Ultrasound Acoustic Shadow Detection (H17-####)

**Research Project: Ultrasound acoustic shadow detection: laboratory study of ultrasound imaging algorithms**

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**1. Purpose**

Ultrasound imaging is a low-cost, non-ionising, and real-time imaging modality. This makes it a useful tool for imaging a number of organs and bones within the body, particularly at in a point-of-care setting. However, a given ultrasound image may contain regions of shadows with little or not useful information. These shadows are commonly caused by poor contact of the ultrasound transducer with the surface of the area being imaged or regions of high acoustic impedance, such as bones, beyond which the ultrasound signal is not transmitted further. While some studies have investigated the ability of computer algorithms to identify shadow regions, they commonly attempt to leverage ultrasound transducer characteristics or identify specific regions such as bones themselves. These studies have not looked solely at the ultrasound image, and even more so, have not looked specifically at the characteristics of shadow regions themselves. Identifying shadow regions within ultrasound images without the need for manual interpretation or dependency on ultrasound characteristics is a necessity for image processing techniques that are dependent on the quality of data. Notifying the ultrasound operator of a shadow region generated by bad contact with the surface would benefit training as well. To that end, this study proposes the development of an image processing algorithm for shadow detection that can work on number of different regions fully automatically and independent of ultrasound transducer characteristics.

**2. Hypothesis**

The hypothesis is that the acoustic shadow detection algorithm can identify acoustic shadowing as good as manual inspection (measured by having greater than 90% sensitivity and selectivity in comparison to manual inspection) in scenarios of shadowing due to bone or an air gap between the transducer and skin.

**3. Justification**

Identification of acoustic shadows is done by manual inspection by an experienced radiologist or sonographer in practice. There are several previous studies conducted in detecting acoustic shadows, mainly focusing on shadowing from bone and with algorithms dependent on ultrasound transducer characteristics. This study aims to improve on previous algorithms by characterizing shadowing due to air gaps in addition to bone and using an algorithm independent on the ultrasound transducer such that the detection method can be applied to many ultrasound machines, increasing the usability of ultrasound.

**4. Objectives**

The objectives of this study are:

1. To obtain ultrasound images depicting acoustic shadows due to bone or an air gap between the transducer and skin surface.
2. To develop an algorithm that can identify acoustic shadows on an ultrasound image with at least 90% sensitivity and specificity when compared to manual outlining of a shadow region by an expert
3. To identify when acoustic shadowing occurs due to an air gap between the transducer and skin surface.

**5. Research Method**

This study will recruit voluntary participants at the UBC Vancouver campus. Recruitment posters will be posted around campus with information about the study. Interested participants will contact the research team (Mr. Hu) to participate. Mr. Hu will obtain signed consent from participants. These participants will be approached at least 24 hours before participating. Mr. Hu will assign a subject ID to each participant (not derived from any personally identifying information). The gender, height and weight of each participant will be recorded. The height and weight will be used to later calculate the body mass index (BMI). No other personally identifying information is recorded, and the study is fully anonymous. Participants will be asked to be scanned in the engineering laboratory at UBC Vancouver.

As part of participating, participants will be scanned using ultrasound by a trained member of the study team. Ultrasound is non-ionising, and does not incur risk to participants. The trained member of the study team will perform a 20 minute scan of two major areas - the forearm and ribcage - using a standard, FDA and Health Canada approved ultrasound machine. Further details are described for each area as follows:

**5.1 Forearm**

1. The participant will be asked to be in a seated position in a chair and asked to expose their forearm. Their forearm will be placed on a flat table surface in the supinated position with open palm facing upwards.
2. The trained scanner will apply standard acoustic coupling gel to the subject’s forearm and perform an ultrasound scan. This ultrasound scan will be recorded.
3. The trained scanner will repeat and record, in total, five ultrasound scans of the forearm. This involves sliding the ultrasound probe from the near the elbow to near the wrist.

**5.2 Ribcage**

1. The participant will be asked to lie down in a lateral position and expose their right rib cage.
2. The trained scanner will apply standard acoustic coupling gel to the subject’s skin and perform an ultrasound scan of their ribcage region. This ultrasound scan will be recorded.
3. The trained scanner will repeat and record, in total, five ultrasound scans of the ribcage. This particularly focuses on the epigastric and hypochondriac regions, where the scanner will sweep the ultrasound probe from the right side of the ribs towards the sternum.

In both cases, after scanning, the trained scanner will clean the coupling gel off from the participant. The trained scanner will complete the scan by storing it on the ultrasound machine for later processing. Only the subject ID will be used to label the recorded dataset.

After the data collection has been completed, the ultrasound images will be processed and analyzed in the engineering laboratory at UBC. This process involves manual segmentation of each data set for regions of shadow, and the development of a computer algorithm that can take as input an ultrasound image and produce on the image a region it has determined to be shadow.

This data is to be used for research purposes only. No diagnosis of any condition will be made on the subjects. In the small likelihood that the ultrasound examination reveals an incidental finding of an injury, disease, pathology or relevant medical condition, the trained scanner will first communicate the finding to the participant at the time of examination, and state that the principal investigator will prepare and deliver a short written report in collaboration with the ultrasonographer. The qualified and experienced ultrasonographer will provide information on common artifacts in ultrasound imaging to help minimize needless concern to participants and unnecessary burden of follow-up. The report will include the recommendation that the participant discuss the incidental finding with their general practitioner.

**6. Statistical Analysis**

Once the ultrasound images have been obtained, the shadow regions on an ultrasound image automatically detected by the acoustic shadow detection algorithm will be compared with shadow regions on the same image outlined manually by an trained ultrasound expert. The manually outlined region will be used as a gold standard. Sensitivity and specificity values will be computed to compare how accurate and selective the automatically detected region is compared to the manual region.

The primary end point to identify successful shadow detection is achieving at least 90% sensitivity and specificity when comparing the automatically detected region to the manual region. Due to the data driven nature of this, 100 subjects will be scanned.

**7. Declaration of Conflict of Interest**

There are no conflicts of interest declared.