Estimation of Human Body Shape in Motion with Wide Clothing

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Problem statement

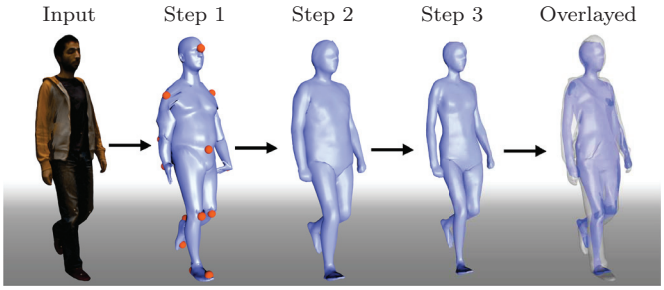
Given an input motion sequence of oriented point clouds (with unknown correspondence) showing a dressed person, the goal is to estimate the body shape and motion of this person.

Contributions

- An automatic approach to estimate 3D human body shape in motion in the presence of loose clothing.
- A new benchmark consisting of 6 subjects captured in 3 motions and 3 clothing styles each that allows to quantitatively compare human body shape estimates.

Method

Overview of our pipeline:



Energy function:

$$E = \omega_{lnd} E_{lnd}\left(\vec{F},\vec{\beta},\vec{\Theta}\right) + \omega_{data} E_{data}\left(\vec{F},\vec{\beta},\vec{\Theta}\right) + \omega_{cloth} E_{cloth}\left(\vec{F},\vec{\beta},\vec{\Theta}\right)$$

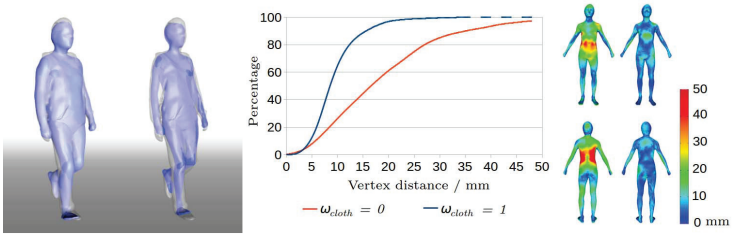
Optimization steps:

- Step 1. Pose initialization with Stitched Puppet [1] on every single frame.
- Step 2. Initial identity and pose estimation for the sequence.
- Step 3. Identity refinement based on the sequence considering wide clothing.

Clothing term:

$$E_{cloth} = \sum_{i=1}^{N_v} \delta_{out}\delta_{\vec{NN}} \left\| \vec{s}_i\left(\vec{\beta},\vec{\Theta}\right) - \vec{NN}\left(\vec{s}_i\left(\vec{\beta},\vec{\Theta}\right),\vec{F}\right)\right\|^2 + \omega_r \left\|\vec{\beta} - \vec{\beta}_0\right\|^2$$

Influence of E_{cloth} on walking sequence:



Left: input data overlayed with result with $\omega_{cloth} = 0$ (left) and $\omega_{cloth} = 1$ (right). Middle: cumulative per-vertex error of estimated body shape with $\omega_{cloth} = 0$ and $\omega_{cloth} = 1$. Right: color-coded per-vertex error with $\omega_{cloth} = 0$ (left) and $\omega_{cloth} = 1$ (right).

Dataset

A new dataset is acquired aiming to qualitatively evaluate body shape estimation algorithm. The dataset contains:

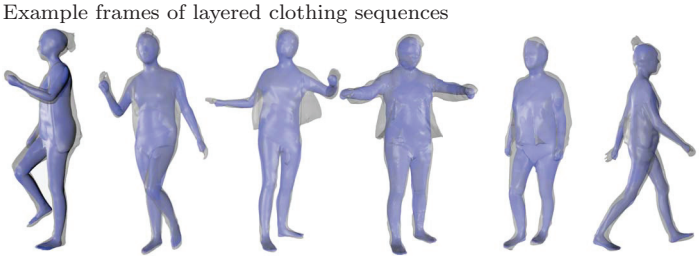
- 3 females and 3 males with large body shape variation.
- 3 motions: walk, knees-up, rotating upper body.
- 3 clothing styles: tight, layered, wide.
- Synchronized motion capture data and surface mesh.

Six representative examples:

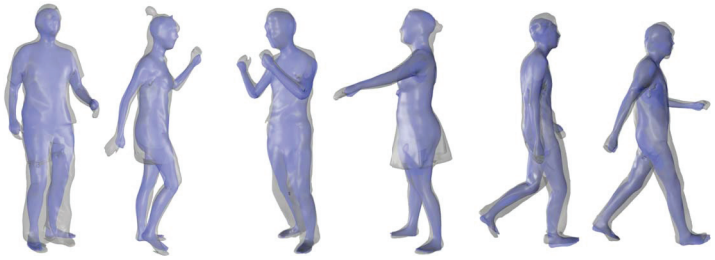
Dataset is publicly available. Details on instructions of using dataset can be found in the paper or on the website.

Result

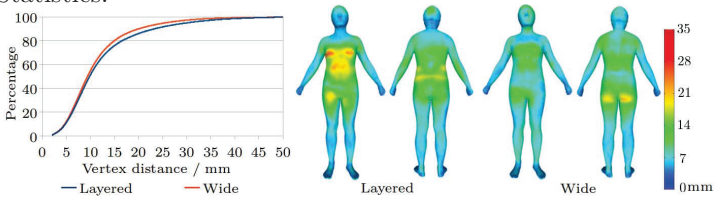
Example frames of layered clothing sequences



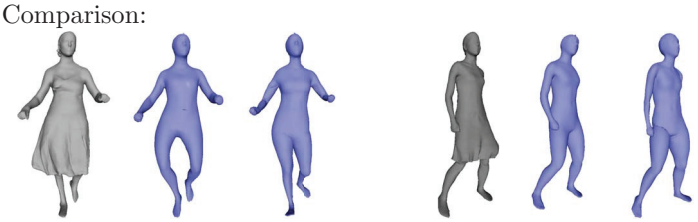
Example frames of wide clothing sequences



Statistics:



Comparison:



References

[1] Zuffi, S. and Black, M.J., 2015, June. The stitched puppet: A graphical model of 3D human shape and pose. In 2015 IEEE Conference on Computer Vision and Pattern Recognition (CVPR) (pp. 3537-3546). IEEE.
[2] Wuhrer, S., Pishchulin, L., Brunton, A., Shu, C. and Lang, J., 2014. Estimation of human body shape and posture under clothing. Computer Vision and Image Understanding, 127, pp.31-42.
[3] Neophytou, A. and Hilton, A., 2014, December. A layered model of human body and garment deformation. In 2014 2nd International Conference on 3D Vision (Vol. 1, pp. 171-178). IEEE.

Website

Paper Kinovis