

BACKGROUND

- Rheumatoid Arthritis (RA) is a chronic autoimmune disease which causes articular cartilage destruction and bone erosion.
- In this work, we develop a novel 3D imaging system in photoacoustic (PA) and ultrasound (US) Doppler dual-modality which can automatically detect and scan multiple RA diseased hand joints.

System setup

- The imaging system is based on the GEHC Vivid E95 ultrasound system. The custom probe holder, combining GEHC L8-18i-D linear probe and fiber bundle, is attached to the Universal Robots Robotic Arm (UR3).

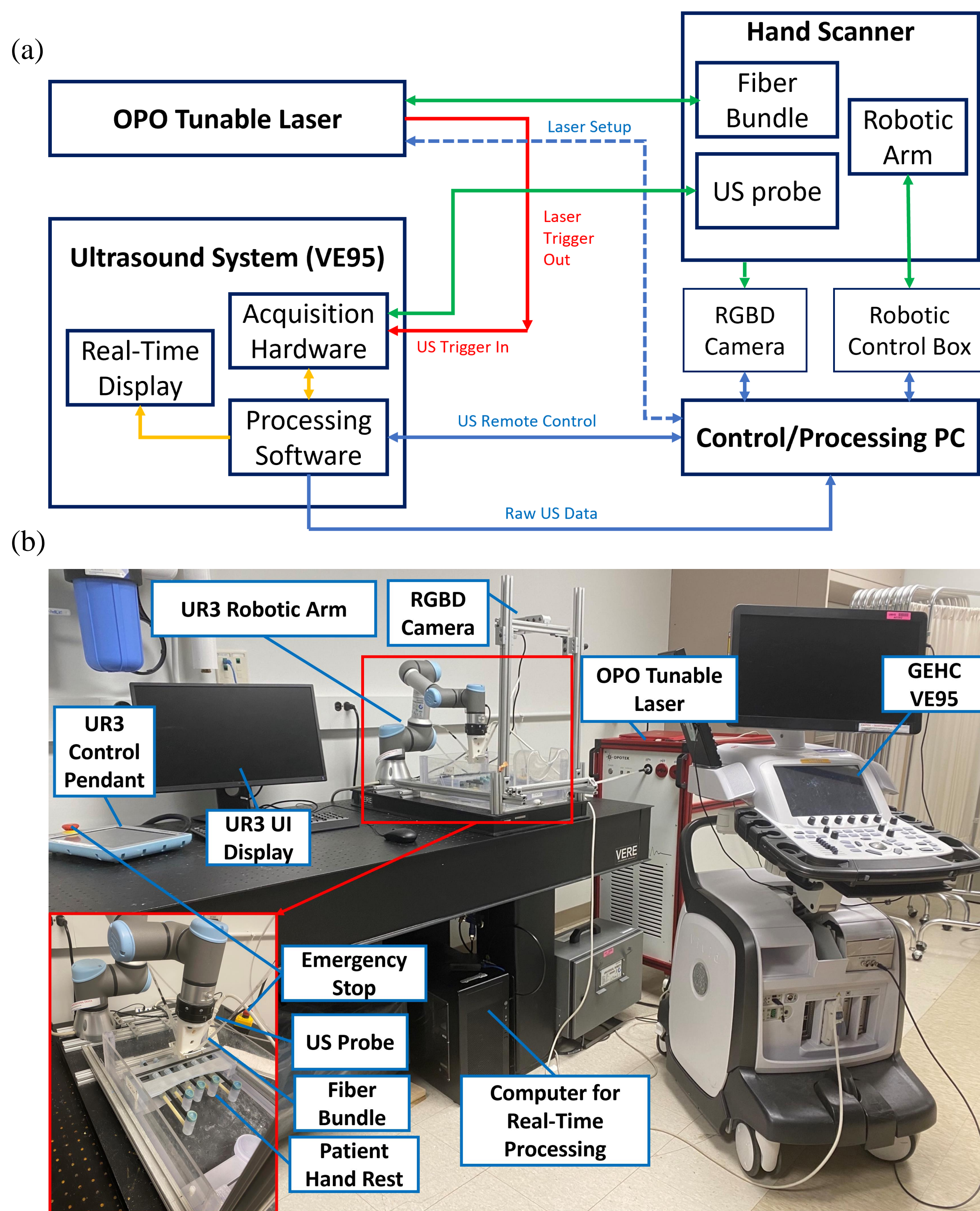


Fig 1. Schematic of 3D automatic imaging system. (a) System block diagram. OPO Laser is the primary illumination source with a repetition rate of 10Hz for PA imaging. VE95 US system acquires and processes B-mode US images and PA images with real-time display. The hand scanner can detect hand joints using RGBD camera and move the probe holder to targeted hand joints automatically. (b) Photo of PA/US dual-modality imaging system. Zoomed photo (left-bottom corner) of hand scanner with US probe (inside probe holder) and fiber bundle (on both side on probe holder).

RESULTS

Series of patient joint images

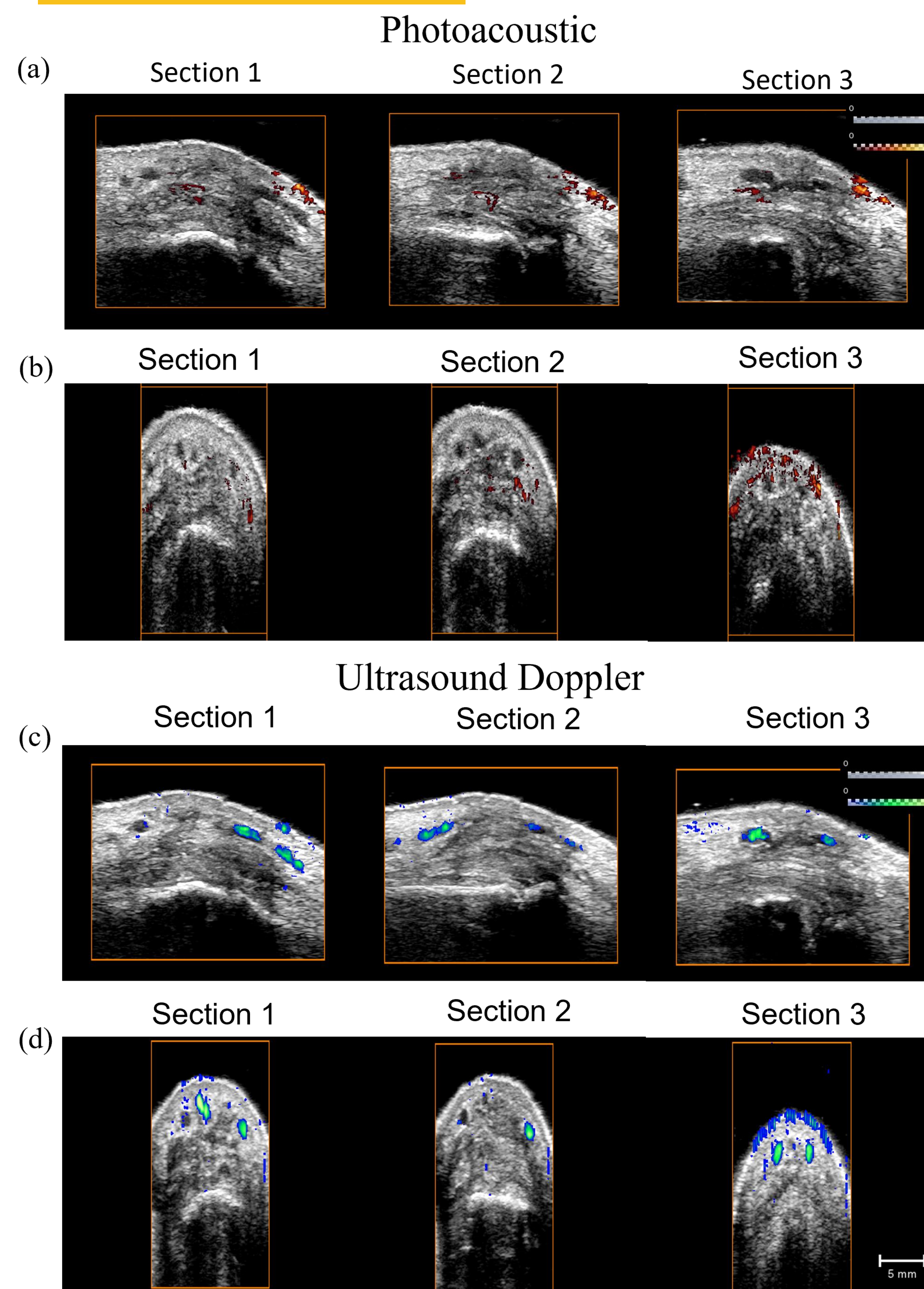


Fig 2. Representative imaging results: series of patient right 4th PIP joint images. Sections of (a) long-axis and (b) short-axis photoacoustic imaging @750nm wavelength. Sections of (a) long-axis and (d) short-axis power doppler ultrasound imaging.

3-dimensional and volumetric view

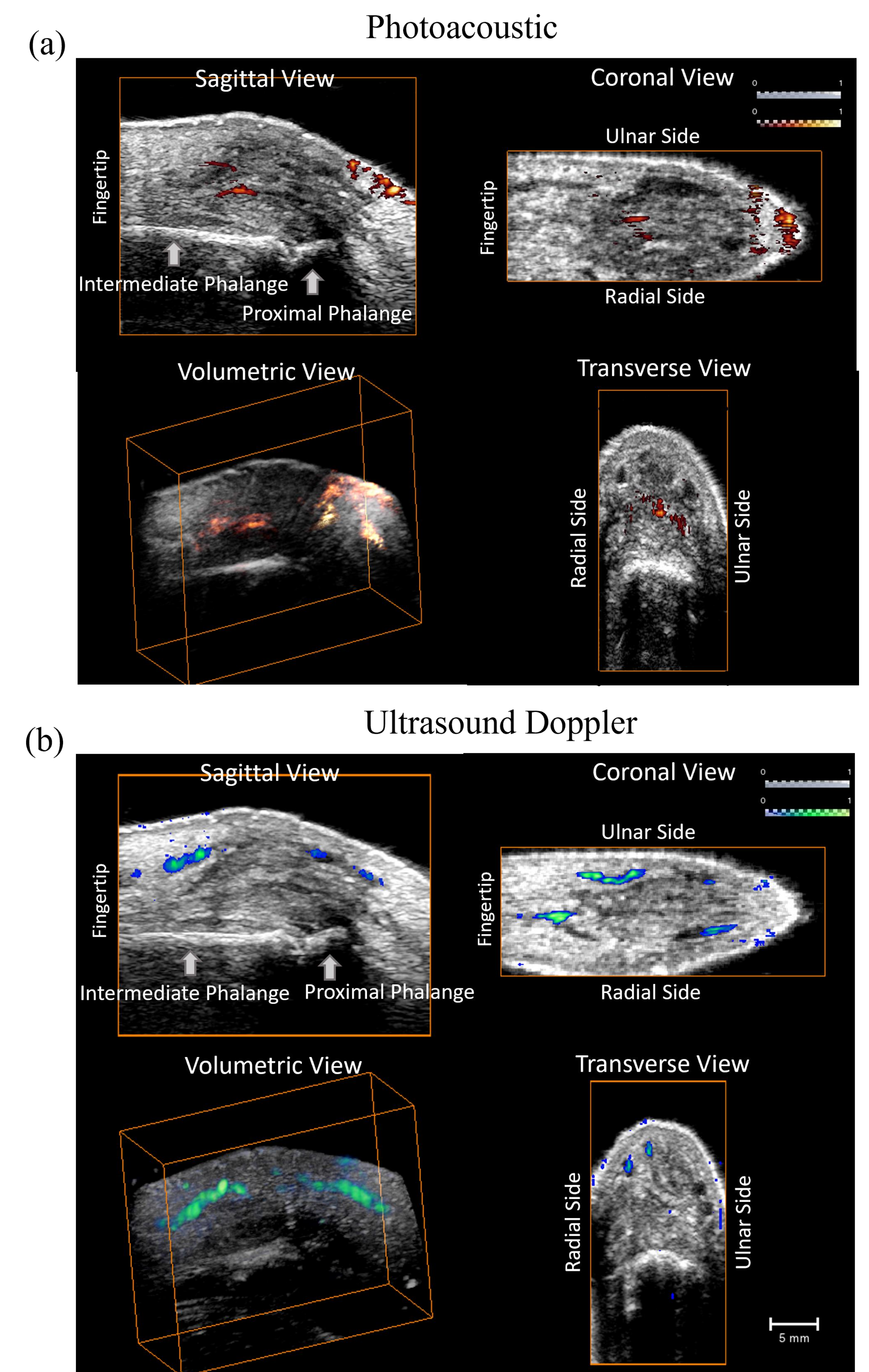


Fig 3. 3-dimensional view and volumetric view of patient right 4th PIP joint of (a) photoacoustic imaging and (b) ultrasound doppler imaging.

Discussion & conclusion

- The automatic hand joint detection algorithm provides the feasibility of scanning free-positioned hand on the adjustable stage.
- With the automatic scanning, we can speed up the acquisition while eliminating the need of an expert sonographer.
- In the Doppler US images, we can see enhanced flow in several large superficial vessels close to the skin, which confirms the active synovitis in this joint. However, unlike the PA imaging, the Doppler US images are not sensitive to microvascular flow and did not show any activities in the areas close to the phalanges.
- PA imaging function of this system could detect and display the hyperemia deep in the joints with good sensitivity and high image quality.