ULTRASOUND SPIRAL CT FOR THE FEMALE BREAST
FIRST PHANTOM IMAGING RESULTS

M. Ashfaq, H. Ermert
Lehrstuhl für Hochfrequenztechnik, Ruhr-Universität Bochum

Mohammad.Ashfaq@ruhr-uni-bochum.de

INTRODUCTION
Although the sonographic examination of the female breast has proved to be a useful supplement to x-ray mammography, the conventional ultrasound B-scan often fails to distinguish between healthy and tumorous tissues. In addition, the examination is operator dependent and often not reproducible.

MATERIALS AND METHODS
The propagation of ultrasound through tissue depends on the attenuation and the speed of sound. Clinical studies have clearly shown the usefulness of the parameters speed of sound and tissue attenuation [1], if they can be imaged with a suitable spatial resolution. In the past two decades certain tomographical techniques have already been introduced for the measurement of those two parameters. The clinical applicability of these techniques was, however, extremely limited due to the fact that they either used some elaborate and dedicated measuring systems [3], [4] or their spatial resolution was too poor to be useful[2].

We introduce a new tomographic concept for the reconstruction of the tissue attenuation and the speed of sound. The data acquisition is carried out with a commercially available ultrasound scanner coupled with a specially designed applicator, whose construction is based on that of a customary Spiral-CT. The speed of sound and the tissue attenuation are reconstructed with the help of a subsequent data processing in addition to regular echosonographic B-scans. The specially designed applicator allows a three dimensional registration of the female breast. The spatial resolution could be improved with the help of the spiral-CT method chosen here. In addition, the applicator is so constructed that, that it may easily be used in conjunction with customary ultrasound tranceducers, which significantly facilitates its clinical use.

The acquisition of the RF data is carried out with the help of a customary ultrasound system which allows access to its raw and image data via a telnet connection with an external PC. The control of stepping motors and the data acquisition is synchronised using a specially developed software. The speed of sound and the tissue attenuation are reconstructed from the acquired data using the method of filtered back projection [5].
RESULTS:
A 3% agar-agar phantom, as shown in Figure 2, was used for the experimental study of the concept presented above. The phantom used here is of cylindrical shape with a diameter of 6.4 cm. Oil was filled in the two cylindrical holes of diameters 1.3 cm and 0.6 cm, to create a non-uniformity for the speed of sound and for attenuation. The phantom was placed in a water bath resting on its base. The ultrasound transducer travelled along a part of the spiral trajectory, also inside the water bath, so that it completed 180° in steps of 0.9° around the cylinder and moved 1 cm along the cylinder in the vertical direction in steps of 0.05 mm. A B-scan was taken during each step. The echo from the metallic plate was used to estimate the time of flight profiles for each measurement. One of the tomograms portraying the speed of sound distribution is shown in Figure 3. A similar approach was applied to calculate the attenuation-tomograms. The amplitude of the echo from the metallic plate was used to calculate the attenuation profiles through the phantom in comparison with a similar measurement taken without the phantom. Figure 4 shows the difference of the attenuation from its average value, which in turn is set to a value of zero in grey scale. The complete set of measurements took about 20 minutes, the data acquisition system is however being optimised to minimize the data acquisition time to practical limits. The B-scan RF-data from the ultrasound system was transferred to a PC for the calculation of the tomograms.

CONCLUSIONS:
The phantom studies clearly show that the speed of sound and the attenuation can be reconstructed using the concept presented here. The speed of sound of the non-uniformity (oil) comes out to be about 1565 m/s, and that for the phantom background to be about 1525 m/s. The attenuation of the liquid in the cylindrical holes is about 0.3 dB / mm higher than that of the background. A better spatial resolution can be achieved with a larger number of projections and thinner slices.

The ultimate goal of this study is to apply the concept to the female breast in vivo. Previous clinical studies have shown that the speed of sound and the tissue-attenuation can contribute decisively to the tissue characterization of the female breast [1]. The major advantage of the technique presented here is its capability to reconstruct these parameters with an adequately good accuracy and spatial resolution in three dimensions and to have 3D B-scan information available as well.

LITERATURE