# Freehand 3D/4D Ultrasound: Extending existing U/S devices

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3D ultrasound is the extension of 2D ultrasound to the third dimension. In case of acquiring heat motion, we speak about 4D (3 spatial and one temporal dimension). Our 3D/4D approach uses a 2D transducer in a free-scan technique where the transducer movement (performed by the physician) is measured by an additional tracking device. Freehand acquisition requires no intervention in the ultrasound devices and is therefore an upgrade possibility for nearly every conventional 2D device.

## Material and Methods

The video output of the conventional ultrasound device is connected with the frame grabber card in the PC. During data acquisition all B-scan images visible on the monitor of the ultrasound device are digitised by the frame grabber (25Hz, PAL, Fig 1). Simultaneously a magnetic tracking device attached to the probe (Fig 2) acquires the spatial position and orientation of the ultrasound transducer. The receiver has the size and weight of a sugar cube and therefore does not influence in any way the movement of the transducer and the freedom or the usual working procedure of the physician. The recording step is completed within ca. 10 seconds.

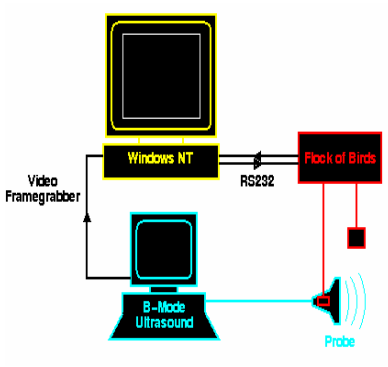


Fig.1: Hardware Parts of the 3D-US Acquisition

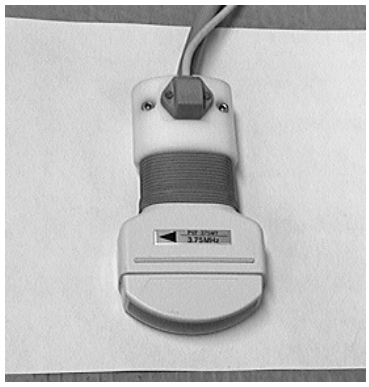

Fig.2: Mounting the receiver on the transducer.

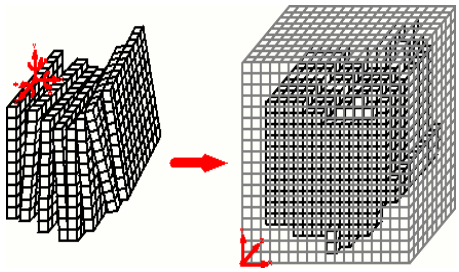

Fig.3: Resampling principle.

The second step after the recording of the image sequence is the conversion (*Resampling)* of the arbitrarily oriented images into a regular volume data set (Fig 3). The software allows a very comfortable and especially fast generation of 3D images from volume data. In addition, tools for processing 'noisy' ultrasound data are included as well. The latest version supports also visualisation of dynamic sequences of the heart. By means of an ECG trigger, the image storage is synchronised with the heartbeat (Fig 4). Our software is capable of rendering any desired combination of anatomic or flow information (Fig 7, 8).

## Results

The current implementation runs on usual Windows PCs, parallelised versions employing several processors are available as well.The described method has been applied in numerous areas of medicine and with several U/S device suppliers. In general, after a short period of training the physician gets accustomed with the rules for acquiring good quality U/S images.

Fig. 5 shows 3D reconstruction of liver vessels in B-mode and Angio-mode. Figure 5 shows an unborn baby acquired endovaginally in the 11$^{th}$ week of pregnancy. Other application areas include urology, orthopaedics, opthalmology etc.

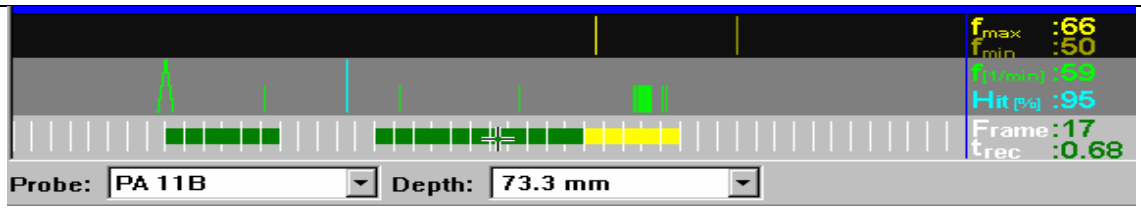


Fig 4: User interface for selecting video-frames within the ECG-cycle

Fig 5: 3D Reconstruction of vessels in B-mode (left) and Angio-mode (middle, right) showing liver vessels and vascularisation around a carotis tumour

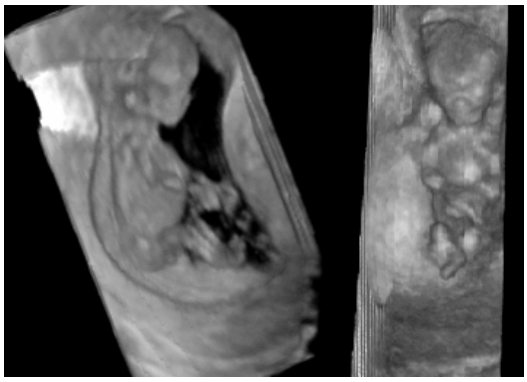

Fig 6: Endovaginal scans of a foetus in the 11th week

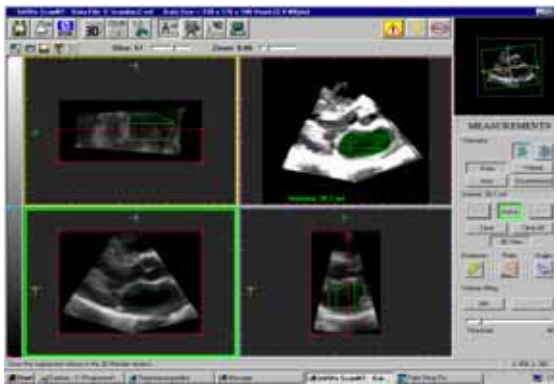

Fig. 7: Volumetry on free-hand cardiac scan

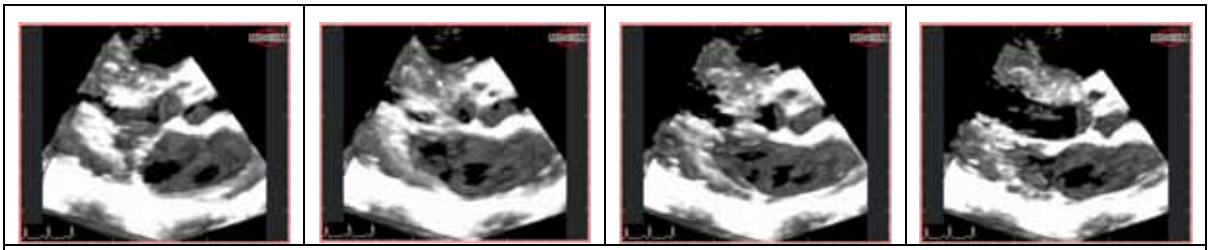

Fig 8: Samples form a dynamic hart sequence showing the movement of the mitric valve