Monocular 3-D Tracking of the Golf Swing

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CVLAB, EPFL, CH| CVLAB,

Problem:

Model-based 3D people tracking from monocular video.

Approach:

Deterministic nonlinear optimization based on

- subspace model for pose trajectories
- detection of key poses for automatic initialization
- background subtraction
- 3-frame correspondence

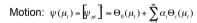
Result:

With generic optimization methods the tracker fits smooth motions to monocular video. A multiple hypothesis tracker (e.g., particle filter) is not needed to resolve ambiguities.

Prior Motion Model

PCA is used to learn a subspace model for pose trajectories (ie. sequences of joint angles from kinematic human model).

- 10 examples same subject CMU database
- PCA: An eigenvector is the whole motion



Pose: $\psi = \left[\psi_{\mu_1}, \dots, \psi_{\mu_N}\right]^T \approx \Theta_0 + \sum_{i=1}^{m} \alpha_i \Theta_i$

α: style coefficient

μ: virtual time

G: global motion

Key Pose Detection

4 key poses:









Tracking as Deterministic Hill-Climbing

Minimize

$$F = \sum_{i=1}^{mobs} w^{type_i} \left\| Obs^{type_i}(x_i,S) \right\|^2 + w_a \left\| G_i - \hat{G}_i \right\|^2 + w_\mu \left(\mu_i - \hat{\mu}_i \right)^2 + w_\mu \left(\mu_i - \hat{\mu}_i \right)^2 + w_a \sum_{i=1}^{m} \left(\alpha_i - \hat{\alpha}_i \right)^2$$

With respect to $\phi = [\alpha_1,...,\alpha_m,\mu_1,...,\mu_f,G_1,...,G_f]$

 $\frac{\partial F}{\partial \alpha_{i}} = \sum_{j=1}^{ndef} \frac{\partial \theta_{j}}{\partial \alpha_{i}} \frac{\partial F}{\partial \theta_{j}} \qquad \frac{\partial F}{\partial \mu_{i}} = \sum_{j=1}^{ndef} \frac{\partial \theta_{j}}{\partial \mu_{i}} \frac{\partial F}{\partial \theta_{j}} \qquad \frac{\partial \theta_{j}}{\partial \mu_{i}} = \sum_{j=1}^{m} \alpha_{i} \frac{\partial \Theta_{ij}}{\partial \mu_{i}}$

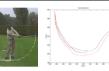
Tracking Objective function

1) Consistency with 2D joint detection









2) Silhouette consistency: Reprojection inside mask



3) 2D Correspondences in a 3 frame bundle adjustment

Complementarity of the function terms











Tracking an approach swing

Tracking a golf swing



Initialization

Mean motion





Conclusion

Deterministic approach
Fully 3D motion
Lower cost than probabilistic
Applications: Sport, Orthopedics

Motion synthesis

Future work

Larger database Non linear models Multi-activity database

VLAB.EPFL.CH| CVLAB.EPFL.CH| CVLAB.E



