PHOTOACOUSTIC GUIDANCE FOR SKULLBASE SURGERY

COMPUTER-INTEGRATED SURGERY II
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INTRODUCTION

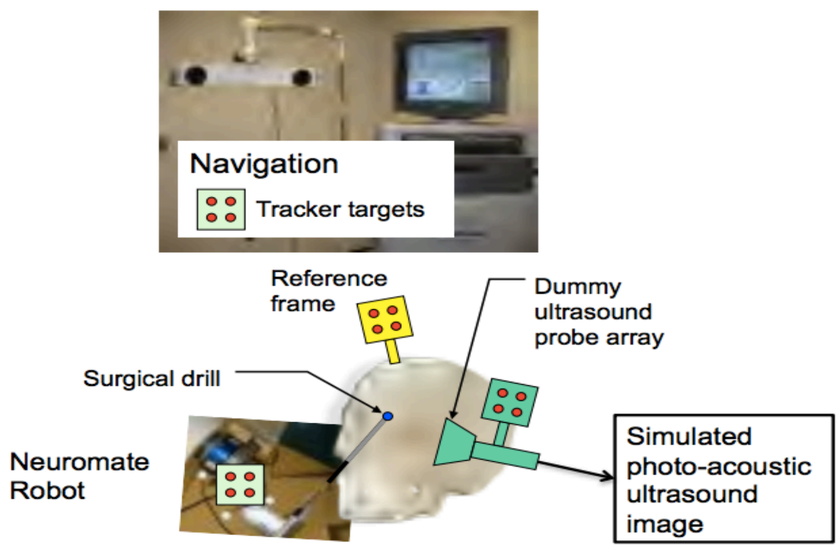
Transsphenoidal skull base surgery gives access to the pituitary region through the sphenoid sinus and is the preferred method of entry in adults. However, it is technically more difficult in children due to their smaller anatomy, and the region includes critical structures such as the carotid artery that must be avoided. In this study, we developed a software framework that incorporates simulated photo-acoustic ultrasound and showed that intraoperative photo-acoustic imaging has high potential to reduce the error (less than 1mm in some cases) in the existing computer-integrated skull base surgery system, thereby improving the feasibility of this modified system for clinical use.

THE PROBLEM

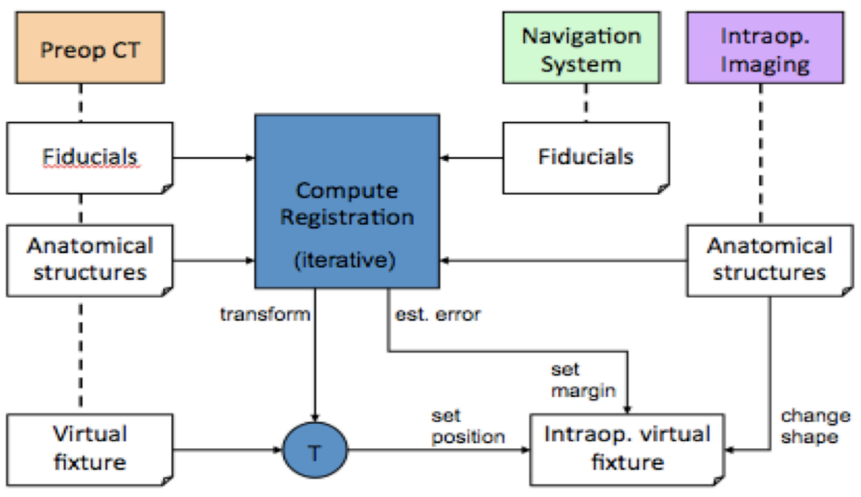
- Skull base surgeries represent a diverse number of approaches to address diseases and conditions focused in the delicate cranial regions. Access to these areas are currently limited by their anatomical complexity.
- In 2008, Dr. Kazanzides developed a system that integrates computer planning and navigation with robotic assistance for use in skull base surgery. However, the system was only able to achieve and average of **1-2mm** of error, with a maximum of **3mm**.
- The need for improved accuracy of this system will provide a clinical solution to the challenges involved in various skull base surgeries.

THE SOLUTION

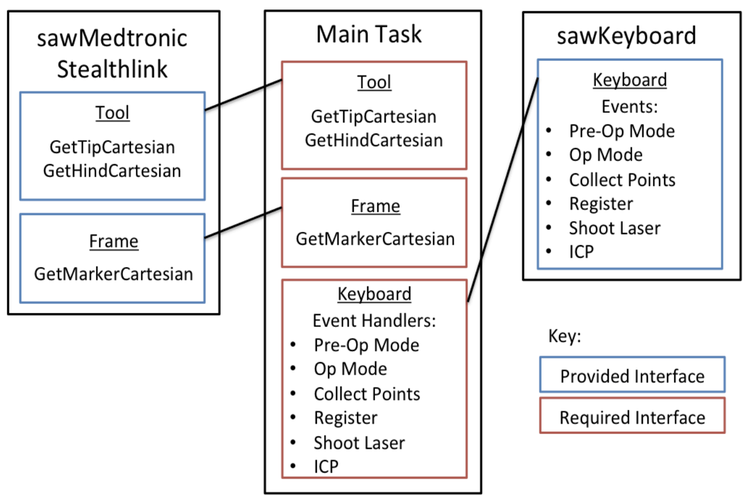
Goal: To improve the accuracy of computer-aided transsphenoidal skull base surgery through the use of intra-operative imaging to protect critical structures such as the carotid artery.



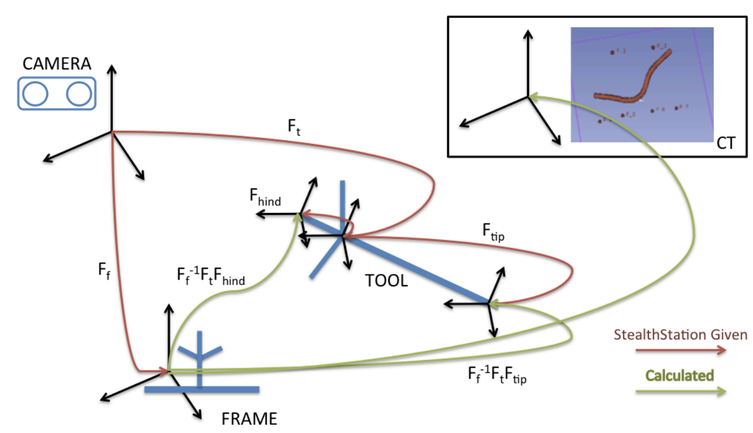
The positional information of anatomical structures collected intra-operatively can be used to re-compute the registration to the pre-op CT. The aim of this study is to put together and test a basic framework that will reduce the error to clinical specifications using ultrasound. We are concerned with system set-up, registration software development, and proof-of-concept.



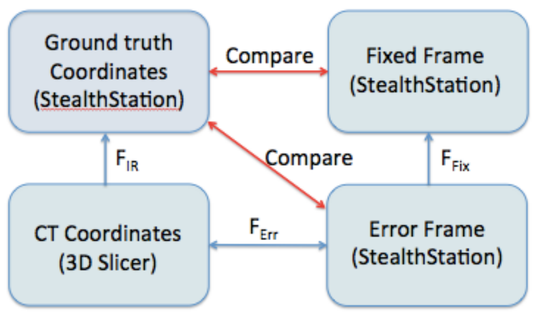
OUTCOMES: SOFTWARE ARCHITECTURE/SYSTEM SET-UP



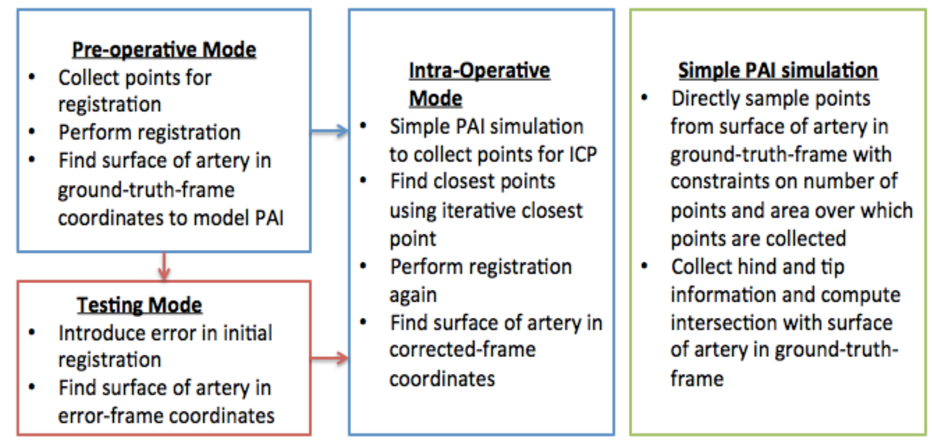
Software Architecture and Implementation



Registrations with Navigation System (StealthStation)



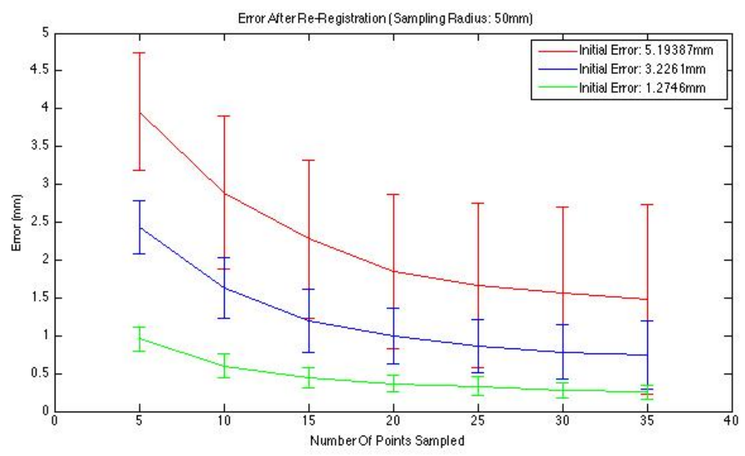
Experimental Design: introduce error and use ICP to correct and compare to ground truth



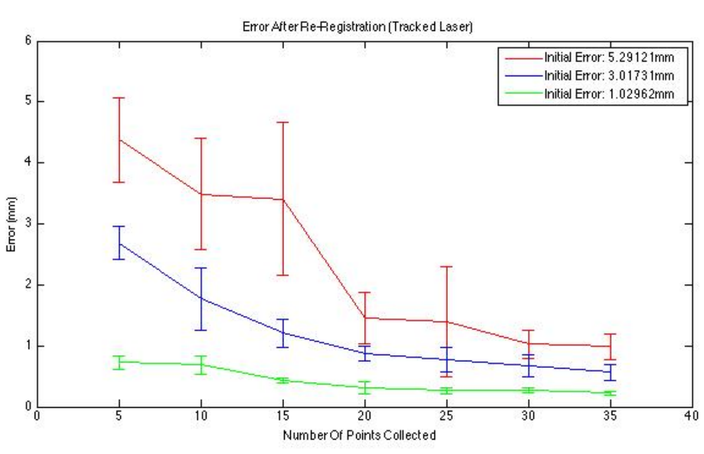
Software/Experimental Workflow

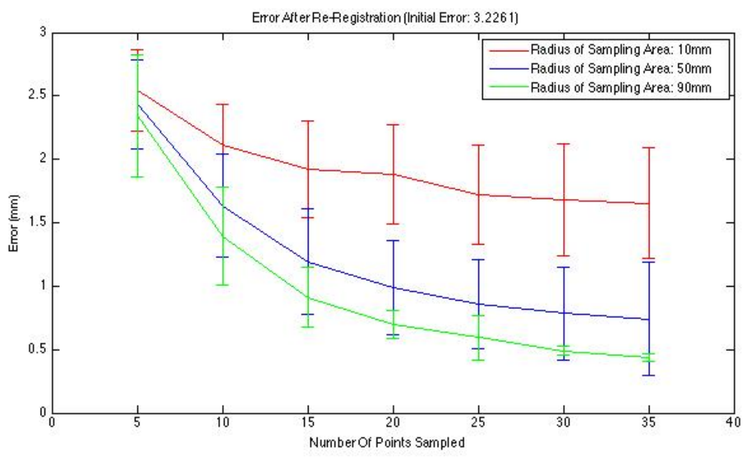
OUTCOMES: RESULTS

Simulated

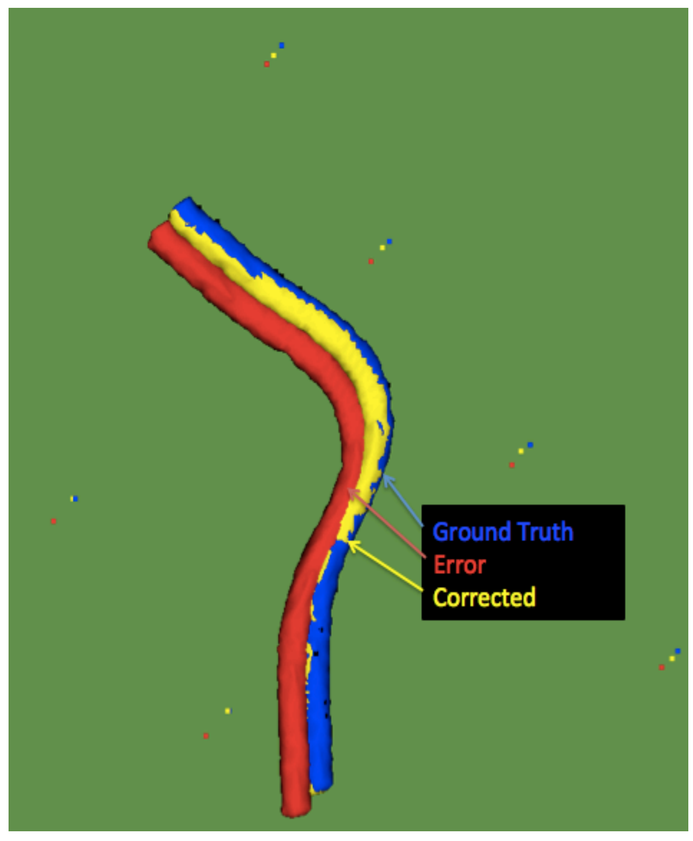


Tracked With StealthStation





With 25-35 points for ICP, the system is able to reduce the error to roughly **0.2mm** with a 1mm starting error, and roughly **0.6mm** with a 3mm starting error, both of which are in the clinically accepted range. The large standard deviations for higher introduced errors are due to higher starting error available for correction. Multiple trials of ICP will need to be done to insure accuracy. The cases with the least error involved sampling points from a larger area, which may be problematic for a surgeon working in a small space. Future work is headed in this direction.



LESSONS LEARNED

- Intra-operative PAI can reduce initial registration error
- Extent of the reduction in error and reliability is dependent on number of points collected and area of over which points are collected
- More points -> More reduction in error
- More area -> More reduction in error

FUTURE WORK

- Design and implementation of GUI interface and real-time visualization
- Incorporation of Neuromate and virtual fixture implementations
- Incorporation of actual PAI system
- Potential for better accuracy in using 2D PAI scanning to increase number of points

CREDITS

- Grace Yeo – Software Design/Implementation
- Allen Zhu – Experimental Design/Phantom

ACKNOWLEDGEMENTS

- Dr. Kazanzides and Dr. Bell for support
- Nathan Cho and Esteban Velarde for help with the CT scan
- Tutken Sen for help with our phantom