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VERSATILE ROBOTIC PROBE CALIBRATION FOR FREEHAND 3D ULTRASOUND

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Purpose: Ultrasound probe calibration is essential when using ultrasound in image-guided therapy. Substantial research has been done in this field the last two decades, and this has resulted in a number of fast, automatic and accurate calibration methods. While these methods are usually developed for a specific probe, they are in principle easily adapted to other probes. In practice, however, this adaption often proves tedious, requiring modifications to several central components, such as phantoms and image processing algorithms. This is impractical in a research setting, where ultrasound guidance regularly is applied to new medical fields, all of which have their own more or less specialized ultrasound equipment. Therefore, we have developed a method which is not particularly fast, nor completely automatic, but which is accurate and, most importantly, easily adapted to new probes.

Materials and Methods: The method is point-based, using a plastic sphere in a water tank as an imaging target. The sphere was attached to a three-axes robot mounted above the water tank, and the ultrasound probe that was to be calibrated was rigidly attached to the water tank. This setup had to main features:

1. The plastic sphere was relatively large compared to the ultrasound image resolution, making it easier to segment accurately than a small point target whose image is often smeared out. By switching between spheres of different sizes, the setup was easily adapted to different probes.
2. The robot made it possible to automatize the calibration process. Its slow, accurate motion also facilitated an accurate segmentation of the centre of the plastic sphere.

Results: Three probes differing both in shape, size and image resolution were successfully calibrated with very small modifications to the calibration setup. The calibration process took approximately 90 minutes per probe, and the error was below 1.5 mm in all cases.

Conclusions: In our experience, most fast, automatic calibration methods are not sufficiently robust to be applied to very different ultrasound probes

without considerable and tedious modifications. Our simple method is therefore better suited in a research setting where new and different probes are to be calibrated on a regular basis.