Image Registration of 3D Trans-Esophageal Echocardiography and X-Ray Fluoroscopy for the Guidance of Trans-Catheter Aortic Valve Implantation

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Trans-catheter aortic valve implantation (TAVI) is an alternative to conventional open aortic valve replacement and is becoming more widespread. The procedure is performed by delivering the new valve via a catheter inserted either via the femoral artery or through the apex of the heart. Current-ly, TAVIs are routinely guided using X-ray fluoroscopy and 3D trans-oesophageal (TOE) echocardiography. X-ray fluoroscopy is excellent for device visualization and TOE is excellent for visualizing the anatomy of the heart. Correct positioning of the new valve is critical. In this study, we demonstrate a robust and efficient method to register TOE and X-ray images and validate this using data from 3 TAVI patients. We hypothesize that real-time fused data will be a powerful combination to guide valve implants. Three TAVI procedures were performed using a GE Innova 2100IQ X-ray system. Echo images were acquired using a Philips iE33 echocardiography system and a X7-2t 3D TEE probe. For each patient, multi-view X-ray im-ages were acquired simultaneously with 3D TEE images during the proce-dure. The image data were processed off-line for co-registration. The registra-tion was achieved using a combination of calibration of the TOE probe and localization in the X-ray images. Localization was carried out by GPU-accelerated 2D-3D registration of a nano-CT-derived 3D model of the TOE probe to the X-ray data. The registration accuracy was assessed by manual expert localization of the implanted devices in both the TOE and X-ray data. The target registration error was 2.7 ± 1.8mm, 4.2 ± 3.0mm, 2.3 ± 2.1mm respectively for the 3 different patient data. In conclusion, we demonstrate a novel technique for registration of 3D TEE and X-ray fluoroscopy images for the guidance of TAVI procedures. We have evaluated our approach off-line and shown clinically acceptable accuracy. Once developed as a real-time solution, this approach is likely to have a significant clinical impact.