The physician exerts significant force in uncomfortable positions during examination. Probe force and orientation need to be fine-tuned to obtain good image qualities. Previous works have been focused on uni-direction orientation adjustment on flat phantom[1][2] and surface exploration of spherical probe[3].

**System setup**

- UR5e robot arm
- Ultrasound Phantom
- Force transducer
- Z-wires
- Calibration Phantom

**Zero-force mode**

\[ V_f[i] = \alpha K F_f[i] + (1 - \alpha)V_f[i - 1] \]

- \( V_f = [\omega_1, \omega_2]^T \): desired twist in force sensor frame
- \( \alpha \): constant of low-pass filter
- \( K \): diagonal matrix of scaling factors
- \( F_f = [F_1, M_f]^T \): wrench reading from the UR5 force sensor.

\[ V_s = \begin{bmatrix} R & 0 \\ 0 & R \end{bmatrix} V_f \]

\( V_s \): desired twist in space frame

\[ V_j = J^{-1}V_s \]

\( V_j \): joint velocity

\( J \): instantaneous Jacobian matrix from MoveIt.

**Image segmentation**

1. Gaussian filtering
2. Thresholding
3. Hough transform

Left: starting position
Right: end of orientation adjustment

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**References**

