

Checkpoint:

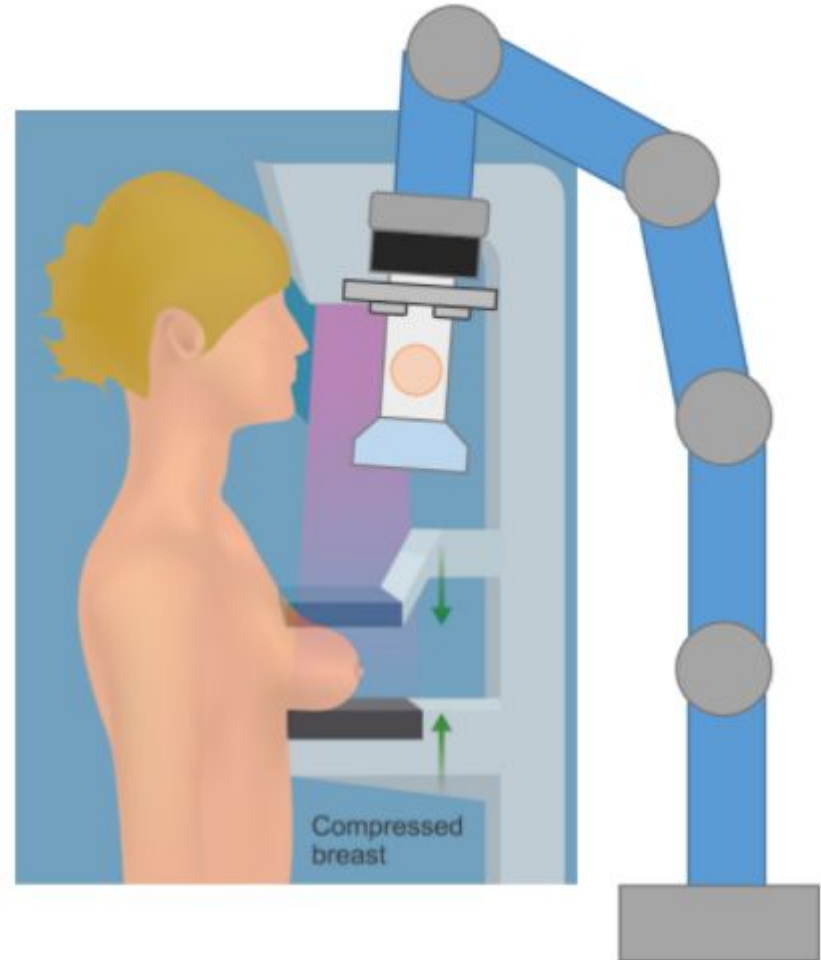
Co-Robotic Ultrasound Imaging of Breast Assisting Mammography

Team: Julian Brown, Yuxin(Ethan) Chen, Kevin Wang

Mentors: Dr. Emad Boctor, Dr. Web Stayman, Dr. Russell Taylor, Yixuan Wu

Project Summary

- We are seeking to develop a robotic device for augmenting current mammography with ultrasound imaging
 - Calibration
 - UR5
 - Cameras
 - Hand-Eye
 - Ultrasound
 - Motion Planning
 - Movement Algorithm



Updated Deliverables

- Completed
- In Progress
- Not Started

Minimum:

- Calibration of the camera and robotic arm.
- ~~Hand over hand control of the robot (already developed but needs to be integrated)~~
- Simple motion planning to land the ultrasound probe on a specific location on the compression plate. Offline (open loop) control, directing ultrasound probe to lesion from target.
- Setup of the imaging validation and tests.

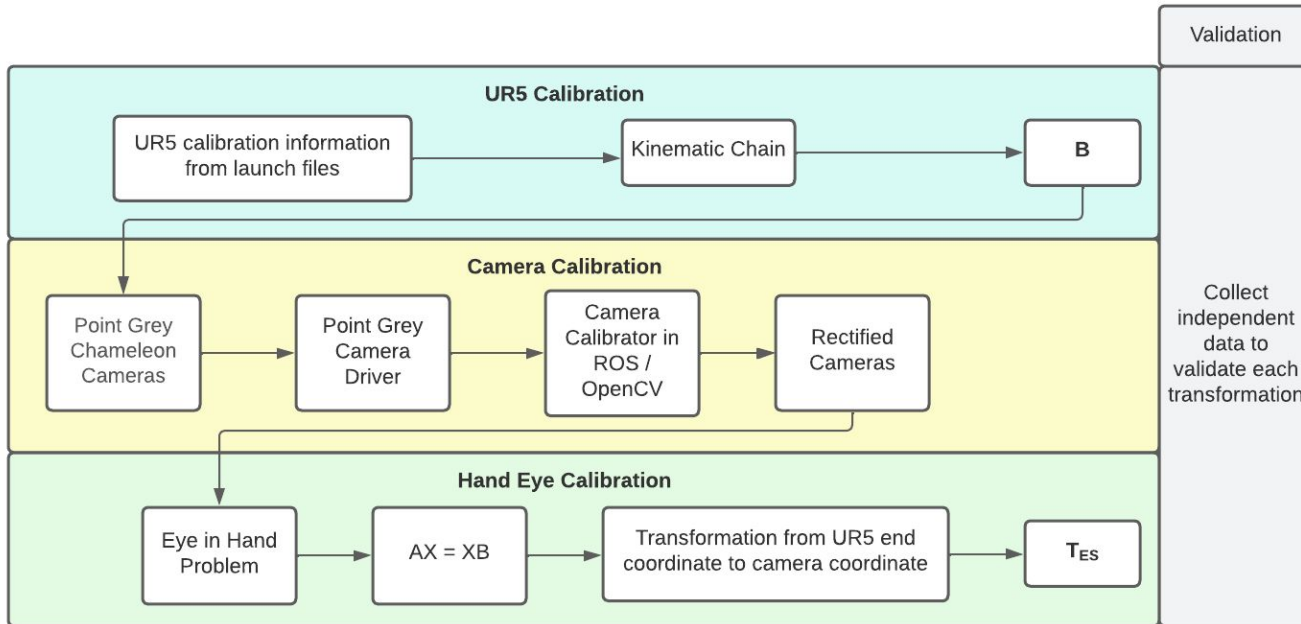
Expected:

- A real-time interface to acquire camera and ultrasound images.
- Demonstrate automatic ultrasound acquisition of a region of interest (whole lesion) with a known location with respect to the tracking tag on the compression plate.
- Documentation

Maximum:

- Demonstrate dynamic and real-time adaptation as the tracking tags move.
- Force control of the robot arm to ensure safety.
- Integration and registration with a second modality (Mammography, CT, or preoperative 3D ultrasound).

Calibration of the camera and robotic arm



Validation:

Fixed tag. Moved the robot to different positions. Calculated the tag position relative to the base of robot. The error on translation is less than 1mm. The error on orientation is less than 0.01 radian.

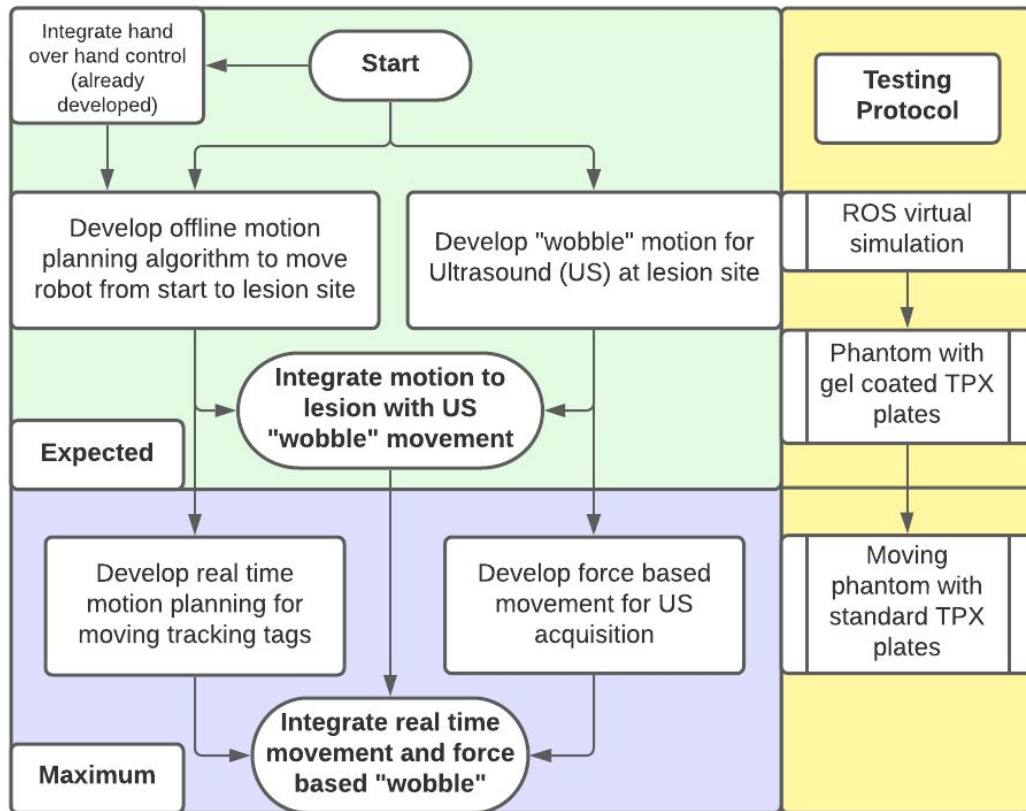
Checkpoint: Robot Motion

Completed Movements - used PRM algorithm

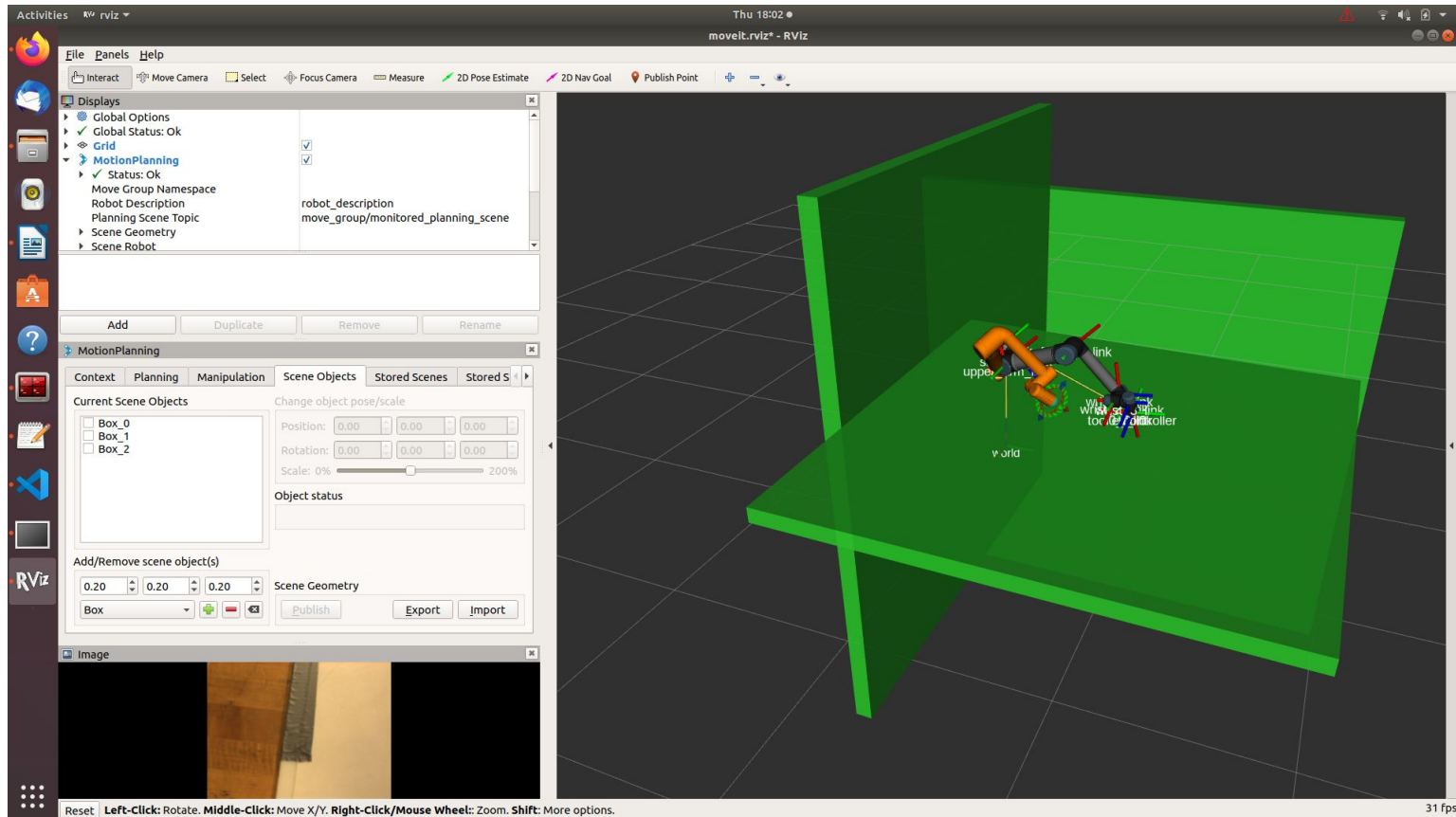
1. Movement from start to lesion site
2. "Wobble" Movement about lesion for Ultrasound volume

Completed Approach

1. Offline approach



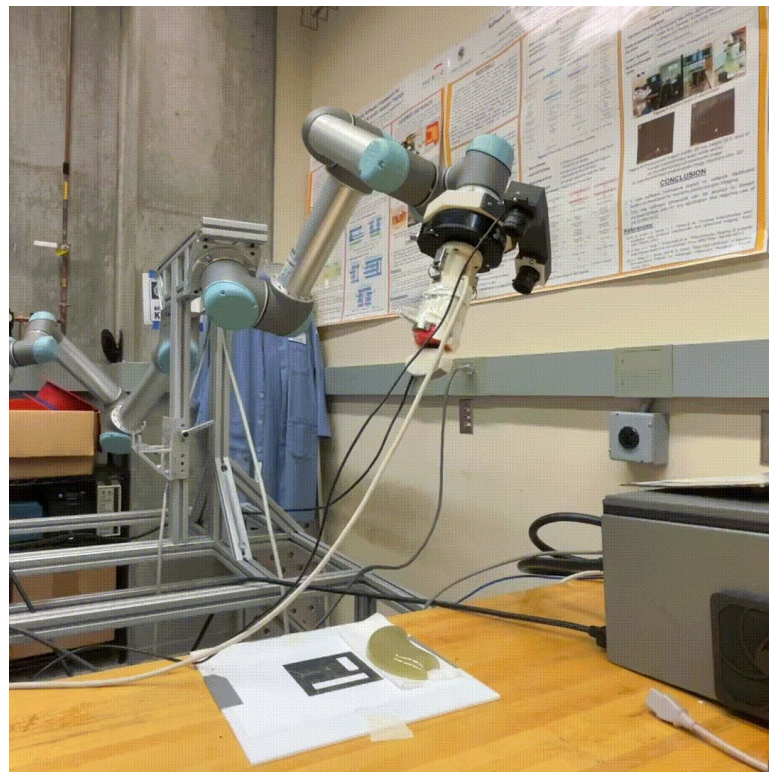
Rviz Workspace



Results - from different initial positions



Initial position at left



Initial position at right

Result - to different tag positions



Tag on the left



Tag on the right

Result:

Movement to Lesion and Translational Wobble

- Robot moves from initial position to lesion location
- Robot “performs” ultrasound scan of lesion
- Base alignment results in vertical drift



Documentation

| Avatar | Filename | Action | Time |
|----------|------------------------------------|----------------------|-------------|
| ychen506 | Add files via upload | 756683b | 9 days ago |
| | 14 commits | | |
| | motion_planning | Add files via upload | 11 days ago |
| | Progress.odt | Add files via upload | 11 days ago |
| | README.md | Update README.md | 11 days ago |
| | basic_movement.cpp | Add files via upload | 9 days ago |
| | ur5_ros_control_moveit_rviz.launch | Add files via upload | 11 days ago |

☰ README.md ✎

Co-Robotic-Ultrasound-Mammography

File List

ur5_ros_control_moveit_rviz.launch

- Launches moveit and rviz with physical robot loaded in
- Run with: `$roslaunch ur_modern_driver ur5_ros_control_moveit_rviz.launch robot_ip:=172.22.22.2`
- Place in: `src/modern_driver/launch`

motion_planning

- Motion planning package that allows for motion planning with physical robot.
- Place in: `src/`
- `basic_movement.launch` moves the robot to a specified x-y-z-theta coordinate in `basic_movement.cpp`
 - you need to rebuild the workspace when making changes to `basic_movement.cpp`

Progress.odt

- Progress notes and troubleshooting steps

Github

<https://github.com/KevinWang905/Co-Robotic-Ultrasound-Mammography>

February 24

Motion Planning in Rviz

*** MAKE SURE YOU HAVE `roscmelodicrosccontrollers` installed
`sudo apt install roscmelodicrosccontrollers`

change `controllers.yaml` to

```
controller_list:
- name: /vel_based_pos_traj_controller #or /pos_based_pos_traj_controller
  action_ns: follow_joint_trajectory
  type: FollowJointTrajectory
  default: true
  joints:
  - shoulder_pan_joint
  - shoulder_lift_joint
  - elbow_joint
  - wrist_1_joint
  - wrist_2_joint
  - wrist_3_joint
```

Terminal for robot movement

```
$ cd catkin_cb2
$ source devel/setup.bash
$ roslaunch ur_modern_driver ur5 ros_control.launch robot_ip:=172.22.22.2
$ roslaunch ur5_moveit_config ur5_moveit_planning_execution.launch
$ roslaunch ur5_moveit_config moveit_rviz.launch config:=true
```

updated March 13, all in one script

```
$roslaunch ur_modern_driver ur5 ros_control moveit rviz.launch robot_ip:=172.22.22.2
```

March 1

Dependencies:

- `roscmelodicrosccontrollers`
- `roscmelodicroscroshash`

March 3

Packages added to workspace:

- `robot_state_publisher`
- `urdf`

To get transformation btwn base and controller: `roslaunch tf_echo base_link tool0_controller`

March 13

Progress.odt

Current Work

Ultrasound Calibration

- Acquire crosswire phantom
- Perform BxP calibration

Wobble Motion

- Platform angle
- Implement rotational wobble
- Emulate real breast ultrasound acquisition protocol

Adaptive Motion Planning

- Split robot path into waypoints and check marker position
- Adapt path based on marker location

User Interface

- Allow for easy launching of ROS Nodes
- Allow for easy input of location and shapes of regions of concern
- Allow for easy viewing and saving of acquired Ultrasound Images

Dependencies

| Dependency | Domain | Status | Backup |
|---------------------------------|-----------------------------------|--------------------------------|----------------------------|
| Linux System | Motion Planning | Acquired | Wyman computer lab |
| ROS | Motion Planning & Computer Vision | Acquired | Wyman computer lab |
| OpenCV | Computer Vision | Acquired | ROS package |
| Hand over hand code integration | Software environment | Acquired | Rewrite the code |
| Mentor Availability | All | Acquired but subject to change | Communication and planning |

| Dependency | Domain | Status | Backup |
|----------------------------------|------------------------------|----------|--------------------------------------|
| UR5 Robot | Motion Planning | Acquired | ROS Simulation |
| Two Point Grey Chameleon Cameras | Motion Planning | Acquired | ROS Simulation |
| 6 DoF Force Sensor | Force Sensing | Acquired | ROS Simulation |
| Ultrasound Probe | Ultrasound Imaging | Acquired | Path planning without US acquisition |
| TPX plates | Ultrasound Imaging | Acquired | Purchase and construct |
| Acoustic Gel | Ultrasound Imaging | Acquired | Purchase |
| Cross Wire Phantom | Ultrasound probe calibration | Required | Build by ourselves |

Milestone Progress

| Milestone | Expected Completion Date | Status |
|------------------------------|---------------------------------|---------------|
| Camera Calibration | February 27 | Complete |
| UR5 Calibration | February 27 | Complete |
| Hand Eye Calibration | March 4 | Complete |
| Ultrasound Probe Calibration | April 20 | In Progress |
| Hand over Hand Integration | March 11 | Removed |

| Milestone | Expected Completion Date | Status |
|-------------------------------|---------------------------------|---------------|
| Offline Motion to Lesion Site | April 15 | Complete |
| Wobble Motion | April 15 | In Progress |
| Adaptive Motion Planning | April 29 | In Progress |
| Force Sensitive Wobble | April 29 | Not Started |
| US-CT Registration | April 29 | Not Started |

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Questions?