MIRA-CLE X: A new Imaging MIMO-Radar for Multi-Purpose Applications

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***Abstract*—The research field of MIMO radar offers a bunch of new opportunities for various applications. Imaging MIMO radars can be used as a significant supplement to usual SAR and phased array radars and can extend the common applications for radar. MIRA-CLE X is an X-band MIMO radar consisting of 16 transmit and 14 receive antennas. During signal processing, 224 virtual antenna elements are generated to enable 2D radar imaging. This paper presents the radar system, the signal processing approach as well as a detailed analysis of first imaging results.**

I. Imaging MIMO Radar

While SAR systems need an aspect angle change of the sensor in order to generate a radar image (usually achieved by the motion of the sensor), phased array systems can be used also stationary without any motion by using beamforming techniques. However, in order to reach a reasonable spatial resolution together with an adequate image quality, the phased array has to be quite large and the distances between the elements of the array have to be close to $\lambda/2$ (λ is the radar wavelength). This results in a large number of single antenna elements which increases the cost and the weight of the radar.

Imaging MIMO radars use colocated transmit and receive antennas which are arranged as a highly sparse array [1] [2] [3] [4]. A fully distributed virtual antenna array can be synthesized during signal processing if the real antennas are arranged in a special and optimized way. One possible arrangement is shown in Fig. 1.

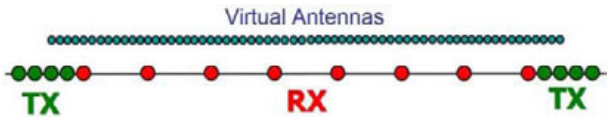

Fig. 1. Antenna distribution for an imaging MIMO radar.

With this MIMO approach, only a fraction of the antenna number of a comparable phased array system is needed. These cost efficient and light imaging MIMO radars open the door to new and promising applications, like a continuous 24/7 environmental monitoring of high risk areas for avalanche and land slide forecast. Mobile devices for relief organizations, fire fighters, and emergency services can become life saving devices for search and rescue operations.

This paper presents the imaging MIMO radar MIRA-CLE X which operates in X-band and uses 16 transmit and 14 receive antenna elements (Fig. 2). During signal processing, 224 virtual antennas are generated.

TABLE I
Azimuth Resolution of MIRA-CLE X

Distance [m]	Azimuth Resolution [m]
50	0.39
100	0.78
200	1.57
400	3.13

Fig. 2. Photo of the MIMO radar MIRA-CLE X during a test campaign.

II. System Specifications

The experimental setup of MIRA-CLE X is quite cost-efficient, has a simple construction and can be easily used for larger distances by substituting more powerful amplifiers. The spatial resolution in azimuth results from the angular resolution of the whole virtual antenna array:

$$\delta y \approx R\frac{\lambda}{2l_y} \tag{1}$$

l_y is the size of the virtual antenna array in y direction (Fig. 3). The azimuth resolution of MIRA-CLE X for different ranges is given in Table I.