PHASED MIMO RADAR IN HOSTILE ENVIRONMENT

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Doctor of Philosophy

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Abstract

Advanced signal processing algorithms and advanced antenna designs are the main target areas for modern communication and radar system designers. Engineers are mainly working in these two key areas to serve the society better. Single antenna systems has been reformed towards multi-antenna systems.Use of multiple antenna in modern system, improves SNR capacity, serve multiple users, increase data capacity and do many more. MIMO and array are commonly used in for communication and radar to get the advantages of multiantenna technique . But both the system is suffering by some disadvantages, MIMO is suffering by the coherent processing gain, and array is suffering by the diversity gain. Uses of both the gain in favor of radar system can improve the performance of the radar system.

The Phased MIMO technology is one of the recent trends in multi-antenna research which enjoys the benefits of two latest technologies like MIMO and Phased Array. Advantage of diversity gain of MIMO and advantage of coherent processing gain of Phase array systems are targeted to combine into a single platform which is known as Phased MIMO System. Multiple antenna arrays are allowed to overlap to generate multiple beams from array system. This is the key design consideration of Phased MIMO system. The Phased Array system is divided into numbers of subarray, each subarray is assigned to coherently transmit or receive an orthogonal waveform. By designing weight vectors for each subarray, a beam can be formed in a specific direction. Each subarray beam combinely creates MIMO effect over space. Array beamforming is used to scan an area without any mechanical parts, physically moving the antenna. The advantage of very high array's gain within the beam leads to improved detection . The control of array antenna allows a very fast switch from one target to another which helps to perform tracking operation of multiple targets. Proposed Phased MIMO Radar is designed using LCMV and MVDR adaptive beamforming technique, a comparative analysis is presented and simulated results is also shown for corresponding beam pattern. Two well-known bemforming algorithms namely, LCMV and MVDR are applied separately in favor of Phased MIMO Radar, and performance is analyzed in respect to array pattern response. In case of ground-based target detection using radar, surface clutter is more prominent as it will take returns from ground or sea surfaces. To combat with radar clutter Phased MIMO radar is equipped with multi-antenna and advance signal processing algorithms which can improve target detection. Diversity gain and coherence processing gain together can perform well in low SNR condition which is more expected in hostile environment, like vehicular. So, objective of the thesis is to design a Phased MIMO radar which can work under vehicular hostile environment.

Contribution of the work is divided into two part, 1st is simulation of the system and then hardware design. End to end simulation design of multi-antenna based radar is done under vehicular hostile environment, considering autonomous vehicular applications. Different beam forming algorithms are tested for Phased MIMO radar, performance of the same has been evaluated under land clutter and sea clutter environment which is considered as critical hostile environment.

Finally the hardware development of multi-antenna based Phased MIMO Radar technique is targeted under this research. The Phased MIMO radar development is divided into few development stages. Firstly digital single board spread spectrum radar is under development. Here programmable and re-configurable radio architecture or radio protocol is the minimal need for today's radar system. Software-Defined Radio (SDR) is one of the good solutions in which radio protocol could be reprogrammed through software. WARP SDR has been used for digital radar development. Then under next stage multi-antenna techniques are added with digital baseband. MIMO mode is explored using horn antennas. Further two microstrip patch array antennas with 2x2 elements are designed and developed to implement the phased MIMO radar configuration. A Phased MIMO radar hardware developed for target characterization in static environment and also the results are compared with conventional radar.

Finally author has achieved few things under this thesis, some of important achievements are: Design of digital radar baseband which helps to introduce pulsed compression technique in favor of radar. This digital radar is enriched with multi-antenna technique. Diversity gain of MIMO radar and coherent processing gain of Phased array radar is integrated into a single system, and a Phased MIMO hardware is designed and developed for target detection, characterization and imaging.