ULTRASOUND SPIRAL COMPUTED TOMOGRAPHY FOR DIFFERENTIAL DIAGNOSIS OF FEMALE BREAST: SOME PHANTOM RESULTS.

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INTRODUCTION

The early detection of breast carcinoma is one of the major diagnostic challenges of the western world. Mammography is the only established screening method, which in addition to having hazardous ionizing effects of the x-rays shows a limited diagnostic accuracy. Quite frequently a differential diagnosis is carried out on the basis of the conventional ultrasonic B-scan prior to a biopsy or an operation. The morphological examination of the breast based on the B-scan often fails to differentiate between tumours and healthy tissue, because of the similar backscattering properties of the two tissue types. Moreover, the result of such an echosonographic investigation depends on the skill and experience of the examiner in addition to being often not reproducible. In contrast to the qualitative nature of the B-scan, there are quantitatively detectable tissue parameters, acoustic attenuation and speed of sound, whose histological relevance for breast tissue has been proven in clinical studies [1]. The two parameters can not, however, be extracted alone with echosonography. This is only possible under certain anatomical conditions in transmission mode, e.g. by means of computed tomography with ultrasonic waves. Several research groups have proposed transmission tomographic systems for the reconstruction of the two tissue parameters in 70's and 80's [3][4]. The major impediment to an intensive clinical application of the propounded techniques was their complex measuring system and the cumbersome mechanical setup on one hand and the inadequate spatial resolution of the reconstructed parameters on the other hand [2]. A new tomographic concept for the reconstruction of the tissue attenuation and the speed of sound is introduced here. The data acquisition is carried out with the help of a commercial ultrasound system and a specially designed applicator, whose construction is based on that of a conventional spiral CT. The two parameters are reconstructed by means of the established techniques of computed tomography. The special applicator enables a three dimensional registration of the whole female breast due to the spiral computed tomography technique. In addition, the applicator is conceived in such a way that it may be used in conjunction with any standard ultrasound transducer. This would facilitate the clinical use of the proposed technique in addition to supplying the normal echosonographic images for further processing. The results of the phantom studies are presented. An *in vivo* validation of the suggested system is planned.

MATERIALS AND METHODS

The applicator used here is schematically shown in Fig. 1. It consists of a mounting bracket for the ultrasound transducer and a metallic reflector. The organ to be examined is placed between the mounted ultrasound transducer and the reflector in a water tank. This mechanical setup is driven with the help of two stepping motors so that the ultrasound transducer and the reflector describe a spiral trajectory.

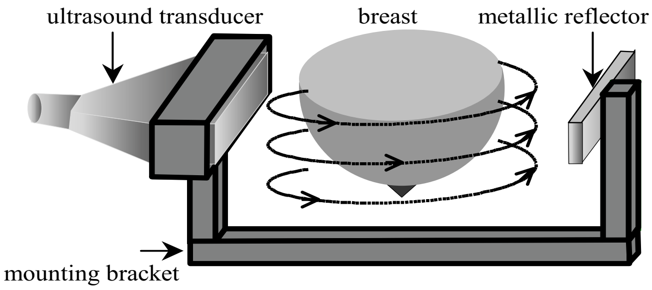

Fig. 1: schematic diagram of the applicator.

A 7.5 MHz ultrasound transducer of a commercial ultrasound system is used for the acquisition of RF data. The ultrasound system allows access to its raw and image data via TCP/IP from an external PC. The control of stepping motors and the data acquisition is synchronized by means of a specially developed software. The speed of sound and the tissue attenuation are reconstructed from the acquired data employing the well known spiral CT techniques [5]. A 3% agar-agar phantom of cylindrical shape with a diameter of 6.4 cm, as shown in Fig. 2, was used for the experimental study of the concept presented here. Oil was filled in the two cylindrical holes of diameters 1.3 cm and 0.6 cm, to create a non-uniformity for speed of sound and for attenuation. The phantom was placed in a water tank resting on its base. The ultrasound transducer traveled along a part of the spiral trajectory, also inside the water tank, in such a way that it completed each of 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 Fig. 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

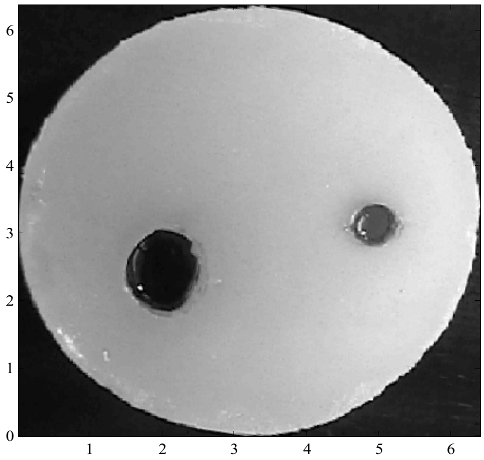

Fig. 2: agar-agar phantom

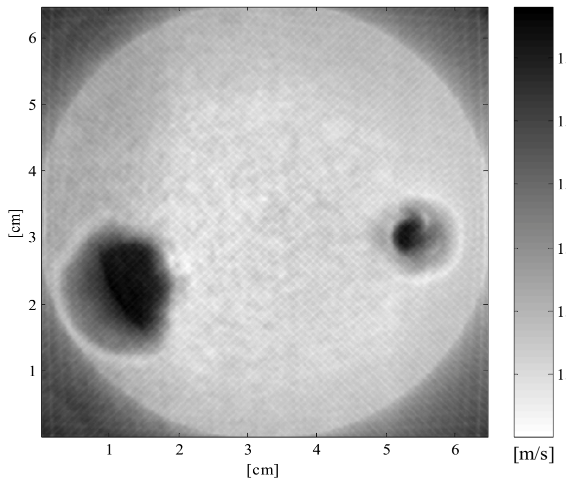

Fig. 3: speed of sound distribution in phantom

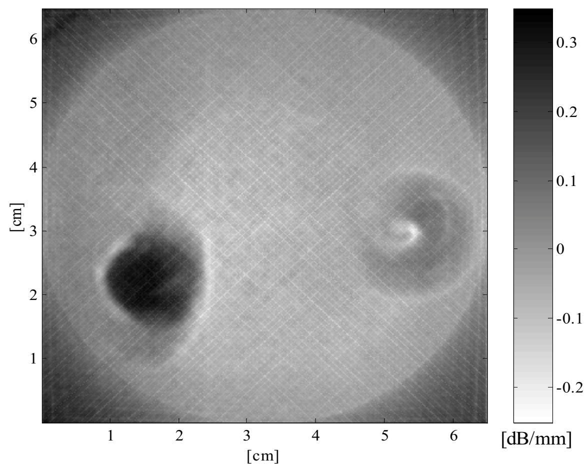

Fig. 4: attenuation distribution in phantom

comparison with a similar measurement taken without the phantom. Fig. 4 shows the difference of the attenuation from its average value, which in turn is set to a value of zero in gray scale. The complete set of measurements took about 20 minutes, the data acquisition system is however being optimized to minimize the data acquisition time to practical limits.

CONCLUSIONS

The phantom studies show the feasibility of the concept presented here. The average difference between the speed of sound through the non-uniformity (oil) and through agar-agar comes out to be about 60 m/s. The attenuation of the liquid in the cylindrical holes is about 0.3 dB / mm higher than that of the background. These ranges correspond to the published data for healthy breast tissue and breast carcinoma [6] which shows the potential of the concept for a clinical application. The transducer frequency for the phantom studies was 7.5 MHz. There is still some room for the improvement of the achieved spatial resolution at this frequency, if the larger number of projections and thinner slices are chosen. Some of the major advantages of the technique presented here are its capability to reconstruct the acoustic parameters with an adequately good accuracy and spatial resolution in three dimensions and to have 3D B-scan information available as well. The latter may further be processed to perform compounding.

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