

SYNTHESIS OF RADIO IMAGES BY MICROWAVE PHOTONICS METHODS

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The radio vision is the most promising method for the maximum possible information about objects to obtain. Below are the basic methods for image synthesis by means of the radio vision:

1. Method of holography. The reference microwave signal is added to the microwave echo signal and then the intensity of an interference pattern is measured and digitized. After digital processing, the image of the object is reconstructed.
2. A method for determining the amplitude-phase distribution in the receiving antenna opening and obtaining an image of the object after digital data processing.
3. The inverse synthetic aperture radar (ISAR) method. This method uses versatile signal processing technique rather than large aperture antennas to identify and reconstruct a moving target.
4. The MIMO (multiple inputs, multiple outputs) method based on distributed radar network.

For all methods, the microwave photonics technology provides a great resolution improvement over the traditional electronic one. The application of ISAR and MIMO methods implemented with microwave photonics technology is studied in detail in [1]. Below, reconstruction of an object using the holography and the amplitude-phase distribution measurement methods realized with microwave photonics is considered.

To form a hologram or measure the amplitude-phase distribution, the signal from each element of the radar phased antenna array (PAA) is fed for modulation to the input port of one arm of a dual-parallel Mach-Zehnder modulator, and a reference microwave signal is fed to the input port of the second arm. At the output of the modulator, the sum of two optical fields is formed, and each is modulated by its own signal. As a result, the signal after photodetector is determined by the interference of the echo wave field at the location of the PAA element and the reference wave, i.e. it is an element of the radio hologram. By measuring such elements of the radio hologram over the entire aperture of the PAA and digitizing them, it is possible to obtain an array of data describing the complete radio hologram. The radio image of an object can be synthesized after performing a fast Fourier transform. Similarly, the amplitude-phase distribution of the echo signal can be obtained using an additional intensity measurement at the output of the low-noise amplifier after each PAA element.

The image reconstruction procedure may require significant computing resources. In this case, it may be much easier to carry out this procedure in the optical range, since the dimensions of the receiving aperture are significantly smaller and focusing lenses are available for the optical range, providing almost instant Fourier transform and observation of the object image in the focal plane. In addition, a wide range of algorithms, technologies and devices designed for optical images processing can be used. The formation of the corresponding amplitude-phase distribution in the optical region of the spectrum can be carried out by evenly distributing the radiation of the master CV laser in a beam of parallel optical fibers whose outputs in space repeat the configuration of the PAA. A phase modulator and a controlled attenuator are installed in each fiber. These elements are supplied with signals proportional to the values of phases and intensities measured at the output of the photodiodes. A lens is installed near the beam slice, in the focus of which the image of the object is formed. Also, instead of the phase modulators and attenuators, a spatial light modulator can be used.

Our measurements of the phase differences and the intensities for the reference and reflected signals in the X range confirmed the effectiveness of the developed techniques, which allows us to proceed in future to the formation of radio images of complex objects.

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[1] J. Dong et al. Photonics-enabled distributed MIMO radar for high-resolution 3D imaging, *Photonics Research*, vol. 10, pp. 1679-1688, (2022).