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Evaluation of subjective and objective ultrasound quality assurance sensitivity assessment methods

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Introduction

Current B-mode (BM) quality assurance (QA) procedures incorporate subjective tests to detect changes in system sensitivity, i.e., variations in the ability of an ultrasound system to detect and display weak echoes. While it is apparent that automated methods (e.g. Thijssen et al. 2007) could reduce the time intensiveness of QA, it is not clear to what extent automation influences the accuracy and reproducibility of relative sensitivity tests and also which sensitivity assessment method is most reproducible.

Method

The inter- and intra-user mean, standard deviation (SD) and coefficient of variation of automated and manual analysis for two routine QA sensitivity tests were assessed:

- the in-air reverberation (AR) distance
- the maximum depth of penetration (DOP)

Following guidelines (IPEM Report 102 (Russell et al. 2010), AAPM Task Group No. 1 (Goodsitt et al. 1998)), data was acquired from three scanner / transducer combinations:

- SuperSonic Imagine Aixplorer/SL15-4
- Medison Accuvix XQ/L5-12IM
- Zonare Z.one/L10-5

For the DOP test, BM images were acquired from a homogenous speckle region of a QA phantom (CIRS Model 040GSE). For the AR test images were acquired with the probe operating in air.

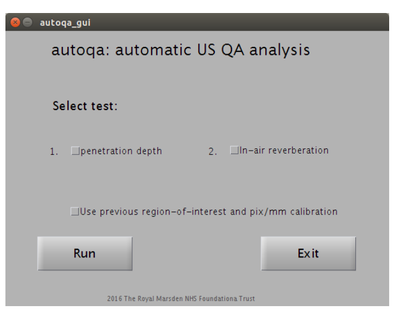

Figure 1. Software was developed in-house to automatically estimate the in-air reverberation and depth of penetration distances.

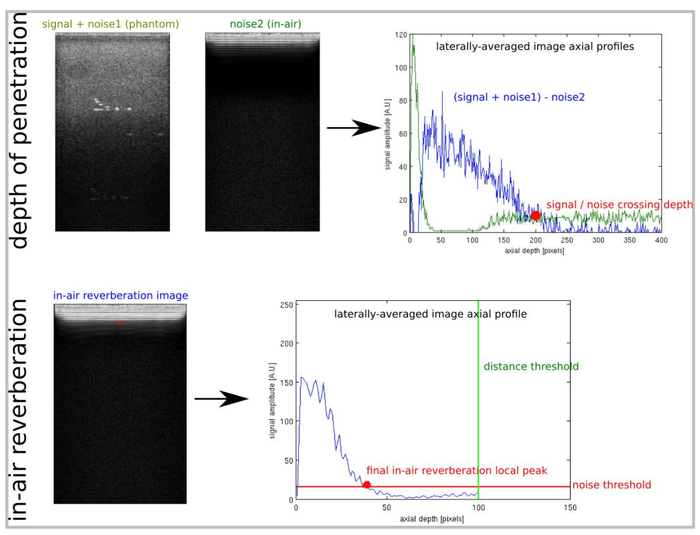

Image analysis software developed in-house using MATLAB R2012b (Mathworks Natick, USA) was used to estimate the AR and DOP (Figure 1) from saved images (offline) and compared with the AR and DOP estimates performed on the scanner (as illustrated in Figure 2) by four users (three times each).

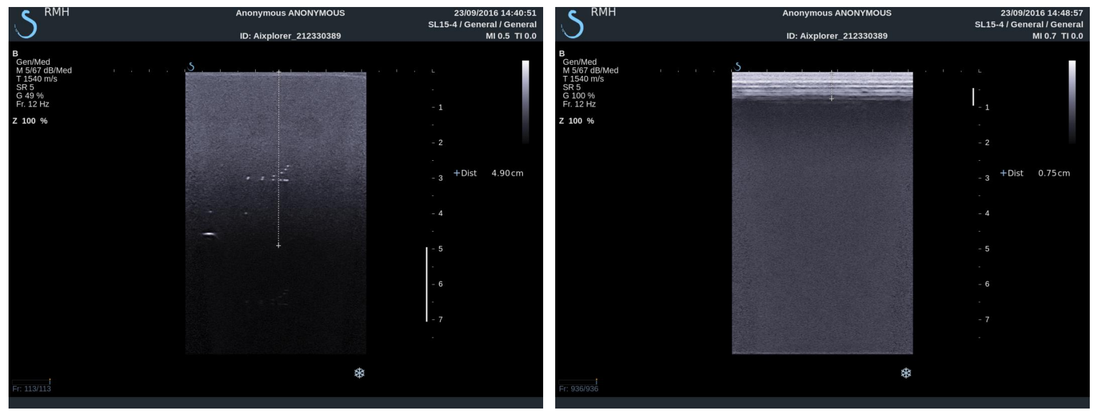

Figure 2. Illustration of manual user estimation of depth of penetration (DOP) (left) and in-air reverberation (AR) (right) for a linear array transducer and Aixplorer (Supersonic Imagine, France) ultrasound scanner. DOP is the depth where the noise starts to dominate over the speckle pattern. AR distance is estimated from the deepest fully visualised reverberation band.

Results

- Comparison with mean manual inter- and intra-user estimates of AR and DOP showed that automated methods could provide distances with differences that were either within guideline tolerances (i.e. ± 1 reverberation line (AR) or one centimetre (DOP)) or were not statically significant (Figure 3).

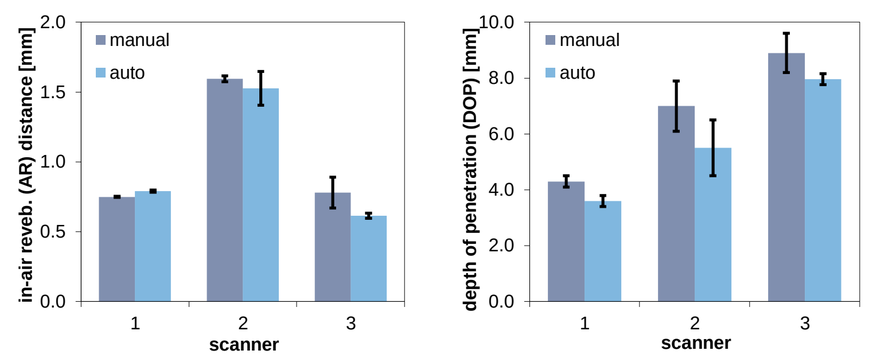

Figure 3. Comparison of inter-user (mean ± standard deviation over all acquisitions) manual and automatic estimates of in-air reverberation distance (A.R.) and depth of penetration (DOP).

- Automated methods did not significantly improve the inter- or intra-user reproducibility (coefficient of variation) (Figure 4)

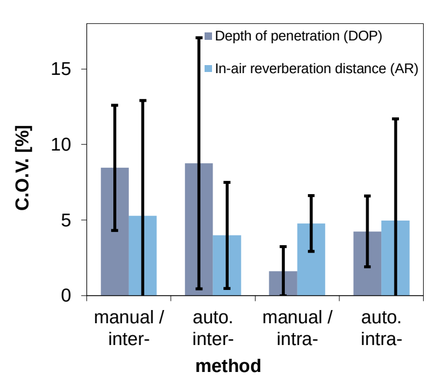

Figure 4. Comparison of (mean ± SD) coefficient of variation.

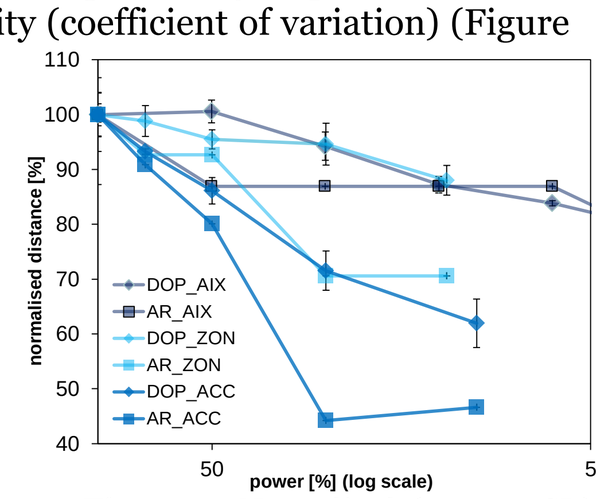

Figure 5. Normalised (mean ± SD) intra-user distance estimate as a function of transmit power.

- The reproducibility of either sensitivity assessment method was not significantly better than the other although for reproduced acquisition settings, the automated AR test may be more sensitive to scanner changes (Figure 5).

Conclusion

The results support the use of automated and objective estimates of relative sensitivity. Automatic methods would speed-up QA. Automatically reproduced image acquisition settings such as a QA preset could also be employed to remove subjectivity in image interpretation. In this study the in-air reverberation test appeared to be more sensitive to changes in scanner sensitivity than depth of penetration.

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