PHASE CODED IN MULTI INPUT MULTI OUTPUT RADAR SYSTEMS

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Abstract

The recent advances in multiple-input multiple-output (MIMO) radar, we apply ternary phase coded waveforms to MIMO radar system in order to gain better range resolution and target direction finding performance. We provide and investigate a generalized MIMO radar system model using orthogonal phase coded waveforms. We slightly modify the system model to improve the system performance. We propose the concept and the design methodology for a set of ternary phase coded waveforms that is the optimized punctured systems. We also study the MIMO radar ambiguity function of the system using phase coded waveforms, based on which we analyze the properties of our proposed phase coded waveforms which show that better range resolution could be achieved. We apply our proposed codes to the two MIMO radar system models and simulate their target direction finding performances.

The simulation results show that the first MIMO radar system model could obtain ideal target direction finding performance when the number of transmit antennas is equal to the number of receive antennas. The second MIMO radar system model is more complicated but could improve the direction finding performance of the system.

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I. INTRODUCTION

Multiple-Input Multiple-Output (MIMO) technology is a wireless technology that uses multiple transmitters and receivers to transfer more data at the same time .Wireless products with 802.11n support MIMO. In radio multiple-input and multiple-output, or MIMO is the use of multiple antennas at both the transmitter and receiver to improve communication performance. It is one of several forms of smart antenna technology. Note that the terms input and output refer to the radio channel carrying the signal, not to the devices having antennas.

MIMO technology has attracted attention in wireless communications, because it offers significant increases in data throughput and link range without additional bandwidth or increased transmit power. It achieves this goal by spreading the same total transmit power over the antennas to achieve an array gain that improves the spectral efficiency (more bits per second per hertz of bandwidth) or to achieve a diversity gain that improves the link reliability. Because of these properties, MIMO is an important part of modern wireless communication standards such as IEEE 802.11n (Wi-Fi), 4G, 3GPP Long Term Evolution.

Wireless communication using multiple-input multiple-output (MIMO) systems enables increased spectral efficiency for a given total transmit power. Increased capacity is achieved by introducing additional spatial channels that are exploited by using space-time coding. In this article, we survey the environmental factors that affect MIMO capacity. These factors include channel complexity, external interference, and channel estimation error. We discuss examples of space-time codes, including space-time low-density parity-check codes and space-time turbo codes, and we investigate receiver approaches, including multichannel multiuser detection (MCMUD). The 'multichannel' term indicates that the receiver incorporates multiple antennas by using space-time-frequency adaptive processing. The article reports the experimental performance of these codes and receivers.

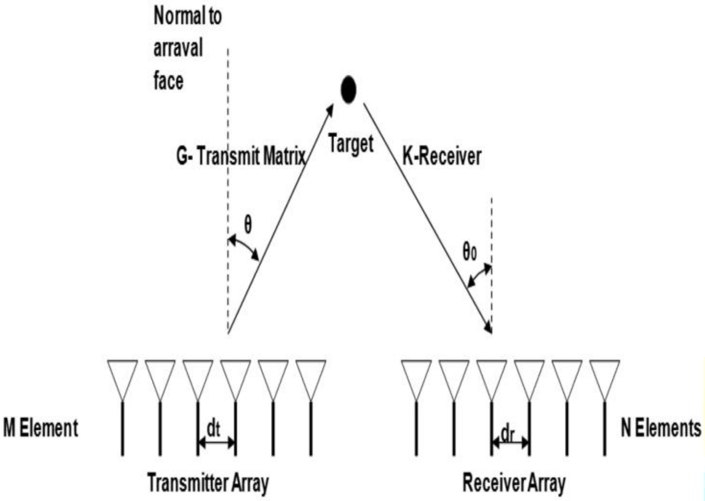


Figure 1.1 MIMO radar technology model

Multiple-input multiple-output (MIMO) systems are a natural extension of developments in antenna array communication. While the advantages of multiple receive antennas, such as gain and spatial diversity, have been known and exploited for some time the use of transmit diversity has only been investigated recently. Fig 1.1 The advantages of MIMO communication, which exploits the physical channel between many transmit and receive antennas, are currently receiving significant attention while the channel can be so non stationary that it cannot be estimated in any useful sense in this article we assume the channel is quasistatic. MIMO systems provide a number of advantages over single-antenna-to-single-antenna communication.

Sensitivity to fading is reduced by the spatial diversity provided by multiple spatial paths. Under certain environmental conditions, the power requirements associated with high spectral-efficiency communication can be significantly reduced by avoiding the compressive region of the information-theoretic capacity bound. Here, spectral efficiency is defined as the total number of information bits per second per Hertz transmitted from one array to the other.

Fig 1.2 After an introductory section, we describe the concept of MIMO information-theoretic capacity bounds. Because the phenomenology of the channel is important for capacity, we discuss this phenomenology and associated parameterization techniques, followed by examples of space-time codes and their respective receivers and decoders. We performed experiments to investigate channel phenomenology and to test coding and receiver techniques

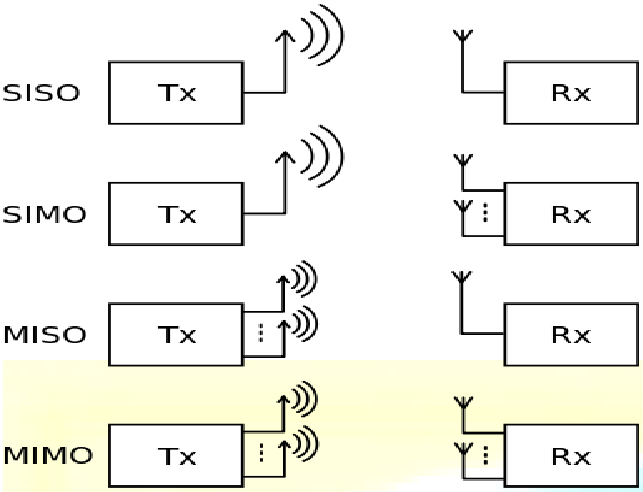


Figure 1.2 SISO, SIMO, MISO and MIMO to the radio channel

II MIMO RADAR SIGNAL MODELS

We describe a signal model for the MIMO radar system using orthogonal pulse compression codes to improve the direction finding performance.

Assume a radar system that utilizes an array with M antennas at the transmitter and I antennas at the receiver. For simplicity, we assume that it is a point target, and the arrays at the transmitter and receiver are parallel. A transmitting linear array is made up of M elements equally spaced a distance dt apart.

The elements are assumed to be isotropic radiators in that they have uniform response for signals from all directions. The first antenna will be taken as the reference with zero phases. The signal radiated by the transmit antenna impinges at angle µ which is the AOA. From simple geometry, the difference in path length between adjacent elements for signals transmitting at an angle µ with respect to the normal to the antenna, is dt sinµ. This gives a phase difference between adjacent elements of Á =2¼(dt=¸) sinµ, where ¸ is the wavelength of the transmit signal.

The phase difference for the mth transmit antenna is Ám =2¼((m¡1)dt=¸)sinµ. Preparing your Electronic Paper Prepare your paper in full-size format, on US letter paper 8 ½ by 11 inches).

III. OPTIMIZED PUNCTURED PHASE CODED WAVES

According to results in the previous sections, orthogonal pulse compression codes could be used in the MIMO radar system to improve the range resolution and direction finding performance. It is also known that it is impossible to have perfect ACF and CCF simultaneously, since the corresponding parameters have to be limited by certain bounds, such as Welch bound, Sidelnikov bound, and Sarwate bound. As a result, based on the propose a set of ternary codes and design the construction methodology of the codes.

A. The Definition and Properties of Phase Coded Waves

First of all, we consider a sequence-pair set (U,V), where U is a set of M sequences (um 2 U, m =0,1,2, : : : ,M ¡1)) and V is a set of M sequences (vm0 2 V, m0 =0,1,2,: : : ,M ¡1). Both um and vm0 are of the same length N.

Phase coded waveforms in the radar system; some properties are of particular concern in the optimization for any design in engineering. They are the peak sidelobe level, the energy of autocorrelation sidelobes and the energy of their mutual cross
Correlation. Therefore, the peak sidelobe level which represents a source of mutual interference and obscures weaker targets can be presented as maxK jRumvm (k)j. Another optimization criterion for the set of sequence-pair is the energy of autocorrelation sidelobes joined together with the energy of cross correlation. By minimizing the energy, it can be distributed evenly, and the peak autocorrelation level can be minimized as well.

B. Definition and Design for Optimized Punctured Phase Coded

Matsufuji and Torii have provided some methods of constructing ZCZ sequences in this section a set of novel ternary codes, namely, the optimized punctured ZCZPS, is constructed through applying the optimized punctured sequence-pair to the phase wave form. In some other words, optimized punctured phase coded system is a specific kind of phase systems.

IV. MIMO RADAR PHASE FUNCTIONS

The MIMO radar phase function for phase coded waveforms which is used to analyzed the proposed sequence-pair set. Based on the result of the first model, we focus our attention on this model and assume that the number of transmit antennas is the same as the number of receive antennas.

Here, the target spatial frequency f and the assumed spatial frequency f0 represent the spatial mismatch. ¿ is the delay corresponding to the target range, and º is the Doppler frequency of the target. r »= dt=dr where the spacing between the transmitting elements is dt and the spacing between the receiving elements is dr. M is the number of transmitting antennas and the function Âm,m0 (¿,º) is called the cross ambiguity function. Taking, the cross ambiguity function of phase coded waveforms.

V. PROPERTIES OF OPTIMIZED PUNCTURED PHASE CODED WAVEFORMS

The autocorrelation and cross-correlation properties can be simulated and analyzed with MATLAB. For example, the optimized punctured ZCZPS (U,V) is constructed by 5-bit length optimized punctured binary sequence-pair (x,y), x = [++¡+¡], y = [++000] (using “+” and “¡” symbols for “1” and “¡1”) and matrix H of order 4. We follow the three steps present

The ambiguity function parallel along time domain at Doppler shift º = 0 has high peaks at the period of the ZCZ expect for a short sharp at zero time delay. However, there might be the concern that multiple peaks of the ACF would lead to ambiguity in ranging. Since the periodic correlation function is used in this paper, the peaks from other targets would not be high enough to mask the peak of the target under the study. In

addition, we are studying the single target system in this research and controlling the PRF (pulse repetition frequency), the only concern is that multiple peaks of the transmitting signal reflected from one target may affect determining the main peak of ACF. As a matter of fact, the matched filter here could shift at the period of ZCZ length to track each peak instead of shifting bit by bit after the first peak is acquired, which could make the system work more efficiently. Like the tracking technology in synchronization of code-division multiple access (CDMA) systems, checking several peaks instead of only one peak guarantees the precision of PD and avoidance of PFA. And the range could be determined by obtaining the middle point of the time range of the first and the last high peaks where we could achieve a short sharp.

VI. SIMULATIONS AND ANALYSIS

We are running MATLAB simulations of the MIMO radar system using a different number of transmit antennas and receive antennas to see the direction finding performance. The configurations of transmit and receive antennas. The transmit antennas are spaced sufficiently far from each other, and the antenna array is used in the receive part. Fig 7.1The target fluctuating model in which the channel fluctuated according to a Rayleigh distribution is considered besides the non fluctuating model. The MSEs of the AOA estimation is used as the common figure of merit for comparing the performance. Using none fluctuating and fluctuating target models, the MIMO radar systems of different antennas. MIMO radar system achieves better MSE of AOA estimation than the 4£4 MIMO radar system; it is expected that more transmit and receive antennas can work better than less transmit and receive antennas. Fig 7.2 On one hand, if the number of receive antennas is increased from 4 to 8, the direction finding performance of the 4£8 MIMO radar system becomes worse than that of the 4£4 MIMO radar system.

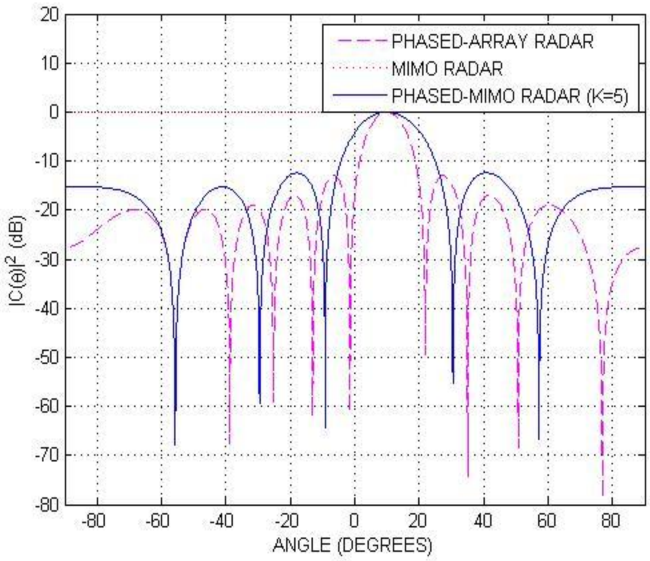


Figure 7.1 Phase Array Radar System Model

Fig 7.3 The 4 £8 MIMO radar systems could perform better than the 8 £4 MIMO radar systems when the value of signal-to-noise radar (SNR) is small. However, the 8 £4 MIMO radar systems obtain less MSE of AOA estimation than the 4 £8 MIMO radar systems as the value of SNR increases. The noise interference brought by extra transmit antennas is not as severe as the noise introduced by extra receive antennas shown as the second part of (14) when the value of SNR is large. Fig 7.4 The performance for fluctuating model is degraded, since the the variable RCS value brought by Rayleigh fading may interfere with the orthogonality of the transmit waveforms and the receive waveforms. So we can see that the model using our proposed codes could work well both under fluctuating and none fluctuate conditions. As a result, a general conclusion could be drawn that based on the same number of transmit antennas and receive antennas, the more antennas MIMO radar system utilized the better direction finding performance could be achieved.

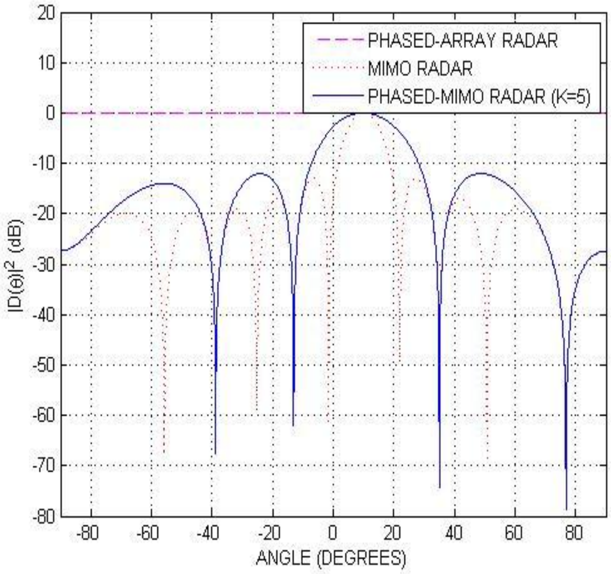


Figure 7.2 Phased MIMO Radar System model

VII. EXPERIMENTAL PROCEDURE

A. Problem Solving from Existing System:

Orthogonal phase coded waveforms is applied and system performance is low then the modification is done for the improvement of the system performance

We are running MATLAB simulations of the MIMO radar system using a different number of transmit antennas and receive antennas to see the direction finding performance.

In MIMO radar system; it is expected that more transmit and receive antennas can work better than less transmit and receive antennas.

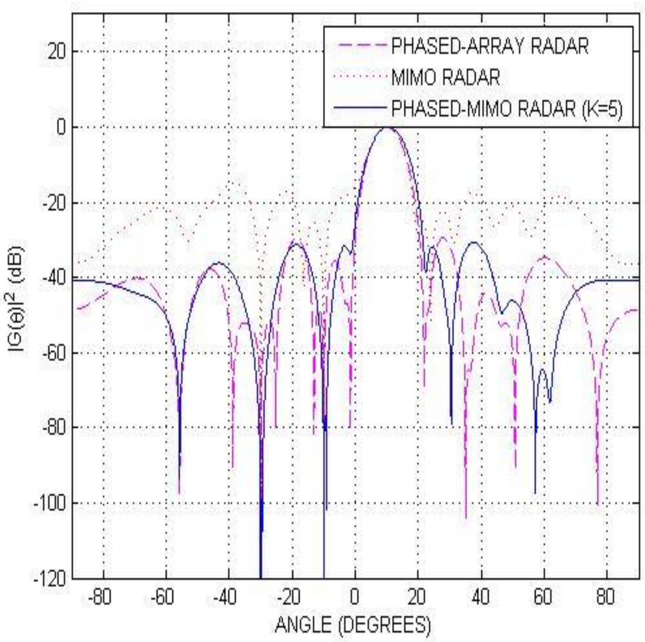


Figure 7.3 MIMO Radar Signal Systems

On one hand, if the number of receive antennas is increased from 4 to 8, the direction finding performance of the 4x8 MIMO radar system becomes worse than that of the 4x4 MIMO radar system.

It is also easy to see that the 4x8 MIMO radar systems could perform better than the 8x4 MIMO radar systems when the value of signal-to-noise radar (SNR) is small.

The results show that increasing the number of either transmit antennas or receive antennas could improve the direction finding performance of the system as expected. The 2x4 MIMO radar system that more receive antennas introduce more noise to the receive part.

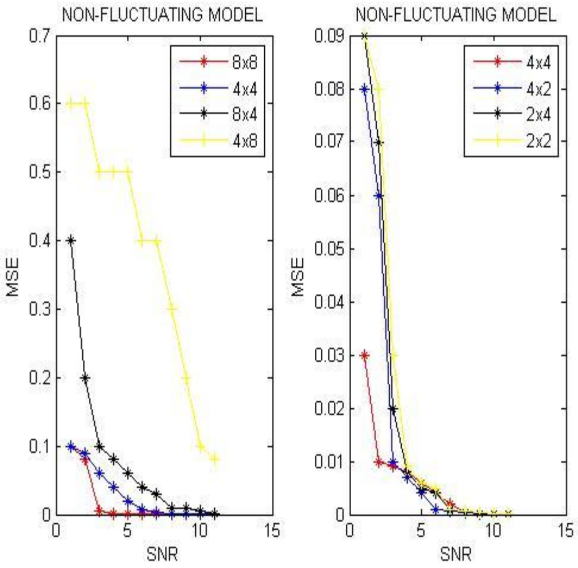


Figure 7.4 Signal Noise Ratio System Models

B. Steps to be followed for Proposed System:

In MIMO radar in to gain better range resolution and the achieve target direction performance

Ternary phase coded waveforms is applied and the Increase the system performance

The better range resolution should be achieved

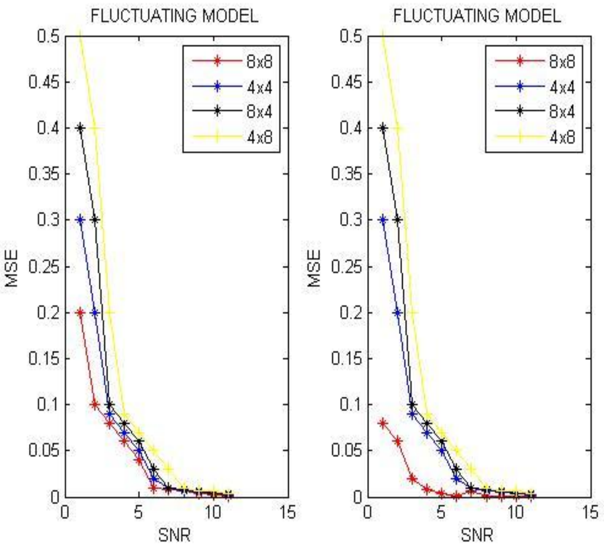
Beam forming is used to find the direction of the target at the receiver part.

The direction finding performance is improved .Orthogonal pulse compression codes is applied to find the direction of a single fixed target

VIII. CONCLUSION AND RESULT

The presented and analyzed two MIMO radar system models, in which beam forming is used to find the direction of the target at the receive part. We also proposed a new set of orthogonal phase coded waveforms and apply them to the proposed MIMO radar systems to improve the radar range resolution and direction finding performance. We provided the definition and constructing method of the optimized punctured. The MIMO radar ambiguity function of the system within phase coded waveforms is investigated and used to study the properties of our proposed codes. Simulation results showed that significant diversity gain could be obtained in both MIMO radar systems using orthogonal phase coded waveforms. In the first

MIMO radar system model, the more antennas applied, the better performance obtained only if there are equal number of transmit antennas and receive antennas.



In addition, the direction finding performance could be improved by increasing the number of either transmit antennas or receive antennas for the second MIMO radar system model. The paper is only to introduce the basic concept of our newly provided MIMO radar system with orthogonal pulse compression codes to find the direction of a single fixed target. In subsequent work, we may consider the Doppler shift effect for moving targets and some complicated radar channel models for the new approach.

According to the observations from literature review, I'm going to propose a system on "Phase Coded in Multi Input Multi Output Radar Systems".

REFERENCES

1. Spatial Diversity in Radars Models and Detection Performance

Eran Fishler, Member, IEEE, New York University,Alexander Haimovich, Senior Member, IEEE, New York University,Rick S. Blum, Fellow, IEEE,New York University

2.On Probing Signal Design For MIMO Radar

Petre Stoica, Fellow, IEEE, Ohio State University,Jian Li, Fellow, IEEE Ohio State University.,

3. Waveform Synthesis for Diversity-Based Transmit Beam pattern Design

Petre Stoica,IEEE Member, Jian Li,IEEE Member , Xumin Zhu,IEEE Member, Ohio State University.

4. Waveform Design for MIMO Radars

Leonard J. Cimini, Jr., Fellow, IEEE, Dmitry Chizhik,IEEE Member, New York University

5. Transmit Beam forming for MIMO Radar

Benjamin Friedlander, Fellow, IEEE, University of California Santa Cruz

6. MIMO Radar Waveform Design Based on Mutual Information and Minimum Mean-Square Error Estimation

Yang yang, Student Member, IEEE, Rick S.blum, Fellow, IEEE ,Lehigh University

7. Minimax Robust MIMO Radar Waveform Design

Yang Yang, Student Member, IEEE, and Rick S. Blum, Fellow, IEEE

8. MIMO Radar Ambiguity Functions

Geoffrey San Antonio, Student Member, IEEE, Daniel R. Fuhrmann, Senior Member, IEEE, Ohio State University

9. MIMO Radar Ambiguity Properties and Optimization Using Frequency

Chun-Yang Chen, Student Member, IEEE, P. P. Vaidyanathan, Fellow, IEEE, California Institute of Technology

10. Reducing the Waveform Cross Correlation of MIMO Radar With Space

Xiufeng Song, Student Member, IEEE,Shengli Zhou, Member, IEEE, The University of Texas at Austin.

11. Evaluation of Transmit Diversity in MIMO-Radar Direction Finding

Nikolaus H. Lehmann, Student Member, IEEE ,Eran Fishler, Member, IEEE Lincoln Laboratory.