COMPUTER-AUGMENTED POINT-OF-CARE ULTRASOUND TECHNOLOGIES AND APPLICATIONS

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Abstract. Point-of-care ultrasound (POCUS) has the potential to significantly raise the standard of care for a multitude of clinical tasks by providing timelier, less invasive, more quantitative, and more accurate diagnoses, in well-served as well as in underserved populations. Herein we describe the application of POCUS to in-field trauma patient triage and scoliosis monitoring. For POCUS systems to achieve their potential in these and other applications, we must envision POCUS systems as new diagnostic tools, not simply as low-cost portable ultrasound devices. The proposed computer-augmented POCUS systems utilize custom hardware and machine learning so that they can be operated without extensive clinical training.

1. METHODS AND EXPERIMENTS

Two hardware designs are proposed, Fig. 1. Each facilitates one hand operation and allows the operator to maintain their focus on the patient while receiving instructions from the system. Both designs are low-cost and have integrated IMUs for probe orientation and acceleration tracking.

The first hardware design adds a display onto the probe. It is compact; however, it offers limited computational power, unless body-worn computers or cloud computing are used.

The second hardware design uses a projective augmented reality device. [1] A portable projector and high-speed camera provide depth-from-structured-visible-light scene modeling, while the projector simultaneous displays instructions in the scene. This system integrates with workflows and works outdoors; however, it requires a separate projection/camera/computation device above the patient, making it more suitable for structured environments.

For probe guidance, we use dynamic textures to assess if the image contains expected anatomy. [2] This method must be used in conjunction with pictorial instructions and image quality assessment algorithms. Furthermore, we are investigating Aquaflex™ pads to eliminate image quality issues surrounding operator manipulation of acoustic gel.

For trauma patients, we introduced Ultrasound Spectroscopy (USpect) for the identification of intra-abdominal bleeding using machine learning to interpret RF data acquired at multiple powers and frequencies. [3] We conducted studies involving tissue/blood phantoms to compare b-mode with USpect.

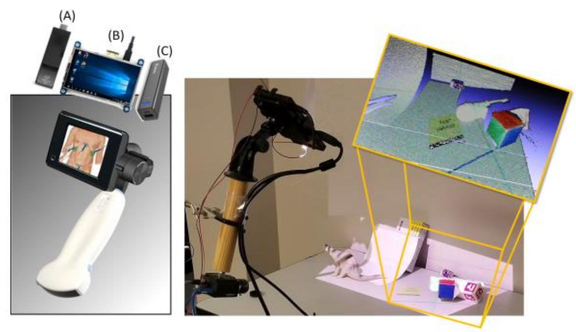

Figure 1. Two POCUS devices. **Left:** USB ultrasound probe (Interson, Inc.), Intel "USB Stick" computer, LCD display, and rechargeable 5V battery are combined. **Right:** Laser projector draws an image at 30 fps using raster lines, and the high-speed camera sees the individual lines to create a depth map.

For scoliosis, we trained a neural network to estimate the angular tilt of vertebrae in b-mode images, and we compose each estimated angle with the probe's IMU angle to define Cobb angles. [4] We evaluated using a spine phantom.

2. RESULTS AND CONCLUSIONS

Effective computer-augmented POCUS systems can be achieved using specialized combinations of hardware and machine learning. USpect provides 98.5% accuracy for pooled blood identification, versus 86.5% for b-mode. The scoliosis system provides a mean accuracy of 2° for vertebrae angle estimation.

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3. REFERENCES

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