Title: Antenna Array Design and Processing for Super-resolution Imaging Radar

This invention generally relates to antenna array design, including both 1D and 2D arrays, and angle estimation method in super-resolution imaging radar systems that requires less array elements, less computation complexity and yet higher resolution.

In this patent, novel array design and signal processing methods are presented in order to achieve 2D high resolution with compact array form factor, less antenna elements and efficient computation. The array configuration invented in this patent is a hybrid sparse and dense array and each of them has uniform array structure so that efficient computation can be exploited.

The major difficulty is how to design an array consisting of both uniform sparse array and uniform dense array and at the same time make use of both sparse array and dense array to achieve high resolution with efficient computation. We overcome this difficult by coming up with a new array configuration, i.e., hybrid array, and signal processing algorithm for DOA estimation tailored to this new array configuration. In short, we jointly design the array configuration and the signal processing algorithm so that high resolution and high accuracy of the array can be obtained with less antenna elements and lower computational complexity.

The main problem solved in this invention is to improve the resolution of the antenna array in MIMO radar while keeping the complexity of antenna array and signal processing reduced. In our invention, we designed the MIMO radar array jointly with the efficient signal processing algorithms. Thus, our invention is able to operate with sparse array that has much better angular resolution and smaller number of antenna elements than the dense arrays in the existing inventions.

This invention presents a new sparse array design and signal processing method to achieve high resolution 2D DOA estimation in radar. The invention designs hybrid sparse array in azimuth and elevation so that high resolution can be achieved with less number of antenna elements. Meanwhile, the unique array design is paired with efficient signal processing algorithm that estimates the azimuth and elevation without ambiguity. In short, this invention codesigns the array configuration and the signal processing algorithm to meet the requirements on high resolution performance and low complexity for 2D DOA estimation.

The invention can be applied to MIMO radar system for vehicles. The invention can also be used in other fields such as conventional phased array radar and MIMO radar in the airborne, spaceborne, and ground-based and ship-based applications. Moreover, this invention can also be applied to general active sensors with sensor arrays for improved angular resolution.

Figures included in the patent:

Figure-1: Radar system architecture

Figure-2: (a) Uniform Linear Array(ULA) of half wavelength spacing with 24 elements, *d* is half wavelength; (b) MIMO radar that achieves equivalent 24-element ULA with four transmitters and six receivers.

Figure-3 (a) MIMO radar with 4 Tx antennas and 6 Rx antennas; (b) the virtual MIMO array of (a); (c) General configuration of array in (b).

Figure-4: 2D generalization of the design in Figure-3.

Figure-5 General signal processing flowchart

Figure-6: 1D DOA estimation

Figure-7: 2D DOA estimation