{aligned} \quad (2)$$

$$\begin{aligned} U_{Rt}&=Diag\{u_{Rt,1}^T[1],u_{Rt,2}^T[2],\cdots,u_{Rt,N_R}^T[K]\}\\ u_{Rt,n}[k]&=(u_{Rt,n1}[k],\cdots,u_{Rt,nM_R}[k])^T\\ u_{Rt,nM_R}[k]&=\zeta_{Rt,nm}\sqrt{E_{R,m}} \end{aligned} \quad (3)$$

The vector U_R,U_{Ct},U_C in equation (2) are defined in a similar way to U_{Rt} .and signal vector:

$$S_{Rt}=(S_{Rt,1}[1]^T,\cdots,S_{Rt,N_R}[K]^T)^T \quad (4)$$

$$S_{Rt,n}[k]=[S_{R,1}(kT_s\text{-}\tau_{Rt,n1}),\cdots,S_{R,M_R}(kT_s\text{-}\tau_{Rt,nM_R})]^T$$

The other signal vector S_R,S_{Ct},S_C in equation (2) are defined in a similar way to S_{Rt}. Clutter and noise component denotes $\omega_R=(\omega_{R,1}^T,\cdots,\omega_{R,N_R}^T)^T$, assume that ω_R obeys a Gaussian distribution with zero mean covariance matrix Q_R.

(2) Communication receiving signal model

From the analogy of the radar terminal receiving signal model (1), The received signal of the $n'(n'=1,...,N_C)$ communication receiver at time kT_S is modeled as equation (5). Among them, the first four terms respectively represent the target reflection path and direct path corresponding to the communication transmitting signal, and the target reflection path and direct path corresponding to the radar transmitting signal.

$$r_{C,n'}[k]=\sum_{m'=1}^{M_C}\sqrt{E_{C,m'}}\tilde{\zeta}_{Ct,n'm'}S_{C,m'}(kT_s-\tilde{\tau}_{Ct,n'm'})+ \\ \sum_{m'=1}^{M_C}\sqrt{E_{C,m'}}S_{C,m'}(kT_s-\tilde{\tau}_{C,n'm'})+ \\ \sum_{m=1}^{M_R}\sqrt{E_{R,m}}\tilde{\zeta}_{Rt,n'm}S_{R,m}(kT_s-\tilde{\tau}_{Rt,n'm})+ \\ \sum_{m=1}^{M_R}\sqrt{E_{R,m}}S_{R,m}(kT_s-\tilde{\tau}_{R,n'm})+\omega_{C,n'}[k] \tag{5}$$

$\tilde{\zeta}_{Ct,n'm'}$ and $\tilde{\zeta}_{Ct,n'm}$ is the corresponding target reflection coefficient, $\omega_{C,n'}[k]$ denotes clutter and noise component at time k. Let $r_{C,n'}=(r_{C,n'}[1],\cdots,r_{C,n'}[K])^T$, Then the total communication received signal vector be written as:

$$r_C=[r_{C,1}^T,\cdots,r_{C,N_C}^T]^T \\ =\tilde{U}_{Ct}\tilde{S}_{Ct}+\tilde{U}_C\tilde{S}_C+\tilde{U}_{Rt}\tilde{S}_{Rt}+\tilde{U}_R\tilde{S}_R+\omega_C \tag{6}$$

The vector $\tilde{U}_C$, $\tilde{U}_{Rt},\tilde{U}_R$ in equation (6) are defined in a similar way to $\tilde{U}_{Ct}$. Signal vector in (6):

$$\tilde{S}_{Ct}=(\tilde{S}_{Ct,1}[1]^T,\cdots,\tilde{S}_{Ct,N_C}[K]^T)^T \tag{7}$$

$$S_{Ct,n'}[k]=[S_{C,1}(kT_s\text{-}\tilde{\tau}_{Ct,n'1}),\cdots,S_{C,M_C}(kT_s\text{-}\tilde{\tau}_{Ct,n'M_C})]^T$$

Assuming that clutter and noise vector $\omega_C=(\omega_{C,1}^T,\cdots,\omega_{C,N_C}^T)^T$ at communication terminal obeys Gaussian distribution with zero mean covariance matrix Q_C ,, $\omega_{C,n'}=(\omega_{C,n'}[1],\cdots,\omega_{C,n'}[K])^T$.

3. RADAR TARGET DETECTION IN COOPERATIVE MIMO INTEGRATED SYSTEM

In this section, the problem of target detection in cooperative MIMO radar communication integrated system is considered. Using the information shared by the communication system, it is assumed that the radar receiver can decode and reconstruct the communication signal more accurately. Through cooperation, the radar system no longer regards the communication signal as interference, but uses the target echo from the communication end to complete the radar target detection. Therefore, the cooperative integrated system can not only use the target echo of the traditional radar, but also use the target echo carried by the communication signal to complete the radar task, The echo formed when the communication signal is reflected by the target and reaches the radar receiver is used to complete the radar task, rather than being suppressed as interference, which is equivalent to a passive radar system. Thanks to information sharing, the cooperative integrated system can be equivalent to an active passive hybrid MIMO radar system.

It is assumed that the radar task is to detect the existence of a target in the detection unit of interest. According to the radar received signal model of equation (2), the assumption that the target exists in the detection unit is H_1, and the assumption that the target does not exist is H_0, then the detection problem can be described as:

$$H_0: r_R=U_RS_R+U_CS_C+\omega_R \\ H_1: r_R=U_{Rt}S_{Rt}+U_RS_R+U_{Ct}S_{Ct}+U_CS_C+\omega_R \tag{8}$$

In order to simplify the analysis, considering the communication signals has been decoded and refactoring, and can be accessed by assuming that pretreatment methods such as making them reflection coefficient $\zeta_{Rt,nm}$ and $\zeta_{Rt,nm'}$ known, in equation(8), all the other terms except the noise ω_g term are ascertained, Therefore, under the two assumptions, the received signal r_g is Gaussian distribution, and the probability density function is respectively:

$$p(r_R|H_0)=\frac{1}{p^{KN_R}\det(Q_R)} \\ \exp\{-(r_R-U_RS_R-U_CS_C)^HQ_R^{-1}(r_R-U_RS_R-U_CS_C)\} \tag{9}$$

$$p(r_R|H_1)=\frac{1}{p^{KN_R}\det(Q_R)} \\ \exp\{-(r_R-U_RS_R-U_{Rt}S_{Rt}-U_CS_C-U_{Ct}S_{Ct})^H \\ \times Q_R^{-1}(r_R-U_RS_R-U_{Rt}S_{Rt}-U_CS_C-U_{Ct}S_{Ct})\} \tag{10}$$

The logarithm likelihood ratio function can be deduced as:

$$\ln\frac{p(r_R|H_1)}{p(r_R|H_0)}=r_R^HQ_R^{-1}(U_{Rt}S_{Rt}+U_{Ct}S_{Ct}) \\ +r_RQ_R^{-1}(U_{Rt}S_{Rt}+U_{Ct}S_{Ct})^H- \\ (U_RS_R+U_CS_C)^HQ_R^{-1}(U_{Rt}S_{Rt}+U_{Ct}S_{Ct})- \\ (U_{Rt}S_{Rt}+U_{Ct}S_{Ct})^HQ_R^{-1}(U_RS_R+U_CS_C)- \\ (U_{Rt}S_{Rt}+U_{Ct}S_{Ct})^HQ_R^{-1}(U_{Rt}S_{Rt}+U_{Ct}S_{Ct}) \tag{11}$$

The detection statistic can be obtained as:

$$T_R=r_R^HQ_R^{-1}(U_{Rt}S_{Rt}+U_{Ct}S_{Ct})+r_RQ_R^{-1}(U_{Rt}S_{Rt}+U_{Ct}S_{Ct})^H \tag{12}$$

Since R_g is Gaussian distribution under both the H_0 hypothesis and the H_1 hypothesis, it is easy to know that the distribution of T_R under the two assumptions is respectively:

$$T_R|H_0\sim N(\mu_0,\sigma^2)\ ,\quad T_R|H_1\sim N(\mu_1,\sigma^2) \tag{13}$$

$$\mu_0 = 2\,\mathrm{Re}\{(U_R S_R + U_C S_C)^H Q_R^{-1}(U_{Rt} S_{Rt} + U_{Ct} S_{Ct})\}$$
$$\mu_1 = 2\,\mathrm{Re}\{(U_R S_R + U_C S_C + U_{Rt} S_{Rt} + U_{Ct} S_{Ct})^H Q_R^{-1}(U_{Rt} S_{Rt} + U_{Ct} S_{Ct})\} \quad (14)$$
$$\sigma^2 = 2(U_{Rt} S_{Rt} + U_{Ct} S_{Ct})^H Q_R^{-1}(U_{Rt} S_{Rt} + U_{Ct} S_{Ct})$$

The definition of false alarm probability P_{FA},We can get detection threshold is β:

$$\beta = \sigma Q^{-1}(P_{FA}) + \mu_0 \quad (15)$$

On formula of $Q(\bullet)$ said complementary standard gaussian distribution function, expression for:

$$Q(\mathrm{x}) = \int_x^{\infty} \frac{1}{\sqrt{2p}} e^{-\frac{t^2}{2}} dt \quad (16)$$

The radar target detection probability of the integrated MIMO system can be calculated as follows:

$$P_D = P(T_R > \beta \,|\, H_1) = Q(\frac{\beta - \mu_1}{\sigma}) = Q(Q^{-1}(P_{FA}) + \frac{\mu_0 - \mu_1}{\sigma}) \quad (17)$$

4. COMMUNICATION MUTUAL INFORMATION IN COOPERATIVE MIMO INTEGRATED SYSTEM

The cooperative radar system can share its transmitted signals and antenna positions with the communication system, with the help of which the unknown target position θ can be estimated at the communication receive end. Utilizing the estimation results, target returns due to radar transmission can be eliminated. Further, the communication system can extract information not merely from the directly received communication signals, but also those reflected from the target.

Assuming the communication transmitting signal is a Gaussian signal with known distribution, the probability density function of r_C can be obtained :

$$p(r_C \,|\, \theta) = \frac{1}{p^{KN_C} \det(A)} \exp \{-(r_C - \tilde{U}_R \tilde{S}_R - \tilde{U}_{Rt} \tilde{S}_{Rt})^H A^{-1} (r_C - \tilde{U}_R \tilde{S}_R - \tilde{U}_{Rt} \tilde{S}_{Rt})\} \quad (18)$$

The covariance matrix of r_C is:

$$A = E\{(r_C - \tilde{U}_R \tilde{S}_R - \tilde{U}_{Rt} \tilde{S}_{Rt})(r_C - \tilde{U}_R \tilde{S}_R - \tilde{U}_{Rt} \tilde{S}_{Rt})^H\} = \tilde{U}_C \tilde{S}_C \tilde{U}_C^H + \tilde{U}_C \tilde{S}_{Ct} \tilde{U}_{Ct}^H + \tilde{U}_{Ct} \tilde{S}_{Ct}^H \tilde{U}_{Ct} + \tilde{U}_{Ct} \tilde{S}_{Ctt} \tilde{U}_{Ct}^H + Q_C \quad (19)$$

Among $\tilde{S}_c = E\{\tilde{S}_C \tilde{S}_C^H\}, \tilde{S}_{Ct} = E\{\tilde{S}_C \tilde{S}_{Ct}^H\}, \tilde{S}_{Ctt} = E\{\tilde{S}_{Ct} \tilde{S}_{Ct}^H\}$.

$E\{\bullet\}$ denotes solving mathematical expectations. Thus, the maximum likelihood estimate of the target position is:

$$\hat{\theta}_{C,ML} = (\hat{\mathrm{x}}_C, \hat{\mathrm{y}}_C) = \arg\max_{\theta} \ln p(r_C \,|\, \theta) \quad (20)$$

The estimated time delay of the communication signal reflected by the target and the estimated time delay of the radar signal can be expressed as:

$$\hat{\tau}_{\mathrm{Ct},n'm'} = \frac{1}{c}\{[(x_{C,m'}^{Tx} - \hat{x}_C)^2 + (y_{C,m'}^{Tx} - \hat{y}_C)^2]^{\frac{1}{2}} + [(x_{C,n'}^{Rx} - \hat{x}_C)^2 + (y_{C,n'}^{Rx} - \hat{y}_C)^2]^{\frac{1}{2}}\} \quad (21)$$

$$\hat{\tau}_{\mathrm{Rt},n'm} = \frac{1}{c}\{[(x_{R,m'}^{Tx} - \hat{x}_C)^2 + (y_{R,m'}^{Tx} - \hat{y}_C)^2]^{\frac{1}{2}} + [(x_{C,n'}^{Rx} - \hat{x}_C)^2 + (y_{C,n'}^{Rx} - \hat{y}_C)^2]^{\frac{1}{2}}\} \quad (22)$$

$(x_{C,m'}^{Tx}, y_{C,m'}^{Tx}), (x_{R,m}^{Tx}, y_{R,m}^{Tx}), (x_{C,\mathrm{n}'}^{Rx}, y_{C,n'}^{Rx})$ stands for the position of the m'_{th} transmitting station, the m_{th} radar transmitting station and the n'_{th} communication receiving station respectively, The delay estimation result can be further written as:

$$\hat{\tau}_{\mathrm{Ct},n'm'} = \hat{\tau}_{\mathrm{Ct},n'm'} + n_{\mathrm{Ct},n'm'}, \hat{\tau}_{\mathrm{Rt},n'm} = \hat{\tau}_{\mathrm{Rt},n'm} + n_{\mathrm{Rt},n'm} \quad (23)$$

$n_{\mathrm{Ct},n'm'}$ and $n_{\mathrm{Rt},n'm}$ denote the estimation error.

Before eliminating the radar signal, the following approximation is obtained by using the method in reference[7)]:

$$s_{R,m}(kT_s - \tilde{\tau}_{Rt,n'm}) - s_{R,m}(kT_s - \tilde{\tau}_{Rt,n'm} - n_{Rt,n'm}) \approx \frac{s_{R,m}^{(1)}(kT_s - \tilde{\tau}_{Rt,n'm})}{\partial k} n_{Rt,n'm} \quad (24)$$

Among them $s_{R,m}^{(1)}(t) = \partial s_{R,m}(t) / \partial t$ denotes the derivatives of $s_{R,m}(t)$ with respect to t. Therefore, according to formula (24), the interference of radar signal in formula (6) is eliminated, the communication received signal vector can be obtained as:

$$r'_C = r_C - \tilde{U}_{Rt} \tilde{s}_{Rt} - \tilde{U}_R \tilde{s}_R = \tilde{U}_{Ct} \tilde{s}_{Ct} + \tilde{U}_C \tilde{s}_C + \tilde{V}_{Rt} \tilde{n}_{Rt} + \omega_C \quad (25)$$

From equation (25), it can be found that both $\tilde{s}_C$ and $\tilde{s}_{Ct}$ in observation vector r'_C contain useful information of communication signal, so the mutual information of communication of integrated system can be calculated as:

$$\mathrm{MI} = I(\mathrm{r}'_C, \tilde{s}_C, \tilde{s}_{Ct}) = H(r_C') - H(r_C' \,|\, \tilde{s}_C, \tilde{s}_{Ct}) = \log\det\{I + (\tilde{V}_{Rt} Q_{Rt} \tilde{V}_{Rt}^H + Q_C)^{-1} (\tilde{U}_C \tilde{s}_C \tilde{U}_C^H + \tilde{U}_C \tilde{s}_{Ct} \tilde{U}_{Ct}^H + \tilde{U}_{Ct} \tilde{s}_{Ct} \tilde{U}_C + \tilde{U}_{Ct} \tilde{s}_{Ctt} \tilde{U}_{Ct}^H \quad (26)$$

$H(\bullet)$ denotes differential entrpy, $Q_{\mathrm{Rt}} = E\{\tilde{n}_{Rt} \tilde{n}_{Rt}^H\}$.

5. PERFORMANCE ANALYSIS

This section analyzes radar target detection and communication mutual information of cooperative MIMO integrated system through numerical simulation. For the convenience of analysis, it is assumed that the communication system has $M_C = 2$ transmitting antenna and $N_C = 3$ receiving antenna, the positions of transmitting station are (70,0) km and (-70,0) km, and the positions of receiving station are (65,24) km, (-54,50) km and (-12,-69) km respectively. The number of transmitting antenna and receiving antenna of MIMO radar system are $M_R = 2$ and $N_R = 3$, the positions of transmitting station are (0,70) km and (0,-70) km, and the positions of receiving station are (-41,57) km, (-28,-64) km and (69,7) km respectively. Suppose the radar target detection is located at (0.5,0.3) km. The orthogonal frequency division multiplexing (OFDM) signal transmitted by communication system can express as:

$$S_{Cm'}(t) = \sum_{n=-N_f/2}^{N_f/2-1} am'[n]e^{j2pn\Delta ft} p_{T'}(t) \tag{27}$$

Let $\Delta f = 125Hz, N_f = 6, T' = 0.01s$, It is assumed that the transmission power of each communication transmission signal is the same, the covariance matrix is expressed as $Q_C = \sigma_\omega^2 I$ .Radar system transmits frequency spread Gaussian monopulse signal, which is expressed as:

$$s_m(t) = (2/T^2)^{1/4} \exp(-pt^2/T^2)e^{j2pmf\Delta t} \tag{28}$$

Let $\Delta f = 125Hz, T = 0.01s$, The transmitting power of each radar transmitting signal is the same. The covariance matrix is expressed as $Q_R = \sigma_\omega^2 I$ .The total transmit power of cooperative MIMO radar communication integrated system is expressed as E , ratio assigned to the radar is set to α , $M_R E_R = E\alpha$, $M_C E_C = E(1-\alpha)$ .The ratio of signal to clutter plus noise is defined as $SCNR = 10\log(E/\sigma_\omega^2)$ .Let $E = 10^4, SCNR = 5dB$.

(1) Performance gain of radar target detection in cooperative MIMO integrated system

Figure 2 shows the curve of radar target detection probability changing with in two scenarios. The first scenario (cooperation) considers the cooperation between radar and communication system. The second scenario (non-cooperative) considers the situation that the radar in the integrated MIMO system detects the target in the traditional way but does not cooperate with the communication system. It can be seen from the figure that the target detection probability P_D of cooperative integrated system is always higher than that of non-cooperative integrated system, which indicates that cooperation is helpful to improve the target detection performance of radar. It can also be seen from the figure that with the increase of the detection probability P_D of the two integrated systems will increase, but the detection performance gain brought by cooperation will be smaller and smaller, which indicates that there is a tradeoff between detection probability and performance gain.

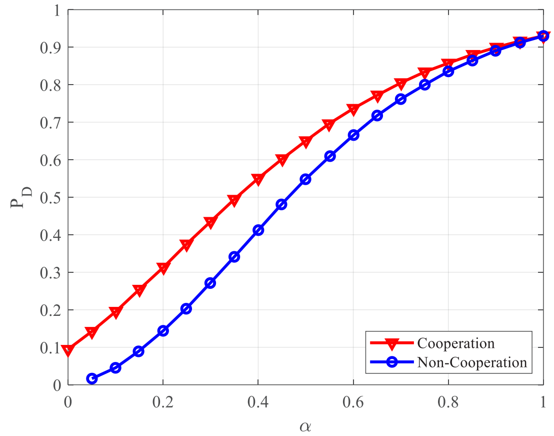

Fig.2 Target detection probability P_D versus α for cooperative MIMO radar-communication systems

(2) Mutual information gain in cooperative MIMO integrated system

Considering the above-mentioned integrated MIMO system, the parameter setting is consistent with the previous example. In addition, it is assumed that the communication signal is a white Gaussian distribution with correlation matrix $E\{S_{C,m'}(kT_s)S_{C,m'}(k'T_s)\} = 0.9^{|(k-k')T_s|}$. Figure 3 shows the curve of mutual information of communication changing with in two scenarios. The first scenario (cooperation) considers the cooperation between MIMO communication and MIMO radar system in the integrated system. The communication system estimates the target parameters and makes use of the echo of the communication target. The second scenario (non-cooperative) considers that the MIMO communication system in the integrated system does not cooperate with the MIMO radar, but uses the traditional way of communication. It can be seen from the figure 3 that the mutual information of cooperative situation is always larger than that of non-cooperative situation, which indicates that cooperation with radar system is helpful to improve communication mutual information. At the same time, it can be seen from the figure that with the increase of α mutual information and performance gain gradually decrease.

Based on the comprehensive analysis of Fig.2 and Fig.3, the cooperation between radar and communication in the integrated MIMO system can make both radar and communication gain performance, but there is a tradeoff between radar performance gain and communication performance gain.

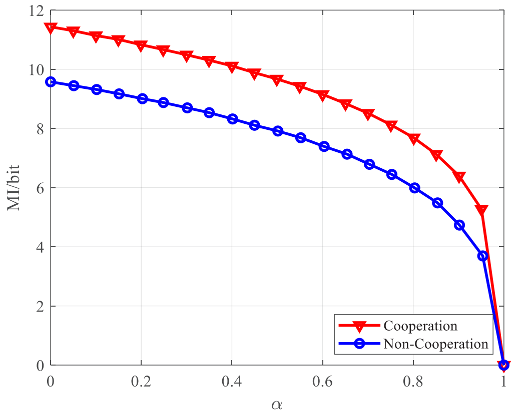

Fig.3 MI versus α for cooperative MIMO radar-communication systems

6. CONCLUSION

In this paper, the signal model of cooperative MIMO radar communication integrated system is given, that is, the target echo and direct wave from radar and communication transmission are considered at the receiving end. On the radar side, the Cooperative integrated system is equivalent to an active passive hybrid MIMO radar. The target detection probability of the hybrid MIMO radar is analyzed. In the communication end, using the shared radar information, the communication echo can also be used to extract useful communication information. This paper deduces the mutual information to measure the effectiveness of communication. In the numerical analysis, the OFDM communication signal and frequency extended Gaussian monopulse radar signal are considered. The simulation results show that the cooperation of radar and communication in the integrated system can significantly improve the performance of radar and communication, and the analysis shows that there is a tradeoff between the performance of radar and communication in the cooperative integrated system, which will shed light on future research on system-level optimization strategies.

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