Temporal Integration of Multiple Silhouette-based Body-part Hypotheses

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Goals

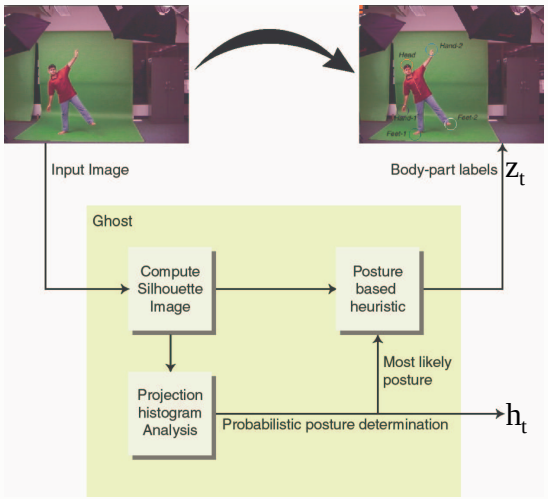
- Estimation of human body-part locations in a video

- Temporal integration framework of an instantaneous labeling technique
  - *"Ghost: A Human Body Part Labeling System Using Silhouettes", I. Haritaoglu, D. Harwood and L. Davis, Proc. ICPR 1998*

Motivation

- Body-part location information can be useful in many ways
  - Tracking
  - Animation
  - Surveillance
- Should be able to do better than instantaneous
- Framework for combining discrete and continuous state information

Instantaneous Estimation : *Ghost*



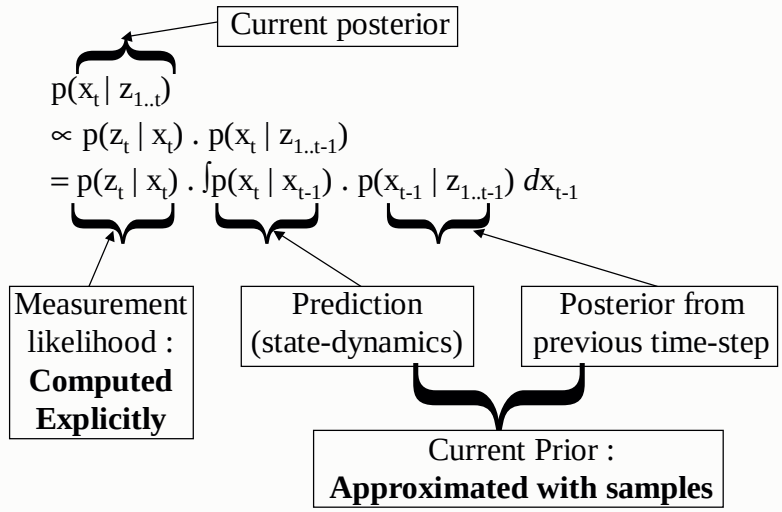
State and Measurements

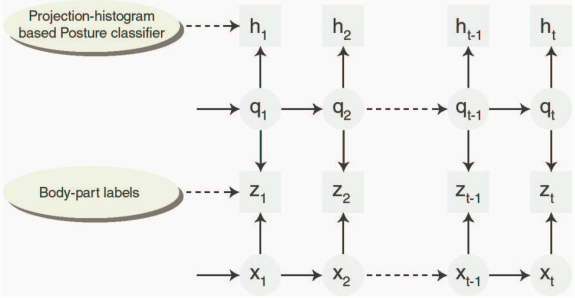
- Ghost outputs a measurement of the state
- q_t : Posture State
- x_t : Body-part location State
- h_t : Posture Measurement (Projection Histogram)
- z_t : Body-part location Measurement : Set of labelings $\{z_{t,q}\}$, one for each posture-based heuristic

Probabilistic State Estimation

- State Estimate
  - Expected value of x_t (body-part location)
  - Most likely value of q_t (posture)
- Probability density estimate
  - Filtered : $p(x_t, q_t \mid z_{1..t}, h_{1..t})$
  - Smoothed : $p(x_t, q_t \mid z_{1..T}, h_{1..T})$
    $\approx$ Filtered + Back propagation
- Non-gaussian density : mixture of continuous and discrete variables – estimate using CONDENSATION

CONDENSATION

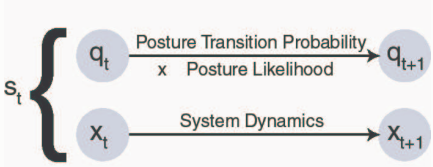




- Prediction
  - Posture transition probability = $\Pr(q_t \mid q_{t-1})$: *heuristically assigned*
  - Body-part dynamics = $p(x_t \mid x_{t-1})$: *velocity predictor*
- Measurement likelihood
  - Projection histogram likelihood = $p(h_t \mid q_t)$: *truncated gaussian*
  - Body-part labelings likelihood = $p(z_t \mid x_t, q_t)$: *truncated gaussian for $z_{t,q}$, $q = q_t$; uniform for other labelings*

Forward Density Propagation

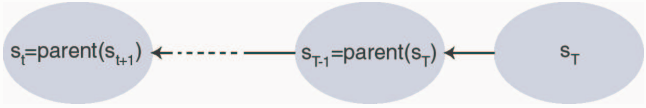
- Select a sample with probability proportional to its likelihood
- Predict state of sample in next time step



- Compute new measurement likelihood for the sample

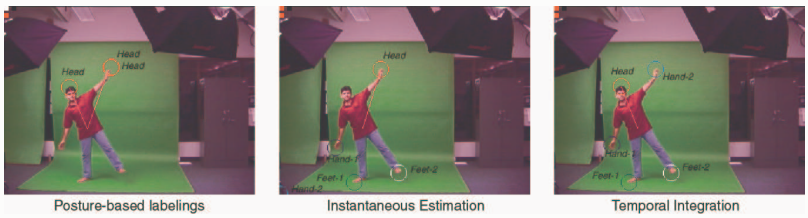
Smoothed State Estimation

- Propagate samples until end of sequence
- Trace ancestors of each sample back to the desired time-step



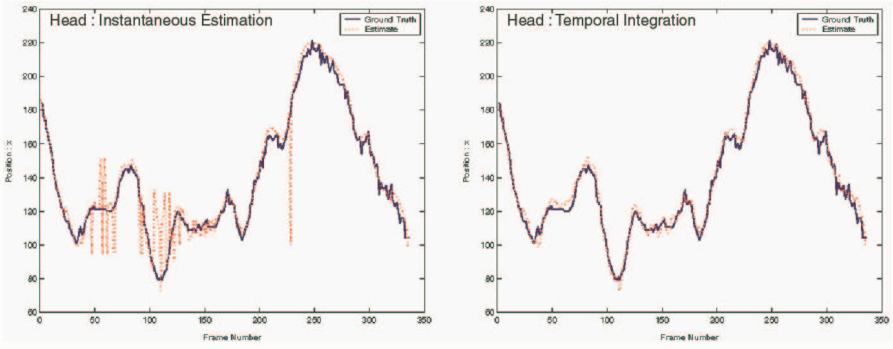
- Compute mean body-part locations and most likely posture from traced samples

Results

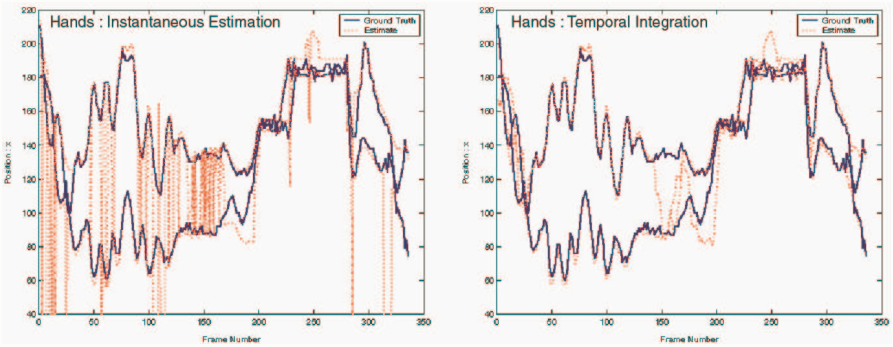


Posture-based labelings | Instantaneous Estimation | Temporal Integration

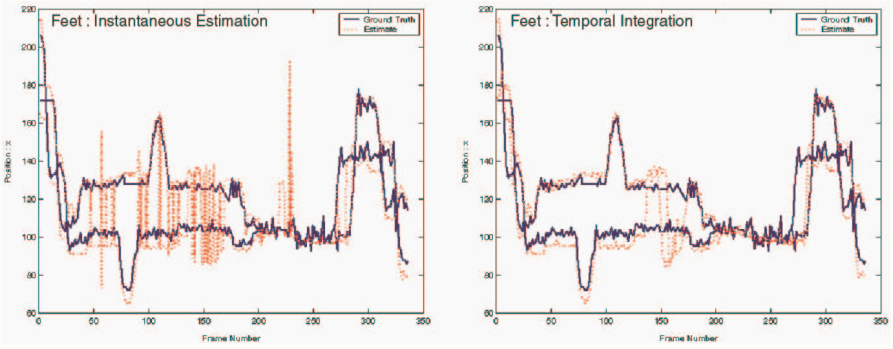
Head



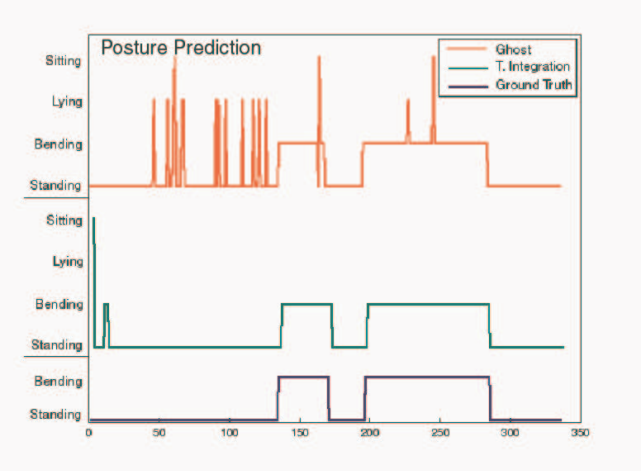
Hands


Hands : Instantaneous Estimation
Ground Truth
Estimate
Position : x
Frame Number
Hands : Temporal Integration
Ground Truth
Estimate
Position : x
Frame Number

Feet


Feet : Instantaneous Estimation
Ground Truth
Estimate
Position : x
Frame Number
Feet : Temporal Integration
Ground Truth
Estimate
Position : x
Frame Number

Posture



Summary

- A framework for temporally integrating an instantaneous body-part labeling method is presented
- Performs density propagation for mixed discrete and continuous states
- The framework is general enough to be applied to other example domains

The End