Automatic Gait Motion Capture with Missing-marker Fillings

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Motivations

Optical motion capture data with the state of the arts systems (e.g. Vicon[1]) has the disadvantages that noise, missing data and outliers that must be filled or removed manually prior to further processing

Seminal work by Herda et. al [2] has two disadvantages:



Marker Tracking

Aim: After the tracking is initialized, recover marker trajectories over the entire sequence

Main constraints: Use temporal and structural constraints for marker tracking

- Temporal constraint
- Marker positions are close to those in the previous frame
- Structural constraint
 - Marker pair distances on a rigid segment do not deviate much from those in human model



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- Require initializing the first tracking frame manually - Error prone process due to lots of erroneous reconstructed markers
- Weak robustness due to the marker motion smoothness assumption in time window
 - Not true in most real scenarios due to abrupt limb motions

Missing data and outlier problem

Main Ideas

Label the markers and infer possible positions of missing markers by exploring the rigidity constraints of body segments and the knowledge of human body structure



Human model [3]

Human model calibration

Approach:

- Use multiple view stereo matching and the marker position in the previous frame to get marker candidates in the current frame
- Select proper markers by using a model based label criterion

Marker label criterion: evaluate how the label result fits with the human model

$$P(S_l) = \prod_{\forall (s,t) \in H} P(\mathbf{C}_s, \mathbf{C}_t) \quad P(\mathbf{C}_s, \mathbf{C}_t) \propto \begin{cases} 0 & (\mathbf{C}_s, \mathbf{C}_t) \notin U(s, t) \\ \exp(-\frac{(d(\mathbf{C}_s, \mathbf{C}_t) - d_{s,t})^2}{2\sigma^2(s, t)}) & (\mathbf{C}_s, \mathbf{C}_t) \in U(s, t) \end{cases}$$

Filling Missing Markers

Aim: Setup the filling candidate set of each missing marker, and select the proper filling markers from the candidate sets by using the above label criterion in the marker tracking





Tracking Initialization

Aim: Label the reconstructed 3D markers using precalibrated human model Main constraints: Human motion contains local geometric invariance in rigid segments, and this allows affine matching with the model at the segment level **Approach**: Label the local rigid segments along the hierarchical human body models



Illustrative results of walking and jumping sequences







Video Demo

Rigid Segment ID

by minimizing the residue error of rigid transformation



markers Blue: a rigid segment in human model

Red: rigid segment candidates of reconstructed markers



markers

model

References:

[1] Vicon, www.vicon.com

[2] L. Herda, P. Fua, R. Plankers, and et. al., "Using skeleton-based tracking to increase the reliability of optical motion capture," Human Movement Science [3] D. Ross, D. Tarlow, and R. Zemel, "Learning articulated structure and motion," International Journal of Computer Vision