ProbeSight

Video Cameras on an Ultrasound Probe for Computer Vision of the Patient's Exterior

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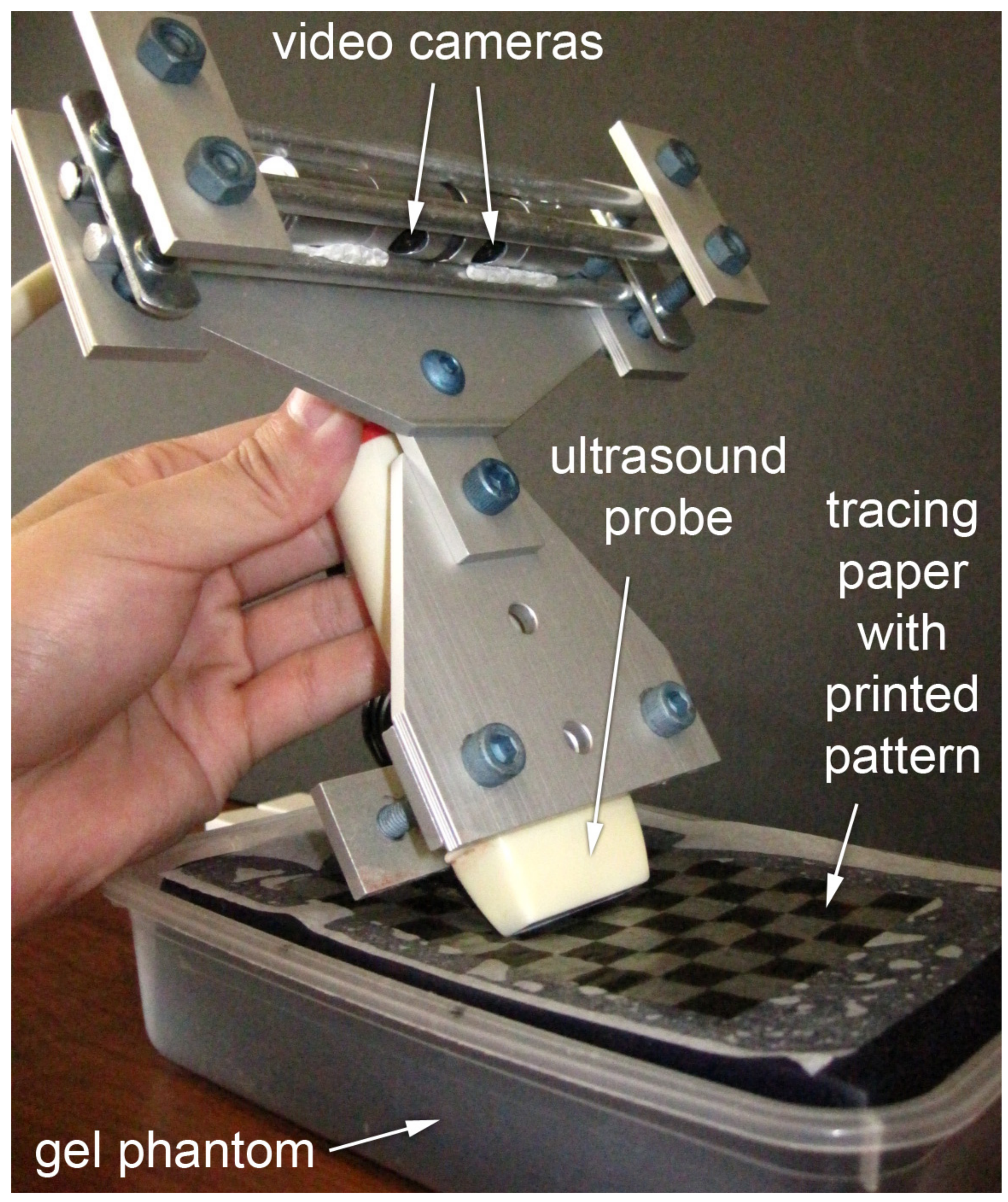
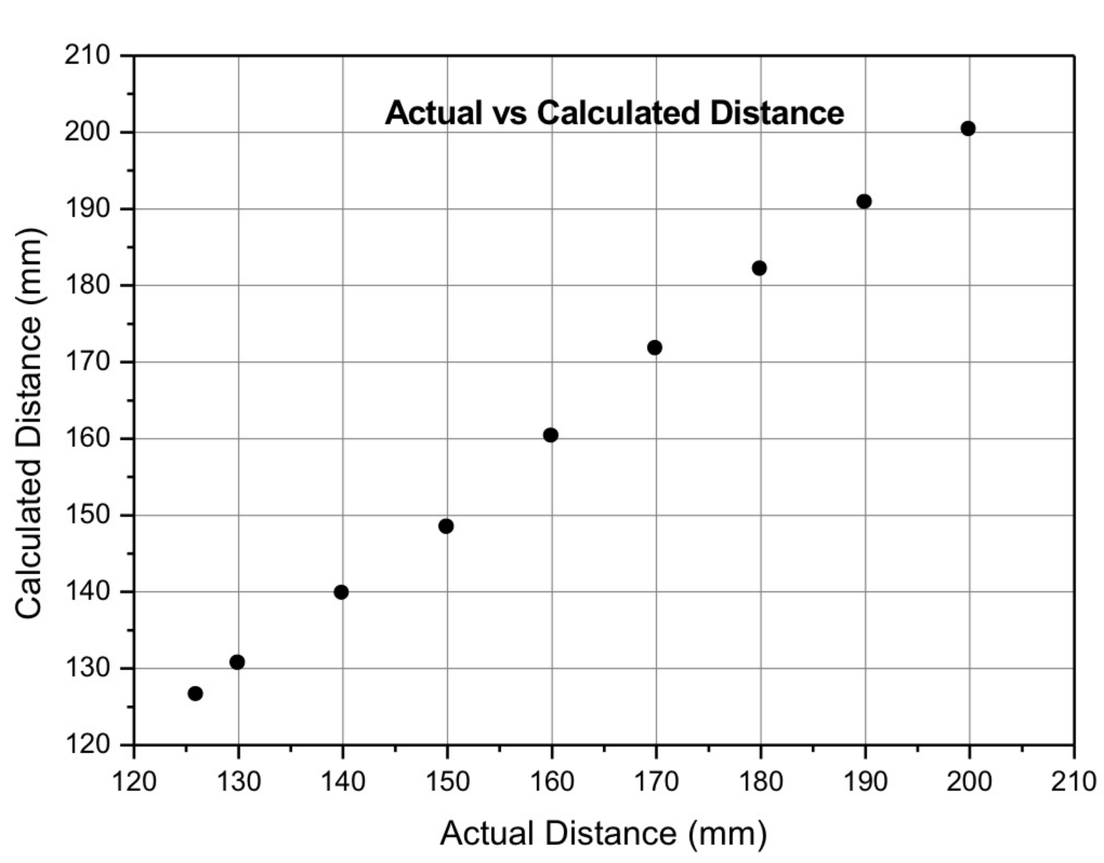
Purpose: Medical ultrasound typically deals with the interior of the patient, but for the human operator scanning the patient, the view of the external anatomy is essential for correctly locating the ultrasound probe on the body and making sense of the resulting ultrasound images in their proper anatomical context. We are now interested in giving vision to the transducer, by mounting video cameras directly onto the ultrasound probe. This could eventually lead to automated analysis of the ultrasound data within its anatomical context, as derived from an ultrasound probe with its own visual input about the patient's exterior.



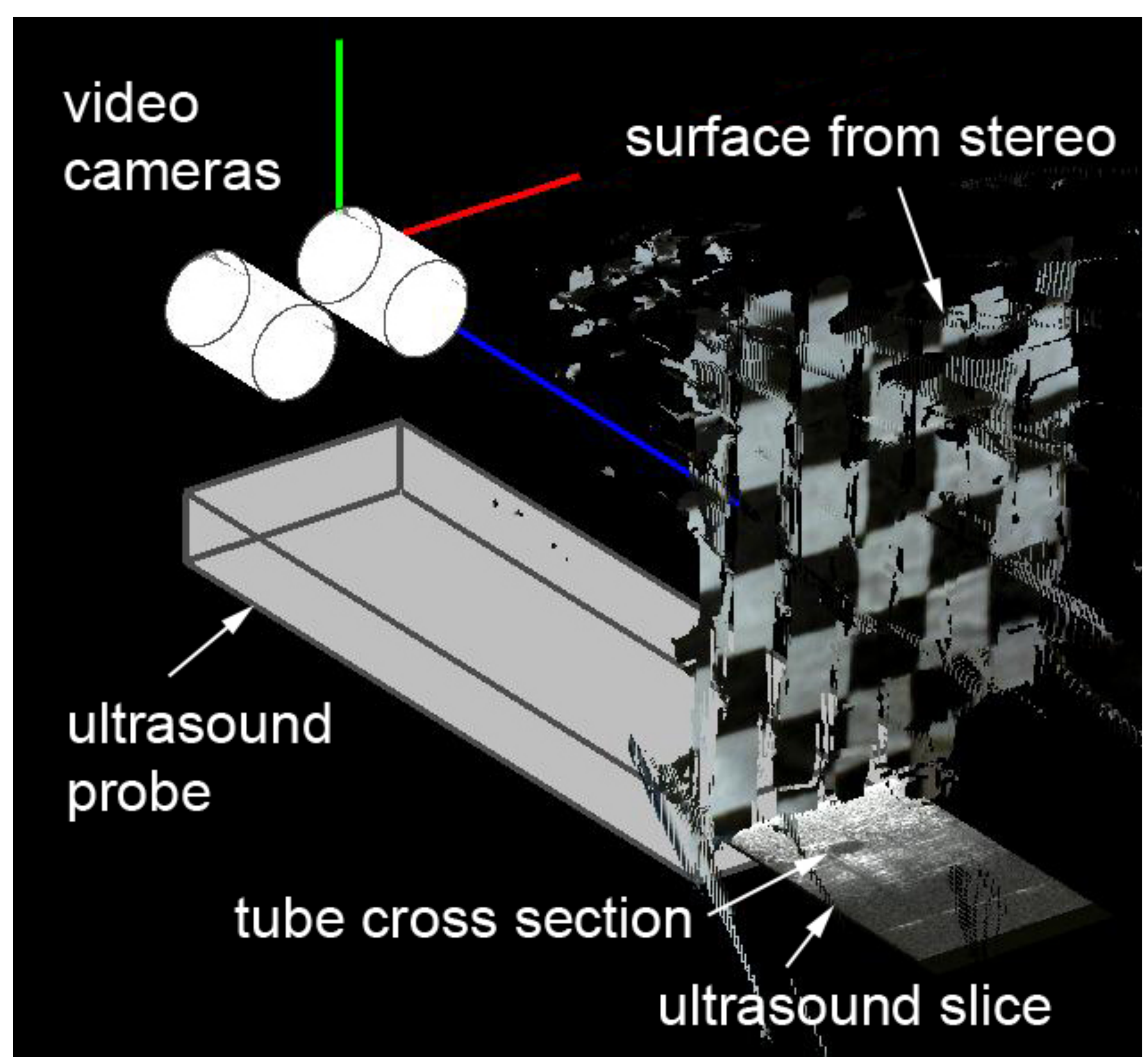
Tracking Surface Texture: Probe position cannot always be disambiguated based only on the external shape of the local anatomy and the ultrasound data. This is especially true for arms and legs, where different cross-sections may look identical. Tracking visual surface texture (freckles, hair, etc.) may provide a solution. To that end, we are now accurately tracking points on the surface over time. We do this by using 2D optical flow to establish temporal correspondences for the tracked 3D points across successive video frames. We plan to use this data to track the full 3D movement between the probe and the patient's exterior.

Calculating Shape and Distance: Our present embodiment of this concept consists of an ultrasound probe with two color-video cameras mounted on it, with software capable of locating the 3D surface of an ultrasound phantom using stereo disparity between the two video images. The separate viewpoints of the cameras allow triangulation of the 3D coordinates of observed points, revealing both the shape and position of the surface relative to the ultrasound probe in 3D in real time.

Testing: We have performed initial testing of our system using an ultrasound phantom, upon which a sheet of checkerboard tracing paper has been laid in order to add visible features to the phantom. The tracing paper was saturated with ultrasound gel so as not to interfere with the passage of ultrasound. We successfully created real-time renderings of both the surface and the ultrasound data, each displayed in the correct location relative to the other.



The RMS error in our system's distance measurements is ±1 mm.



Real-time 3D rendering of the ultrasound probe, the ultrasound data slice, and the surface of the phantom. The ultrasound data and the phantom's surface are correctly positioned relative to one another and to the probe.

Future Work: We plan to additionally use structured-light to improve our computer-vision system's robustness, which is necessary for the curved, deformable surface of human skin.

Conclusion: We believe this research represents important preliminary steps towards a clinically useful approach in merging visual and ultrasound data in real time as the ultrasound probe is moved over the surface of the patient. Eventually, automated analysis of these registered data sets may permit the scanner and its associated computational apparatus to interpret the ultrasound data within its anatomical context, much as the human operator does today.