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GEOMETRICAL OPTIMIZATION OF MULTIDETECTOR ULTRASONIC PROPAGATION SENSOR FOR OBJECT RECOGNITION IN AIR

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ABSTRACT

The paper analyzes the geometrical problems in optimization of multidetector ultrasonic propagation sensors designed to object recognitions in air. The details of the designed system will be presented.

INTRODUCTION

Ultrasonic systems with multidetector and/or multisource field transducers have been applied for many years in underwater remote sensing, as well in medicine tomographic systems. Geometry of ultrasonic transducer array systems were succesfully optimized [1], leading to many excellent commercial systems.

Recently researchers have published many new theoretical methods for array design[2-5], or for individual transducers design [6-9]. Relatively new application of such systems, working in air, are now developed [10-12], mainly for remote recognition of objects by mobile robots, or industrial robots.

The geometry of transducers and arrays need be quite different while working in air because of many specific problems:

- fluctations of propagation media in time ;
- inhomogenity of propagation media;
- lack of ultrasonic transducer materials allowing acoustic impedance broadband matching;
- strong mutual disturbancies of individual transducers inside complex array, resulting from low energy transduction what requires high amplifications of the received signals.

This work have regarded some problems of geometrical optimization of the piezoceramic transducers, array, and signals in the system we designed for application at industrial robots.

THE ELECTRONIC SYSTEM FOR REMOTE OBJECT RECOGNITION BY ULTRASONIC WAVES

We have designed two remote ultrasonic systems working in the air:
A/ system for multipoint distance measuring;
B/ system for object surface recognition by holographic processing of the reflecting waves at linearly situated array of ultrasonic waves detectors.

The system (A) is aimed to measure multipoint distance to the nearest reflecting part of the objects placed on movable industrial transporter. The transporter is placed at distance range 0.5 meter from

ultrasonic transducers of the plain array. The source/detecting transducers of ultrasonic waves were made of piezoceramic materials, unabling conversion of electric voltage into ultrasonic waves and vice versa. The multipoint distance measuring at relatively short time of about 5 miliseconds unables identification of the orientation and dimensions of paralellipided objects placed on the transporter with spatial resolution of 0.5 cm. For that reason we used 40 pair of input/output transducers, placed at regular net of 4x10 array. Every pair have measured the distance to the nearest part of the reflective object. The measuring net created by one linear set of 10 pairs of input/ output transducers was translated by 0.5 cm for the every next linear sets in relation to the previous one. The mutual distances of the individual pairs and the four linear sets were designed and optimized to avoid the falsive decisions during the system operation.

The system (B) is aimed to object surface shapes recognition by analysis of reflective ultrasonic waves signals received by piezoceramic transducers with using well known theoretical models [5] of holographic projection, unabling remote identification of objects.

The design of the systems obey the time shape of the input electric signal. We have used complex input voltage signals with rectangular envelope with monochromatic and/or linearly modulated carriers. Such signals allow us to obtain better signal/noise relations after proper compression of the received signal of the returned waves.

The geometry of arrays for systems (A) and (B) were optimized, taking into account the following problems:

- effect of the directivity characteristics of the individual transducers on the array directivity;
- effect of the relative spatial positions of the transducers on the array properties;
- effect of the frequency characteristics of the transducers on the array system properties;
- effect of the applied input/output signal protocol on the error resistance of the multidector system;
- optimization of the applied ultrasonic piezoceramic/air transducers;

The optimizations were done for objective functions/tasks resulting from the systems applications. The details of the systems design and optimization processes will be presented during the Symposium.

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