Learning an Efficient Model of Hand Shape Variation from Depth Images Supplementary Material

Sameh Khamis[12] Jonathan Taylor[2] Jamie Shotton[2]
Cem Keskin[2] Shahram Izadi[2] Andrew Fitzgibbon[2]
[1]University of Maryland [2]Microsoft Research

In this document, we briefly supplement the material in our paper by providing the parameters settings used as well as the full lifted energy.

1. Parameter Settings

We set the weights for the prior terms as $\lambda_{\text{normal}} = 0.5$, $\lambda_{\text{pose}} = 0.01$, $\lambda_{\text{shape}} = 100$, $\lambda_{\text{arap}} = 40$ and $\lambda_{\text{skin}} = 1e6$. For the data term, we set the scaling along the z-axis in the point position error $\zeta = 0.75$, and the kernel scaling $\sigma = 1$ for both the Cauchy kernel and the Geman-McClure kernel.

2. Full Lifted Energy

The full lifted energy with all the inner minimizations removed is defined as

$$E'(\Upsilon, \mathcal{B}, \Theta, \mathcal{U}, \mathcal{R}) = \sum_{s=1}^{S} \left[\sum_{f=1}^{F_s} \left(\sum_{n=1}^{N_{sf}} E'^{sfn}_{\text{data}}(\mathbf{u}_{sfn}, \theta_{sf}, \beta_s; \Upsilon) + \lambda_{\text{pose}} E'^{sf}_{\text{pose}}(\theta_{sf}) \right) + \lambda_{\text{shape}} E'^{s}_{\text{shape}}(\beta_s) \right] + \lambda_{\text{arap}} E'_{\text{arap}}(\Upsilon, \mathcal{R}) + \lambda_{\text{skin}} E'_{\text{skin}}(\Upsilon)$$

where

$$E'^{sfn}_{\text{data}}(\mathbf{u}, \theta, \beta, \Upsilon) = \rho(\|WQ_{sfn}(\mathbf{x}_{sfn} - \mathcal{S}(\mathbf{u}; \mathcal{P}(\theta; \Phi(\beta, \Upsilon))))\|) + \rho^{\perp}(\|1 - (\mathbf{n}_{sfn})^{\top} \mathcal{S}^{\perp}(\mathbf{u}; \mathcal{P}(\theta; \Phi(\beta, \Upsilon)))\|), \quad (1)$$

$$E'^{sf}_{\text{pose}}(\theta_{sf}) = \sum_i \begin{cases} (\theta^i_{sf} - \theta^i_{\text{min}})^4 & \text{if } \theta^i_{sf} < \theta^i_{\text{min}} \\ (\theta^i_{\text{max}} - \theta^i_{sf})^4 & \text{if } \theta^i_{sf} > \theta^i_{\text{max}} \\ 0 & \text{otherwise,} \end{cases} \quad (2)$$

$$E'^{s}_{\text{shape}}(\beta_s) = (1 - \beta^1_s)^2 + \sum_{k=2}^{K} (\beta^k_s)^2, \quad (3)$$

$$\begin{aligned} E'_{\text{arap}}(\Upsilon, \mathcal{R}) & \quad (4) \\ &+ \sum_{m=1}^{M} \sum_{n \in \mathcal{N}(m)} \|(\mathbf{v}_n - \mathbf{v}_m) - R_m(\mathbf{v}'_n - \mathbf{v}'_m)\|^2 \\ &= \sum_{k=2}^{K} \sum_{m=1}^{M} \sum_{n \in \mathcal{N}(m)} \|(\mathbf{v}_n - \mathbf{v}_m)\|^2 \\ &+ \sum_{b=1}^{B} \sum_{m \in C_b} \|(\mathbf{v}_m - \mathbf{l}_b) - R^{\dagger}_b(\mathbf{v}'_m - \mathbf{l}'_b)\|^2 \\ &+ \sum_{k=2}^{K} \sum_{b=1}^{B} \sum_{m \in C_b} \|(\mathbf{v}_m - \mathbf{l}_b)\|^2, \end{aligned}$$

and

$$E'_{\text{skin}}(\Upsilon) = \sum_{m=1}^{M} \| \sum_{b=1}^{B} \alpha_{bm} - 1 \|^2. \quad (5)$$