LABORATORY FOR Computational Sensing + Robotics

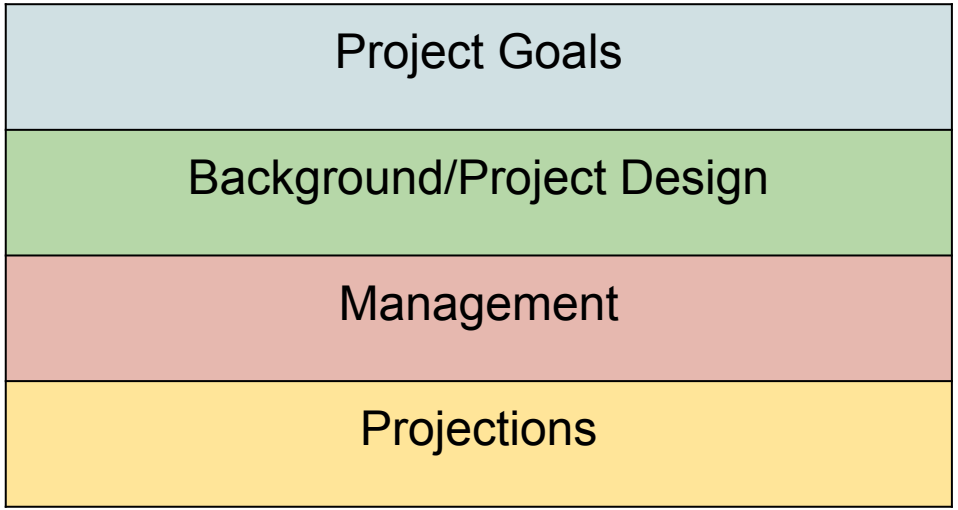
ERC | CISST

Optimized Tissue Structure Modeling

Team 10: Benjamin Strober & Nate Schambach

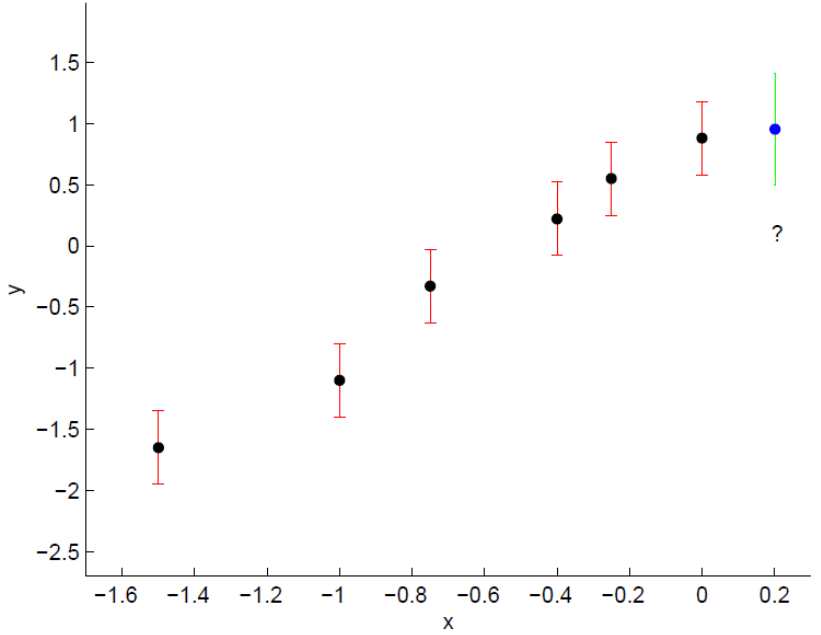
Mentors: Prof. Kobilarov, Prof. Taylor, Preetham Chalasani

Presentation Outline



Project Goals

Determine optimal palpation trajectory for accurate digital tissue reconstruction



Theoretical Framework

- **Gaussian Process:** Model each palpation (force sensor) reading as a gaussian distribution
  - Compute gaussian model of interpolated points within tissue range
- **Cross Entropy Method:** determine optimal trajectory of palpations
  - Optimal trajectories minimizes variance of gaussian process

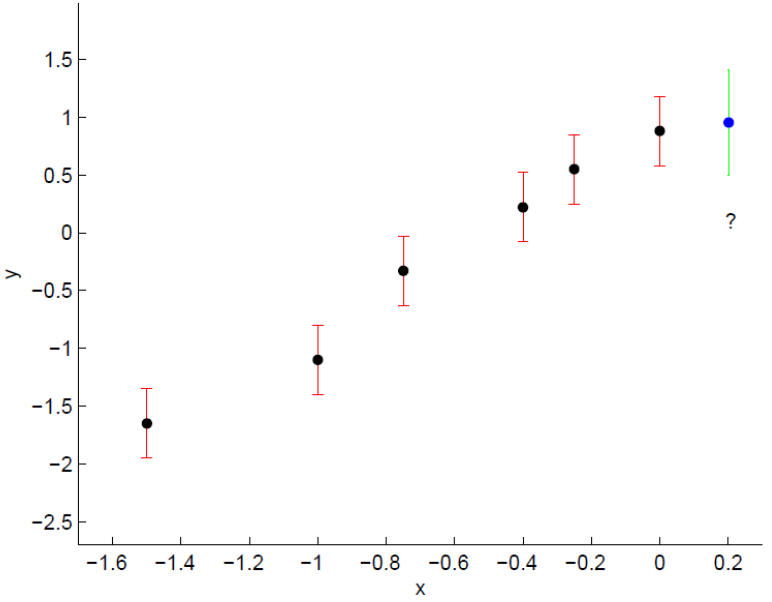
Pseudocode for algorithm

Initialize rough estimate of surface shape

while (variance > threshold) {

- Palpate optimal point and model as gaussian distribution
- Calculate gaussian process
- Model interpolated points within tissue range
- Use cross entropy method to determine optimal next point

}



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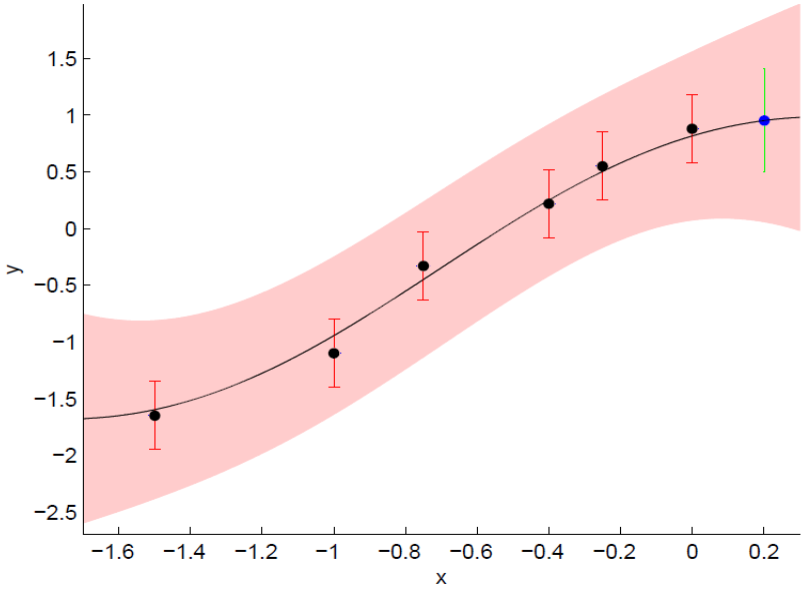
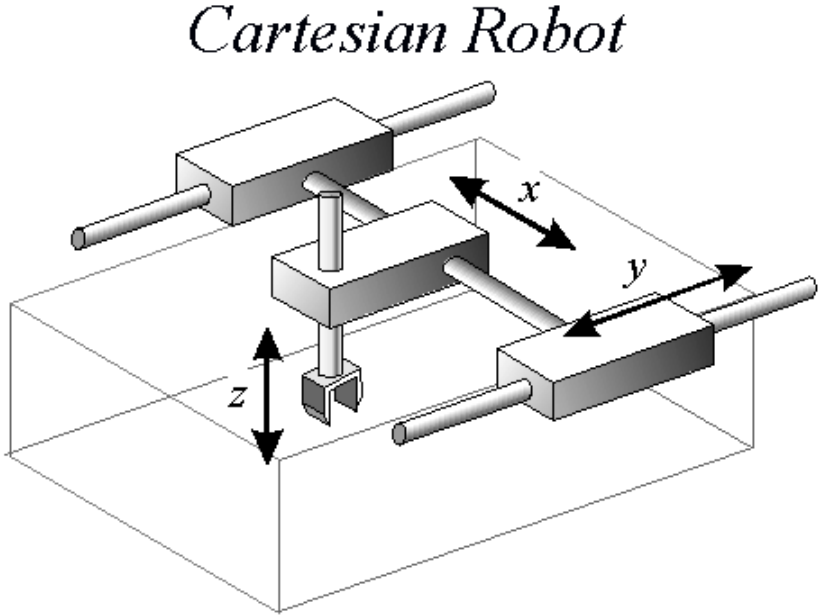


Plan For a Plan: Stiffness Incorporation

Using the computed Geometry Reconstruction, perform GP/CEP to compute the full surface tissue reconstruction.

Obtaining Data Points

- Cartesian Stage and Force Sensor for physical testing
  - Located within robotorium
  - Test on Model Tissue (Foam Shape)



Potential Applications

- Guiding Exploratory Surgery
  - Accurate real time localization of tumors
  - After finding tumor, guiding surgeon to remove tumor utilizing computer vision techniques and virtual fixtures

Deliverables

- **Minimum:** Geometry reconstruction of a sample image using Gaussian process with cross entropy optimization
- **Expected:** Geometry reconstruction of sample tissue using Gaussian process with cross entropy optimization
  - Utilize cartesian stage
- **Maximum:** Using geometry reconstruction of sample tissue, create model of stiffness within tissue

Dependencies

Dependency	Resolution	Projected Date
Force Sensor	Pursue Company	3/3/15
Force Sensor Attachment	CAD, Rapid Prototype	3/3/15
GalilTools	Work with Preetham	3/9/15
PC for Cartesian Stage	Work with Mentors or use our own	3/9/15
Working knowledge of CISST Libraries	Training from Preetham	3/16/15
Robotorium Access	Contact Alison Morrow	2/16/15
Dependencies 1-6	Continue with only simulation	Ongoing
Access To Expertise	Meetings with Mentors	Ongoing

Management

- As we have equivalent skills and there are only two of us, we plan to work side-by-side three times a week
  - This worked well for CIS 1
- We are going to meet with Preetham every Tuesday at 4:30

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Timeline

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Deliverables	2/ 16	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12
Planning phase												
Project Proposal Write Up												
Theory Familiarization												
Existing Code Familiarization												
Initial Implementation												
GP on Image (code and implementation)												
Cross Entropy on Image (code and implement)												
Get Force Sensor												
Attach Force Sensor + Sensor Probe												
Cartesian Stage Operation												
Physical Implementation												
GP in 3D												
CEP in 3d												
Implementation using cartesian stage												
Test using various shapes												
Stiffness Incorporation												
Implement Stiffness Independent of Geometry												
Fusion with Geometry Implementation												
Closure phase												
Presentation Preparation												
Project Documentation and Clean Up												

Background Reading

1. C. E. Rasmussen & C. K. I. Williams, Gaussian Processes for Machine Learning, the MIT Press, 2006, ISBN 026218253X. c 2006 Massachusetts Institute of Technology.
2. Ebden, Mark. *Gaussian Process for Regression: A Quick Introduction*. N.p., Aug. 2008. Web.
3. Neal, R.M.: Regression and classification using Gaussian process priors (with discussion). In Bernardo, J.M., et al., eds.: Bayesian statistics 6. Oxford University Press (1998) 475–501
4. Williams, C.K.I.: Prediction with Gaussian processes: From linear regression to linear prediction and beyond. In Jordan, M.I., ed.: Learning in Graphical Models. Kluwer Academic (1998) 599–621
5. Kroese, D. "The Cross-Entropy Method." *A Unified Approach to Combinatorial Optimtimization, Monte-Carlo Simulation and Machine Learning*. By R. Rubinstein. N.p.: n. p., n.d. N. pag. Print.