White paper

UltraArt Universal Image Processing

ACUSON Redwood ultrasound system

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Introduction

Due to the nature of coherent image formation of ultrasound, speckle is an inherent property of ultrasound images. Speckle is seen as a random granular pattern caused by the constructive and destructive interference of back scattered echoes from scatterers much smaller than the ultrasound imaging wavelength. The presence of speckle degrades the detail and contrast resolution of ultrasound images and 'can make' diagnosis more difficult.

UltraArt universal image processing is a state of-the-art speckle reduction algorithm, developed by Siemens Healthineers to reduce speckle, enhance ridges of directional structures and sharpen edges prior to image interpretation without losing important features (e.g., small, low-contrast structures and texture information), thus improving image detail and contrast resolution.

Speckle Reduction Techniques

Various techniques have been developed and implemented to reduce speckle in research institutions and the ultrasound industry. These techniques can be categorized into two broad areas: (1) Compounding/Averaging-based techniques and (2) Post-processing based techniques.

1. Compounding/Averaging-based techniques

Speckle reduction is achieved by combining uncorrelated images. In spatial compounding, several overlapping uncorrelated component image frames are acquired from different view angles, and then combined into a single compounded image. In frequency compounding, uncorrelated sub-images are obtained by either varying the center frequency on transmission or by dividing the spectrum of RF signals on reception, and recombining to form a frequency-averaged image. In temporal averaging (known as persistence), successive image frames that are uncorrelated through tissue or probe motion are combined into a single image.

2. Post-processing-based techniques

Speckle reduction achieved through single image frame post-processing techniques include linear filtering [1–3], median filtering [4], Lee filtering [5], Wiener filtering [6], anisotropic diffusion filtering [7–9], and wavelet denoising filtering [10–11]. Siemens Healthineers DTCE [12], ContextVision [13], GE SRI [14] and Philips XRES [15] are commercially available proprietary post-processing techniques for this purpose.

Current speckle reduction techniques reduce speckle to various extents. However, it is common to see excessive blurring and an artificial image appearance. As a result, important features may be lost or obscured after performing speckle reduction.

UltraArt universal image processing

UltraArt universal image processing is a state-of-the-art post-processing algorithm developed by Siemens Healthineers utilizing our in-depth understanding of ultrasound image characteristics and clinical applications / anatomies to improve diagnostic confidence. It is implemented not only for B-mode but also for M-mode, Doppler and contrast modes on the new ACUSON Redwood ultrasound system.

In terms of clinical workflow, UltraArt universal image processing is designed to improve:

- **Plunkability:** reduces speckle and increases continuity of specular reflectors, and thus improves **contrast resolution**
- **Usability:** reduces complexity, redundancy and interplay of image processing features, and unifies them under a **simple** and **intuitive** user interface
- Enables robust image presentation and **aesthetics**

Figure 1: The ACUSON Redwood ultrasound system with the UltraArt universal image processing UI.

User Interface (UI)

Traditional post-processing user controls are often non- intuitive, complex and redundant which can prevent users from choosing an ideal combination. UltraArt universal image processing introduces a simple and intuitive image-based graphical user interface. Traditional user controls are replaced by a set of images, each corresponding to a different set of image processing parameters applied to a common input image. The user picks one of the images from the set, based on the desired outcome on the touch screen interface, which determines the UltraArt universal image processing parameters for the exam until a different selection is made. Figure 1 illustrates the UltraArt universal image processing UI.

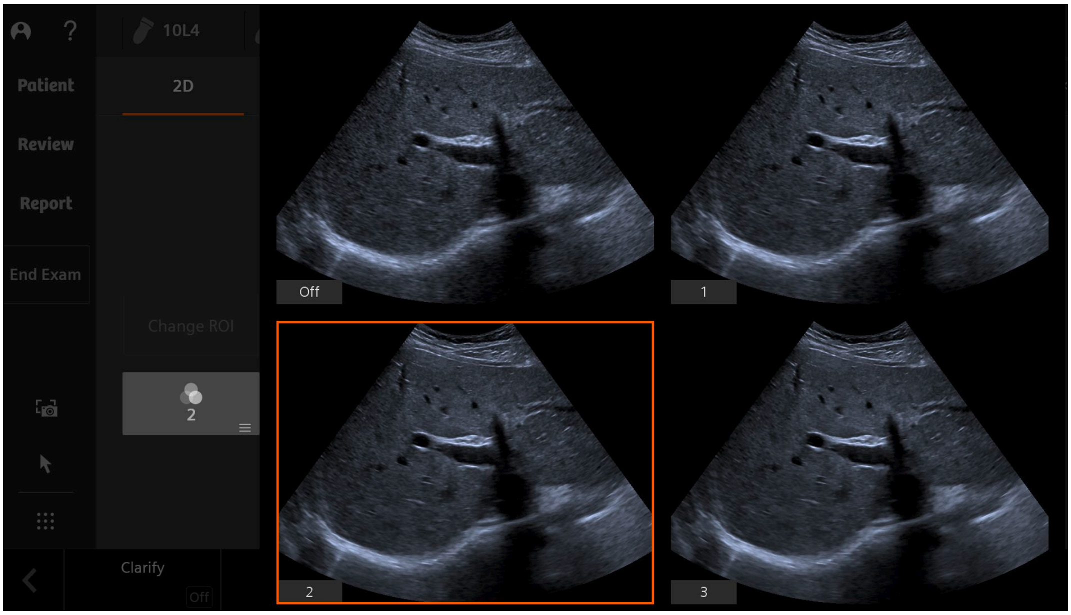

Figure 2:
Simple and intuitive image-based UI showing different levels of image enhancement.

Algorithm Description

There are three major components of image enhancement for UtraArt universal image processing: speckle reduction, ridge enhancement and edge sharpening. Speckle is a granular pattern most noticeable within echogenic area (e.g., tissue). Ridges are formed where the gray value reaches local maxima in a given direction (e.g., bright structures). Edges are borders between areas of high and low gray values.

Two edges can be detected at either side of a ridge. Figure 2 illustrates the major image components. UltraArt universal image processing is designed to control the enhancement of these three major components independently so that ultrasound images can be customized to meet clinical needs. The philosophy of UltraArt universal image processing optimization is preserving information and maintaining natural tissue texture, rather than drastic filtering. Figure 3 illustrates the UltraArt universal image processing signal path. Speckle is reduced by utilizing speckle statistics and echogenicity similarity information while preserving edges of structures and, most importantly, preserving authentic tissue texture (e.g., liver tissue). Anisotropic filters are used to detect and enhance ridges of directional structures. Image analysis identifies the location, strength and direction of edges in the images at multiple spatial scales. Edges are enhanced and/or smoothed via adaptive sharpening/smoothing filters. Finally, local contrast is enhanced by amplifying the difference between the luminance values of each pixel and its local region.

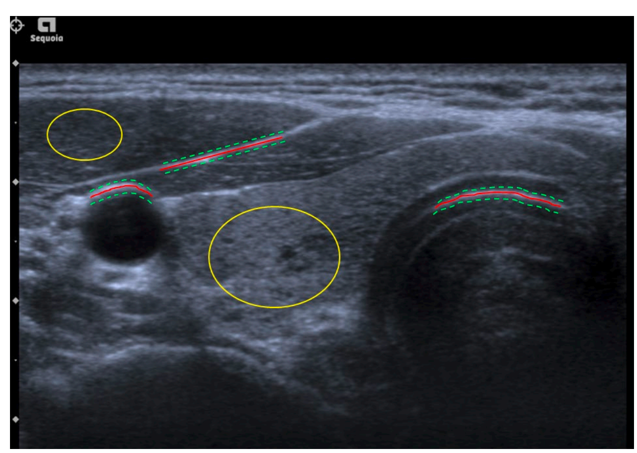

Figure 3: Example areas of speckle (yellow circle), ridges (red solid line) and edges (green dash line) are highlighted in the thyroid image above.

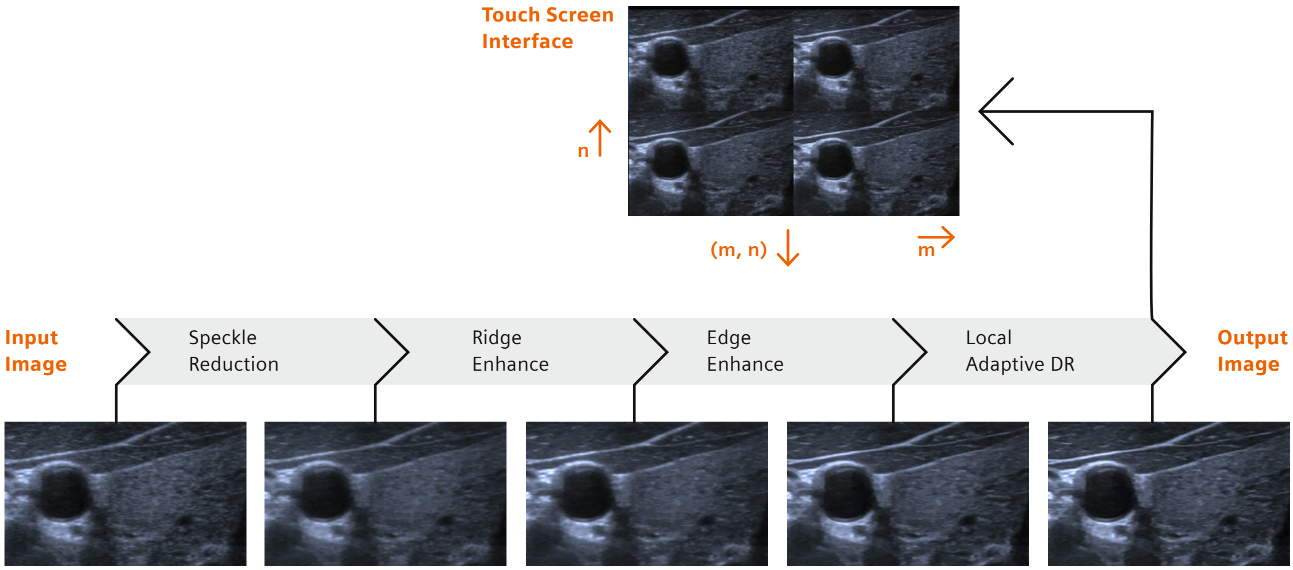

Figure 4: Block diagram describing independent processing components and intermittent results using UltraArt universal image processing.

UltraArt Universal Image Processing Clinical Applications

Abdomen

Figure 5 shows a transverse cross section of (a) a liver with hepatic vein and (c) a liver with longitudinal section of the kidney. Original images show a granular pattern in tissue with noise observed inside the vein and kidney pyramid. In UltraArt universal image processing applied images, speckle is reduced while maintaining natural tissue texture and improving contrast resolution in liver structures and the kidney (e.g., the echo differentiation between the continuity of cortex, medulla, and columns). Noise in the vein and kidney pyramid is also suppressed, and structure definition (vessel wall, diaphragm, interface between kidney and liver, etc.) is improved.

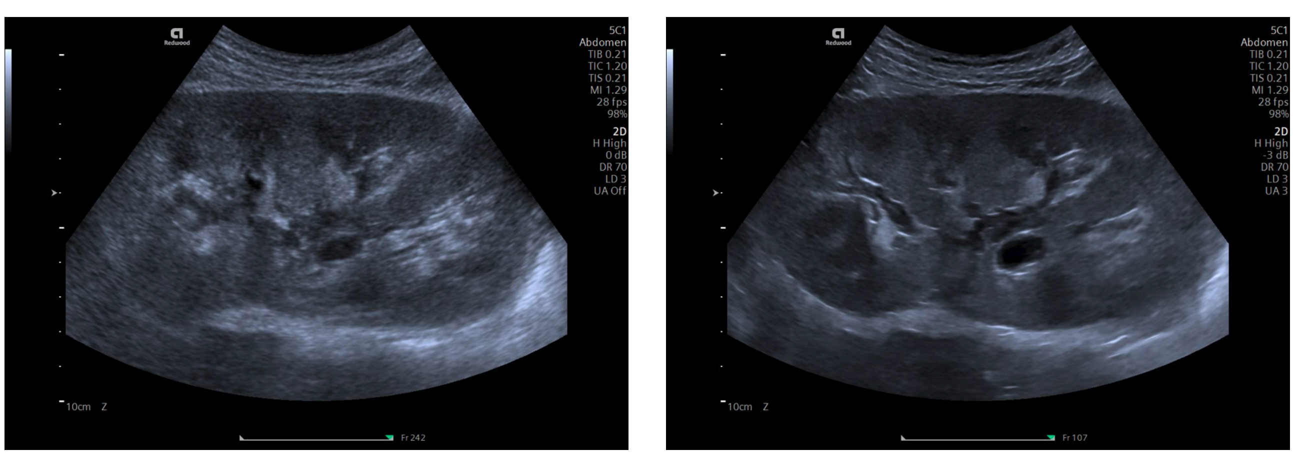

Figure 5: a) Original image using a curved transducer, (b) Image using UltraArt universal image processing.

Thyroid

Figure 6 shows thyroid images. In UltraArt universal image processing applied images, speckle in the sterno-cleidomastoid muscle and thyroid gland is suppressed while enhancing contrast resolution, details and edge structures. Structure boundaries (e.g., thyroid lobes, trachea, intima media) are better defined.

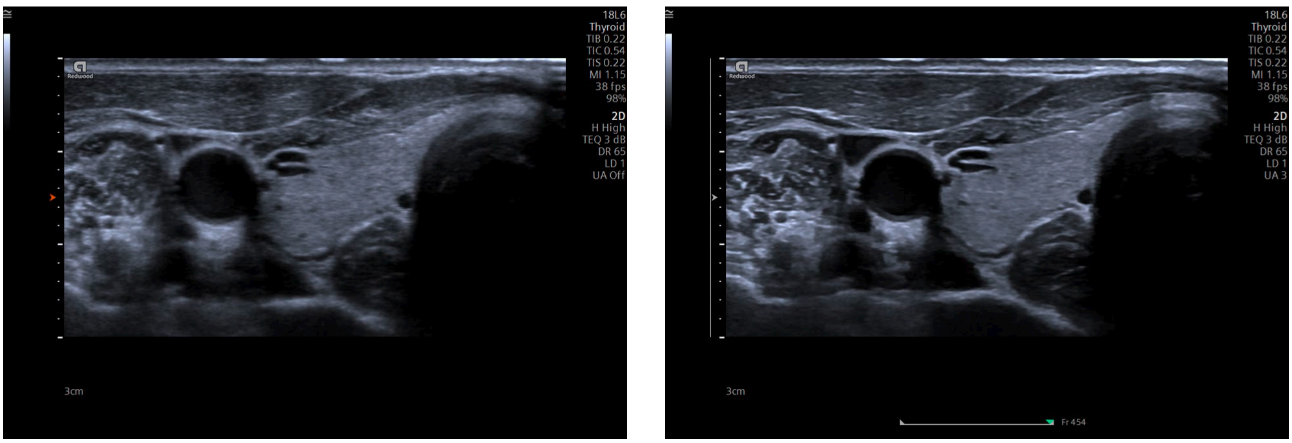

Figure 6: a) Original image using a linear transducer, (b) Image using UltraArt universal image processing.

Figure 7 shows (a) four-chamber echocardiography image. In UltraArt universal image processing applied image (b), clutter noise in the chamber is well suppressed as compared to the original image (a). Contrast resolution in the differentiation of the myocardium, endocardium, and pericardium is improved, and the continuity of the ticuspid and mitral valves is better defined.

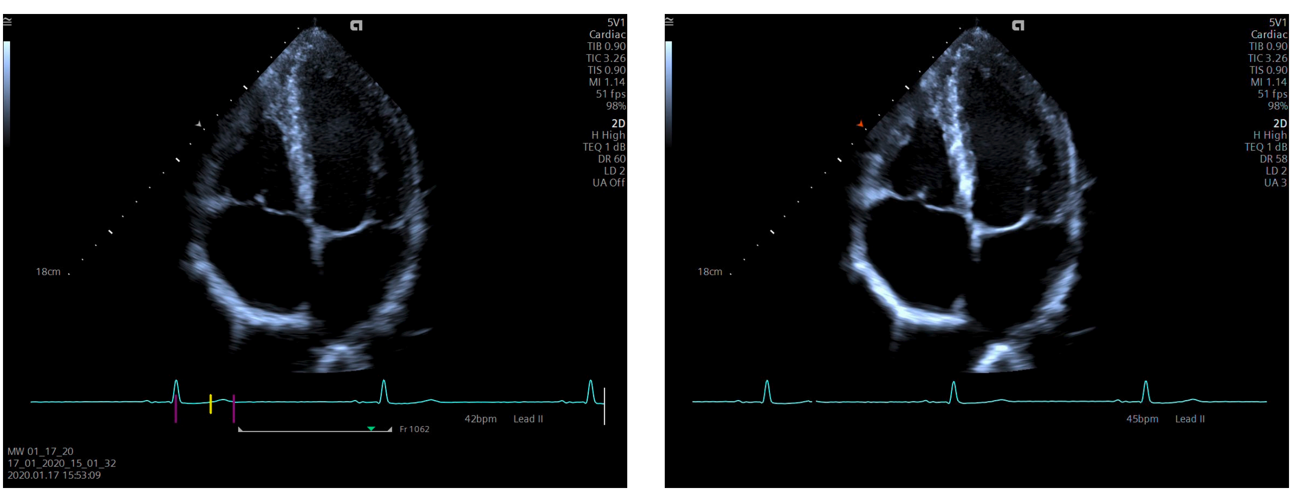

Figure 7: a) Original image using a vector transducer, (b) Image using UltraArt universal image processing.

Conclusion

UltraArt universal image processing is an excellent ultrasound image processing algorithm that improves image quality across clinical applications. Clinical evaluations suggest that it reduces speckle while maintaining natural tissue texture, improves the continuity of structures, and creates better defined borders. All these enhancements improve image detail and contrast resolution.

Plunkability and usability improvements by UltraArt universal image processing can help in improving diagnostic confidence and consistency across different users by producing images of higher quality and by avoiding improper combinations of individual post-processing parameters. By allowing real time modification of the level of speckle in the image, UltraArt universal image processing empowers the user to customize the image to their unique preferences. In this way, UltraArt universal image processing on the ACUSON Redwood system helps to expand precision medicine.

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