P3G-1

HIGH FREQUENCY LINEAR ARRAY SCANNER FOR
THE IMAGING OF SMALL RODENTS

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Mice are particularly popular as laboratory animals as they are relatively inexpensive to keep and are genetically very similar to humans. This together with the ease with which their genome can be manipulated has led to their increasing use as models of human disease processes. While the full range of imaging techniques can be utilised for imaging the mouse, the heart is particularly challenging as a result of rapid heart rate and required image resolution. Echocardiography is a powerful yet relatively inexpensive technique for cardiac imaging potentially able to address these issues. A real time high frequency linear array scanner coupled with a physiological signal capture package has been developed for the functional study of the mouse heart. This system overcomes the limitations of clinical cardiac ultrasound scanners previously employed for this purpose. A commercially available linear array scanner intended for musculoskeletal imaging (Dynamic Imaging Ltd., Livingston, UK) has been modified to extend the frequency range up to 28MHz and frame rate to 300 frames per second. The physiological signal capture system and a software analysis package enable the display of captured cine-loops and corresponding physiological signals. Over 100 mice have been scanned to date. Investigations underway include comparison of LV function in mice which had undergone coronary artery ligation under general anaesthesia with sham operated animals acting as controls, the application and value of ultrasonic contrast agents and the dependence of functional assessment of the mouse heart on scanning frequency.

P3G-2

TRADE OFF STUDY ON DIFFERENT ENVELOPE DETECTORS FOR B-MODE IMAGING

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Generation of B-mode images involves envelope detection of the reflected RF-signals and a logarithmic compression prior to display. Various detection algorithms are available, but a trade off between performance, price, and complexity will in a given system implementation influence the choice of algorithm. The best (ideal) performance is obtained by using a Hilbert Transform (HT) and a subsequent computation of the absolute value. It represents a pricey and complex solution. A simple and low-cost solution is obtainable with the rectifier, but performance is severely degraded. It introduces incorrect nulls in the envelope, which show up as incorrect black spots in the image. This problem is especially evident, when the transducer is moved during a scan providing dynamic imaging. This study has investigated the possibility of providing a detector with a complexity (and cost) close to the rectifier, while maintaining a performance close to the ideal envelope detector. Two low-cost detectors have been implemented and evaluated on in-vivo data. The first approach is an expansion of the rectifier with a median filter (ERM). The filtering aims at solving the problems of the incorrect black spots. A technique from radars, which generates the absolute value as a weighted combination of the real and imaginary signals, is used in the second detector (RAP). The imaginary signal is generated by a simple 90 degree phase shift of the real signal around the center frequency. The four detectors were evaluated on in-vivo data acquired with a B-K Medical 2102 scanner interfaced to the sampling system RASMINE. A B-K Medical 8801 transducer working at a center frequency of 2.7 MHz was used. The transducer was moved across the liver of a healthy male and 100 images acquired. B-mode images with a 60 dB dynamic range were generated. The root-mean-square (RMS) error relative to the ideal detection and a visual inspection - especially in dynamic imaging - determine performance. RMS errors of 491.4 dB, 19.0 dB, and 2.3 dB are obtained for the rectifier, the ERM, and the RAP, respectively. The two new detectors reduce the problem of black spots significantly, and the image quality is improved evidently. The results show that close to ideal envelope detection is obtainable with a detector, which is less complex and costly.

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P3G-3

MULTI ELEMENT SYNTHETIC APERTURE TRANSMISSION USING A FREQUENCY DIVISION APPROACH

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In synthetic aperture imaging an image is created by a number of single element defocused emissions. A low resolution image is created after every emission and a high resolution image is formed when the entire aperture has been covered. This approach provides a poor SNR, since only one element is used at a time. This paper describes a novel method in which the available spectrum is divided into 2N overlapping subbands. This assures a smooth broadband high resolution
spectrum when combined. The signals are grouped into two subsets in which all signals are fully separable. All elements are excited using one subset at a time. The signals can be separated by matched filtration, and the corresponding information is extracted. The individual element information is hence available in every emission and the method can therefore be used for flow imaging, unlike with Hadamard and Golay coding. This approach increases the SNR by a factor of N, provided that N transmission centers are used and that there is a significant overlap of the signal spectra.

The method has been evaluated using simulations in Field II and measurements on the experimental scanner RASMUS. The image quality is compared to standard synthetic aperture imaging on a single wire phantom using a 1 cycle sinusoid excitation.

A 7 MHz 128 element linear array transducer was simulated. The elements were grouped into 8 virtual elements. The spectrum of the transducer was divided into 16 narrow bands and the resulting point spread function (PSF) was compared to a PSF from the standard approach. Axially the resolution of the frequency division (FD) approach was 0.40 mm (-6dB) and 0.70 mm (-20dB), compared to the standard approach of 0.30 mm (-6dB) and 0.55 mm (-20dB). The lateral resolution of the FD approach was 0.87 mm (-6dB) and 1.64 mm (-20dB), compared to the standard approach of 0.65 mm (-6dB) and 1.34 mm (-20dB). The lateral peak sidelobes were in both cases lower than -40 dB.

The FD RASMUS experiment gave an axial resolution of 0.5 mm (-6dB) and 1.8 mm (-20dB). The lateral resolution was 1.8 mm (-6dB) and 3.2 mm (-20dB). This is to be compared with normal synthetic aperture with axial resolution of 0.3 mm (-6dB) and 0.9 mm (-20dB) and lateral resolution of 1.2 mm (-6dB) and 2.4 mm (-20dB).

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P3G-4

A NEW TECHNIQUE FOR IMPROVED SPATIAL RESOLUTION IN HIGH FRAME RATE COLOR DOPPLER IMAGING

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In ultrasound Color Doppler imaging, a grayscale B-mode image and a Doppler image representing velocities are overlaid to produce a color coded image of e.g. blood flow or myocardial movement. Normally, the B-mode and Doppler images are acquired at the same rate, resulting in trade offs between B-mode image quality and Doppler frame rate. In this work, we present a new scan sequencing technique for Color Doppler imaging, where the B-mode image is acquired at a lower frame rate than the Doppler scan. This is achieved by splitting the B-mode image in subscans which are acquired inbetween multiple
scans of the entire Doppler image. In this way, a full width B-mode image with high spatial resolution is kept while the temporal resolution of the velocity information is increased, all in one recording.

For applications where rapid changes in movement has to be captured, for instance in stress echo examinations using Tissue Velocity Imaging (TVI), it is vital to acquire velocity information at high temporal resolution. The new technique has been implemented in the Vivid7 ultrasound scanner from GE Vingmed Ultrasound. In TVI with a 2.5MHz probe (M3S), a Doppler frame rate of 200 frames per second (fps) or more can be obtained with 75° sector width and 15cm depth. Simultaneously, a B-mode image with premium image quality is acquired at 40-50 fps, sufficient for visual assessment of wall motion. Without the new technique, the frame rate would be a trade off between B-mode image quality and Doppler frame rate with either full quality B-mode at 60-70 fps, or Doppler at 200 fps with poor quality B-mode images. In Color Flow, the new technique can be used to visualize jets at high frame rates while having sharp B-mode images of the valves and surrounding geometry. With only two specific applications mentioned here, the technique has a great potential for adding valuable diagnostic information in many applications of color Doppler imaging.

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RECENT ECHOGRAPHIC IMAGES WITH A 64 ELEMENTS CMUT 1D ARRAY
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The electrostatic capacitive, silicon micro fabricated, ultrasonic transducer (cMUT), developed in the last years, is a new promising alternative to the piezoelectric transducer for echographic probes. The cMUT transducer inherently has a larger bandwidth for immersion application and, because it takes advantage of the well established microelectronic technology it is, potentially, less expensive and gives much more flexibility in the design of complex 1D and 2D arrays than piezoelectric transducers. In perspective, a further advantage of the cMUT is the possibility to be integrated with the front-end electronics on the same silicon wafer. In this paper recent echographic images obtained with a 64-elements cMUT probe are reported. The probe is fabricated using a silicon cMUT array which has a pitch of 0.245 mm, kerf 27 µm, and elevation 14 mm.