The Stitched Puppet: A Graphical Model of 3D Human Shape and Pose

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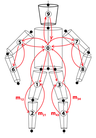
1. Motivation

Popular models used in CV are part-based [1][2]

+: efficient inference with message-passing

-: only pose is modeled



Popular models used in CG are mesh-based and learned from 3D scans of people [3]

+: realistic representation of human shape

-: hard to fit to data

2. Contribution

A 3D part-based statistical shape model

References

[1] P.F. Felzenswalb, D.P. Huttenlocker, Pictorial Structures for Object Recognition, IJCV 2005

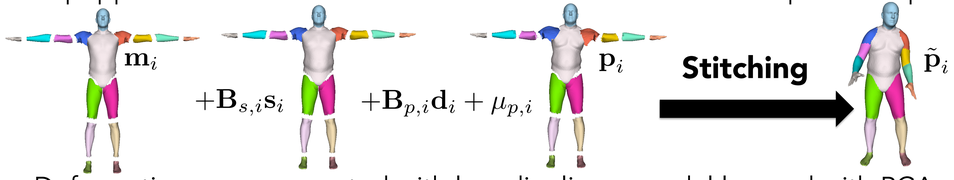
[2] L. Sigal, S. Bhatia, S. Roth, M.J.Black, Tracking Loose-limbed People, CVPR 2004

[3] D. Anguelov, P. Srinivasan, D. Koller, S. Thrun, J. Davis, SCAPE: Shape Completion and Animation of People, SIGGRAPH 2005

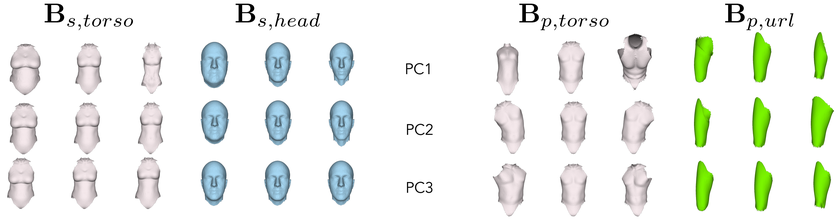
[4] F. Bogo, J. Romero, M. Loper, M.J. Black, FAUST: Dataset and Evaluation for 3D Mesh Registration, CVPR 2014

3. Representation

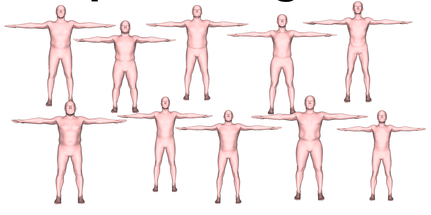
A puppet is obtained as a vertex-based deformation of a template in T-pose



Deformation are represented with low-dim linear model learned with PCA.
We model intrinsic shape deformations and pose-dependent deformations

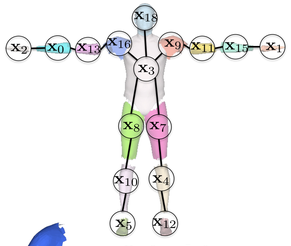


Shape training data



Pose training data

4. Graphical model

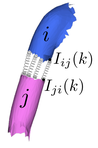


$$p(\mathbf{x}|S) \propto \prod_i \phi_i(S|\mathbf{x}_i) \prod_{(i,j)\in\mathcal{E}} \psi_{ij}(\mathbf{x}_i, \mathbf{x}_j)$$

$$\mathbf{x}_i = [\mathbf{o}_i^T, \mathbf{r}_i^T, \mathbf{d}_i^T, \mathbf{s}_i^T]^T$$

$$\mathbf{p}_i(\mathbf{s}_i, \mathbf{d}_i) = B_{p,i}\mathbf{d}_i + \mu_{p,i} + B_{s,i}\mathbf{s}_i + \mathbf{m}_i$$

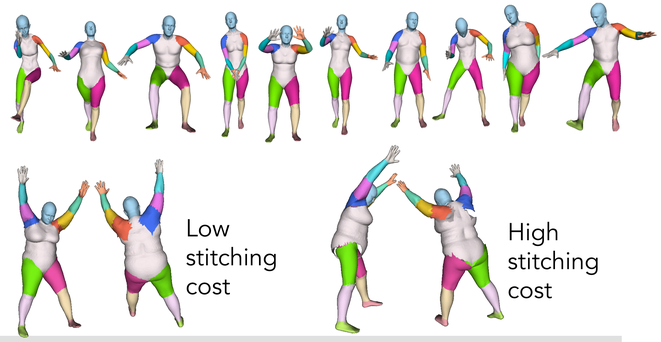
$$\tilde{\mathbf{p}}_i(\mathbf{s}_i, \mathbf{d}_i, \mathbf{r}_i, \mathbf{o}_i) = R_i(\mathbf{r}_i)\mathbf{p}_i(\mathbf{s}_i, \mathbf{d}_i) + \mathbf{o}_i$$



Stitching term

$$\psi_{ij}(\mathbf{x}_i, \mathbf{x}_j) = \exp(-\sum_{k=1..N_{ij}} \|\tilde{\mathbf{p}}_{i_{I_{ij}(k)}}(\mathbf{x}_i) - \tilde{\mathbf{p}}_{j_{I_{ji}(k)}}(\mathbf{x}_j)\|^2)$$

Samples



Low stitching cost

High stitching cost

5. Example application

Alignment of SP (light blue) to the 3D scans of the FAUST benchmark [4] (red)