# Semi-automatic tracking of beach volleyball players

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Methodology Results Summary



[Köpke/beach-inside.de]



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• Videoanalysis in professional sports

#### • Technical training

- Individual training of players
- Improve technique
- Reduce errors
- Analyze habits
- Tactical training
  - Analyze opposing teams
  - Create specific strategy

[http://alleman1965.com/images/video\_cartoon.jpg]







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





## • BeachScouter

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# • BeachViewer

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# • BeachTracker



Tracking software complementing the BeachScouter



# Introduction Methodology

Results Summary



[Köpke/beach-inside.de]



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# Methodology



- Particle filter approach
  - Color histogram based
  - Motion based



[http://www.exploratorium.edu/texnet/exhibits/mot ion/motion\_theater/ken/strobe-motion-ta-08.jpg]



[http://tecfa.unige.ch/guides/xml/epub/test/ epub-source/flash\_tutorials\_files/300px-HSV-color-wheel.png]



- 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



• Calibration from initial frames of the video







 Each player and each particle with a corresponding bounding box



• Reference color histograms for each player



• Weight of the particles proportional to histogram similarity





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





# Motion based weighting



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



 Combination of color histogram and motion cues for weighting

*Pweight* = *Color weight* + *movement weight* 

 Resampling of particles in next frame proportional to particles' weights in current frame



# Predicted players' position



Predicted position as average state of the particle set

# **Methodology**







# Introduction Methodology Results Summary



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#### **Results**







## • Evaluation on 23 video sequences of ~247 frames each

	Average number of frames tracked (rounded)	Percent of correctly tracked frames
Player 1 (front left)	237	95.9 %
Player 2 (front right)	236	95.4 %
Player 3 (back right)	228	92.3 %
Player 4 (back left)	218	88.3 %
Average players front	237	95.7 %
Average players back	223	90.3 %

#### **Results**







# Introduction Methodology Results Summary



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- BeachTracker complementing BeachScouter for semiautomatic 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



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# **Bhattacharyya Distance**



$$D(\mathbf{h}^{ref}, \mathbf{h}^{hyp}) = \sqrt{1 - \sum_{b \in B} \frac{\sqrt{\mathbf{h}_{b}^{ref} \mathbf{h}_{b}^{hyp}}}{\sqrt{\sum_{b \in B} \mathbf{h}_{b}^{ref} \cdot \sum_{b \in B} \mathbf{h}_{b}^{hyp}}}$$

# 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



 $\omega_j^{\ i} = \frac{C}{\sum_{\nu} D_{i,i}} + \sum_{\nu} F$ 

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;