# Group-wise Ultrasound to CT Registration of the Lumbar Spine

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**Objective:** The goal of this research is to design a percutaneous spine intervention system with ultrasound image guidance, requiring only a single preoperative CT or MRI scan. This would reduce the exposure to radiation and allow the procedure to be performed in an office.

**Background:** Currently, these interventions are performed in hospitals under fluoroscopy or CT guidance, exposing both the patient and physician to ionizing radiation. An essential component to an US based system is the registration of US images to a preoperative CT volume.

**Methods:** We propose an algorithm for group-wise registration of US to CT data of the lumbar spine. The vertebrae are transformed independently and reconstructed into a single volume. Similarity is calculated as the correlation between the real US volume and a simulated US volume, based on density information found in CT intensities. The algorithm combines simulated US reflection maps with simulated US images of soft tissue surrounding the vertebrae. The simulation is updated iteratively with the registration. Covariant Matrix Adaption – Evolution Strategy (CMA-ES) is used as the optimization strategy. The metric was also implemented for a rigid volume-to-volume registration of the spine. Three optimization strategies were tested: simplex, gradient-descent and CMA-ES.

**Experiments and Results:** Registration was tested using a phantom of the lumbar spine (L3-L5). The CT volume was perturbed by a random transform from a uniform distribution of ±10 mm translation along each axis and ±10° rotation about each axis. CT volumes were then registered back to the US volume. For group-wise registration, we were able to reliably register vertebra up to initial misalignments of 8 mm. Comparing the optimization strategies for rigid registration, we found CMA-ES to converge slower than gradient descent and simplex. CMA-ES however, was more robust for rigid volume-to-volume registration, accurately registering initial misalignments up to 20 mm.