Intraoperative Fiducial Tracking in TORS

CIS II Project #15

Plan Presentation

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Project Mentors: Wen P. Liu, Anton Deguet

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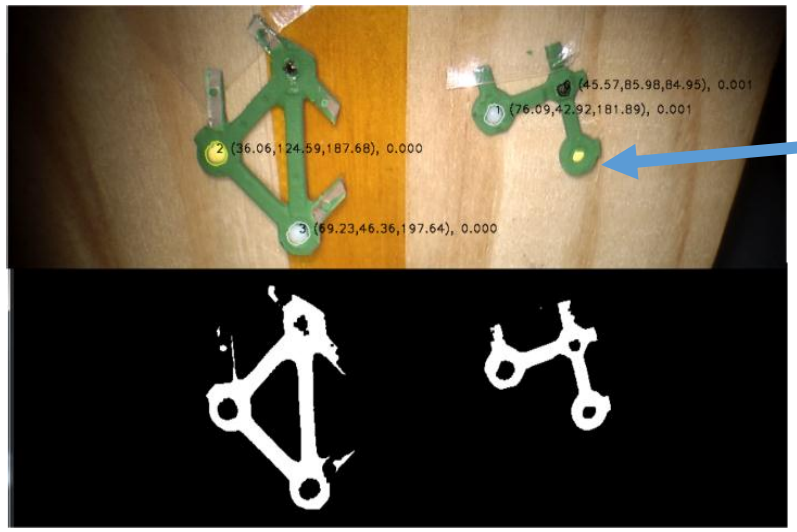
Project Goal

- The goal of this project is to design and implement an intraoperative fiducial tracking algorithm in TORS that can accurately track the fiducial under the endoscope.

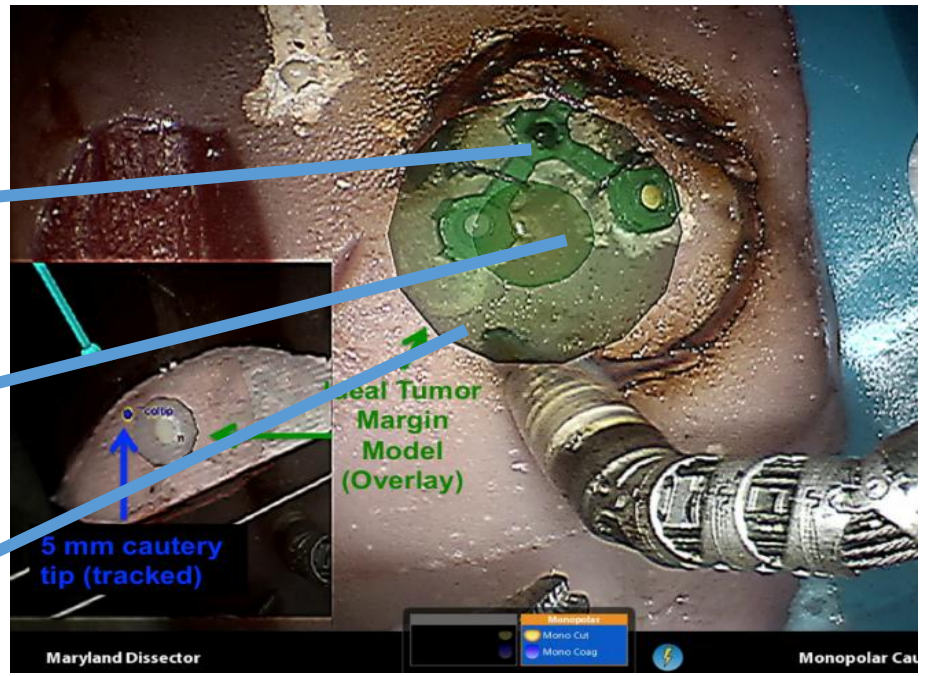


Images courtesy of Wen P. liu

Fiducial

Ideal virtual tumor estimated according to the position of the fiducial

Ideal virtual tumor margin



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Project Background

- TORS: TransOral Robotic Surgery
- The base of tongue tumors has become a significant health care concern. Because most base of tongue tumors are buried deep in the musculature of the tongue, when doing the transoral surgery, expert surgeons always rely on experience to remain correctly oriented with respect to critical anatomy.
- Such practice leaves considerable room for improvement and has brought TORS. It is a minimally invasive surgical intervention for resection of base of tongue tumors.

http://www.ohsu.edu/xd/health/services/comprehensive-robotics-program/surgical-services/transoral-robotic-surgery-tors.cfm

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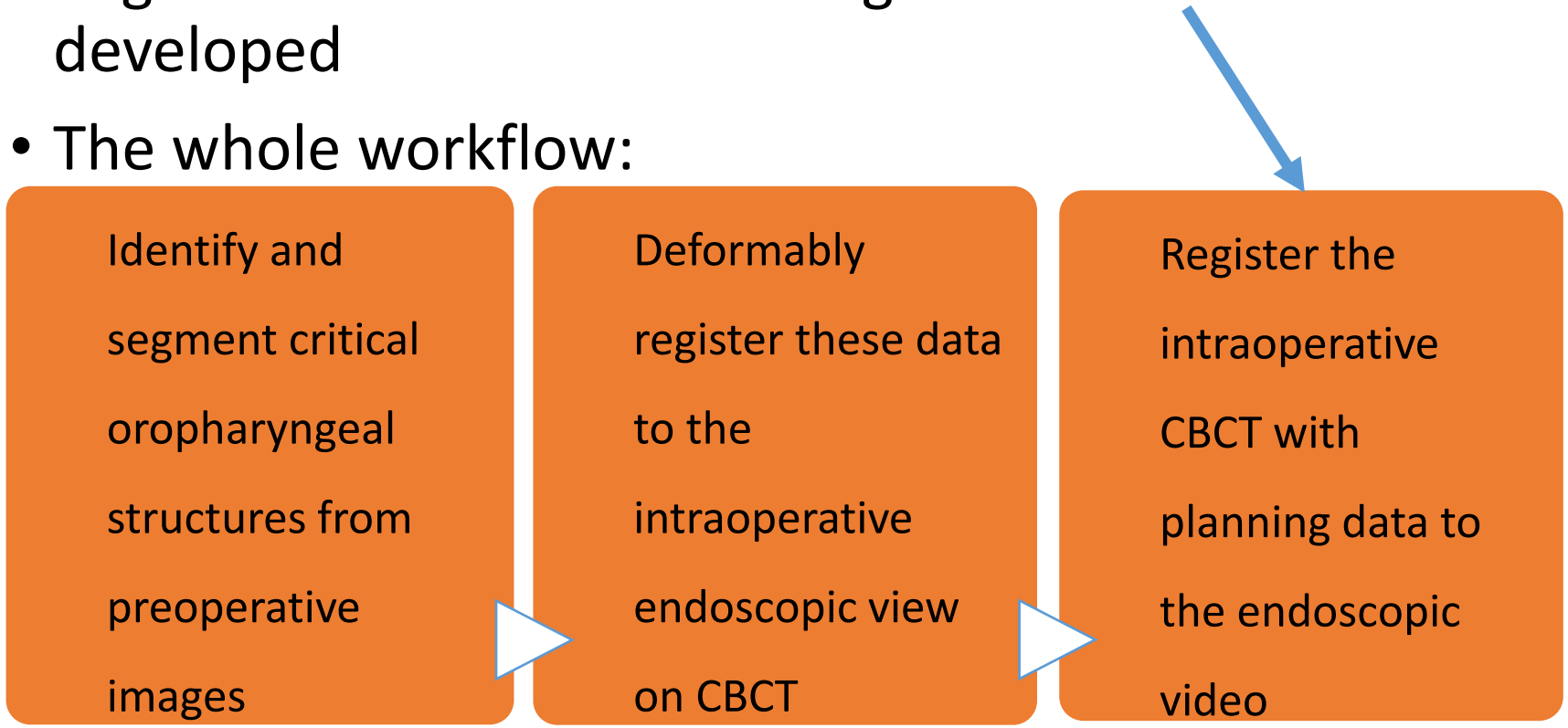
Project Relevance

- A system that uses intraoperative CBCT to do endoscopic video augmentation for base of tongue tumor resection in TORS has been developed
- The whole workflow:

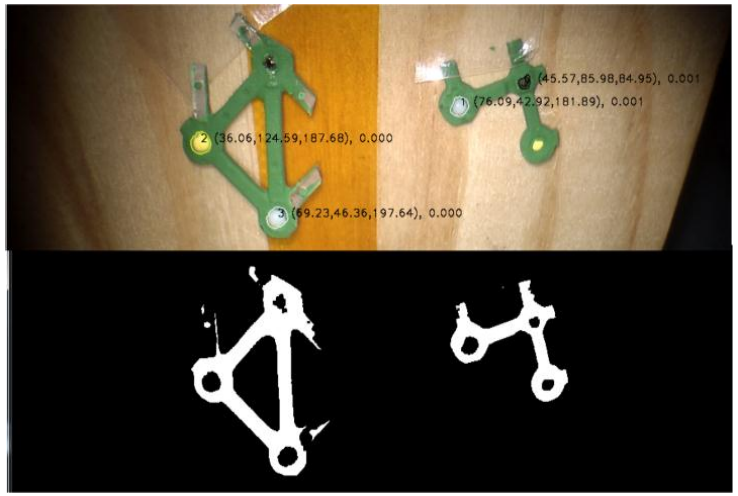


$${}^{\text{Video}}T_{\text{CT}}=({}^{\text{Video}}T_{\text{CBCT}})({}^{\text{CBCT}}T_{\text{CT}})(Data_{\text{CT}})$$

Project Relevance (Continue)

- Stereoscopic Video Augmentation System: ${}^{\text{Video}}T_{\text{CBCT}}$

- Using Fiducial



courtesy of Wen P. liu

$${}^{\text{Video}}P_{\text{fiducial}} = {}^{\text{Video}}T_{\text{CBCT}} * {}^{\text{CBCT}}P_{\text{fiducial}}$$

$$\downarrow$$

$${}^{\text{Video}}T_{\text{CBCT}} = {}^{\text{Video}}P_{\text{fiducial}} * ({}^{\text{CBCT}}P_{\text{fiducial}})^{-1}$$

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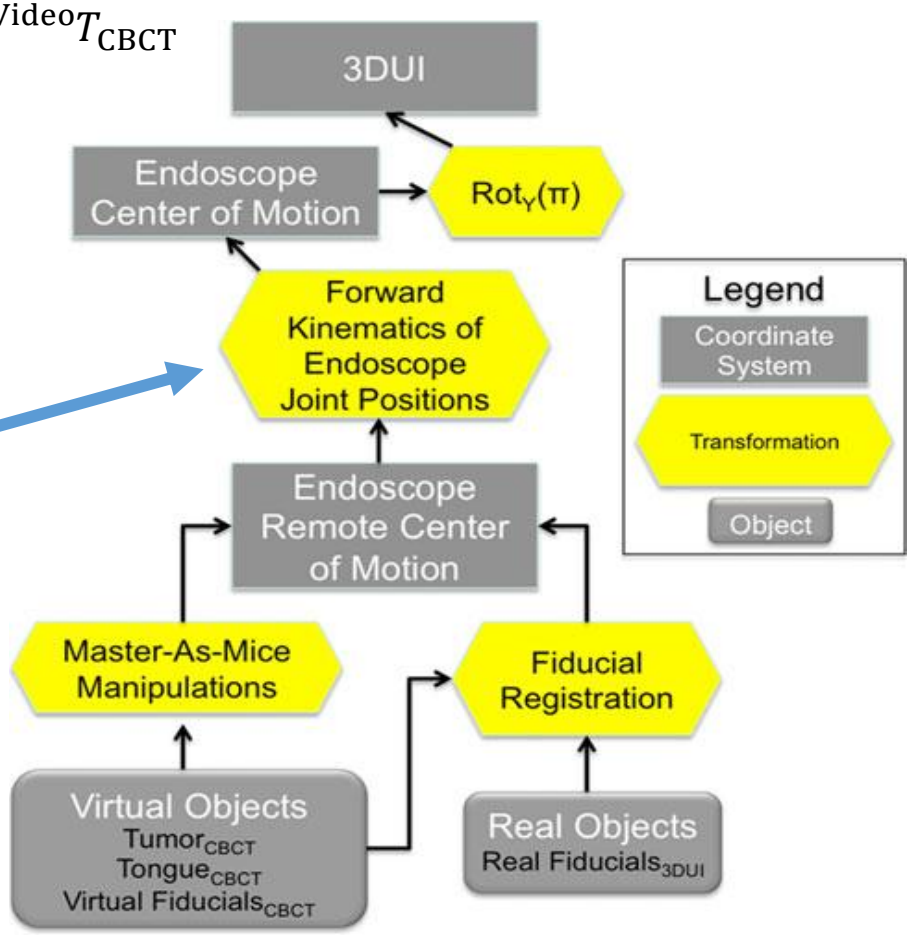
Project Relevance (Continue)

- Stereoscopic Video Augmentation System: ${}^{\text{Video}}T_{\text{CBCT}}$

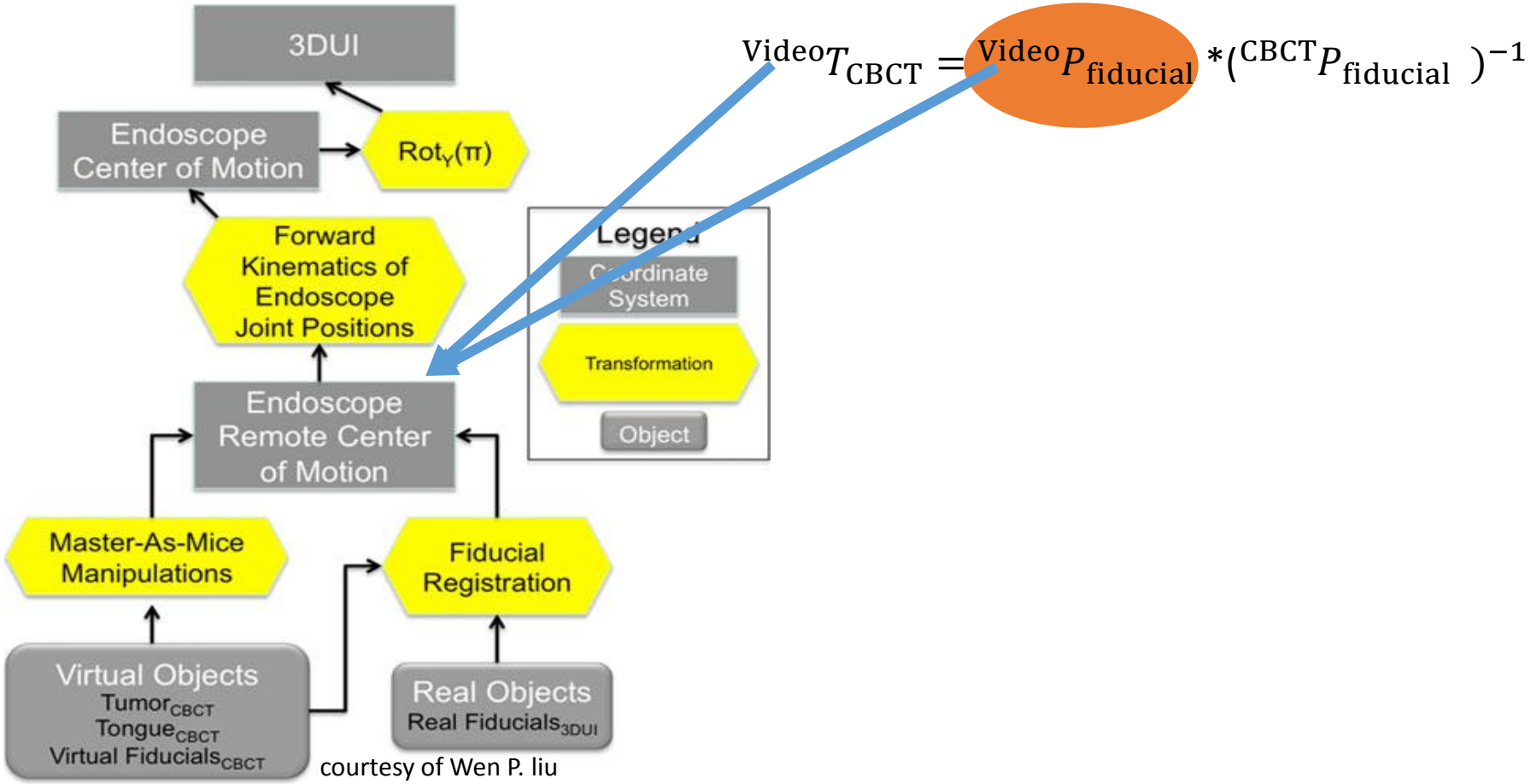
Transformation tree depicting the coordinate systems and associated objects maintained by the video augmentation program through tracking of the da Vinci and registration steps



courtesy of Wen P. liu

Project Relevance (Continue)

- Stereoscopic Video Augmentation System: ${}^{\text{Video}}T_{\text{CBCT}}$



courtesy of Wen P. liu

Project Relevance (Continue)

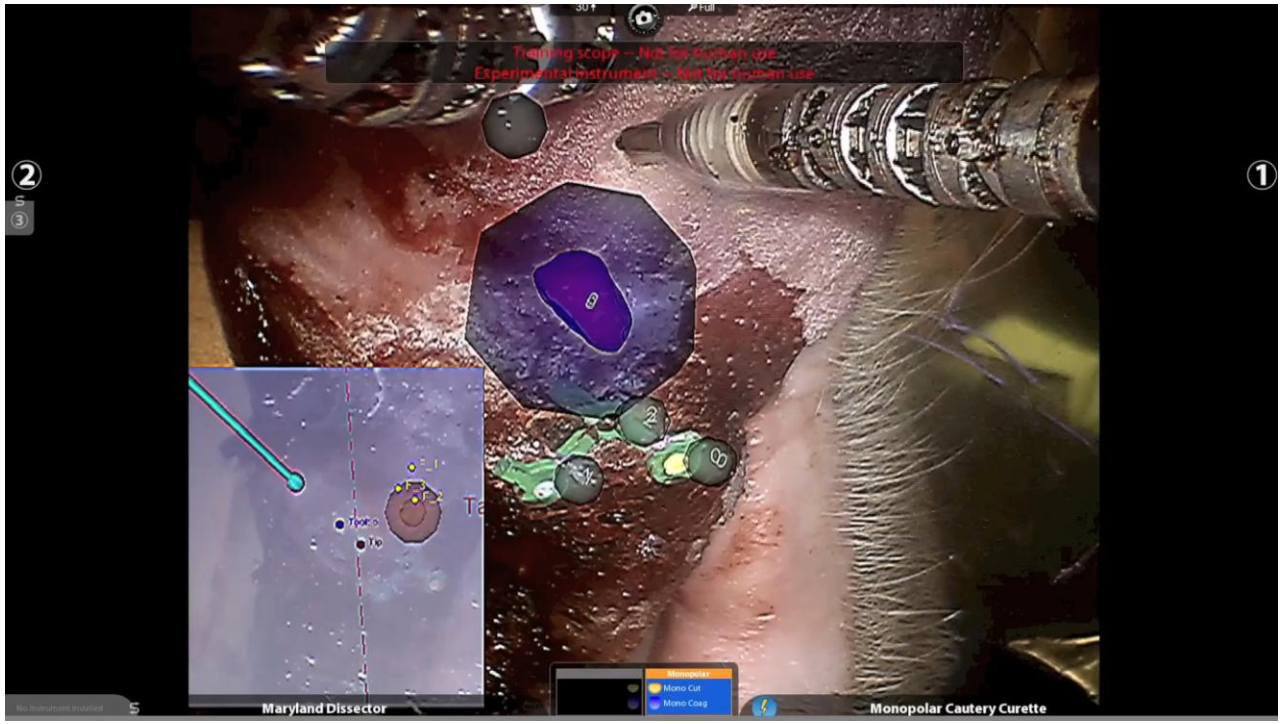
- Stereoscopic Video Augmentation System: ${}^{\text{Video}}T_{\text{CBCT}}$ → ${}^{\text{Video}}P_{\text{fiducial}}$

Fiducial Registration

Intraoperative Fiducial Tracking

Project Technical Summary

- The goal is to achieve real-time fiducial tracking under the endoscopy
- Difficulties are the jitter of the fiducial during the surgery and the complexity of the background information



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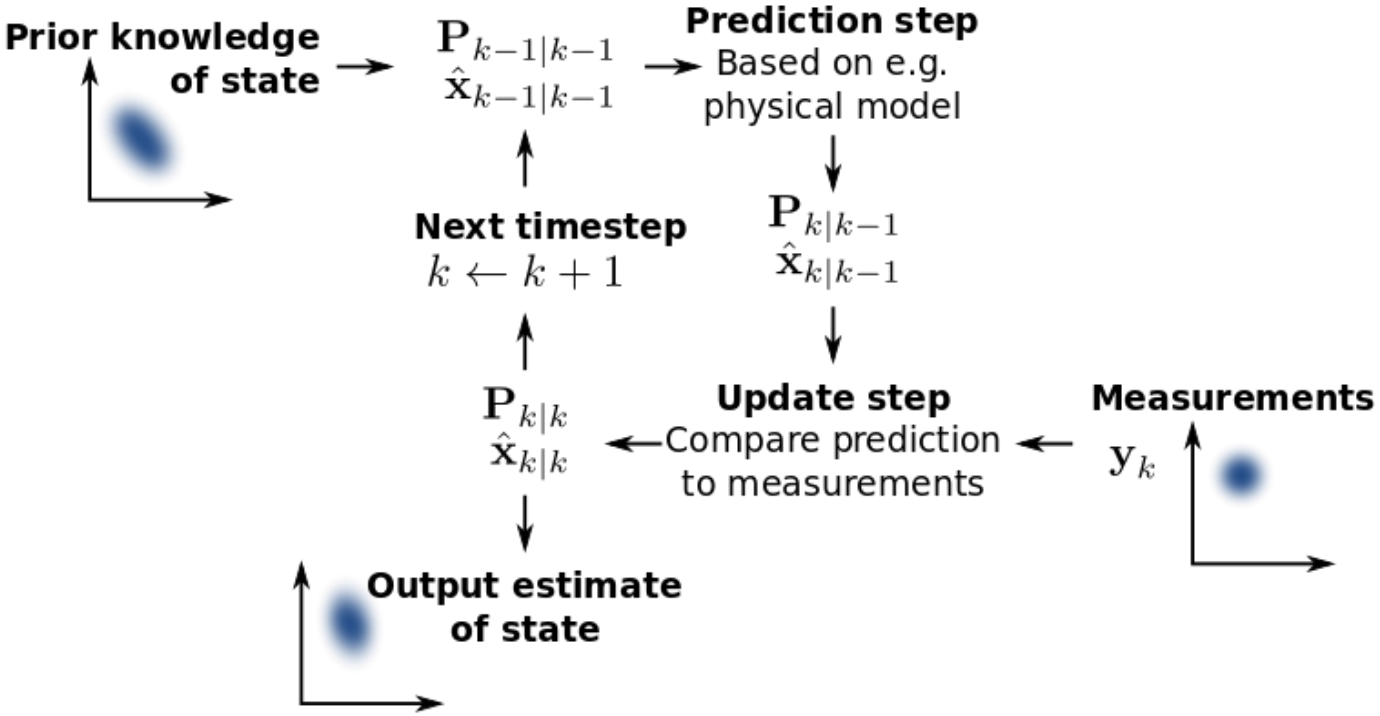
Project Technical Summary (Continue)

- Algorithm: Kalman Filter



http://en.wikipedia.org/wiki/File:Basic_concept_of_Kalman_filtering.svg

Project Technical Summary (Continue)

- Implementation:

  Coding with C++ (using cisst and saw libraries and OpenGL)

- Testing:

  Work on the da Vinci robot console

  Using CAD to design new fiducial

Project Deliverables

- Minimum:

  Implement fiducial segmentation of the intraoperative endoscopic images

  Implement fiducial tracking of the intraoperative stereo video

  Test and optimize the implementation to confirm better result than the already existed tracking method

- Expected:

  Test fiducial tracking under the robot endoscopic camera and get intraoperative real-time tracking result

- Maximum:

  Optimize the implementation to confirm more accurate tracking and record a video for the tracking
  Design new fiducial for better and more accurate tracking

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Project Key Dates

Feb. 20: Complete Software Installation: Visual Studio 9.0, CMake, SVN, cisst saw library, OpenGL

Feb. 21: Begin algorithm design

Feb. 22: Begin software and cisst study

Feb. 23: Begin new fiducial design (optional, might do it after testing the implementation on the robot)

March. 1: Print the new fiducial (optional)

March. 7: Algorithm study and design complete

March. 10: Begin algorithm implementation (coding) with C++

April. 10: (Minimum deliverable) Complete algorithm implementation and optimization

April. 12: Begin testing on the robot

April. 22: (Expected deliverable) Complete testing on the robot and get the intraoperative tracking result

April. 29: (Maximum deliverable) Complete optimization and record video for the fiducial tracking during TORS

May. 9: Post session and project report

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Project Dependencies

- Cisst and saw understanding

  Solution: Read tutorials and ask Wen and Anton

- Access to 3D printer and knowledge of CAD

  Solution: Read books and ask Wen

- Access to the robot

  Solution: Ask Wen and Prof. Taylor for permission

Project Management Plan

- Bi-weekly tele-conference with Wen before March.
  Weekly meeting with Wen afterwards through the completion of the project.

- Bi-weekly meeting with Anton after the beginning of implementation.

Project Reading List

- We P. Liu et al, “Toward intraoperative image-guided transoral robotic surgery”. J Robotic Surg 2013
- Wen P. Liu et al, “Intraoperative Cone Beam CT Guidance for Transoral Robotic Surgery”
- Deguet A et al, “The cisst libraries for computer assisted intervention systems”. MICCA Workshop
- Stoyanov D, “Stereoscopic scene flow for robotic assited minimally invasive surgery”. MICCA-2012
- Desai SC et al, “Transoral robotic surgery using an image guidance system”. Laryngoscope 118(11): 2003

Thank You


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