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A computational tool as support in B-mode ultrasound diagnostic quality control

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Abstract **Introduction**: The quality control (QC) of biomedical equipment is a very important process for the quality assurance of the instruments used in diagnoses and treatments. Ultrasound diagnostic imaging is one of the most widely used techniques for diagnostic imaging in hospitals and medical clinics. However, the time required to complete several B-mode imaging QC tests in ultrasound equipment is very critical for a hospital with a high number of exams. Here, we present a computational tool to assist in the acquisition and storage of data from multiple QC tests in B-mode ultrasound diagnostic equipment to promote an efficient alternative for QC in clinical routines. **Methods**: The project was planned and implemented in C++ programming language and compiled for two computing platforms: Windows and Linux. The most common QC routine tests for B-mode ultrasound were combined in a simple graphical user interface. **Results**: After entering all of the correct QC information in the graphical user interface, a final report in PDF format was created. **Conclusion**: The proposed program has been helpful for students and diagnostic professionals and is a quick and easy application for several QC tests for B-mode ultrasound diagnostic equipment. Our program seeks to help in the dissemination and application of QC tests for B-mode ultrasound equipment in hospitals and clinics and for the technical training of ultrasound professionals.

Keywords Quality control, Ultrasound, B-mode.

Introduction

In several technology application areas, various quality control (QC) procedures are utilized. Such procedures evaluate the general quality of the equipment used in many clinical procedures, for both diagnoses and treatments. Many diagnostic instruments in radiology and radiotherapy are routinely analyzed and tested by several QC procedures, and maintenance reports are provided to ensure the quality of the instruments.

For diagnostic B-mode ultrasonography, various QC tests have been validated. In general, the applied procedure is adapted from international standards (American..., 1995; Goodsitt et al., 1998; Madsen, 2000; National…, 1988) to maintain the routine practice of QC. In fact, ultrasound instruments are one of the most used and disseminated medical devices in various diagnostic imaging procedures. The application of QC tests for the general maintenance and the proper operation of the equipment is essential.

Several research groups have jointly formulated and implemented QC practices for B-mode ultrasonography in Brazil. Several normative works have been conducted for the international establishment of QC procedures (Alvarenga et al., 2001; British…, 1997; Mühlen, 2001; Oliveira et al., 2010). Even with advances in the field, there are still major barriers to their application in Brazil. Typically, the QC process, including data recording and other paperwork, is performed entirely by hand, which increases the time required for the QC data acquisition and analysis and the susceptibility of human error. Additionally, the lost machine time could be used to diagnose patients, and the generated paperwork presents storage issues for the future analyses of the ultrasound equipment. A few efforts have been made to improve the data acquisition and semi-automatic processing (Alvarenga et al., 2001; Gibson et al., 2001; Mühlen, 2001). However, an efficient approach to basic QC tests in B-mode ultrasonography is lacking.

In this study, we created a computer system to assist the QC diagnostics of B-mode ultrasonography. The use of computational programs dedicated to the various QC tests is a promising alternative to reducing the required time for the procedures and guarantees the standardization of QC results. Moreover, a semi-automatic QC tool improves the reliability and removes potential bias in data processing due to fewer human influences. A more formal and accurate analysis must be performed in our computational system to affirm these improvements. However, our purpose is to present a computational tool and its functionalities.

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Methods

The project was planned and implemented in C++ programming language and compiled for two common computing platforms: Windows and Linux. The choice of this programming language was made in view of its computational performance and readily available open source libraries for database creation and data analysis.

It is essential that the program implemented current standardized QC protocols. In general, standardized tests follow the international standards (American..., 1995; Goodsitt et al., 1998). Our computational program combined the most common routine QC test applications, as listed in Table 1. All QC tests were performed from a test object (i.e., phantom), and our program was set up, but not limited, to the use of three typical ultrasound B-mode phantoms made recently available (ATS Laboratories, 2012; Computerized…, 2012; Gammex, 2012). Figure 1 shows a typical phantom configuration. These phantoms are usually known as multipurpose phantoms due to the multiple QC tests that can be performed on only one phantom. There are several different types of ultrasound phantoms with specialized purposes. Here, we used the multipurpose B-mode ultrasound QC phantom.

To increase the availability of the QC procedure, two instruction guide versions are freely provided on

Table 1. Different quality control tests performed in B-mode ultrasound diagnostic equipment. Each procedure is performed in different windows of our software, as observed in Figure 2.

1. Dead Zone
2. Depth
3. Lateral Resolution
4. Axial Resolution
5. Hyperechoic Masses
6. Anechoic Masses
7. Physical Equipment Exam
8. Image Uniformity

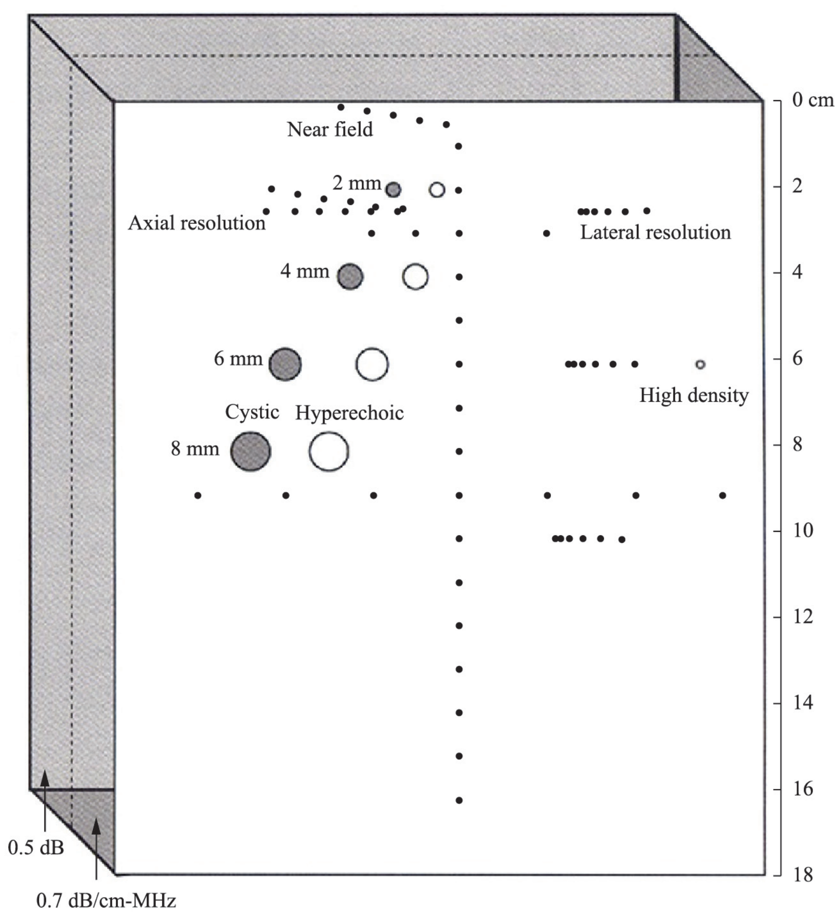

Figure 1. A phantom example developed by CIRS device (Computerized…, 2012). In this phantom, there are several quality control targets, which guide the ultrasound professional through the several quality control procedures listed in Table 1. Every quality control step performed on the phantom has its respective input field in the software to be filled in with the QC information.

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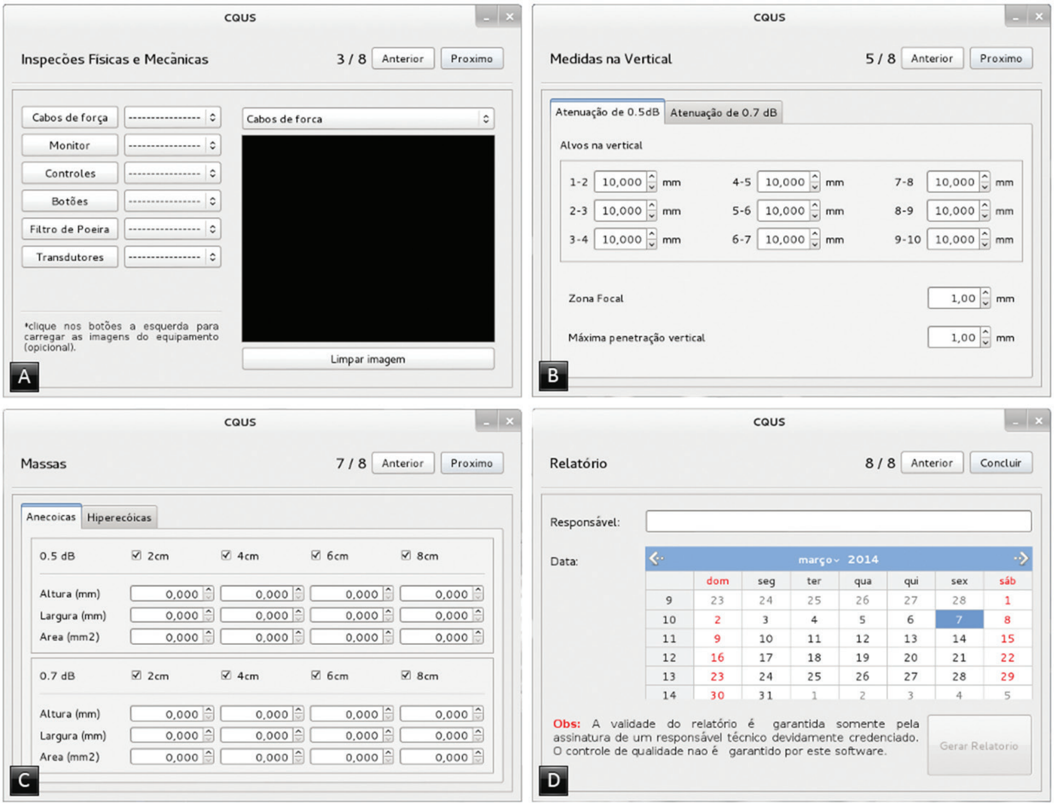

Figure 2. Illustration of a few of the quality control software display windows. Each separate quality control test is in different steps, with easy access for the ultrasound professional. All data entered in the user interface are used for further processing in the formation of the evaluation report in PDF format; only the ultrasound equipment information is stored in a local database for easy access in future quality control evaluations. A) Physical inspection test; B) vertical measurements test; C) anechoic and hyperechoic mass tests; and D) signature and date by person responsible for the procedure.

the software website[1]: one is in A4 paper format and the other is in eBook format. All measurements from the B-mode imaging is performed by the operator following the step-by-step procedures of the guides to minimize intra- and inter-observer variations. Our software only grouped the QC information in an organized report form, without using image processing acquisition techniques. As an alternative to several QC tests, the goal of our approach was to provide improvements in accuracy and reliability by standardizing and minimizing human interference in the final evaluation of the equipment quality.

Results

The user interface was designed to provide friendly and easy access to different QC tests. Each input field was designed for each type of QC test data entry (see Figure 2 for examples of the user interface). All tests were defined according to typical ultrasound QC standards (Goodsitt et al., 1998).

After inputting all corresponding QC field information, a final compliance report was generated in PDF format. If negative results were encountered, the operator responsible for the test can repeat those specific QC procedures and review if issues exist in any non-compliant ultrasonic unit. Scaled information was directly obtained from the ultrasound equipment for data analysis and presented in the report. Our program did not store the numerical QC data on a local database. Only the equipment identification information was stored in a local database for future data acquisition. All QC data were saved in the final PDF report form.

Discussion

Our results show indirect enhancements in the efficiency of QC tests. The ease of data acquisition and data processing add strong incentives for the use of this tool in a clinical setting. A more accurate and

[1] The software is provided on the CQUS page on the CSIM Laboratory website: dcm.ffclrp.usp.br/csim.

formal analysis must to be conducted to validate our computational tool, but this initial result is a promising step in the semi-automatic approach for the QC of B-mode ultrasound instruments. Regarding the use of our tool, the proposed computational program has been a great help for students and ultrasound professionals because it offers the quick and efficient application of several QC tests for B-mode ultrasound diagnostic instruments. Our program seeks to aid in the dissemination and application of QC tests for B-mode ultrasound machines for use in hospitals and clinics and for the education and technical training of ultrasound professionals. Future improvements aim to enable the use of this program on mobile devices (i.e., smartphones and tablets), thereby facilitating mobile QC procedures.

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