Image Registration Assists Novice Operators in Ultrasound Assessment of Abdominal Trauma*

Kirby G. Vosburgh,1 2 Jeffrey Stoll,2 Vicki Noble,3 Kilian Pohl,4 Raul San José Estepar,2 Barnabas Takaes5

Background/Problem
Transcutaneous ultrasound imaging may be used to detect abdominal hemorrhage in the field setting. The Focused Assessment with Sonography for Trauma (FAST) examination was developed to characterize blunt abdominal trauma and has been shown to be effective for assessing penetrating trauma as well. However, it is unlikely that a minimally trained operator could perform a diagnostic examination.

Tools and Methods
In our system, the operator is supported by real-time 3D volume displays and potentially by telecommunications linkages. The operator is directed through the examination by prompts from a computer system or outside expert, with knowledge of the anatomy of the injured patient. The project has had three primary tasks:

1. Development of patient-specific segmented CT-based models to enable accurate navigation and probe positioning. First a template is registered to a patient’s CT scan using previous segmentation results. Then, the results of the registration are coupled with an analysis of the intensity histogram to segment the node into its children. The procedure is iterated.

2. A tracked ultrasound probe is registered with the patient and the CT anatomy to create an Image Registered FAST (IRFAST) capability (Fig. 1.) This system is the latest Image Registered system to be developed by the CIMIT Image Guidance Laboratory; see www.ciglab.org. In prior work for CT registration we used bead markers on the skin or the tips of the ribs of a pig. Either of these methods gives usable registration of less than one centimeter accuracy in x, y, z combined, but neither are practical for the IRFAST technique for human subjects. Thus a key task was to find new, non-invasive localization approaches.


Results
The key elements of the tele-operated FAST exam capability have been demonstrated; the exam is performed with real-time guidance from anatomic images registered to the body. The development of rapid, nearly unguided anatomical segmentations (led by Dr. Pohl) was successful, as shown in Figure 2. To achieve real time registration between the archival CT data and the real time ultrasound, we have mapped out the rib arch and spline fitted to determine transverse and vertical location, and identifying the xyphoid and clavicular notch to determine the main body axis. These do not give reproducible results due to uncertainties in positioning the probe on the skin. We shifted to human subjects, where our approach is based on the use of natural anatomic landmarks. The shape of the ribcage permits relatively easy localization of one point on the longitudinal axis, the umbilicus provides another such point. Transverse and vertical references may be obtained with a simple fixture on the rib cage, although compensation is necessary for the respiratory cycle. The full system was successfully implemented and evaluated by a small number of operators using the porcine model. Initial results show the anticipated benefits (Table 1.) in guiding inexperienced operators.

Conclusions/Discussion
It appears likely that Image Registration will assist hemorrhage detection at the point of injury or in the initial evaluation by a trauma response team. The analysis is complicated by differences between human and porcine anatomy. A challenge is the likelihood that, in the near term, there will be no prior CT examination available. We may assume, however, that the patient is identified, so that his or her general anatomic properties are easily available. With such parameters as height, weight, body type, and gender, we anticipate that we will be able to provide a surrogate CT structure sufficient for the task.

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1 Center for Integration of Medicine and Innovative Technology (CIMIT), Boston, MA
2 Brigham and Women’s Hospital, Boston, MA
3 Massachusetts General Hospital, Boston, MA
4 Isomics, Inc., Cambridge, MA
5 WaveBand Corporation, Irvine, CA
Table 1. Mean time improves significantly for identification of FAST examination landmarks when IRFAST display is used (Subject 2). If the order of use of IRFAST is reversed, the “training effect” is not as strong.
Overview:

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Status of Work/Prior Publication:

This is new work and this will be the first presentation of it.