Semi-automatic tracking of beach volleyball players

Gabriel Gomez, André Linarth, Daniel Link, Bjoern Eskofier
Pattern Recognition Lab (CS 5)
Digital Sports Group
12.09.2012
Outline

Introduction
Methodology
Results
Summary

[Köpke/beach-inside.de]
Introduction

- Videoanalysis in professional sports

  - **Technical training**
    - Individual training of players
    - Improve technique
    - Reduce errors
    - Analyze habits

  - **Tactical training**
    - Analyze opposing teams
    - Create specific strategy

Introduction

- German beach volleyball team uses analysis software by the TUM
  
  - BeachScouter
  - BeachViewer
Introduction

- BeachScouter
Introduction

- BeachViewer
Introduction

- **BeachTracker**

  Tracking software complementing the BeachScouter
Outline

Introduction
Methodology
Results
Summary
Methodology

- Particle filter approach
  - Color histogram based
  - Motion based

[http://www.exploratorium.edu/texnet/exhibits/motion/motion_theater/ken/strobe-motion-ta-08.jpg]

Methodology

- 4 particle clouds with 50-100 particles each
- Set of particles represents Probability Density Function
- Each particle is weighted hypothesis of player’s position
- Homographic transformation from world coordinates to image coordinates
Methodology

- Calibration from initial frames of the video
Methodology

- Each player and each particle with a corresponding bounding box

- Reference color histograms for each player
Methodology

- Weight of the particles proportional to histogram similarity
Methodology

- Bhattacharyya distance used for measuring the similarity of the normalized color histograms

![Graphs showing the pixel value distribution for Player and Sand](image-url)
Methodology

- Motion based weighting

Particle weight also proportional to number of white pixels in each subwindow
Methodology

- Combination of color histogram and motion cues for weighting

\[ P_{\text{weight}} = \text{Color weight} + \text{movement weight} \]

- Resampling of particles in next frame proportional to particles’ weights in current frame
Methodology

- Predicted players’ position

Predicted position as average state of the particle set
Methodology

- Other measures for improving the tracking
  - Calculation of a background image and comparison of histograms
  - Updating of the reference histogram
  - Restrict particle clouds to certain regions
Outline

Introduction
Methodology
Results
Summary
Results
## Results

- Evaluation on 23 video sequences of ~247 frames each

<table>
<thead>
<tr>
<th></th>
<th>Average number of frames tracked (rounded)</th>
<th>Percent of correctly tracked frames</th>
</tr>
</thead>
<tbody>
<tr>
<td>Player 1 (front left)</td>
<td>237</td>
<td>95.9 %</td>
</tr>
<tr>
<td>Player 2 (front right)</td>
<td>236</td>
<td>95.4 %</td>
</tr>
<tr>
<td>Player 3 (back right)</td>
<td>228</td>
<td>92.3 %</td>
</tr>
<tr>
<td>Player 4 (back left)</td>
<td>218</td>
<td>88.3 %</td>
</tr>
<tr>
<td>Average players front</td>
<td>237</td>
<td>95.7 %</td>
</tr>
<tr>
<td>Average players back</td>
<td>223</td>
<td>90.3 %</td>
</tr>
</tbody>
</table>
Results
Outline

Introduction
Methodology
Results
Summary

© Süddeutsche.de/dpa/ebc
Summary

- BeachTracker complementing BeachScouter for semi-automatic tracking of the players

- Color histogram and motion based cues

- Particle filter approach

- Good tracking results when homogeneous illumination conditions
Thank you for your attention
Bhattacharyya Distance

\[ D(h^{\text{ref}}, h^{\text{hyp}}) = \sqrt{1 - \sum_{b \in B} \sqrt{h_b^{\text{ref}} \cdot h_b^{\text{hyp}}}} \]

Where \( B \) denotes the number of histogram bins, and \( h_b \) represents the value of the \( b \)-th bin of the reference or hypothesized histogram.
Particle Weighting

\[ \omega^i_j = \frac{c}{\sum_k D_{i,j}} + \sum_k F \]

Where \( \omega \) is the weight of the \( j \)-th particle, \( i \)-th player; \( k \) is the number of subregions of the bounding box; \( D_{i,j} \) is the Bhattacharyya distance; \( F \) is the normalized sum of foreground pixels; \( c \) is a constant that balances color and motion cue;