Master’s Project

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# Potential Themes

1. System for percutaneous interventional guidance with 3D wobbler ultrasound imaging
2. Open source platform for prototyping 3D wobbler ultrasound guided interventions

# Workflow

## Pre-op – to be determined

### 3d US - 3d US registration

* + - 1. Concerns
         1. Requires US in CT room
         2. Can’t fix markers to the CT

Must recalibrate CT to US every time

* + - * 1. Registration between CT and pre-op US can’t be simple translation

Breathing will cause shifts in markers and organs

* + - 1. Workflow
         1. Calibrate probe & CT tracking
         2. Apply fiducials to patient
         3. Obtain tracked CT scan
         4. Obtain tracked US scan with patient out of machine
         5. Register CT to pre-op US based on calibrated transform

### PET CT – 3d US registration

* + - * 1. Apply fiducials to patient
        2. Obtain CT scan

## In-op

### Apply fiducials to patient

* + - 1. Ring markers
      2. Fiducial frame on sternum – Tamas

### Initial registration of patient to camera coordinate system

* + - 1. based on fiducial frame – Fiducial Registration (point to point)
      2. Camera
         1. Polaris

Tracked pointer to locate fiducials

* + - * 1. Opti-track

Reflective markers

### Registration of CT to US

* + - 1. Initial registration based on ring markers on abdomen
      2. Fine registration based on points in the pre-operative images and the peri-op scan
      3. Branching pts
      4. ICP
      5. May not be able to achieve depending to pre-op workflow

### 3D US collection method with wobbler

* + - 1. Pre-guidance collection
         1. Constant 3D volume
         2. 1 volume collected only
         3. Unable to view needle path in real time
      2. Real time collection
         1. 3D volume constantly changing
         2. US probe held to patient throughout operation
         3. Enables view of needle path in real time

### Navigation

* + - 1. Views – Based on assumption that any sliced of the 3d US volume can be made, assumption patient will be on their back
         1. Red – Axial

Axial slice intersecting the target placing the location of the needle tip intersection with this slice based on its current trajectory

Must decide where to intersect with the target

Predetermined biopsy site

Center of mass of the target volume

Must indicate that the intersection point is not the current needle tip position

Axial slice intersecting the current needle tip position

* + - * 1. Yellow – Sagittal

Sagittal slice intersecting the target placing the location of the needle tip intersection with this slice based on its current trajectory

Must decide where to intersect with the target

Predetermined biopsy site

Center of mass of the target volume

Must indicate that the intersection point is not the current needle tip position

Sagittal slice intersecting the current needle tip position

* + - * 1. Green – Coronal

Coronal slice intersecting the target placing the location of the needle tip intersection with this slice based on its current trajectory

Must decide where to intersect with the target

Predetermined biopsy site

Center of mass of the target volume

Must indicate that the intersection point is not the current needle tip position

Coronal slice intersecting the current needle tip position

* + - * 1. Blue – 3D view

Render volume of target

Render contours of liver/organ?

Is this viable if potentially the full organ is not pictured in the 3D volume

* + - 1. Likely what should be viewed in each window will be highly dependent on whether the US is collected in real time or not. For the red, yellow and green windows view option 1 would probably be more beneficial if there is no real time US
         1. For option 1 change the intersection pt colour if the needle tip is not in plane, in plane, or if the needle is in plane
      2. Additional view
         1. Visualize the plane that is defined by the target point and the line of the needle trajectory
         2. If no biopsy point is chosen and they don’t want to use the center of mass of the target potentially use the nearest point to the needle trajectory?
         3. Add to blue view?
         4. Make independent view?

### Verification

* + - 1. Indicator of whether the needle tip is within the target contour/at the target biopsy site within specified margins

# Pre-existing Frameworks for Similar Tasks

## Example Guidlet Extension

1. Guidlet
2. Sections
   1. Calibration
      1. Empty with ex button
   2. Ultrasound
      1. Buttons for recording a US
      2. Functional?
   3. Settings
      1. Layout options
      2. Full screen
      3. Save scene
      4. Exit slicer
      5. Show 3D slicer user interface
      6. OpenIGTLink connector

## LumpNav

1. Guidlet
2. Sections
   1. Tool Calibration
      1. Calibration of cautery and needle
      2. No calibration for US
   2. Tumor Contouring
   3. Navigation
      1. Different Preset views
      2. Hide/show distances to tumor
      3. Change distance font size
      4. Adjust display
      5. Adjust contour of tumor
      6. Change tool display
         1. Tool model
         2. Stick model
   4. Settings
      1. Layout options
      2. Full screen
      3. Save scene
      4. Exit slicer
      5. Show 3D slicer user interface
3. Breach warning light module

## CathNav

1. Slicelet
   1. Can’t get to load will have to ask how
2. Workflow document

# Framework

## Inputs

1. 3D US volume
   1. Live
   2. Fixed
2. Tracked needle

## Sections

\*Option to load in saved calibrations instead? When to render target and other objects of interest (liver contour? Vasculature?)

### Needle Calibration

* Pivot calibration
* Spin calibration
* New clip calibration

### Probe Calibration

* New clip calibration
* Point to point registration

### Patient Registration

* Point to point registration

### CT Registration

* Initial registration
  + Fiducial registration
* Fine registration
  + tbd

### US Volume

* US controls
  + Brighten
* capture

### Navigation

* 5 views
* Views to be decided (see 2.2.5)

### Settings

* Layout options
* Full screen
* Save scene
* Exit slicer
* Show 3D slicer user interface

Notes:

* Fiducial registration for initial patient registration and probe calibration, do the points need to be in corresponding order?
  + Else use ICP instead?
* Need to put in a section for stylus calibration