

# Friday Update

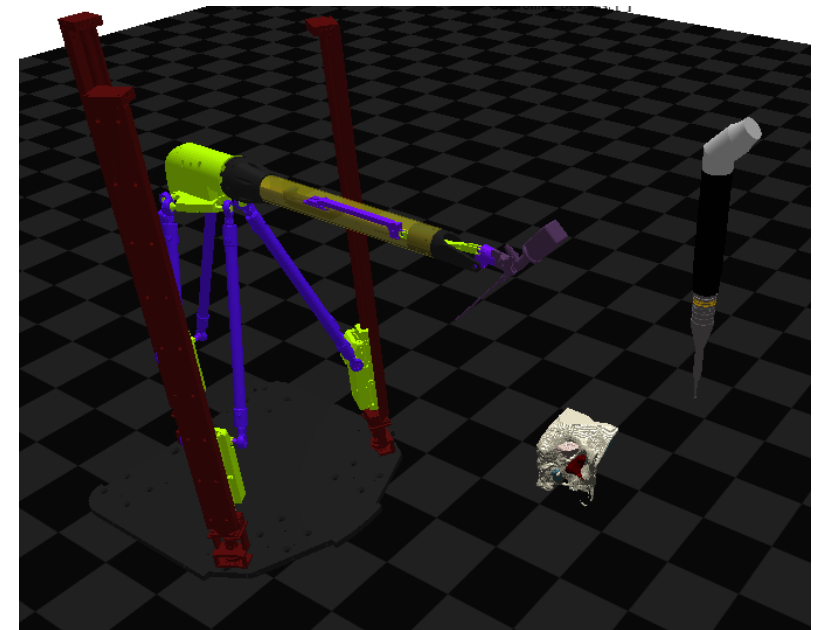
VR Guided Skull-Base Surgery Project

# Joint Position to Simulator Update

- Jintan Demo'd this at Wednesday's Galen Meeting

# Simulation Updates

- Added the volumetric model into the Galen world
- Added the drill model into the Galen world
- Migrating drilling algorithm
  - Light-weight volumetric drilling
- Next step:
  - Attach drill to Galen end-effector
  - Fine tune the Galen mesh model



# Technical Approach 1: 2-Way Control Scheme

AMBF Simulator

1. Command joint velocity mode
2. Update simulator joint state based on virtual volume and constraints

$$F_{sim} = K_p * (q_{sim} - q_{robot}) + K_d * (\dot{q}_{sim} - \dot{q}_{robot})$$

Payload: Simulator Joint State

May also need a KI term??  
Since tracking movement??

Payload: Robot Joint State

$$\dot{q}_{sim\_new} = K_p * (q_{robot} - q_{sim}) + K_d * (\dot{q}_{robot} - \dot{q}_{sim})$$

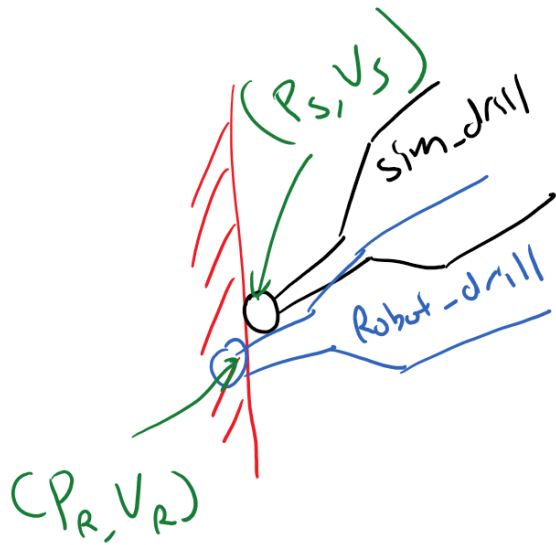
GalenES ForceBehaviorMode

1. **Fsim** +  $F_{handle} \rightarrow \Delta x_{handle}$
2.  $\Delta x_{handle} \rightarrow \text{optimizer} \rightarrow \Delta q_{robot}$
3.  $\Delta q_{robot} / \Delta t_{step} = \dot{q}_{robot\_ft}$
4.  $\dot{q}_{robot} = \dot{q}_{robot\_ft}$
5.  $\dot{q}_{robot} \rightarrow \text{galil} \rightarrow \text{motors}$

Note: Changes to standard pipeline are highlighted

# Sim to Robot Update

P- position    V- Velocity



$$F_{sim} = K_p [d(P_s, P_r)] + K_d [d(V_s, V_r)]$$

Payload: Simulator Joint State  
Joint Position =  $q_s = (q_1, q_2, q_3, q_4, q_5)$   
Joint Velocity =  $\dot{q}_s = (\dot{q}_1, \dot{q}_2, \dot{q}_3, \dot{q}_4, \dot{q}_5)$

Can we receive cartesian  
position/vel at tool tip from  
sim? Would Simplify Math

### 1. Calculate Position Difference

$$P_s = \text{FwdKinTip}(q_s) = [x, y, z, \theta_r, \theta_t]_{\text{sim}}$$
$$P_r = \text{Frm}_{4 \times 4}(R_{\text{tip}}, t_{\text{tip}}) \Rightarrow [x, y, z, \theta_r, \theta_t]_{\text{robot}}$$
$$d(P_s, P_r) = P_s - P_r$$

### 2. Calculate Velocity Difference

$$V_s = J(q)_{\text{ToolTip}} * (\dot{q}_s) = [v_x, v_y, v_z, w_x, w_y]_{\text{sim}}$$
$$V_r = J(q)_{\text{ToolTip}} * (\dot{q}_r) = [v_x, v_y, v_z, w_x, w_y]_{\text{robot}}$$
$$d(P_s, P_r) = V_s - V_r$$

### 3. Calculate Resulting Force Vector at ToolTip

$$F_{\text{sim}} = k_p * d(P_s, P_r) + k_d * d(V_s, V_r)$$
$$F_{\text{sim}} = [F_x, F_y, F_z, T_x, T_y, T_z = 0]$$

### 4. Resolve Force Vector at End Effector and Sum

$$F_{\text{sim\_ee}} = (g_{\text{ee\_tip}} * [F_x; F_y; F_z; 1], g_{\text{ee\_tip}} * [T_x; T_y; T_z; 1])?$$
$$F_{\text{total}} = F_{\text{sim\_ee}} + F_{\text{handle}}$$

# Other Updates

- Emailed Dr. Creighton about IRB
- Group Repository location

# Timeline

#Week 1-3	4	5	6	7	8	9	10	11	12	13	14	15-16
Preparation	Presentation		Today									
	Simulation follows robot											
		Robot gets feedback from simulation										
			Add "Volumetric Drilling" to Galen World	Finetune Robot mesh models in virtual world								
				Assemble and test combined virtual environment	Testing synced Robot and simulation							
						VR Support						
							Interface for combining other groups' work					
							Usability improvement					
								Working towards maximum deliverables			Final Report Final Presentation	