Presentation of volunteers images taken „in situ“ with 3D-scan-adapter and 2D-imagers

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Introduction

With equipment for quality control of imagers like a simple mechanical 3D-scan-adapter it is feasible to take the 3D-images at volunteers from liver, breast and other organs. The computer image analyses of taken images offer the possibility of the imager quality assessment or at least to estimate and detect the image deteriorations source.

The 3D-images direct taken on human body (in situ) are as a study very helpful in knowledge improvement for 3D-image processing and image quality judgment. Some of processing potentials and promising solution will be shown in this contribution.

The 3D-images may by taken simple. For plausible and acceptable presentation must be performed by suitable conversion. The planes, perpendicular to each other, must be quickly shown in all depth and lateral directions on the display.

3D-Image presentation

The simplest way to present the 3D-images is to show the natural sequence of normal images. The PC screen is too small to show all images of a sequence simultaneously. The PC allows very fast image exchange. The scrollbar is almost the ideal control object for free choice of an image sequence. At the same principle it is possible to show simultaneously all 3 perpendicular sequences, Fig.1.

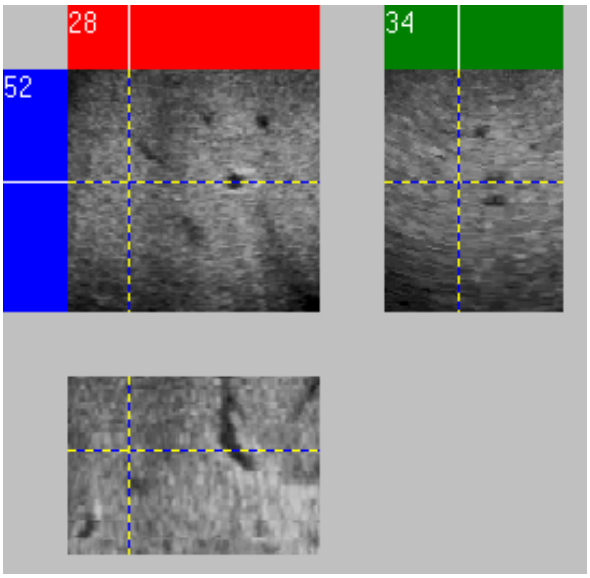


Fig.1 – 3 cross cuts of the 3D-image. 34. B-plane, 52. C- and 28. D-plane from liver image.

The colored bars blue, red and green are mouse control fields for image selection in all three projections. Green for images in B-plane, blue for images in C-plane and with red the images in D-plane. In spite of simple control in all planes the spatial impression of the 3D-image is not perfect. The plenty of spatial image information is not shown “simultaneously” although it is possible to show the transparent volume as one image.

3D-Image display variations

It is possible by long processing to produce the rendering images. Geometrically seen those are the projections images, which are produced from different visual angles. Fig.2 show the projections image from the part of liver that shows the outside surface from "liver cube". The same image can be shown in two other modes. It is possible to accentuate the bright targets and produce the transparent projection image, Fig. 3. Unfortunately, the given example doesn't deliver very promising display with plenty of useful information. The accentuation of the dark targets shows the blood vessels and all objects darker than surrounding. Which display have to be applied, depends on the object itself. All projection images from rendering sequences (see the display program) deliver the spatial impression with "visual rotation".

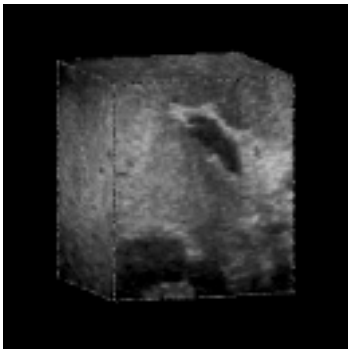


Fig.2 – Projection image from liver „cube".

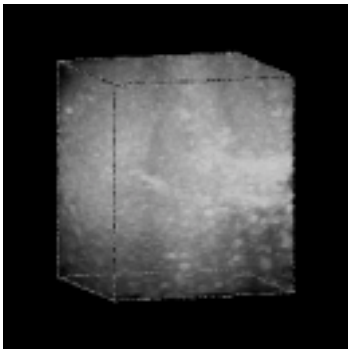


Fig. 3 – Liver projection image with accentuated bright targets.

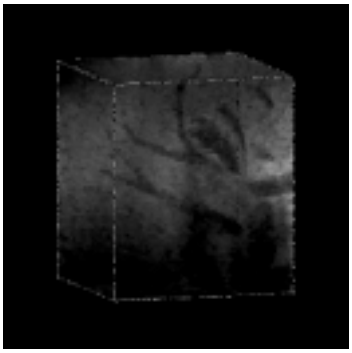


Fig. 4 – Accentuation of dark objects.

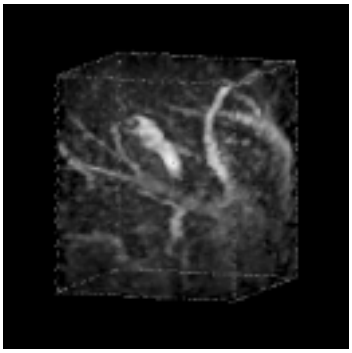
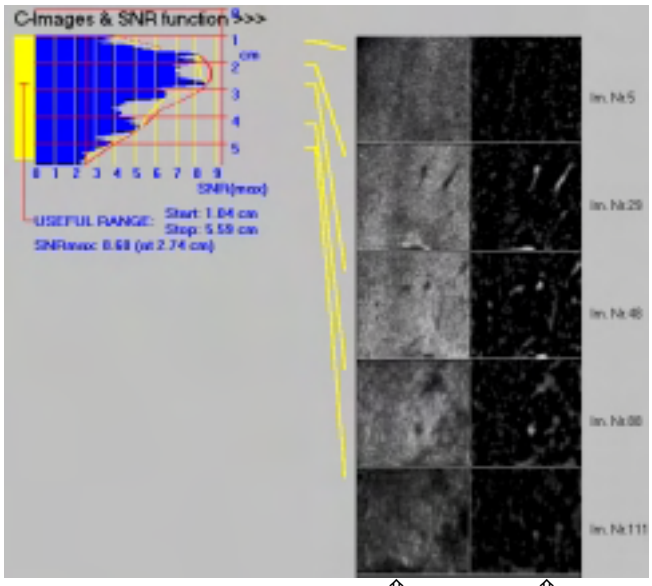


Fig. 5 - SNR – projection liver image. Largest SNR caused the blood vessels and gall bladder.



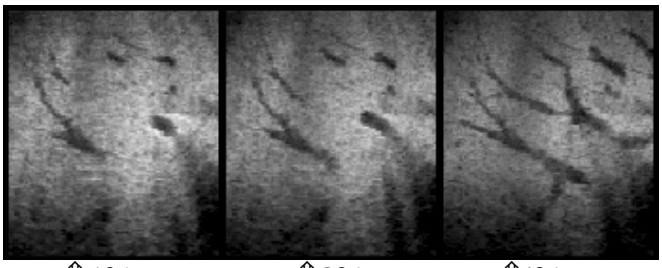
⇑ C-images ⇑ SNR

Fig. 6 – Only in focal range are small vessels visible.

For quantitative determination of image quality is the calculation of signal-to-noise ratio (SNR) of importance. The same processing is applicable for producing the SNR rendering images. With gray scale inversion and accentuating the bright targets (formally dark) will be displayed very expressive image, Fig. 5.

Independent from diagnostic value of this image, the valuable information is obtained about the SNR and resolution of the imager. In focal range are thin blood vessels visible. Outside of this range exists also small blood vessels, but this part will be not resolved. The better visibility of such objects deliver the C-images, produced from the same volume, Fig. 6.

For image quality determination from the liver image it is necessary to calculate the SNR from single blood vessels. It has to be taken in account the orientation and diameter of blood vessel.



⇑ 10 images ⇑ 20 images ⇑40 images

Fig. 7 - 10 - 40 dark accentuated slices

Interesting liver display may be produced with slices of 10 to 40 transparent images with accentuation of dark targets. Inside of 10, 20 or 40 images will be the darkest pixel (voxal) selected. With growing number of images grow the number of visible vessels and the noise will be simultaneously reduced. It improves the detectability and visibility of dark objects, Fig. 7-10.

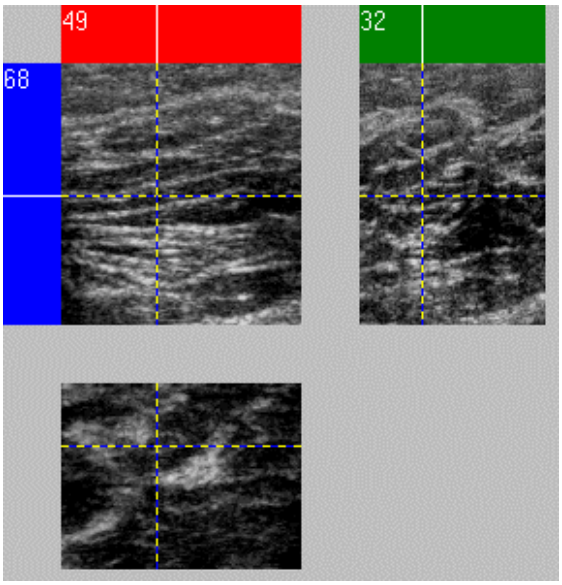


Fig.8 – 3 cross sections of breast image.

3D-Breast images

Volume- breast images show completely different structure and cannot be compared with liver images. In breast the strong reflecting surfaces prevail and that require another evaluation of the image.

Fig. 8 shows the part of the breast in 3 cross-sections. The breast is acoustically inhomogeneous medium with ultrasound propagation seldom existing by other organs. Only in abdominal wall exist the slices or randomly distributed fat and collagen similar as in breast.

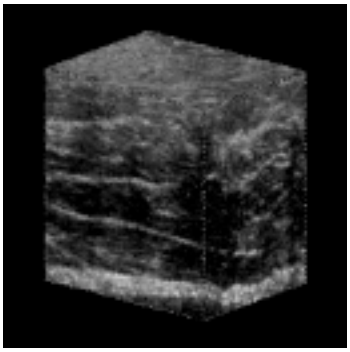


Fig. 9 - Surface of the breast image projection.

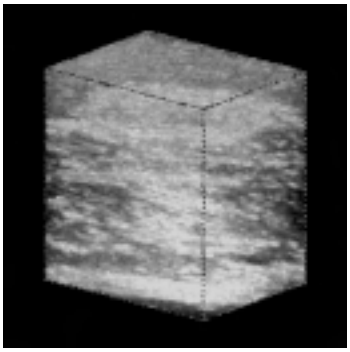


Fig. 10 – The breast slices are in transparent mode better

Fat and collagen have the different speed of sound and cause the phase aberration. Large impedance differences cause the strong reflections and reverberations (multiple reflections). The totally erratic phase aberrations inside

of some breast tissue produce the side lobes and together with reverberations influence very strong the SNR.

If the depolarization of piezo-ceramics in process of aging takes place or the ultrasound head is damaged or defective then a transducer can produce side or grating lobes. Both, the side lobes and reverberations in inhomogeneous medium and side and grating lobes produced within a defective head worsen the SNR.

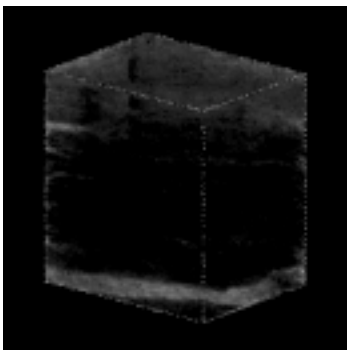


Fig. 11 - Accentuated dark objects in projection of breast 3D-image

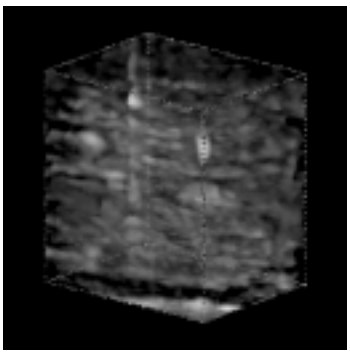


Fig.12 – Breast SNR-3D-image

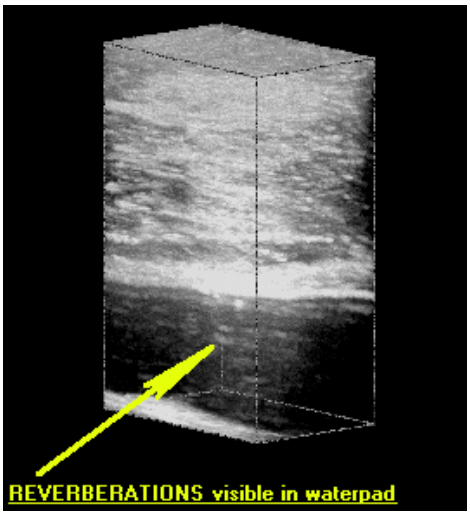


Fig. 13 - Reveberations in the breast are visible behind the breast in water pad.

Fig. 9 shows the surface of the breast detail in 3D-image projection. The structure of breast is in a bright, accentuated and transparent mode better visible. Fig.10. The accentuation of a dark object show unexpected less interesting details then in liver, Fig. 11. The calculated SNR image from breast disappoint with low content of information, Fig.12.

The C-images show not adequately in the SNR-C-images the structure details, which are visible and recognizable by analyzed liver images, Fig.13. The reason is to see in the quite different breast structure, which not allows seeing small blood vessels as in liver. The small vessel and milk ducts exist but such objects are seldom in breast image visible because the strong echoes from muscles and collagen are superimposed to week echoes from surface of blood vessels and milk ducts. The reason for such behavior may be explained with phase aberrations and

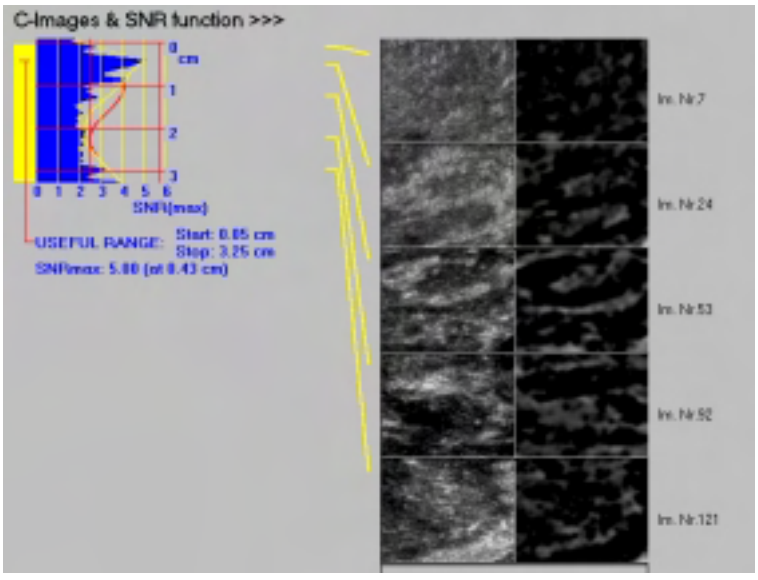


Fig.14 – C-images and SNR-C-images don't show the blood vessels inside of the breast.

reverberations producing the side lobes and filling up the echo free objects with noise. The confidence that reverberations are really in breast present can be shown with water pad positioned behind the breast, Fig.13.

All what is visible in water pad is primary generated in the breast and eventually existing resolved blood vessels, cysts or lesions will be not visible in the breast image. The spaces with higher brightness in the breast can be almost eliminated on the same way as shown at Fig. 7. The image Fig. 15 shows the detail of the breast with accentuated dark objects. Best images are obtained from the 40-image package with selection of darkest pixel (voxal). The probability to "hit" the dark pixel in 40 slices is much higher than in package with 5-20 slices. Therefore is an image with 40 slices darker then images with 5-20 slices.

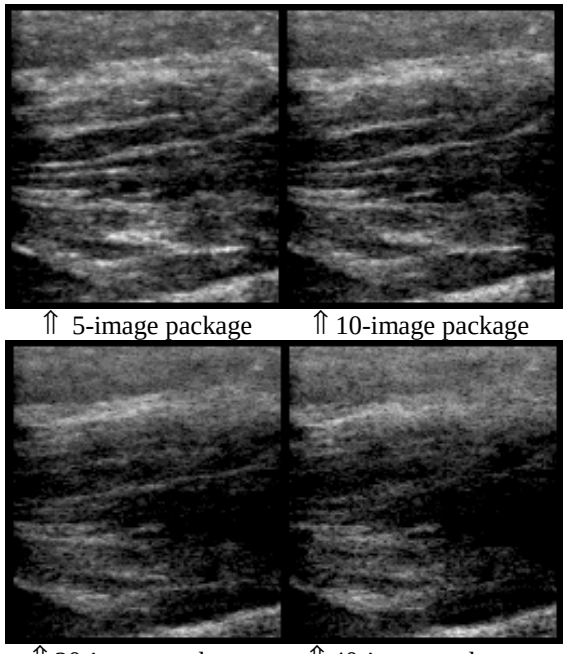


Fig.15 – Dark accentuated breast images with different number of images in the package.

At the moment it is not known the diagnostic importance of images processed on this way where strong echoes from, probably muscles and speckle noise, are almost eliminated. The lifted transparency is followed by speckle reduction.

Large number of described images can be displayed like image sequence as rendering (rotation) or simple as sequence as repetitive manifestation. For such 3D-presentation is the CD technology especially suitable.

The 3D ultrasound image acquisition open the way of processing not available at conventional B-scan. It will be primary used in quality control where quantitative approach is from special interest. Nothing is on the way to use the recently tested 3D presentation advantages promptly in ultrasound diagnostic.