Rotation Invariant Moveme Discovery from Static Poses

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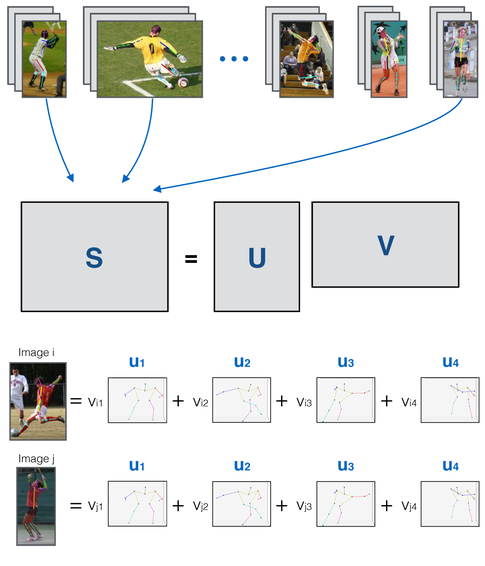
PROBLEM STATEMENT

- What are typical ranges of motion for human arms?
- What leg movements correlate with specific shoulder positions?
- How will the arms most likely move given the current body pose?



Goal: Learn a basis space to capture movemes from a generic collection of 2D images.

Applications: Extract pose priors from 2D pose datasets, improve activity recognition, animation.

Setting: Leeds Sports Dataset since sport activities have characteristic motions and share trajectories of parts of the body.

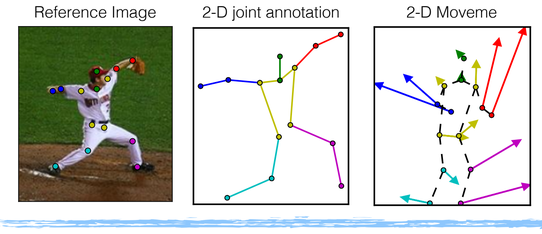
Method: Rotation-invariant latent factor model that can recover a set of 3D bases poses from a training set of 2D projections.

HUMAN MOTIONS

Moveme: simplest meaningful pattern of motion, short target-oriented trajectory that cannot be further decomposed

Action: predefined sequence of movemes

Activity: stochastic combination of actions



MODELS

Objective & Loss Functions

$$\mathbf{U},\mathbf{V},\theta = \arg\min_{\mathbf{U},\mathbf{V},\theta} \mathcal{L}(\mathbf{U},\mathbf{V},\theta)$$

$$\mathcal{L}(\mathbf{U},\mathbf{V},\theta) = \mathcal{E}(\mathbf{U},\mathbf{V},\theta) + \Omega(\mathbf{U},\mathbf{V},\theta)$$

$$\mathcal{E}(\mathbf{U},\mathbf{V},\theta) = \sum_j (\mathbf{s}_j - \hat{\mathbf{s}}_j)^2$$

Baselines

SVD $\hat{\mathbf{s}}_j = \bar{\mathbf{s}} + \mathbf{U}\cdot\mathbf{v_j}$

SVD+ROT $\hat{\mathbf{s}}_j = \bar{\mathbf{s}}(a_j) + \mathbf{U}(a_j)\cdot\mathbf{v_j}$

$$\Omega(\mathbf{U},\mathbf{V},\theta) = 0$$

LFA2D

$$\hat{\mathbf{s}}_j = \bar{\mathbf{s}}(a_j) + \mathbf{U}(a_j)\cdot\mathbf{v_j}$$

$$\Omega(\mathbf{U},\mathbf{V},\theta) = R_{reg}(\mathbf{U},\mathbf{V},\theta) + R_{spat}(\mathbf{U},\mathbf{V},\theta)$$

$$R_{reg}(\mathbf{U},\mathbf{V},\theta) = \sum_{a=1}^{p}\left[\lambda_U\|\mathbf{U}(a)\|_F^2 + \lambda_V\|\mathbf{V}(a)\|_1\right]$$

$$R_{spat}(\mathbf{U},\mathbf{V},\theta) = \lambda_{spat}\sum_{a,a'}\kappa_{a,a'}\|\mathbf{U}^{(x)}(a) - \mathbf{U}^{(x)}(a')\|_F^2 + \sum_{a,a'}\mathbf{1}\left(\mathbf{U}^{(y)}(a),\mathbf{U}^{(y)}(a')\right)$$

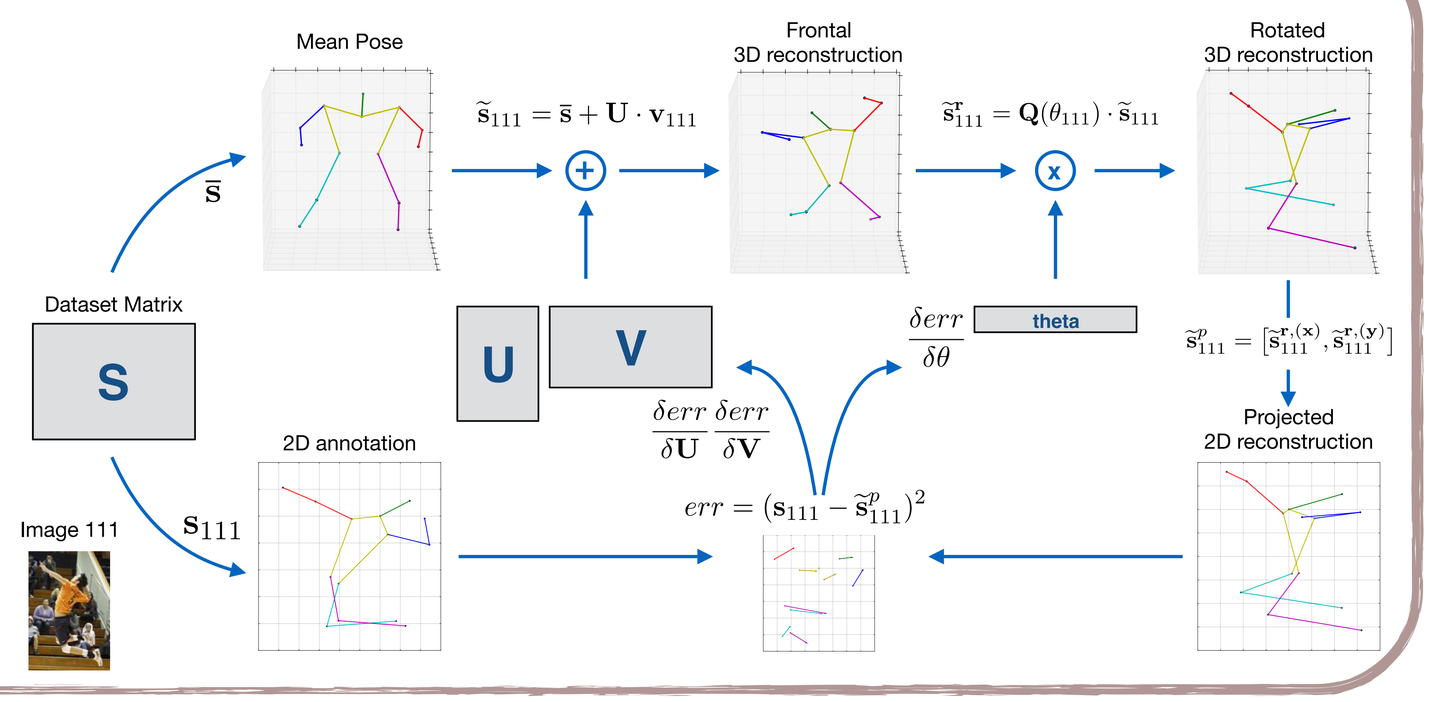
LFA3D

$$\hat{\mathbf{s}}_j = \left[\mathbf{Q}(\theta_j)\left(\bar{\mathbf{s}} + \mathbf{U}\cdot\mathbf{v}_j\right)\right]^{(x,y)}$$

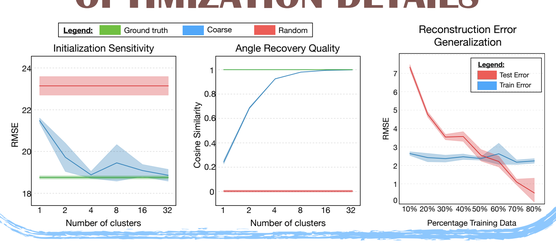
$$\mathbf{Q}(\theta_j) = \begin{bmatrix} \cos(\theta_j) & 0 & \sin(\theta_j) \\ 0 & 1 & 0 \\ -\sin(\theta_j) & 0 & \cos(\theta_j) \end{bmatrix}$$

$$\Omega(\mathbf{U},\mathbf{V},\theta) = \lambda_U\|\mathbf{U}\|_F^2 + \lambda_V\|\mathbf{V}\|_1$$

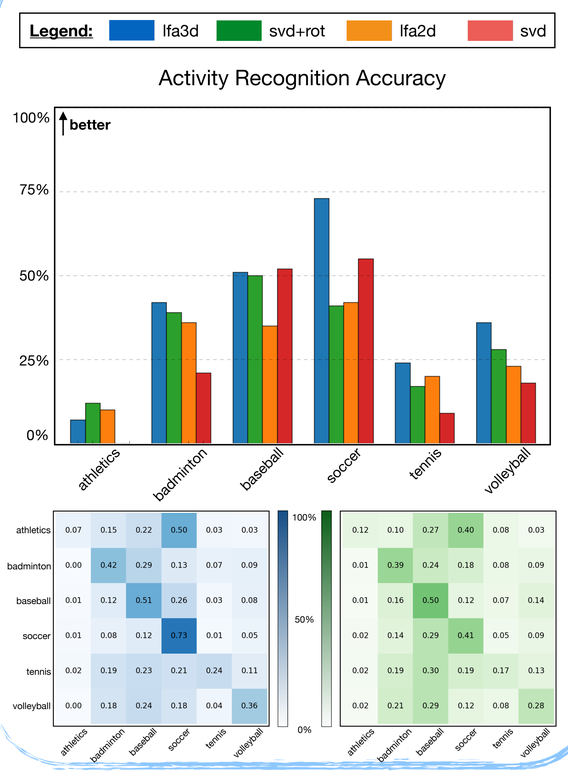
LFA3D OPTIMIZATION PIPELINE



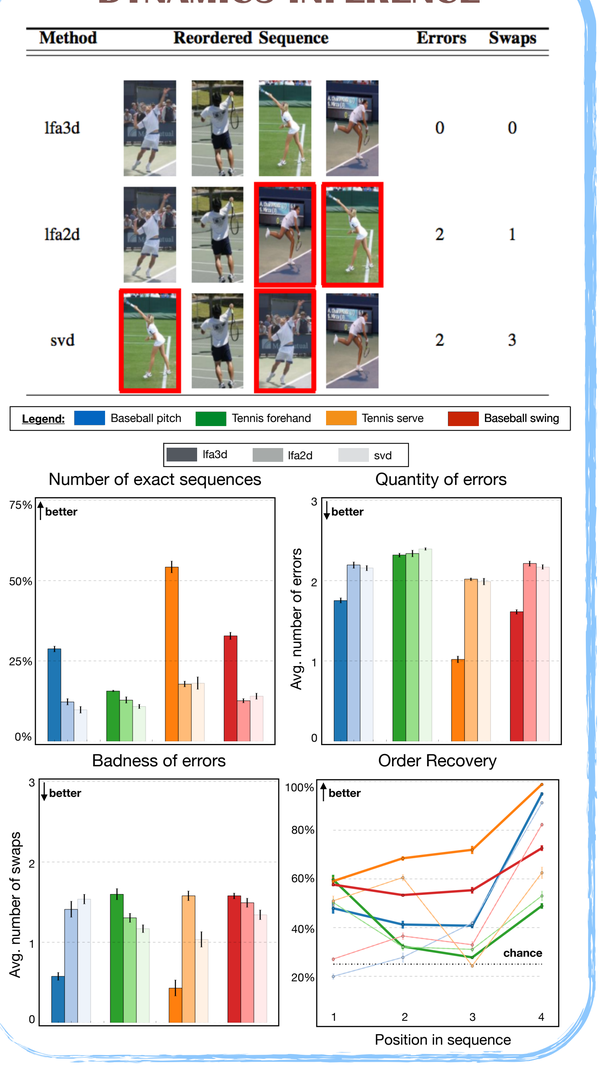
OPTIMIZATION DETAILS



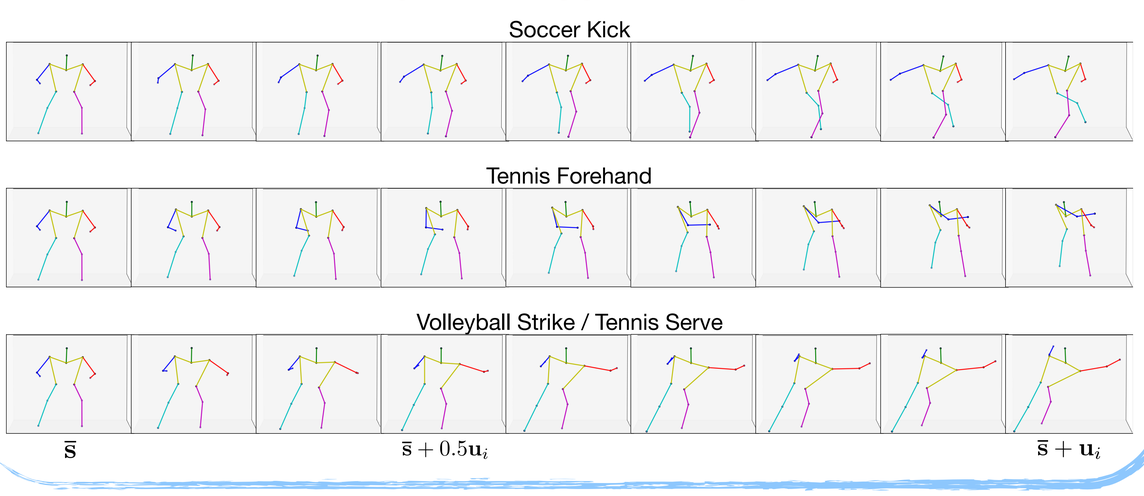
ACTIVITY RECOGNITION



DYNAMICS INFERENCE



MOVEME VISUALIZATION



MANIFOLD VISUALIZATION