Automatic Evaluation of Sports Motion

A Generic Computation of Spatial and Temporal Errors

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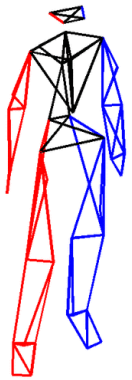
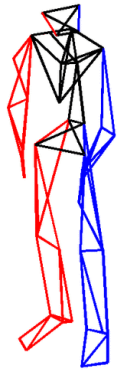
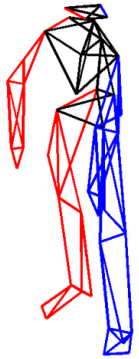
Summary

Introduction: objectives and issues





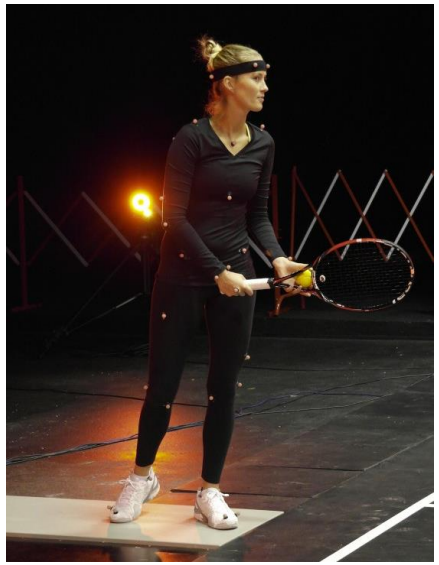


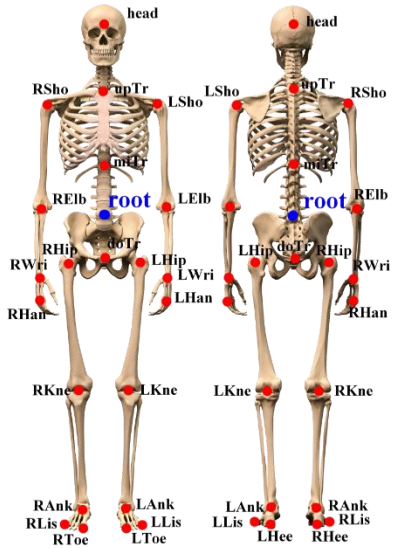
Any sport motion
Any morphology
Any execution rate

No prior-knowledge on the sport

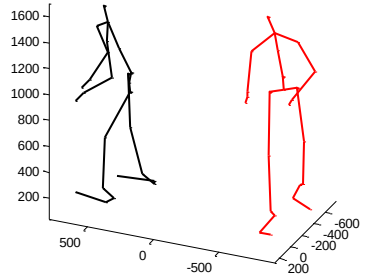
Innovative automatic evaluation process

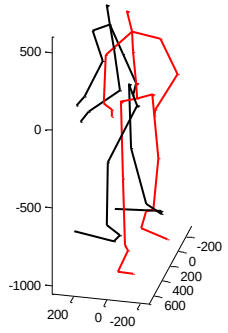
Experts' motion database

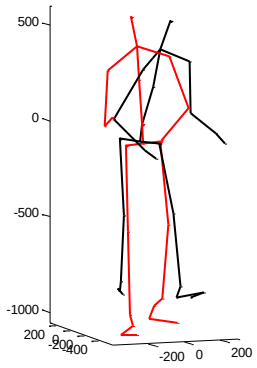


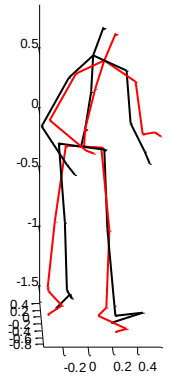


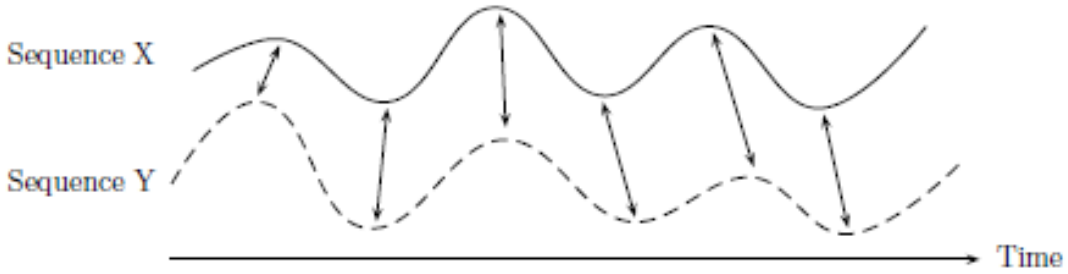
- Dataset of karate gestures and tennis serves recorded by a motion capture system (Vicon)
- Local frame oriented by the hips and centered by the root. Scaling with respect to the torso length.

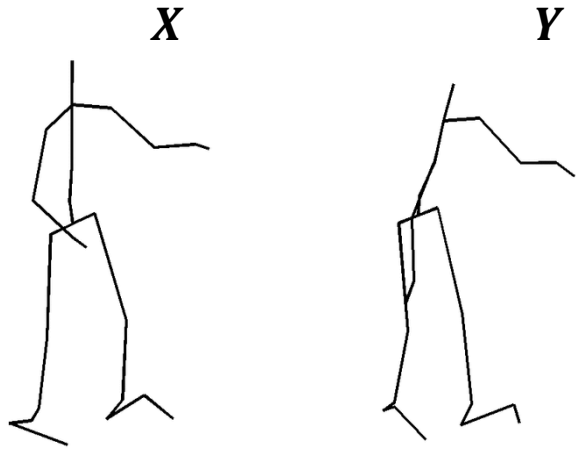






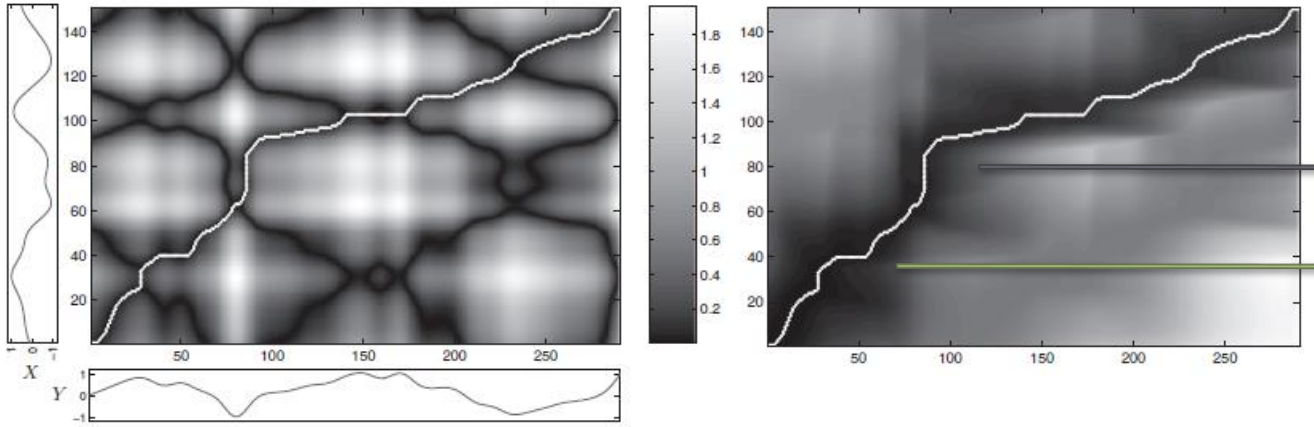






$$d(i,j) = \left(X(i) - Y(j)\right)^2$$

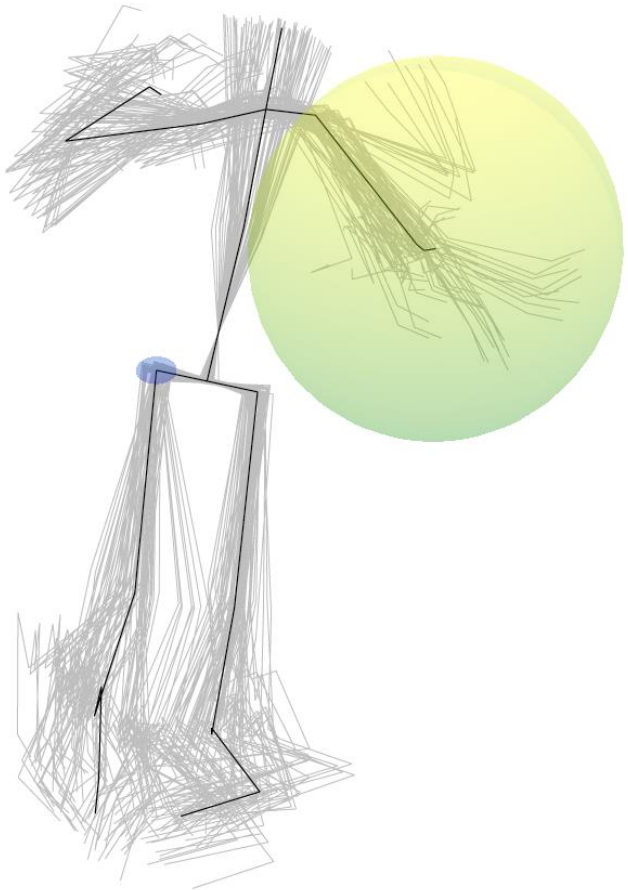
$$d(i,j) = \sum_{a \in joints} \left(\boldsymbol{X}_a(i) - \boldsymbol{Y}_a(j)\right)^{\mathrm{T}} \left(\boldsymbol{X}_a(i) - \boldsymbol{Y}_a(j)\right)$$



$$d^l(i,j) = \sum_{a \in S_l} \left(\boldsymbol{X}_a(i) - \boldsymbol{Y}_a(j)\right)^{\mathrm{T}} \left(\boldsymbol{X}_a(i) - \boldsymbol{Y}_a(j)\right)$$

$\phi_{i \to j}$ warping path of the ith signal on the jth

$\phi^l_{i \to j}$ warping path of the ith signal on the jth only based on the lth limb



Nominal motion : Averaging the aligned experts' motion

$$\boldsymbol{X}_n(t) = \frac{1}{N_E} \sum_{i \in experts} \boldsymbol{X}_i\left(\phi_{i \to 0}(t)\right)$$

Spatial tolerance : Variance of the aligned experts' limbs

$$\Sigma^{l}_{SPA}(t) = COV\left\{\mathbf{X}^{l}_{i}\left(\phi^{l}_{i \to n}(t)\right)\right\}_{i \in experts}$$

Spatial error :

$$E_{SPA,i}^{l}(t) = \sqrt{F_i^l(t)^T \left(\Sigma_{SPA}^{l}(t)\right)^{-1} F_i^l(t)}$$

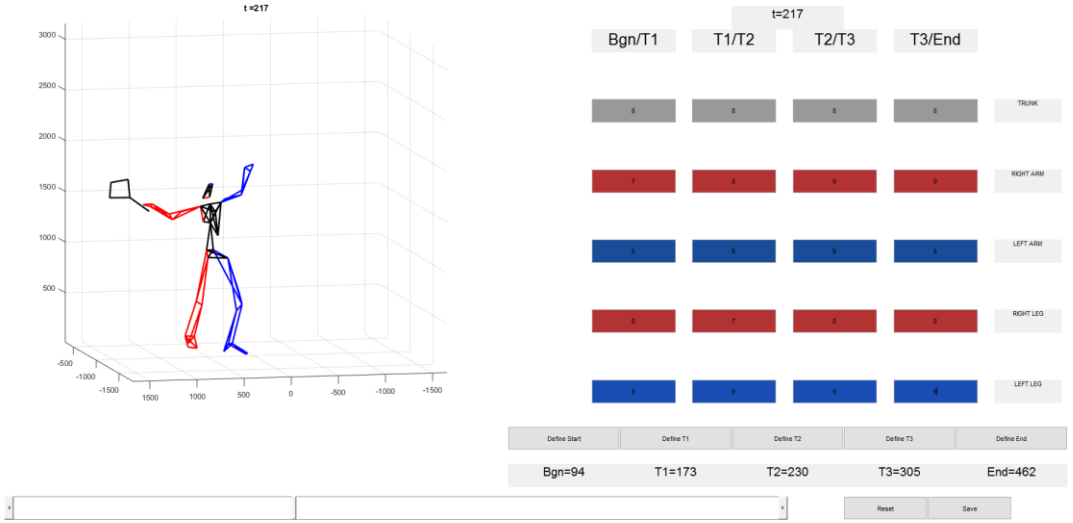
$$F_i^l(t) = \boldsymbol{X}_i^l\left(\phi_{i\to n}(t)\right) - \boldsymbol{X}_n^l(t)$$

Temporal error :

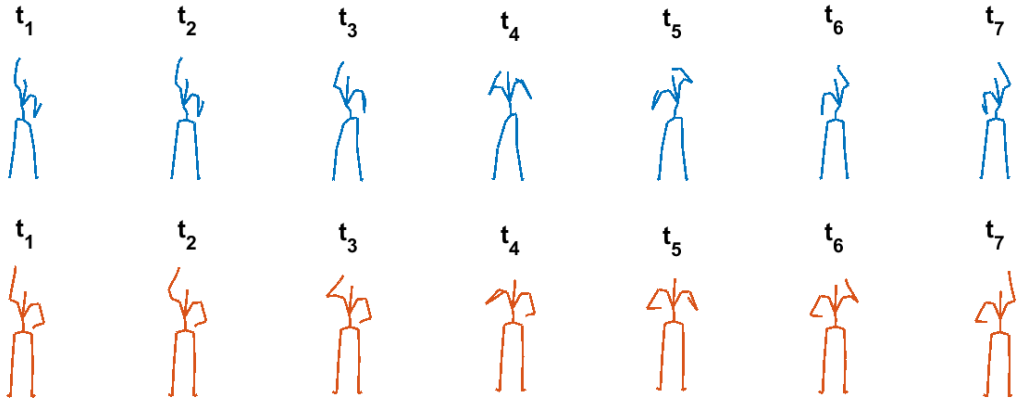
$$E_{TEMP,i}^{l_1,l_2}(t) = \gamma^{l_1,l_2}(t) \times \left(\phi_{i\to n}^{l_2}(t) - \phi_{i\to n}^{l_1}(t)\right)$$

$$\gamma^{l_1,l_2}(t) = \frac{\max\left(\left\|\dot{\boldsymbol{X}}_n^{S_{l_1}}(t)\right\|, \left\|\dot{\boldsymbol{X}}_n^{S_{l_2}}(t)\right\|\right)}{\sum_{t=1}^{M_0} \max\left(\left\|\dot{\boldsymbol{X}}_n^{S_{l_1}}(t)\right\|, \left\|\dot{\boldsymbol{X}}_n^{S_{l_2}}(t)\right\|\right)}$$

Tennis serves

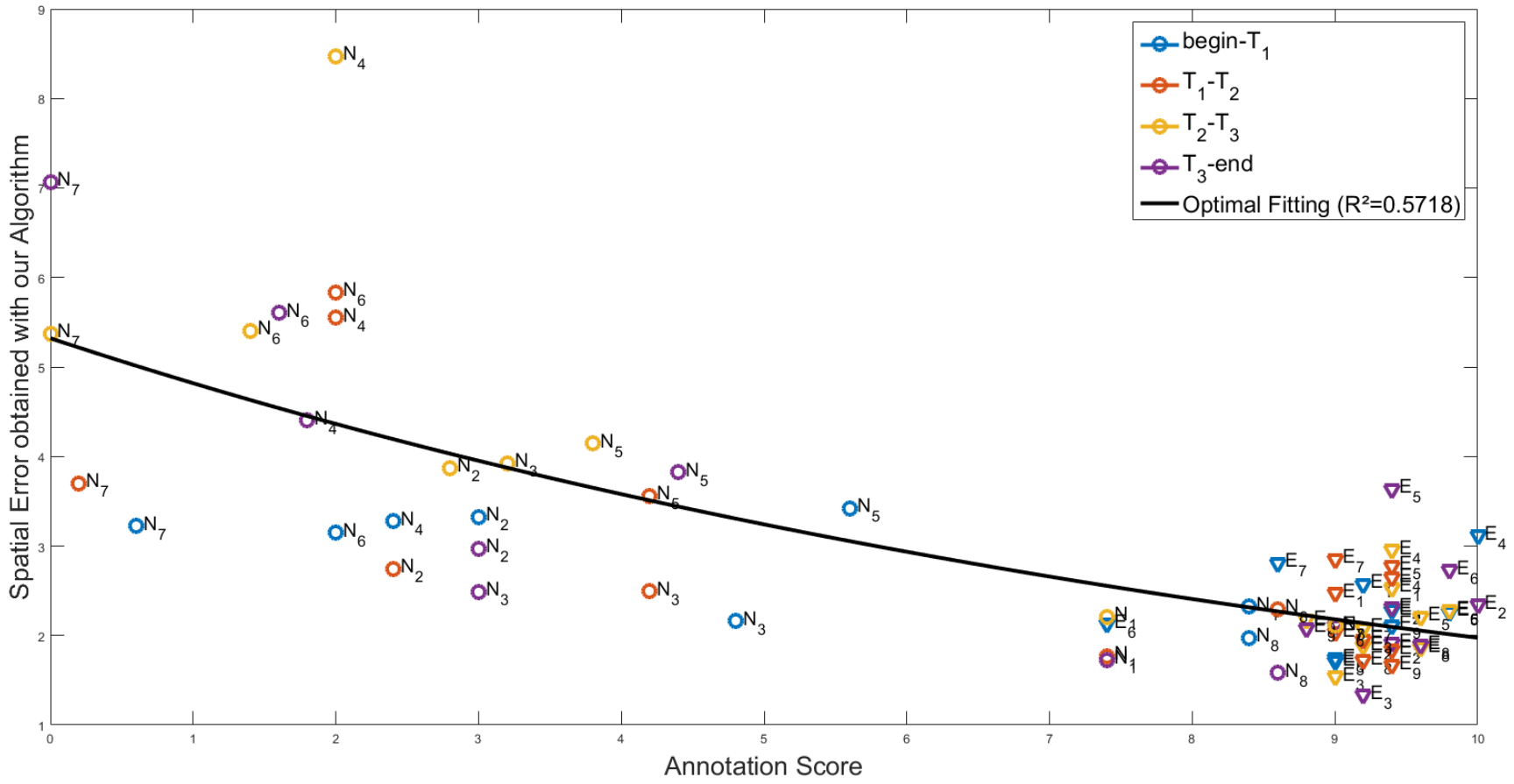


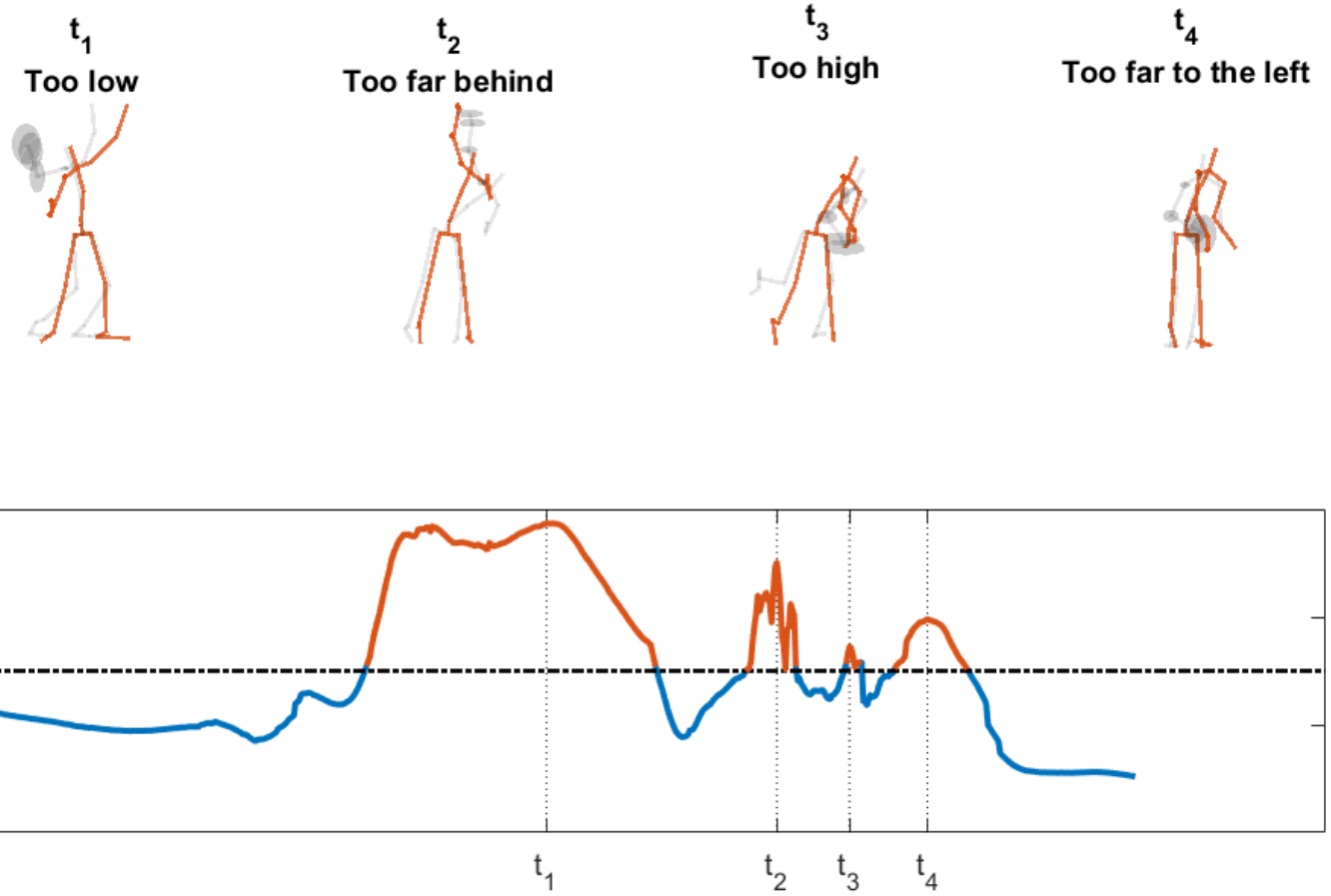
Karate *tsuki* dataset

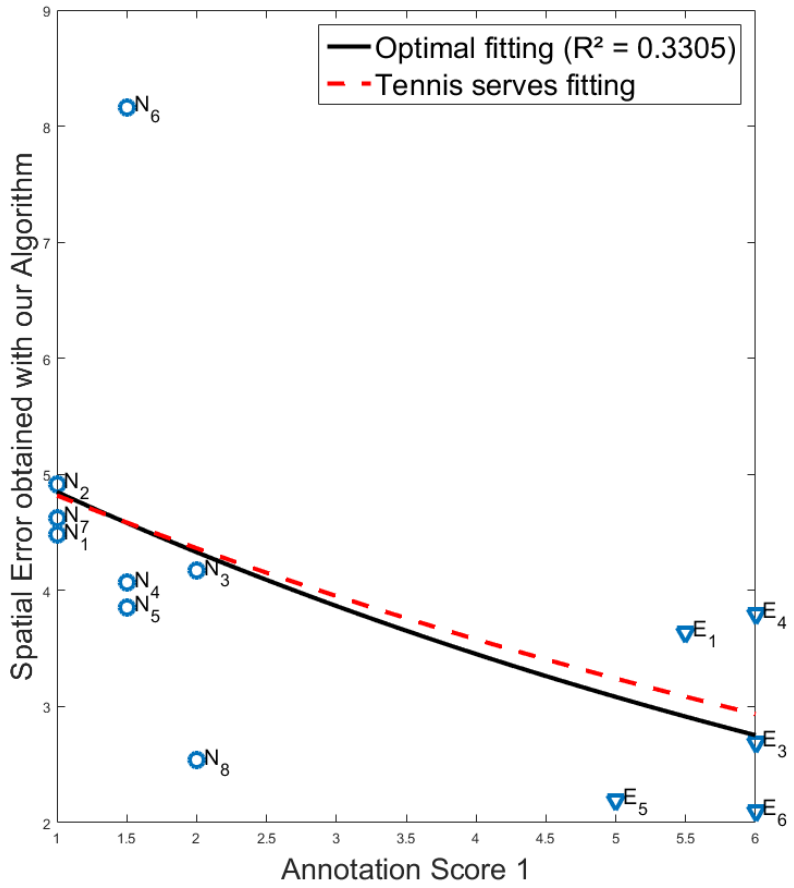


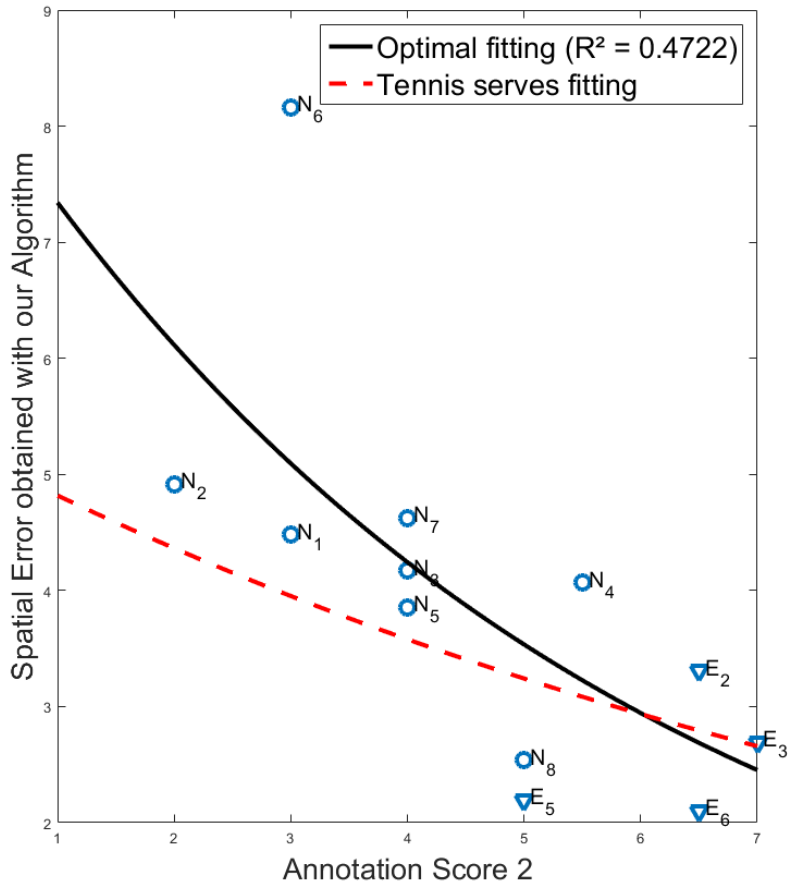
Spatial scores given by one coach
- by phase
- by limb

Temporal scores given by 2 coaches
- right arm / left arm


begin-T1
T1-T2
T2-T3
T3-end
Optimal Fitting (R²=0.5718)
Spatial Error obtained with our Algorithm
Annotation Score


t_1
Too low
t_2
Too far behind
t_3
Too high
t_4
Too far to the left
Spatial Error
6
4
2
0
t_1
t_2
t_3
t_4


Optimal fitting (R² = 0.3305)
Tennis serves fitting
Spatial Error obtained with our Algorithm
Annotation Score 1
N6
N2
N7
N1
N4
N5
N3
N8
E1
E4
E3
E5
E6

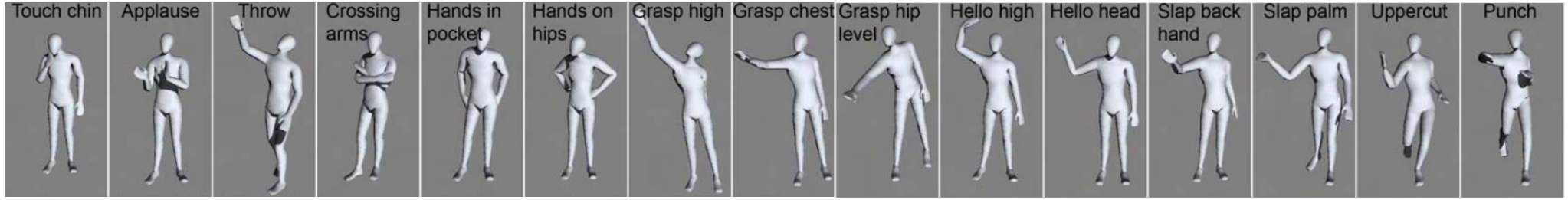

Optimal fitting (R² = 0.4722)
Tennis serves fitting
Spatial Error obtained with our Algorithm
Annotation Score 2
N6
N2
N1
N7
N3
N5
N4
E2
E3
N8
E5
E6

Real-time evaluation tool with Kinects

- Extract the Kinect body in real-time
- Deal with different representations of the skeleton (Mocap and Kinect)
- Create a user-friendly tool
- Choose a well-adapted feedback

Classification

- Learn a nominal motion and a spatial tolerance for each class
- Test each example by computing the spatial and temporal error



Thank you!

Any questions?