Target Localization Methods for Frequency-Only MIMO Radar

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***Abstract*—When the time resolution of the signals is not so good, we can't rely on the time of arrival (TOA) information. On the other hand, if the frequency resolution of the signals is good, than frequency of arrival (FOA) informations will be more reliable. Localization of a moving, non-maneuvering target is possible by using Doppler-shift measurements in MIMO radar systems. A new method for target localization in frequency-only MIMO radar is proposed and it is compared with previous method. These methods use only received frequencies, and all of other unknown quantities can be written by using locations of the target, the receivers and the transmitters. If the received frequencies are known only, desired area can be searched grid by grid for all possible (x, y) coordinates to find the position of the target in 2D space.**

I. Introduction

MIMO radar is defined broadly as radar system employing multiple transmit waveforms and having the ability to jointly process signals received at multiple receive antennas[1]. In literature there are a lot of MIMO radar papers on the target detection. MIMO radar increases the detection performance by using angular spread [2]. The advantage of having widely separated receiver and transmitter units can be used for target tracking. To track a target, first of all, the target localization should be estimated accurately. There is no published work on target tracking in MIMO radars, yet. However, target localization is another popular research area for MIMO radar. As shown in [3] and [4] a non-maneuvering target can be localized from Doppler-shift measurements by using multi sensor architecture. In [3], there are N passive sensors, and they try to localize a moving source which is non-maneuvering and radiates a constant frequency tone. In [4] this method is expanded to active MIMO radar case. Instead of using a target which radiates a tone, an active MIMO radar system with N_T transmitters and N_R receivers which are widely separated from each others is used. Each transmitter/receiver pair works in bistatic manner and there is no monostatic radar configuration, i.e.; transmitters don't receive any signal. In general, if the time of arrival (TOA) information of the received signals is known, localization is performed on TOA. This process requires at least three bistatic radar units for unambiguous position information [5]. When the time resolution of the signals is not so good or TOA is not available, frequency of arrival (FOA) informations can be used to find the target location. In [1], target localization methods for MIMO radar is summarized, and CRLB is derived. In the same paper, MIMO radar for widely separated case is investigated and target localization is performed by using only TOA information. Signal model doesn't includes doppler shifts. Similarly in [6], CRB is derived when there is an phase error on coherent processing. In [7], CRB is derived for moving target localization in a doppler frequency-only radar system,which includes 2 transmitters and one reveivers. In [8] target tracking is considered for a network of Doppler radars. These radars work only monostatic configuration and Cramer-Rao bound on motion parameter uncertainty is obtained for phase and frequency based estimation strategies.

In this paper, a new method to localize target based on the measurements of Doppler shifts is presented for MIMO radar. To localize target is determining the target parameters which are the position coordinates (x, y) and velocity coordinates $(\dot{x}, \dot{y})$ at a given instant of time. Depending upon the target position, a cost function is defined and then the position of the target at a given instant is found in two dimensions by searching the desired area using the grid search method. Moreover, the results will be compared with the target localization method in [4].

This paper is organized as follows: In Section II, problem formulation and models are given. In Section III, simulation results can be seen. And finally, Section IV contains the conclusions.

II. Problem Formulation

A. Target Model

System includes N_T transmitters and N_R receivers. All radars work bistatic, hence system has total $N = N_T \times N_R$ bistatic radar pairs which are ground based and nonmoving. A non-maneuvering target is moving on a constant speed (V). N_T transmitters emit unmodulated CW tone signals in different frequencies which are $f_1, f_2, \dots f_{N_T}$ and N_R receivers intercept the Doppler-shifted versions of these frequencies because of the target motion. Each receiver can measure N_T radiated frequency and each transmitted frequency can be separated in the receiver sites. The general system geometry can be seen in Fig. 1.a, and in Fig. 1.b bistatic geometry can be seen for one transmitter-receiver pair.