**Introduction**

During this project, we

- Obtained CBCT images before, during and after robot-assisted surgical procedure
- Achieved sub-millimeter accuracy in registering CBCT images to pre-opera CT, tracker and robot
- Performed target-pointing and foam ablation experiments with effective virtual fixture (VF) constraint and real-time visualization

We aim at introducing intra-operative imaging as update to image-guided robotics, helping it better provide precise mechanical assistance and safety constraints.

**Outcomes and Results**

**CBCT-CT Registration**
Mean FRE: ~0.8 mm
Mean TRE: ~1mm

**CBCT-Tracker Registration**
Mean FRE: 0.5–0.8 mm
Mean TRE: <1mm

**Tracker-Robot Registration**
Pivot calibration error:
- Robot end effector: 0.43mm
- Robot rigid body: 0.64mm
Registration error: 0.65 mm

**The Problem**

- Neurosurgery, especially skull base surgery, requires high accuracy in localizing anatomical structures.
- Previous robot system starts with small pre-opera registration error but ends with cut out of VF in cadaver studies, and navigates only on pre-opera CT images.

**The Solution**

Intra-operative Cone Beam CT imaging is integrated into current skull base robot system to update registration, deformation, and ultimately virtual fixture.

**Future Work**

- Cadaver experiment
- Deformable CT-CBCT registration

**Lessons Learned**

- Accuracy control and system integration are of much important

**Credits**

- Hao: CBCT-CT and CBCT-Tracker registration
- Zihan: Tracker-Robot registration and visualization

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