Three-dimensional Measured Ultrasound Field

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Abstract *This article describes a three-dimensional representation of the ultrasound pressure distribution in a space. This will be used for classifying the field and for a determination of the ultrasound intensity. There was realized a software for processing and 3D representation of the measured ultrasound field. The data are acquired by scan of a space in an ultrasonic tank with a hydrophone.*

1. Introduction

The unique ultrasound measuring system was designed and realized to verify theoretical premises and model studies of a radiation of an ultrasonic (us) probes. The system contains an ultrasonic tank, a hydrophone and a control computer. It is used to check the radiation characteristic of elementary transducers and systems of ultrasonic probes too. The measuring proceeds in a water bath of the ultrasonic tank. There is hydrophone MH28-5 used for a scanning of an acoustic pressure generated by the us probe. This probe which generates us field has stationary position, vice versa hydrophone is fixed to position system. It allows a movement at three orthogonal directions. During measuring, the three-dimensional scanning of a tank space is performed. Acoustic signal from the hydrophone is amplified and sequentially sampled by the measuring card located inside the control computer. The control of hydrophone position system is supported by the control computer. The communication of the position system with control computer goes on a CAN bus.

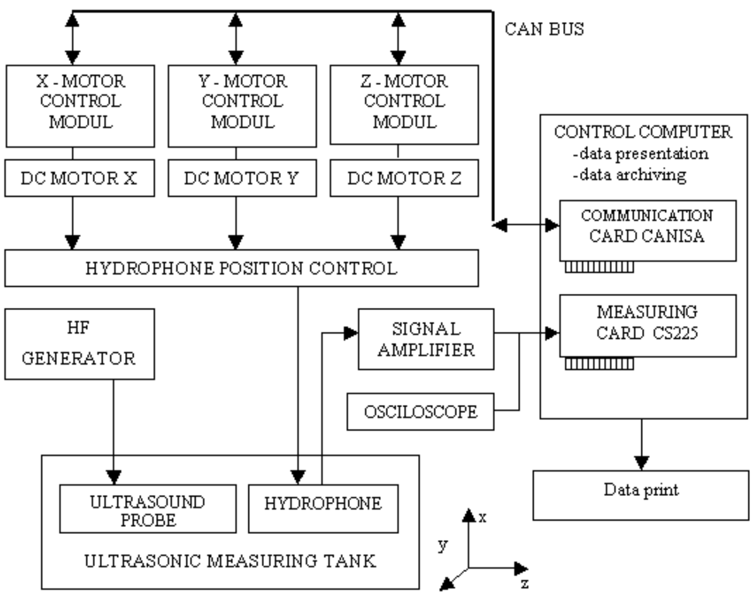


Fig. 1: *Block diagram of the ultrasound measuring system*

2. Ultrasonic PROBES

The quality of ultrasonic diagnostic applications are mainly depends on the properties of ultrasound (us) probes. There are different types of us probes used in pulse-echo imaging methods. The physical scanning process can be effected in two basic ways. Either by actual movement of a transducer having a fixed beam axis, or by electronically controlled movement of the beam axis relative to a transducer array. The former category is obsolete and an ultrasound beam steering was usually realized by a scanning arm or a rotating wheel, also a beam focusing was mechanically performed by placing an acoustic lens on the surface of the transducer or using a transducer with a concave face. These types were replaced with the latter category, which includes so-called linear and phased multi-element transducer arrays. Principles of ultrasound beam steering and focusing are directed by sequentially stimulating each element. This feature creates the sector scan by rapidly steering the beam from left to right to give the two dimensional cross sectional image.

The measuring system acquires data of pressure characteristic at each point of the required space. The centre of interest is concentrated to focal zone where are often highest values of positive, negative pressure respectively.

3. Visualization AND PROCESS OF MEASURING DATA

There were measured several ultrasonic diagnostic systems for an experimental examination of the ultrasound measuring system, such as:

I. ADR 4000 3.5MHz linear probe with scanning arm,

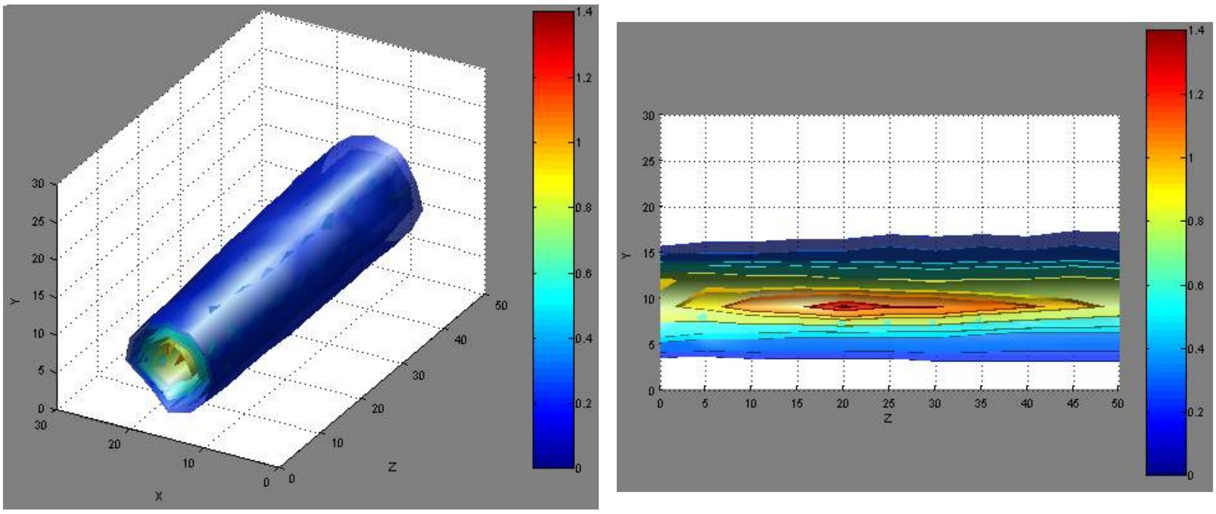
II. SonoSite 180 Plus, microconvex wideband probe (C15/4-2),

III. GE medical systems SystemFive, 2.5MHz linear wideband phased array (128el/19mm).

Maximum, resp. minimum, voltage measured values are used to visualize ultrasound field with isosurfaces, resp. isolines. A gradient of an alternation is presented by a different distance of individual isosurfaces. Colour scale describes a level of a measured voltage that is proportional to a pressure. The software allows to change many parameters of visualization such as an elevation, an azimuth, direction of light, type of projection, a count of isosurfaces eventually count of planes of isolines etc.

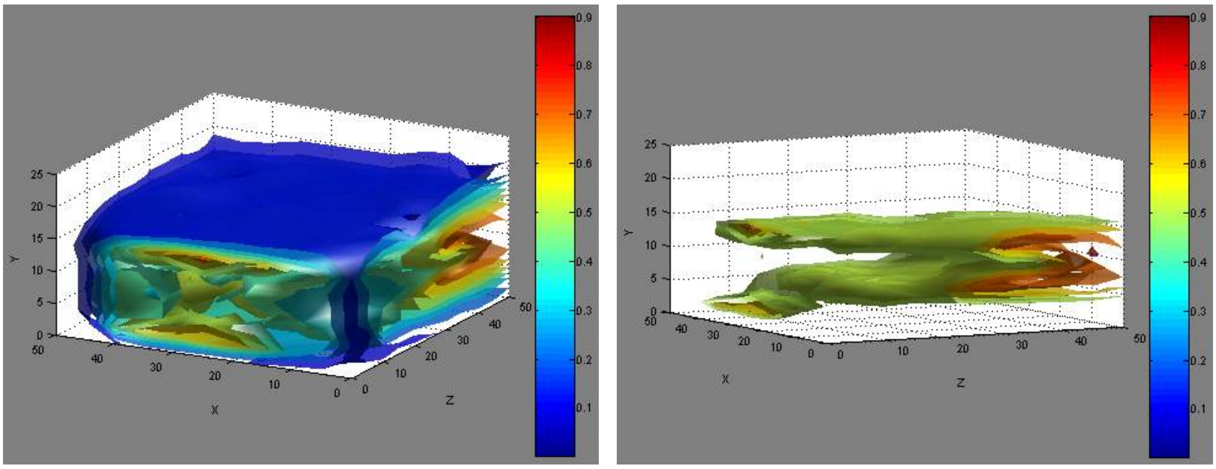
The measured field was 1 cm far from a head of probes and a number of measuring points were 11 at every axis. The distance between two points was 3 mm at X, Y axis and 5 mm at Z axis for ADR system. For the others, there was the distance 5 mm at X, Z axes and 2.5 mm at Y axes. Dimension of spatial axes is in millimetres.

Following figures are showing 3D representation of ultrasound fields of three different probes from both above-mentioned categories. Fig. 2 represents a simple round transducer without the motion and mechanically focused to point, for the reason that the graph is axially symmetric, (fig.2a), and there is the clear point of a focusation at the distance 3 cm from a head of a probe, (fig.2b). Fig. 3 and 4 represent a category of multi-element arrays. The array of elements of microconvex probe is curved with a certain radius, what can be seen on wide opened global view, fig.3a. It is possible to reduce number of isosurfaces in a graph. It is useful to uncover isosurfaces with higher pressure value. There are two main lobes manifested in fig.3b and hence this probe's array has probably two rows of elements to get higher depth of focusation. Maximum value of depth attributed by SonoSite is 24.6 cm.



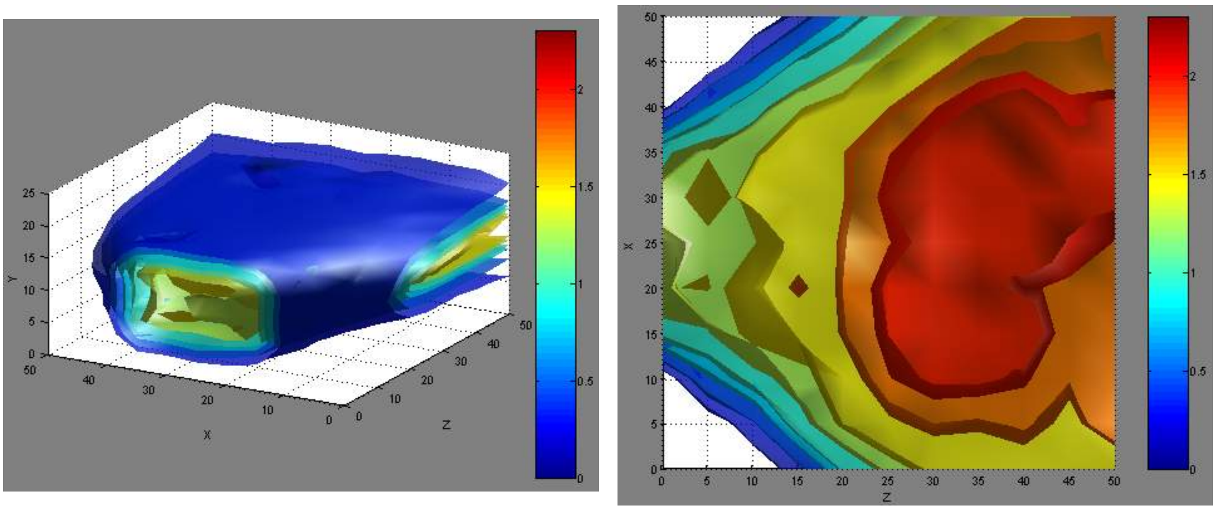
a) *b)*

Fig. 2: *3.5MHz linear probe in TM mode: a) global view, b) cross-section.*



a) *b)*

Fig. 3: *Microconvex probe C15/4-2: a) global view, b) view of lower-bounded isosurfaces*



a) *b)*

Fig. 4: *2.5MHz linear wideband probe: a) global view, b) longitudinal section.*

Figure 4 shows the pressure distribution of linear probe. There is evidently smaller angle of a scanning sector than of the microconvex probe even so the length of the array is longer by 4 mm. From wave interference conditions and division of zones (fresnel, focal, fraunhoffer), it can be supposed that the area, in fig. 4b, with the highest pressure distribution, can be called a focal zone.

Conclusions

In this article, there is described a 3D representation of the ultrasound field. Experimentally, there were measured fields generated by three ultrasonic probes of different ultrasonic diagnostic system in a pulse mode and were found their characteristic properties. Three-dimensional representation in built-up software gives more interactive and complex view of ultrasound maps. Results of a further research certainly contribute to sanitary standards specification of ultrasound diagnostics.

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