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Phase information as a basis for wave vision of technical systems

Abstract of Dissertation PhD
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The work is devoted to the problem of obtaining images using waves, primarily radio and ultrasonic nature, which doesn't carry images. Images can be obtained by using phase of the signal which reflected or scattered from object. Theoretical and experimental result shows that phase information from reflected object is more sensitive, to reconstruct the images, this includes to obtaining their 3D tomography.

Three measurement proposals are considered in this paper, which can be used to extract their phase information from scattered objects.

The first is a classical scheme of direct conversion, in which the transmitter signal is used as a reference for heterodyning. Heterodyne multiplies two signals; one is from reflected object other is reference signal. This produces two set of frequency signals low-high, which further filtered the low frequency components. This signal is nothing but amplitude multiplied by cosines of its phase. In experiment, this scheme is implemented in a standard high-frequency displacement sensor RSM 2650, operating at a frequency of 24 GHz. This scheme is applicable to construct the systems in secret screening of passengers at airports. The results are shown in experimental and theoretically.

The second proposal contains two-stages. First, the high frequency is partially lowered to the level which makes direct digitization of the sampling the signal. In experiment, this situation occurs when using ultrasonic sensing (MA40S4S) at a frequency of 41 kHz. The frequency of heterodyne is set to 40 kHz. In this case, the difference frequency is equal to 1 kHz, which makes it possible to use almost any analog-to-digital converters (ADCS) for digitizing the signal. This digitalized signal contains two quadratures components, but it's sufficient to extract only one of its quadrature components from signal, this further simplifies complexity of system. This technique can be applicable in multidimensional array of sensor system for example, in road surfaces scanner and radio holography. This has implemented both experimental and theoretically.

The third scheme does not use heterodyning techniques. It simply measures the intensity of received signal; this is nothing but reflected signal from object and sum of its reference signal, i.e. the interference field of these two waves. If reference signal are more dominant, than one of its quadratures components can be used to record its

intensity. This technique can be preferable in unmanned aerial vehicles to obtain radio-wave images of earth. This result has shown in theoretical.

Synthesis method plays important role to obtain images by using quadrature components which uses multidimensional consistent filtering to scan data in spatial domain. And this system uses basic Green's Function which describing the reaction on point object. Because of consistent filtration method, the system allows to use, fast algorithms for example Fourier Transform. Experimental result shows that, one of its quadrature components is sufficient to obtain quality images. This ideal has implemented both theoretical and practical.

When transmitter is probed at absorbing media (skin layer), it has known that skin layer will prevents the penetration of radio-waves, but only at certain distance. This distance is determined by the boundary of near zone in background medium and significantly depends on the frequency of waves. Here it's shown that, amplitude of the signal has very less role, but phase information from the reflected object can be used to reconstruct the images (reflected object). And furthermore, it is sufficient to move skin layer to sense an object by frequency scanning and focusing the radiation on it by the known migration method which results to implements idea of synthesizing a large aperture. This has implemented only in theoretical.

The following provisions to be defended:

1. Phase information is the basis for obtaining wave images in technical vision system (radar), while measuring at each observation point, one of its quadrature components is sufficient, from the reflected field.

2. In the absence of direct phase measurements, possibility to restore the quadrature component from the reflected wave is, to register its intensity of interference field from the wave, with a significantly dominant field.

3. To reconstruct images of an object in absorbing media, the necessary condition is to analyze the phase structure of its secondary field during spatial movement; of skin layer to the object by frequency scanning.