Visual Tracking of Surgical Tools in Retinal Surgery Using Particle Filtering and Mutual Information

William Yang and David Li, under the instruction of Dr. Rogerio Richa and Dr. Russell Taylor

**Outcomes and Results**
- Implemented on videos both prerecorded from actual surgery and live from phantom
- Error analysis conducted with MATLAB to model the Poisson distribution generated from the histogram of intervals of correct tracking
- Current gradient descent methods using sum of square differences or mutual information have P-values of 0.1

**Problem**
- Vitreoretinal surgery treats issues with retina and vitreous fluid
- Long surgical times and high risk of complications
- Further visualization techniques possible, but restricted
- Current procedures involve manual observation
- Surgeon desires something easy to implement, using current equipment, noninvasive, and simple to use

**Introduction**
- Project contributes to alleviating difficulties with indirect visualization by providing valuable data for other visualization techniques for integration such as intraocular OCT
- A tool tracking system using particle filters was created using mutual information as a similarity measure
- Used to track the position and angle of retinal tools with both live and prerecorded video
- Preliminary error analysis was performed using a ground-truth annotated data set

**Solution**
- Solution: Create software-based tool tracking method
- Particle filters were implemented for computational efficiency and avoidance of local minima
- Mutual information was used for robustness in varying illumination, rotation, and limited texture information
- Particle filter implementation is provided by OpenCV library
- CISST library integration via tracker filter included

**Future Work**
- Asynchronous tracking
- Parallelization of code to support multiple particles at once
- Parallelization of mutual information algorithm
- Methods for dealing with specularity and background textures by using disparity maps
- Method for dealing with erroneous shadow tracking

**Lessons Learned**
- Installation of OpenCV, CISST, and CUDA is a top priority
- Optimization of code for CISST and parallelization should be performed from the start of development
- Particle filtering is very robust, but an ideal application should attempt to cover any weaknesses possible
- Lack of texture information used by mutual information can cause problems with specularity

**Division of Labor**

**Support by and Acknowledgements**
- Supported in part by the NIH Bioengineering Research Partnership grant NIH 1R01 EB007969
- Thank you to Dr. Rogerio Richa for excellent mentorship
- Thank you to Haluk Noyan Tokgozoglu and Dr. Russell Taylor for instruction