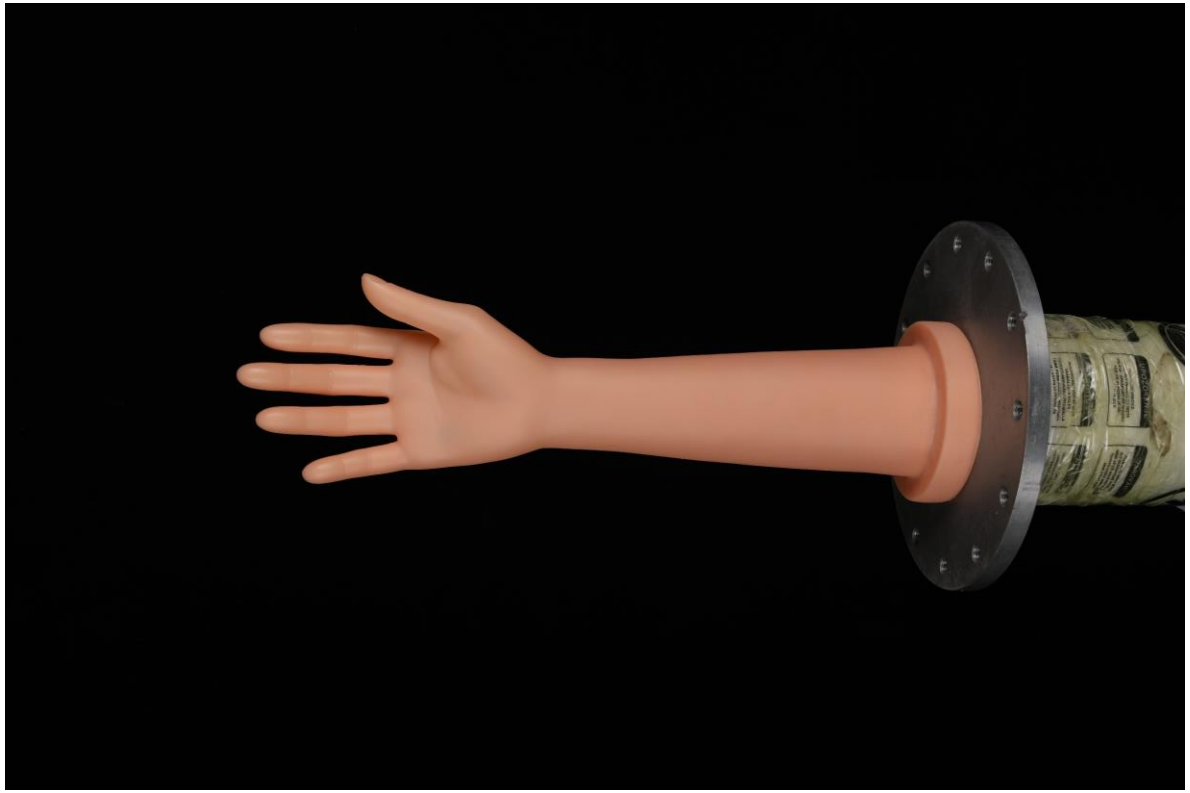
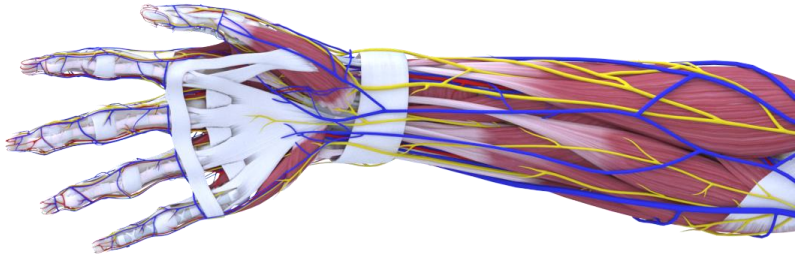
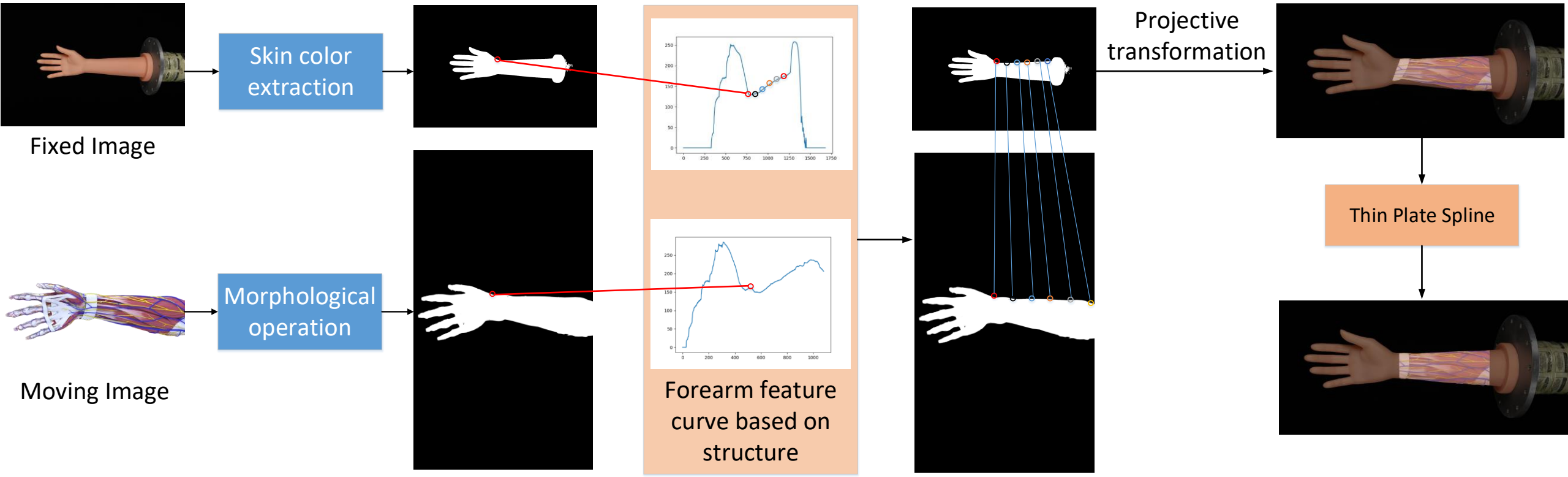
基于结构特征的人体小臂配准方法

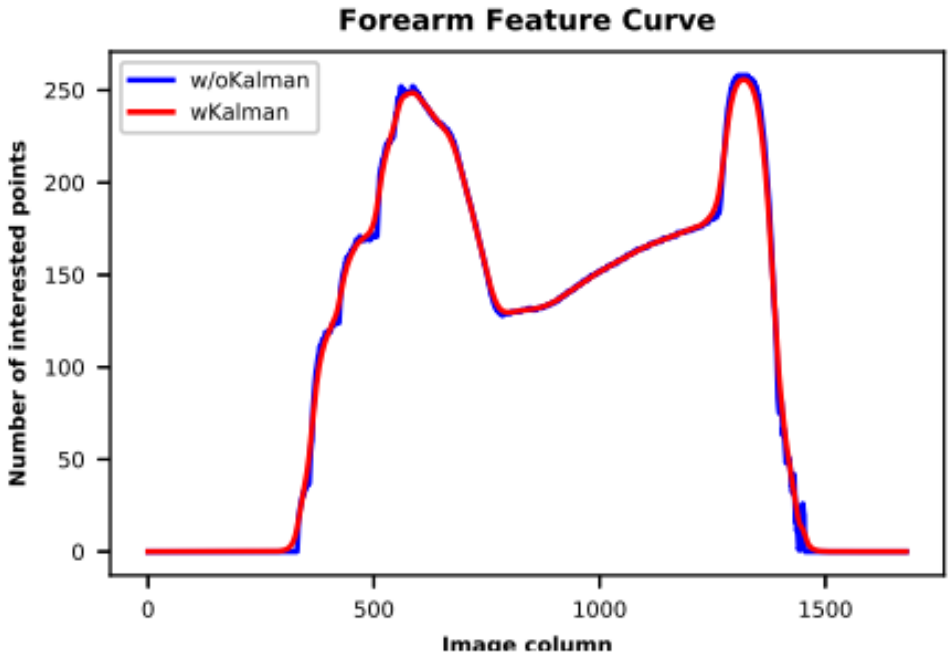




配准框架


Extract key points
Skin color extraction
Fixed Image
Morphological operation
Moving Image
Forearm feature curve based on structure
Projective transformation
Thin Plate Spline

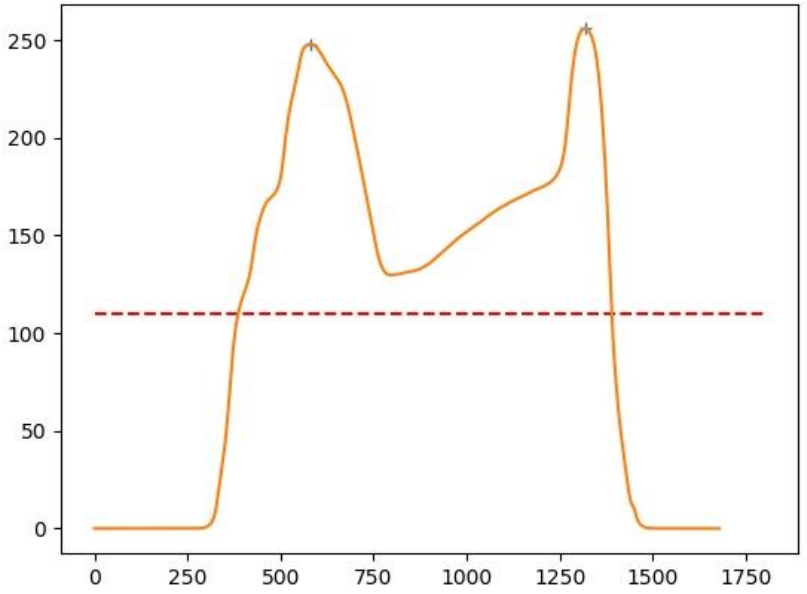
基于结构的小臂特征曲线

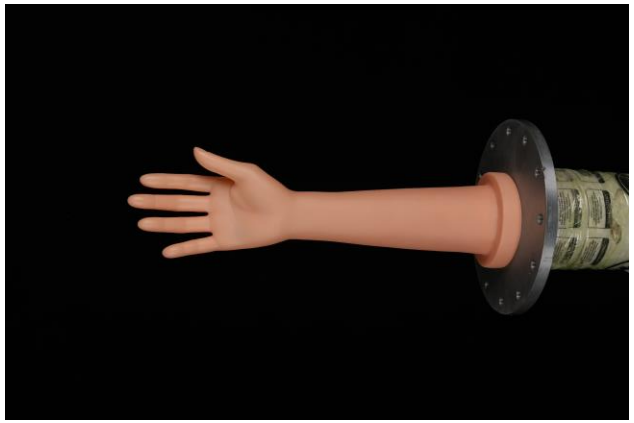


Real Forearm Picture

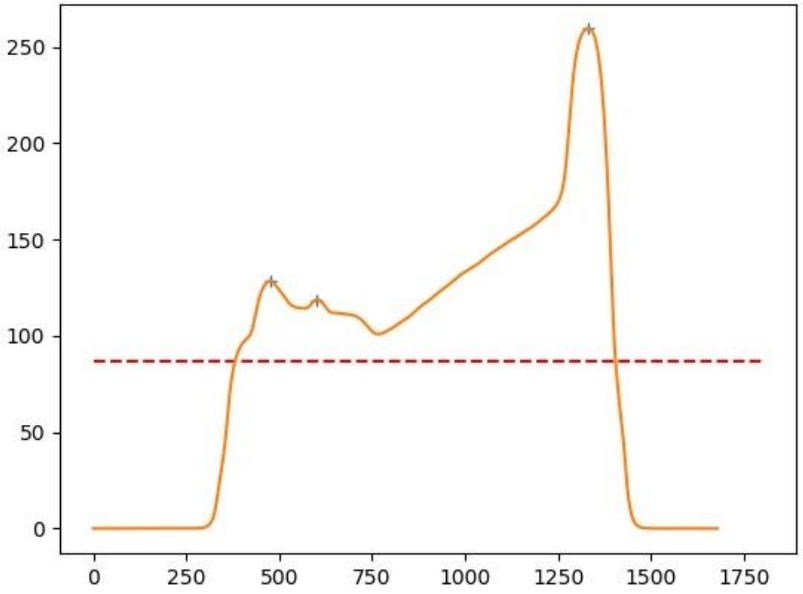
After Skin Color Extraction

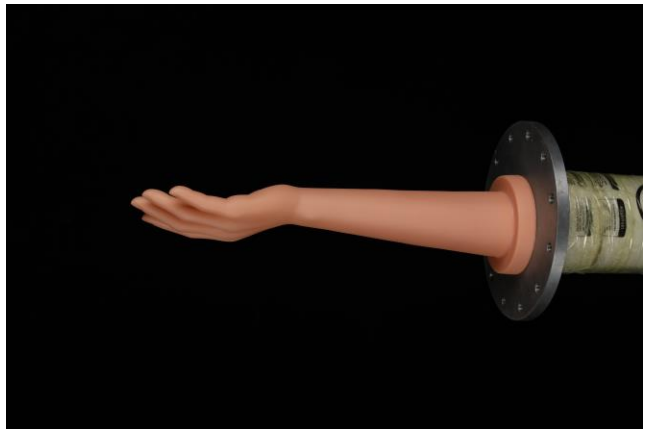
基于结构的小臂特征曲线





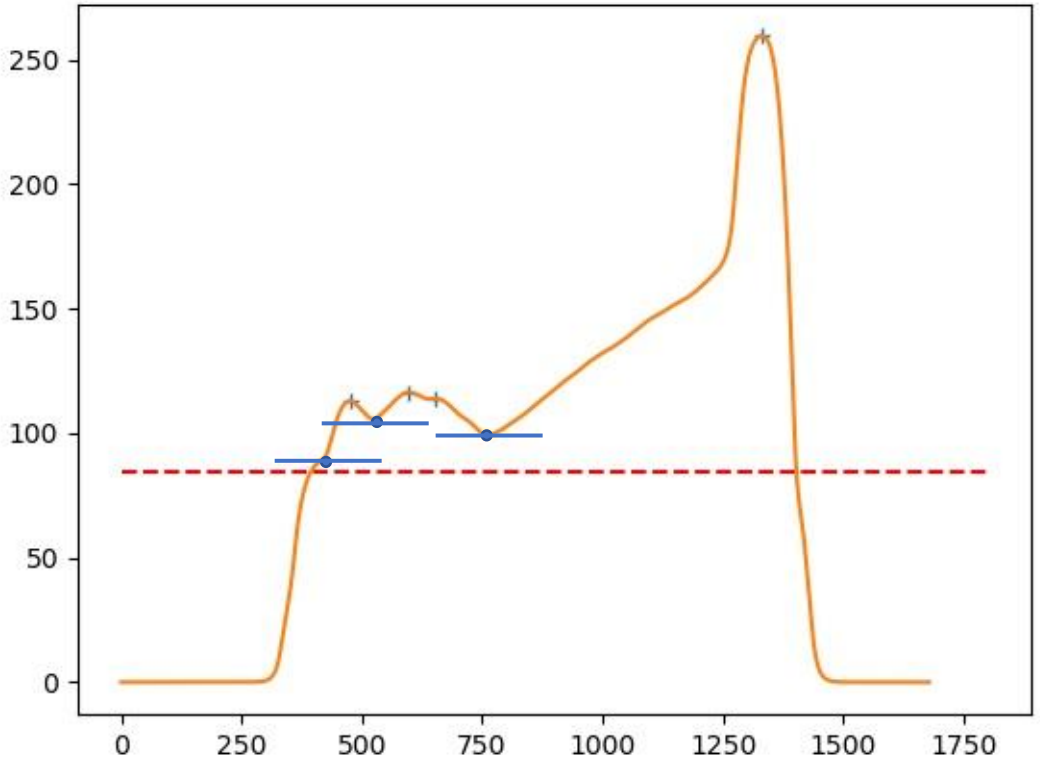
“好”小臂





“坏”小臂

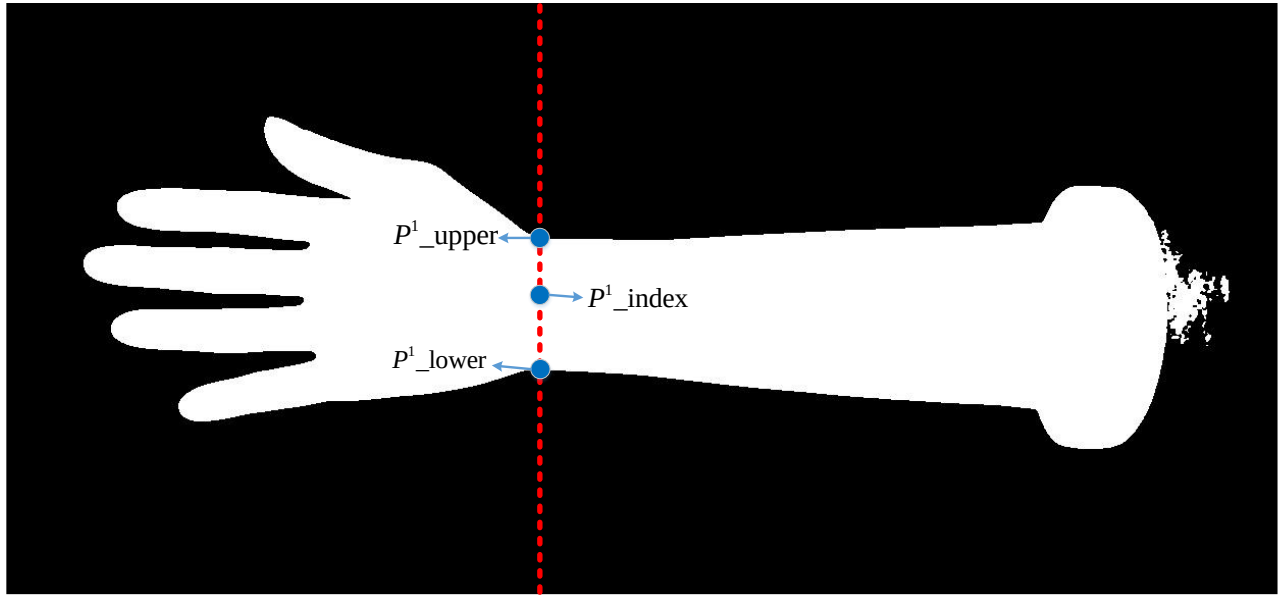
基于结构的小臂特征曲线

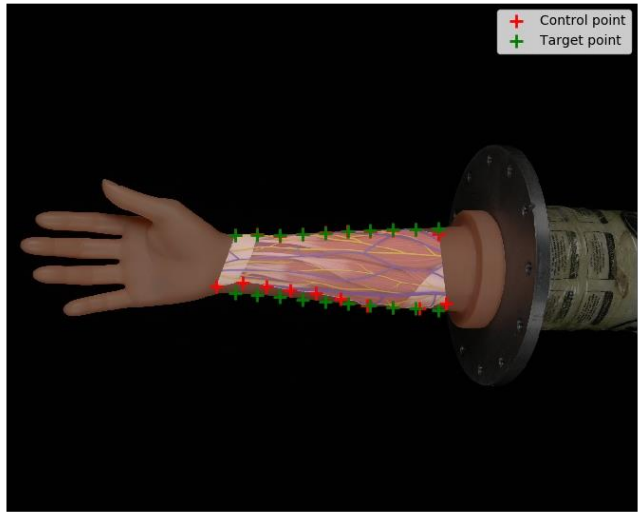


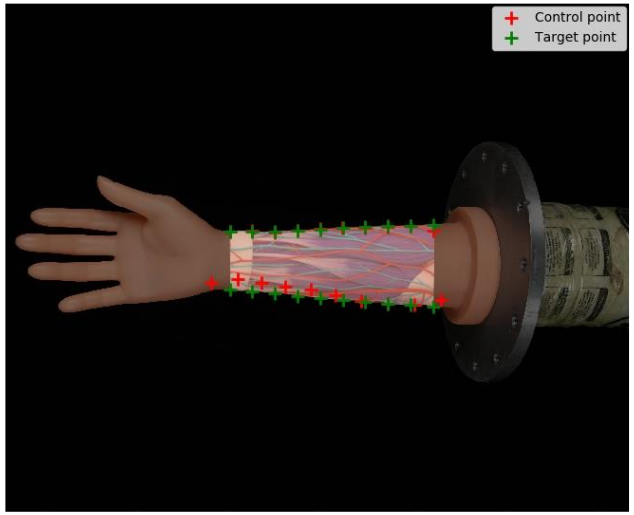
- 特征曲线中的波谷点

平台
（L=1/5mask长度）

关键点选择及非刚性配准

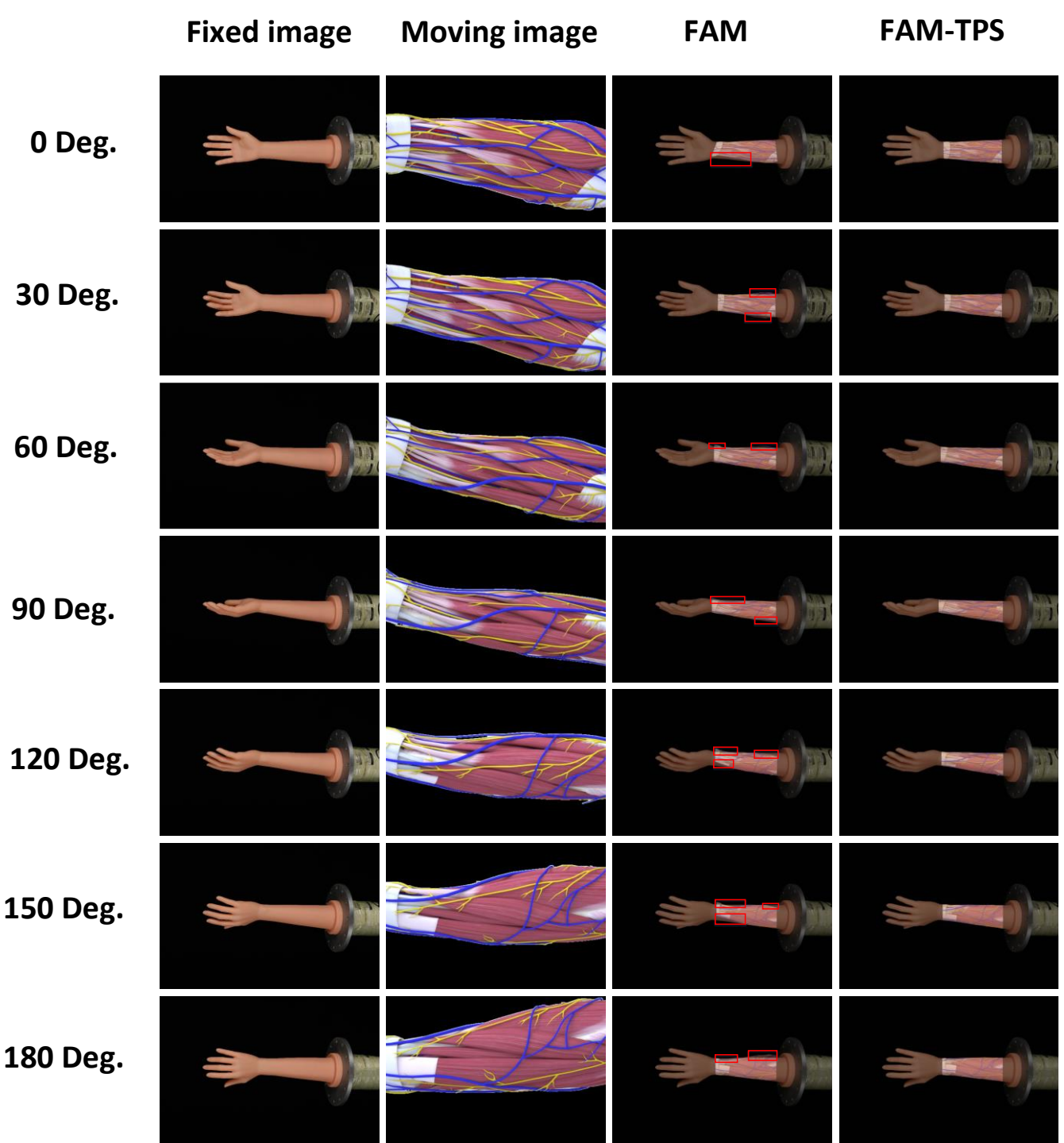




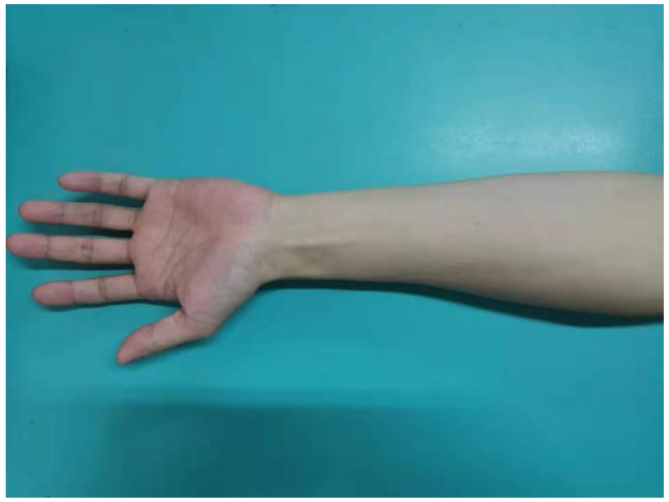


FAM **FAM-TPS**

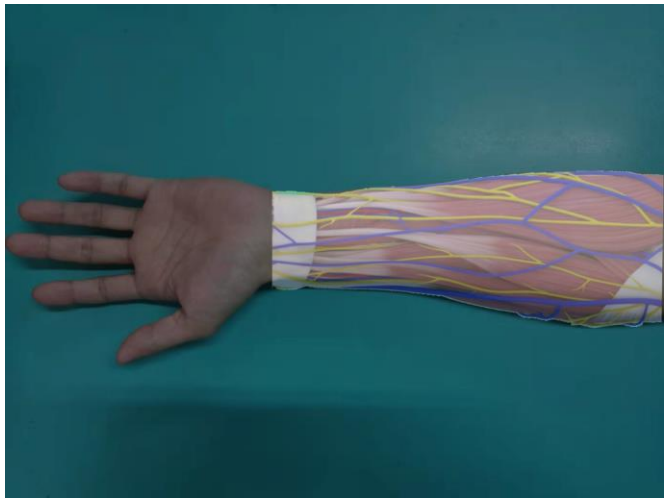
不同旋转角度的配准结果



其他结果

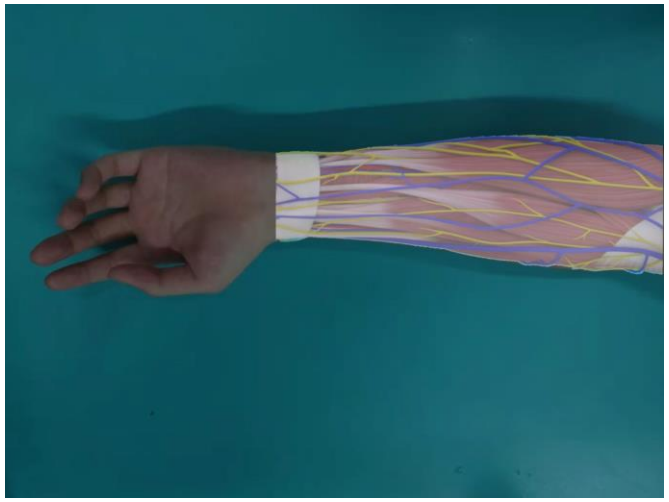


Forearm (Person A)



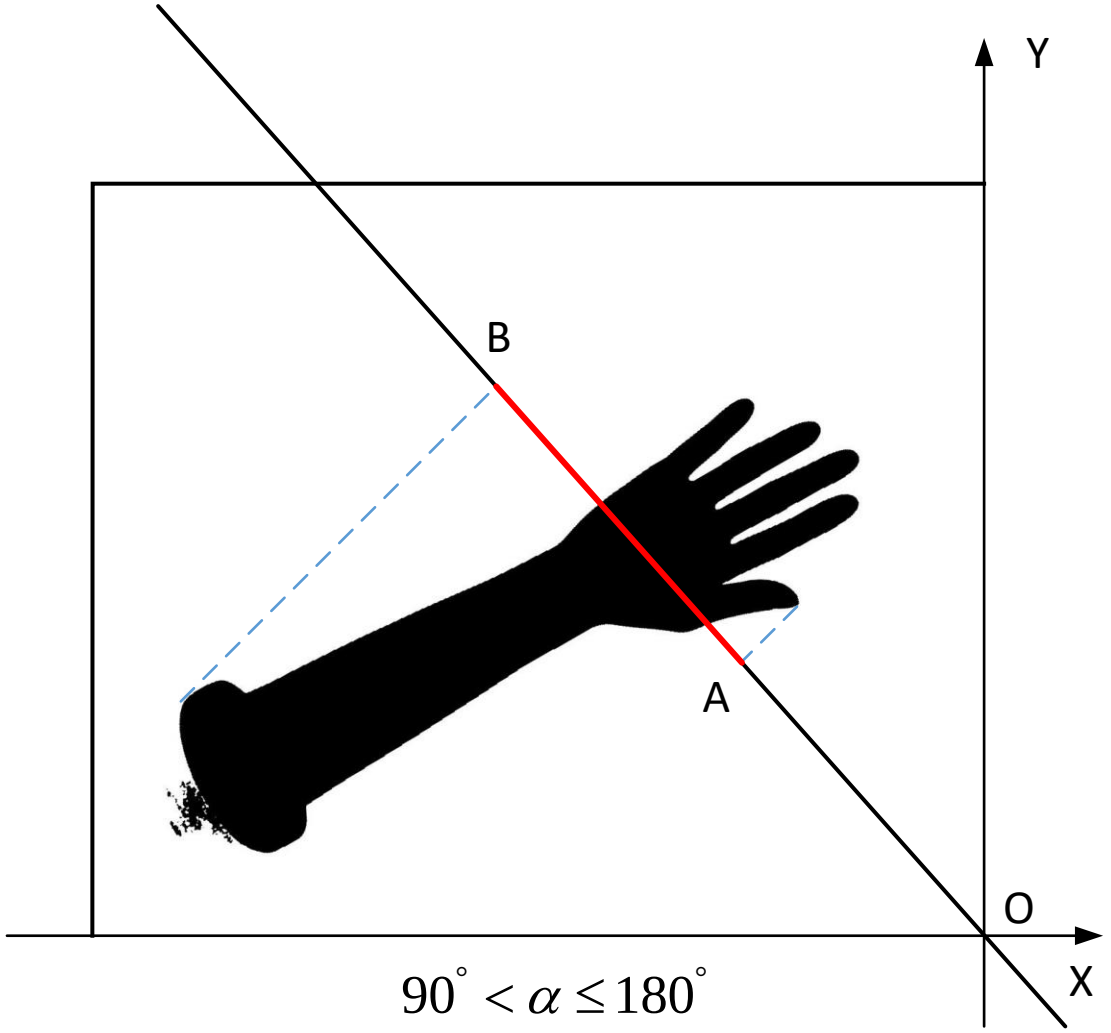
Result (Person A)

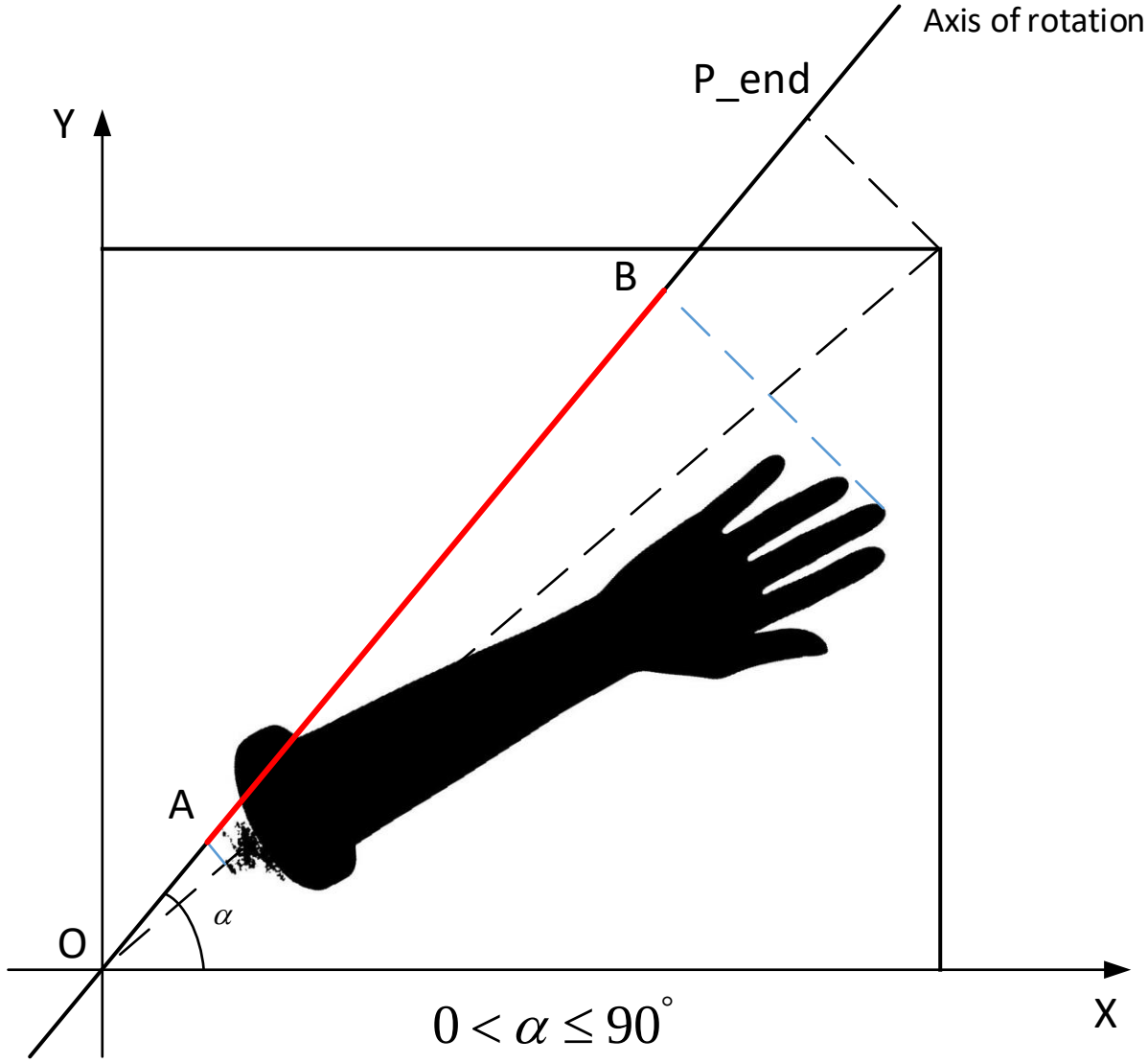
Forearm (Person B)



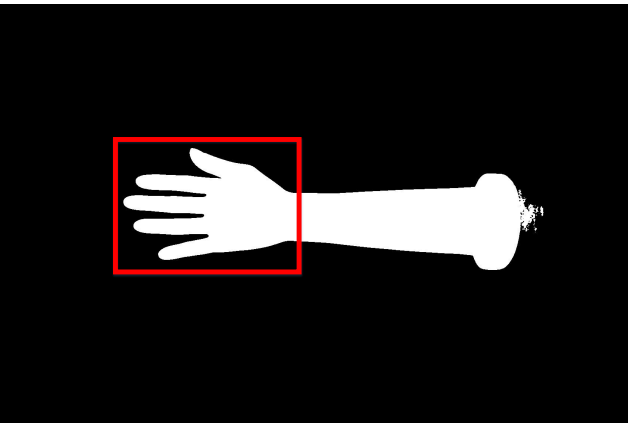
Result (Person B)

确定主方向——手臂调平

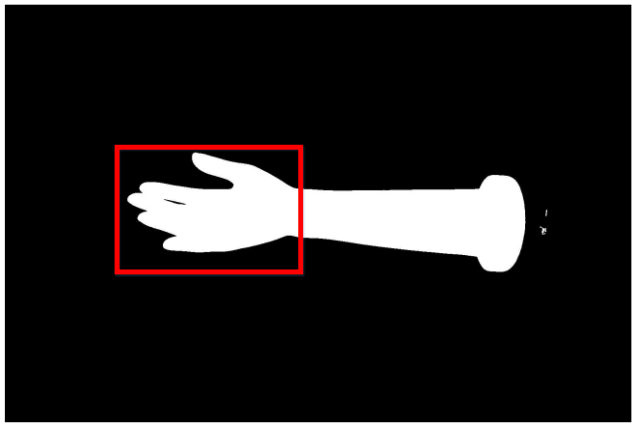

Y
B
A
O
X
$90^\circ < \alpha \leq 180^\circ$


Axis of rotation
P_end
Y
B
A
O
α
X
$0 < \alpha \leq 90^\circ$

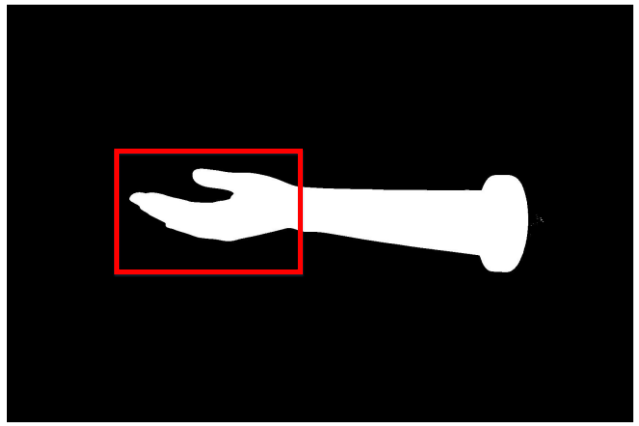
轴向旋转的手掌的投影关系



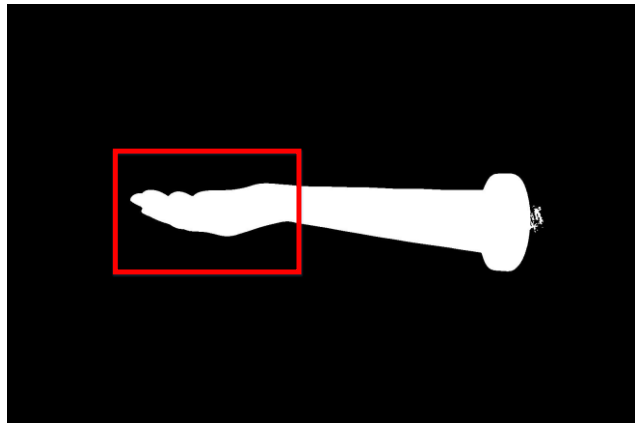
0 Deg.



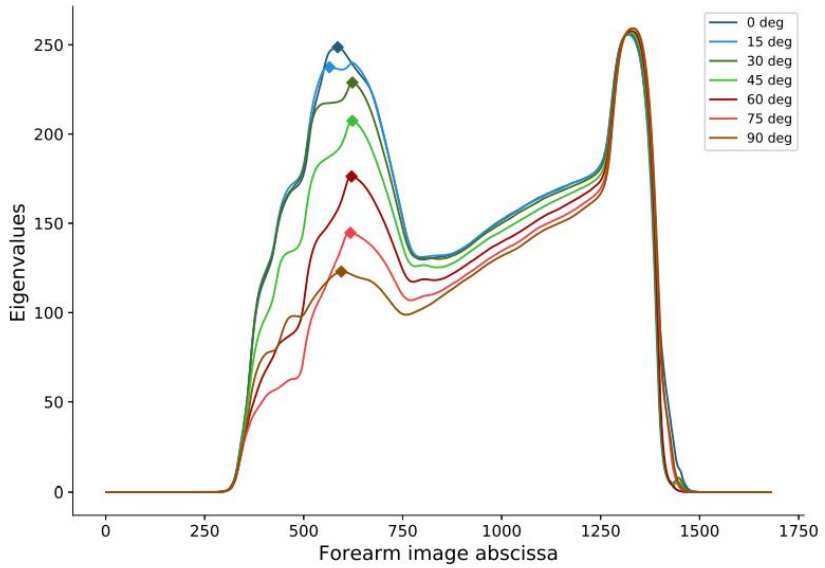
30 Deg.



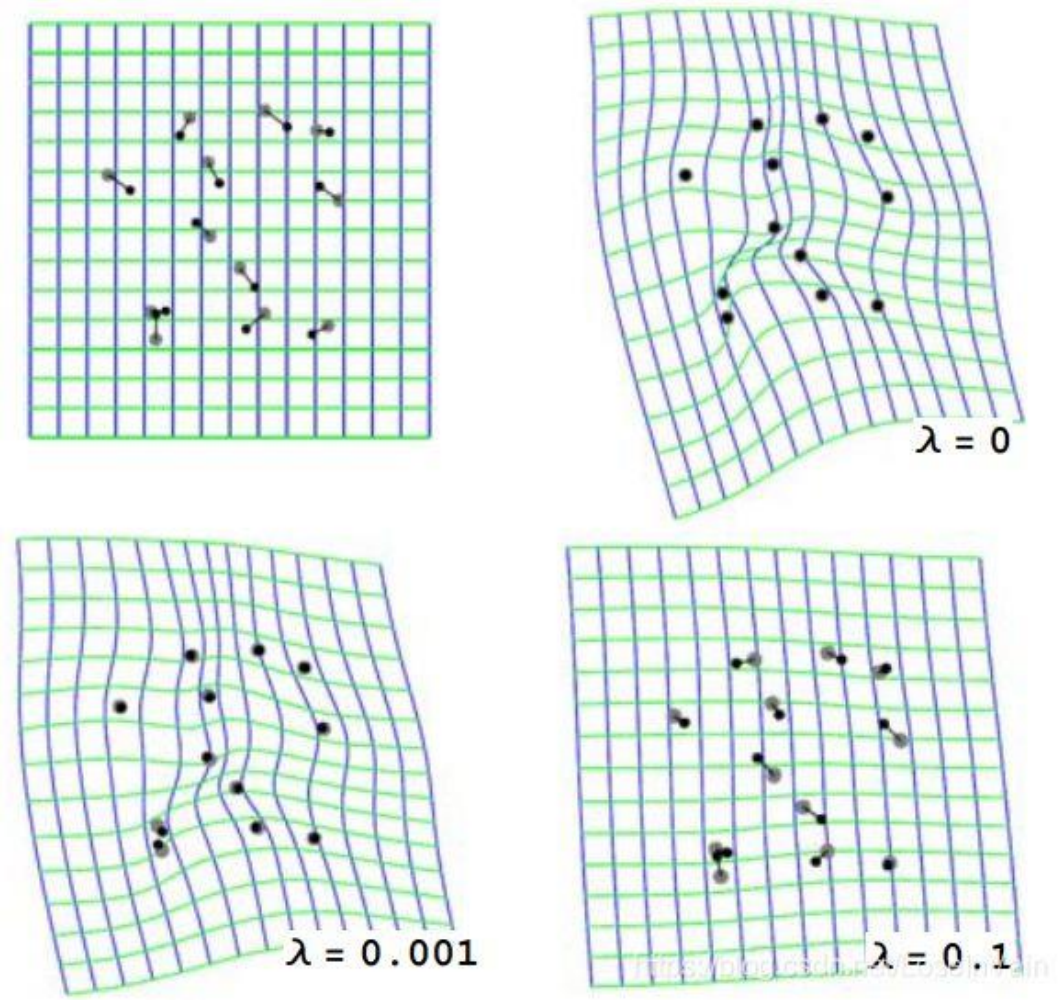
60 Deg.



90 Deg.



TPS-thin-plate-spline(薄板样条插值)



$$\mathcal{E} = \mathcal{E}_\Phi + \lambda \mathcal{E}_d$$

$$\mathcal{E}_\Phi = \sum_{i=1}^{N} ||\Phi(p_i) - q_i||^2$$

$$\mathcal{E}_d = \int\int_{\mathbb{R}^2} \left(\left(\frac{\partial^2 \Phi}{\partial x^2} \right)^2 + 2 \left(\frac{\partial^2 \Phi}{\partial x \partial y} \right)^2 + \left(\frac{\partial^2 \Phi}{\partial y^2} \right)^2 \right)^2 dxdy$$

前一项是拟合项，测量将源点变形后目标距离点的大小；第二项是扭曲项，测量曲面的扭曲大小。

$$\Phi(p) = \mathbf{M} \cdot p + m_0 + \sum_{i=1}^{N} \omega_i U(||p - p_i||)$$

最小化能量方程的闭式解

拟合面

弯曲项

TPS-thin-plate-spline(薄板样条插值)

$$\Phi(p) = \mathbf{M} \cdot p + m_0 + \sum_{i=1}^{N} \omega_i U(||p - p_i||)$$

拟合面　　弯曲项

$$\mathbf{M} = (m_1, m_2)$$

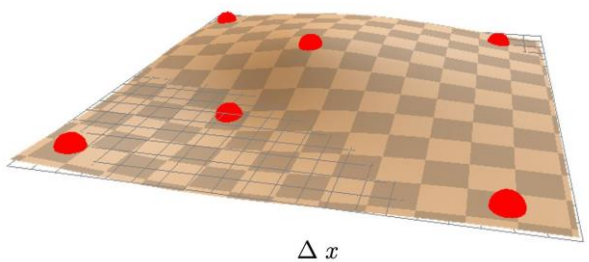
径向基函数 $U(x) = r^2 \log r$

$$\mathbf{K} = \begin{bmatrix} U(r_{11}) & U(r_{12}) & \cdots \\ U(r_{21}) & U(r_{22}) & \cdots \\ \cdots & \cdots & U(r_{NN}) \end{bmatrix}$$

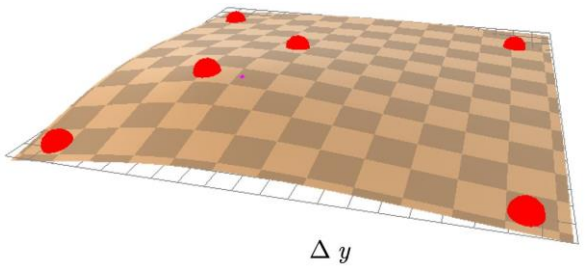
$$\mathbf{L} = \begin{bmatrix} \mathbf{K} & \mathbf{P} \\ \mathbf{P}^{\mathrm{T}} & \mathbf{0} \end{bmatrix} \in \mathbb{R}^{(N+3)\times(N+3)}$$

$$\mathbf{Y} = \mathbf{L}(\Omega | m_0, m_1, m_2)^{\mathrm{T}}$$

$$\mathbf{P} = \begin{bmatrix} 1 & x_1 & y_1 \\ 1 & x_2 & y_2 \\ \vdots & \vdots & \vdots \\ 1 & x_n & y_n \end{bmatrix} \qquad \mathbf{Y} = \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ v_n \\ 0 \\ 0 \\ 0 \end{bmatrix}$$



Δx



Δy