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TELEMANIPULATION AND TELESTRATION FOR MICROSURGERY

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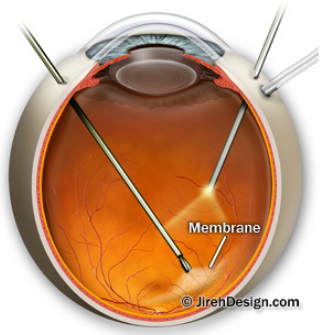
Group-7
Computer Integrated Surgery-II



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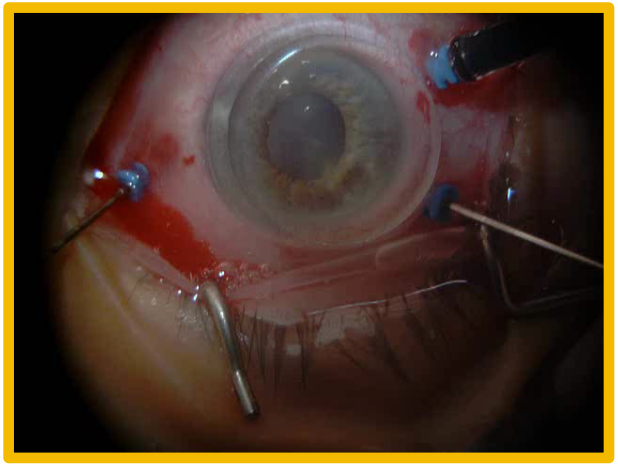
Background

- Retinal Disease and Surgery
  - Surgery:
    - Eye is a fragile organ
    - Leading cause of blindness
    - Requires extreme care before, during and after the surgery
    - **Success rate is largely dependent on the surgical skill**

  - Challenges:
    - Force attenuation from tool
    - Freehand manipulation of delicate structures
    - Lower tactile sensation than human
    - Involuntary hand tremor
    - **Surgeon fatigue**
    - No tactile feedback
    - Poor visual
    - Patient movement
    - Miniature instrumentation
    - **Surgeon training**



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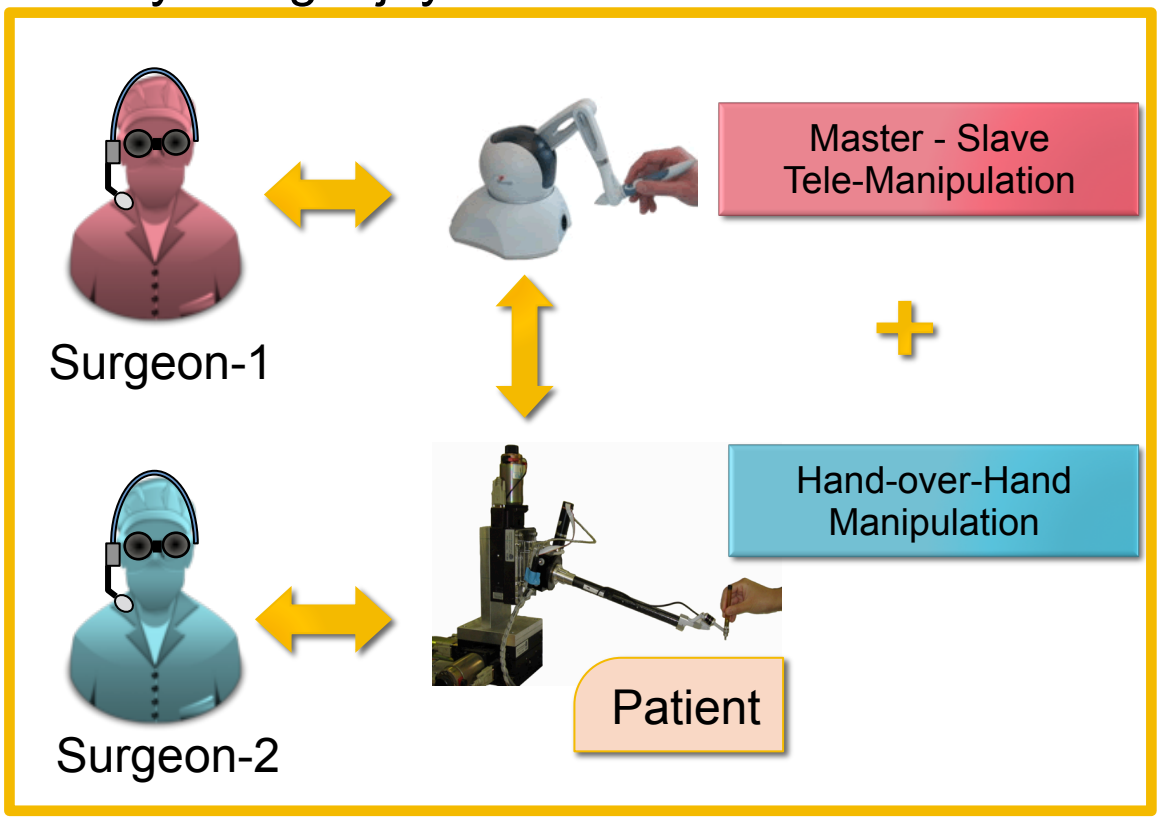
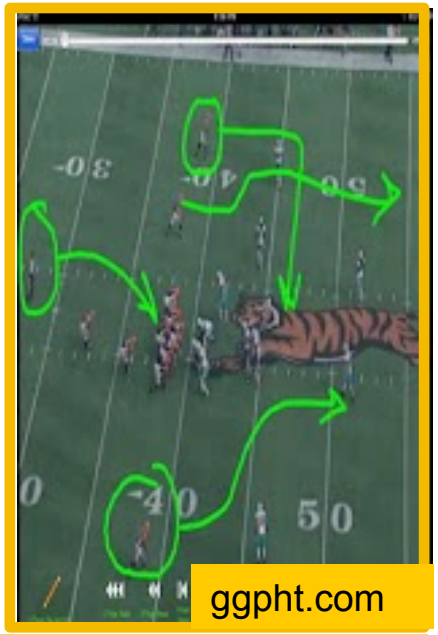
Telemanipulation

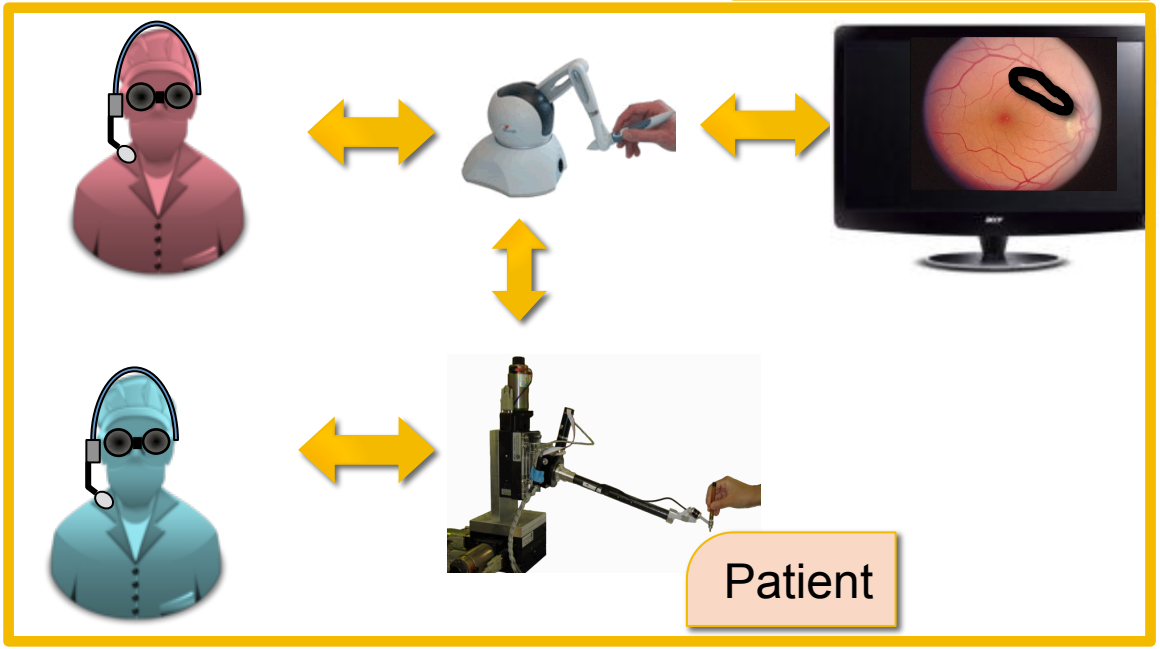
- What is it?
  - Manipulating a Robot remotely using a joystick control mechanism
- Why is it useful?
  - Education
  - Cooperative surgery
  - Motion scaling
- Important to whom?
  - Surgeons
  - Trainees



Telestration

- What is it?
  - Freehand drawing with the 3D video display
- Why is it useful?
  - Intraoperative communication
  - Anatomical annotation
  - Defining virtual fixtures pictorially
  - Education
- Important to whom?
  - Surgeons
  - Trainees





System Components

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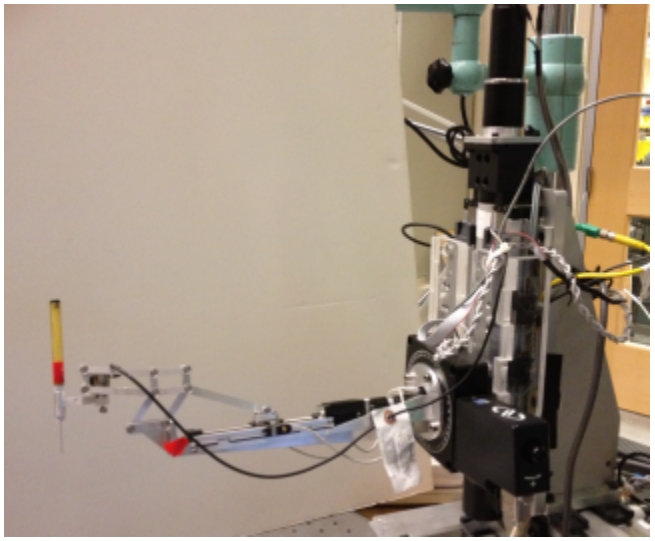

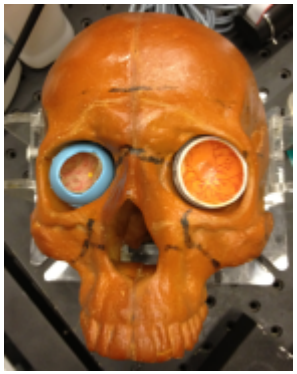

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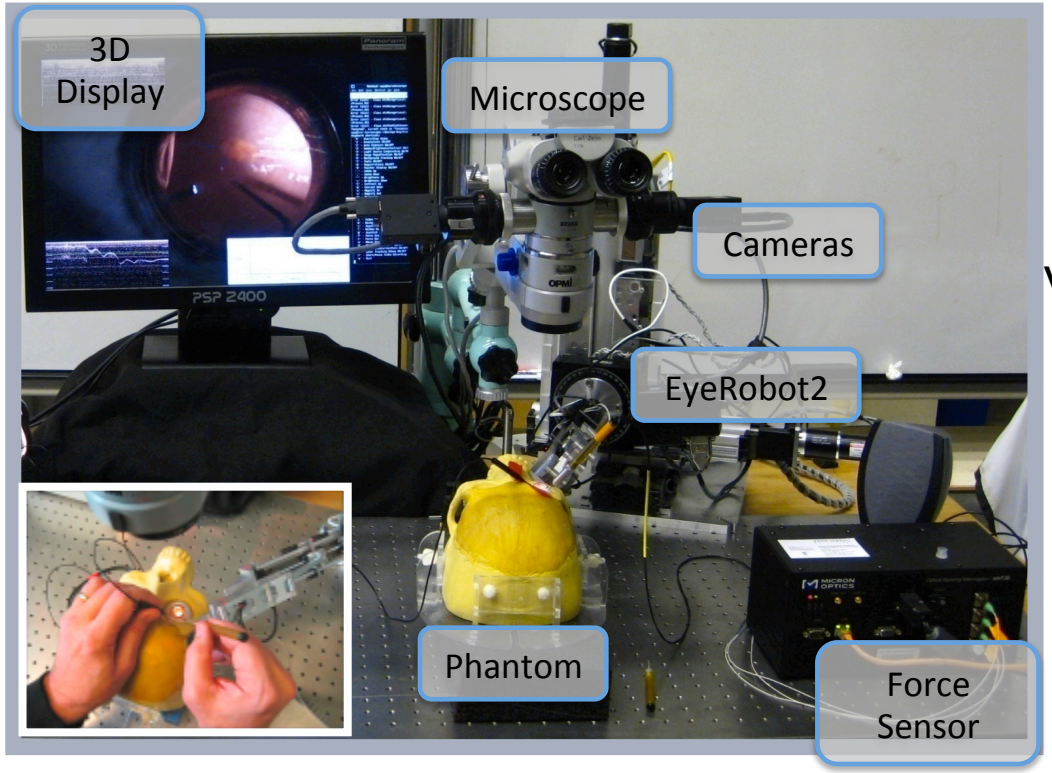
System Overview



RH Taylor et al.

Video/Sensor Data

Position Exchange

Current Status and Our Goal

- What exists:
  - Rough prototype telemanipulation via Omni
  - Tele-stereoviewer application

- What are we going to do:
  - User friendly Telemanipulation user interface (Pedal, GUI)
  - Refine Telemanipulation via Omni
  - Bimanual and bilateral teleoperation with two Omnis
  - Bimanual and bilateral teleoperation with da Vinci master console
  - Telestration
  - Virtual fixtures via telestration
  - Documentation / User manual / Project Report

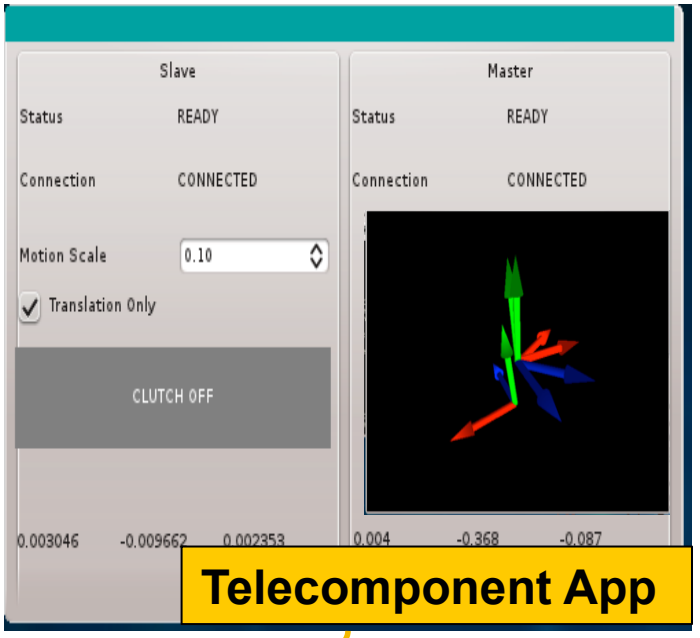
Motivation

- Why use telemanipulation and telestration?
  - Surgeon training
  - Multiple surgeons can cooperate and specialize
  - Increased precision for delicate manipulation tasks
  - Reduce fatigue

- Why add multiple features?
  - Surgeons should ultimately decide what is most useful and/or helpful during surgery
  - Surgeons will be able to gain a sense of usefulness when these features are available and working
  - There has been some initial interest in these features from surgeons

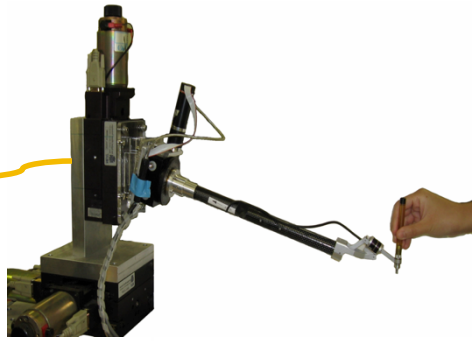
Technical Approach: Telemanipulation

- Modify **Teleopcomponent App**
- Based on cisstMultiTask library
- Interfaces to existing robotic components including Omni and Eye Robot
- Runs tele-operation algorithms and logic (e.g. clutching)



Telecomponent App

cisstMultiTask



Balicki et al.

Technical Approach Cont.

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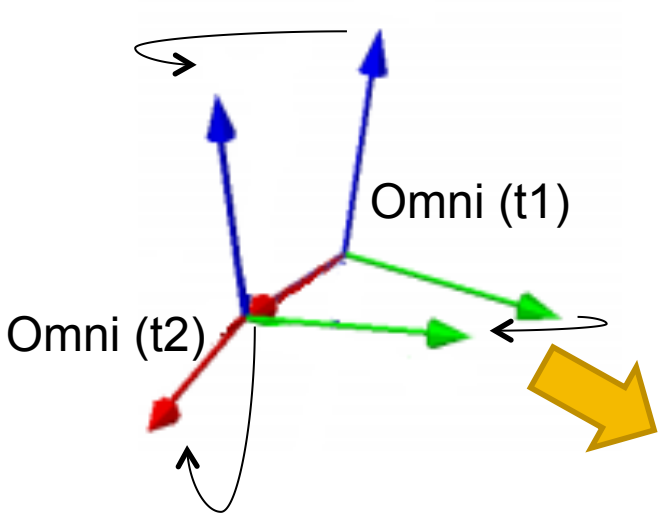
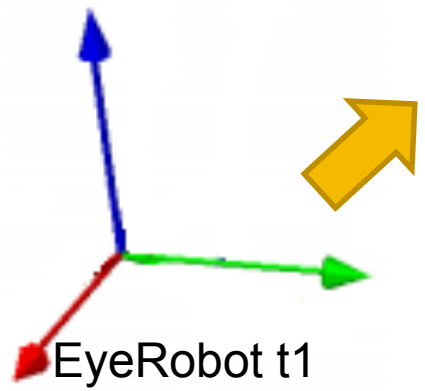


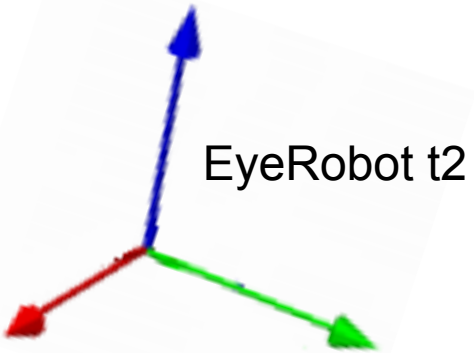
Under Investigation:

- Position to position exchange
- Constraint control optimization
- Force or position reflection
- Motion scaling
- Bilateral input control

Teleoperation Control Algorithm

Eye Robot moves with Δx, Δy, and Δz.

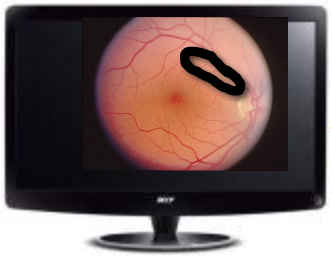




Technical Approach - Telestration

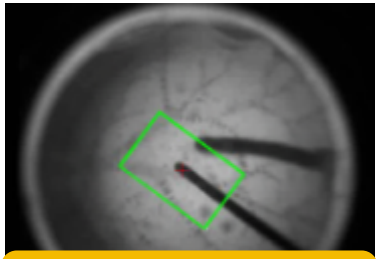
F_{OD}

Scaling / mapping



F_{RD}

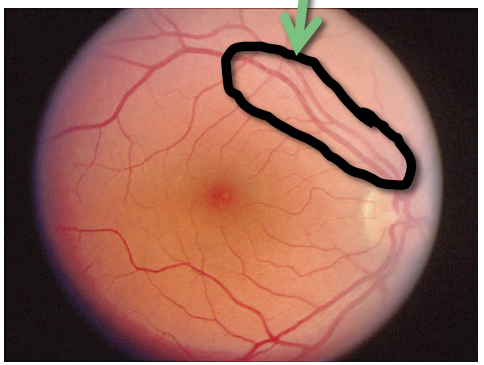
Points from retinal coordinate system
$\{p_1, p_2, \ldots, p_n\} \in \{R\}$



Retinal Tracker

Virtual Fixture Logic Algorithm

Virtual Fixture



Deliverables

- Minimum
  - Improve telemanipulation
  - Telestration using Omni
  - Develop a friendly/ergonomic user interface (pedal/mode changing)
  - Documentation
- Expected
  - Bilateral teleoperation
  - Bimanual teleoperation with two steady hand eye robots and two Omnis
  - Telestration primitives (arrows, regions , …)
- Maximum
  - Virtual fixture definition via telestration
  - Telemanipulation and telestration via da Vinci Master Console
  - Design validation experiment

Milestones

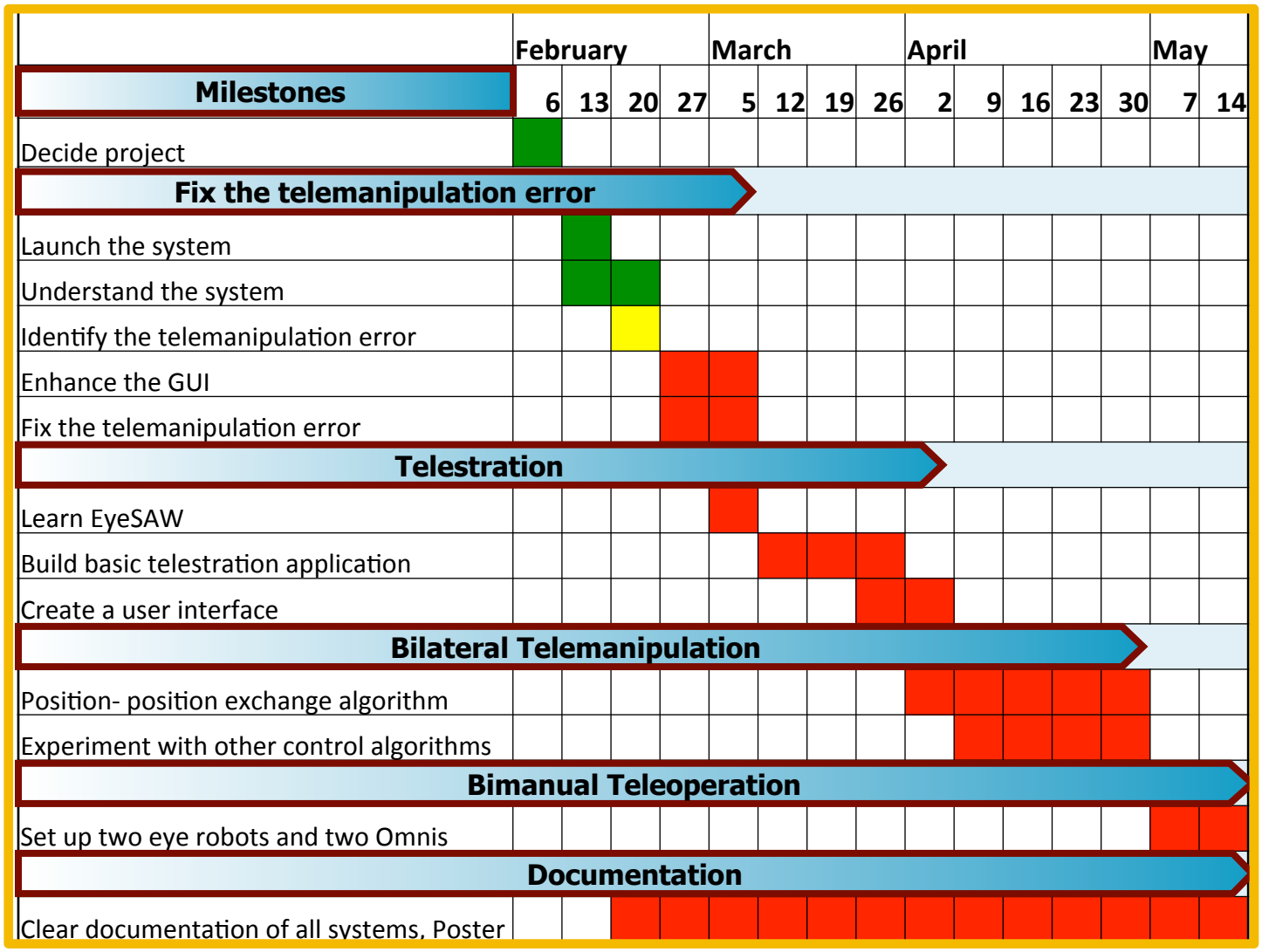
- Basic telemanipulation (Unilateral) and User interface
  - Complete by: March 5th
- Telestration
  - Complete by: April 2nd
- Bilateral telemanipulation
  - Complete by: April 30th
- Bimanual teleoperation
  - Complete by: May 14th
- Documentation
  - Complete by: May 14th

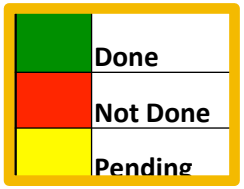
Validation:
- Simplified tasks
- Mentor review
- Surgeon review
- Surgeon questionnaire
- Test virtual fixtures

Management Plan

- Meet with mentor weekly (Mondays 4pm-5pm)
  - Inform of any challenges or problems that arise
  - Help as needed
- Attend EyeBRP meetings on Fridays 3pm-4pm
- Responsibilities
  - Intend to work together on all portions of the project

Timeline


February
March
April
May
Milestones
6 13 20 27 5 12 19 26 2 9 16 23 30 7 14
Decide project
Fix the telemanipulation error
Launch the system
Understand the system
Identify the telemanipulation error
Enhance the GUI
Fix the telemanipulation error
Telestration
Learn EyeSAW
Build basic telestration application
Create a user interface
Bilateral Telemanipulation
Position- position exchange algorithm
Experiment with other control algorithms
Bimanual Teleoperation
Set up two eye robots and two Omnis
Documentation
Clear documentation of all systems, Poster


Done
Not Done
Pending

Dependencies

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Dependency	Plan of Action
Eye Robot 2.0	• Almost always available at nights/on weekends. • Med campus Eye Robot 2.1 • Can expect to use Eye Robot 1
Omni	• Safe to assume at least one is always available
3D Video Display	• Older technology is available all the time • Will use the newer technology when available • Can use 2D display for debugging
Marcin	• In the lab ~7 days a week
Access to the Lab	• Resolved (have access)
Access to Med Campus Lab	• Pending
EYE-BRP SVN	• Resolved (have access)
da Vinci Master Console	• Will resolve as needed

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References

- Uneri et. al., “New Steady-Hand Eye Robot with Micro-Force Sensing for Vitreoretinal Surgery,” *IEEE RAS & EMBS*, 2010.
- Balicki et. al., “Prototyping a Hybrid Cooperative and Telerobotic Surgical System for Retinal Microsurgery,” 2011.
- Ammi et. al., “Robotic Assisted Micromanipulation System using Virtual Fixtures and Metaphors,” *IEEE Int. Conference*, 2007.
- Kazanzides et., al., “Component-based software for dynamic configuration and control of computer assisted intervention systems,” 2011.
- Bohn et. al., “User interface integration and remote control for modular surgical assist systems,” 2010.

References

- J. Funda, R. Taylor, B. Eldridge, S. Gomory, and K. Grube, “Constrained Cartesian motion control for tele-operated surgical robots,” IEEE Transactions on Robotics and Automation, vol. 12, pp. 453-466, 1996.
- Additional readings on Ali Uneri and Gorkem Sevinc CIS 2 final project report on “Tele-operation of the Eye Robot”
- Additional readings on Seth Billings and Ehsan Basafa CIS 2 final project report on “Tele-operation of LARS Robot”

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THANK YOU FOR LISTENING

QUESTIONS?

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