Semi-automatic tracking of beach volleyball players

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für Sportwissenschaft

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TECHNISCHE FAKULTÄT

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

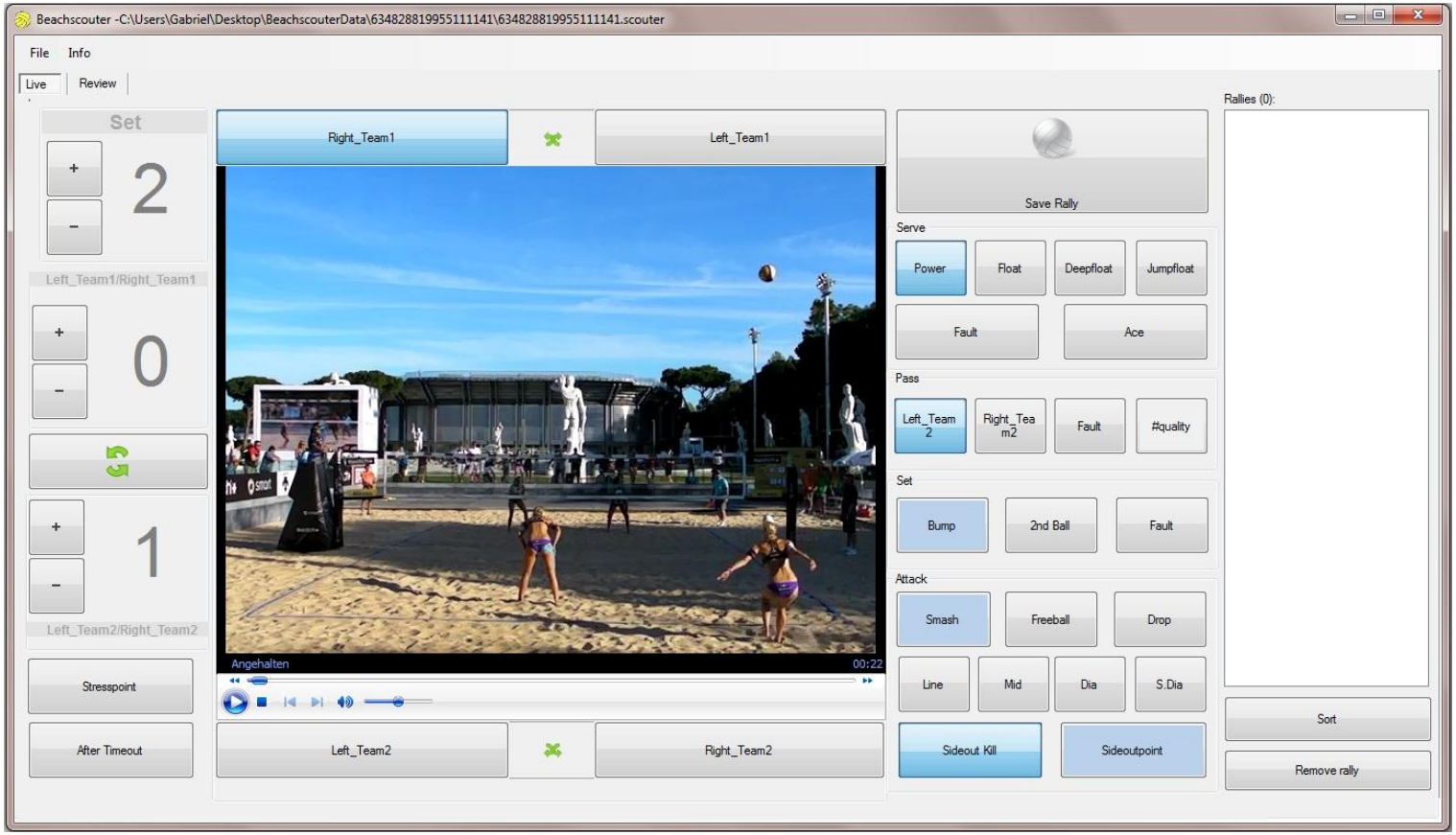
[http://alleman1965.com/images/video_cartoon.jpg]

Introduction

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

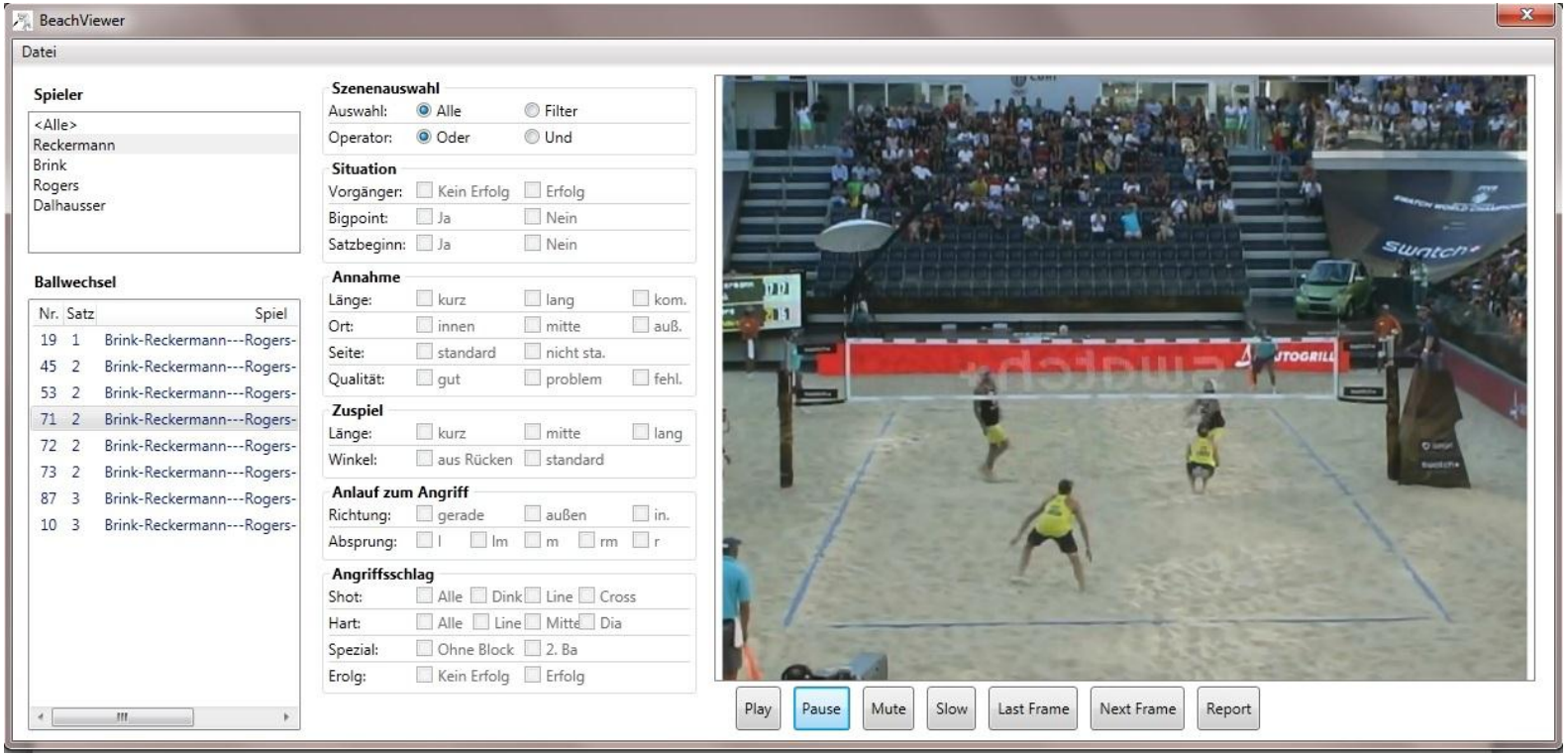
Introduction

- BeachScouter



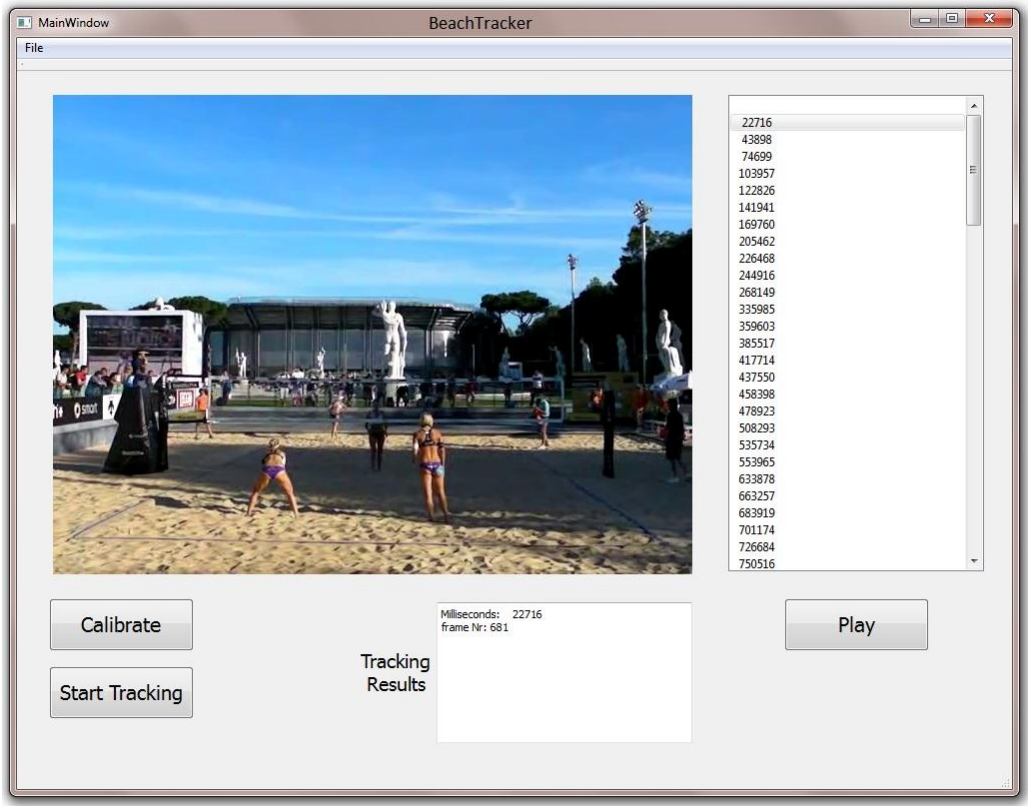
Introduction

- BeachViewer



Introduction

- BeachTracker



Tracking software complementing the BeachScouter

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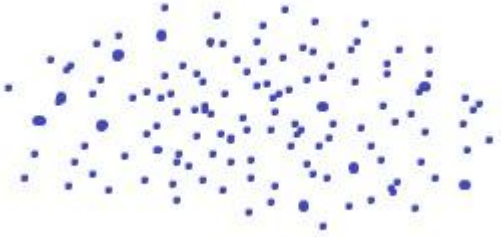
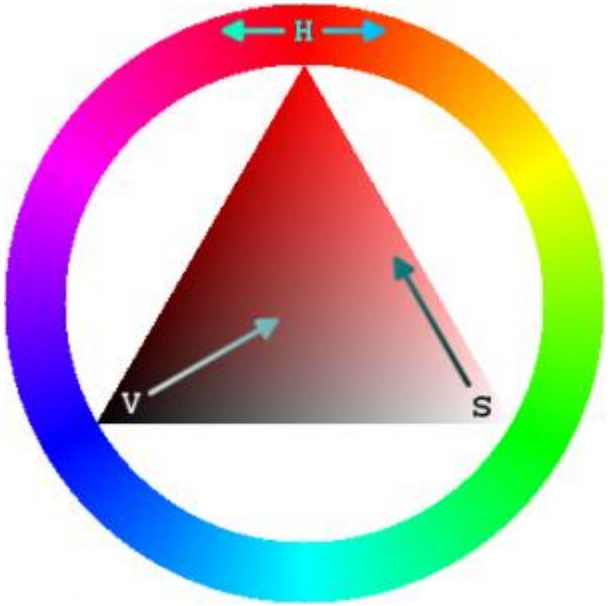
Methodology

- Particle filter approach
  - Color histogram based
  - Motion based



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



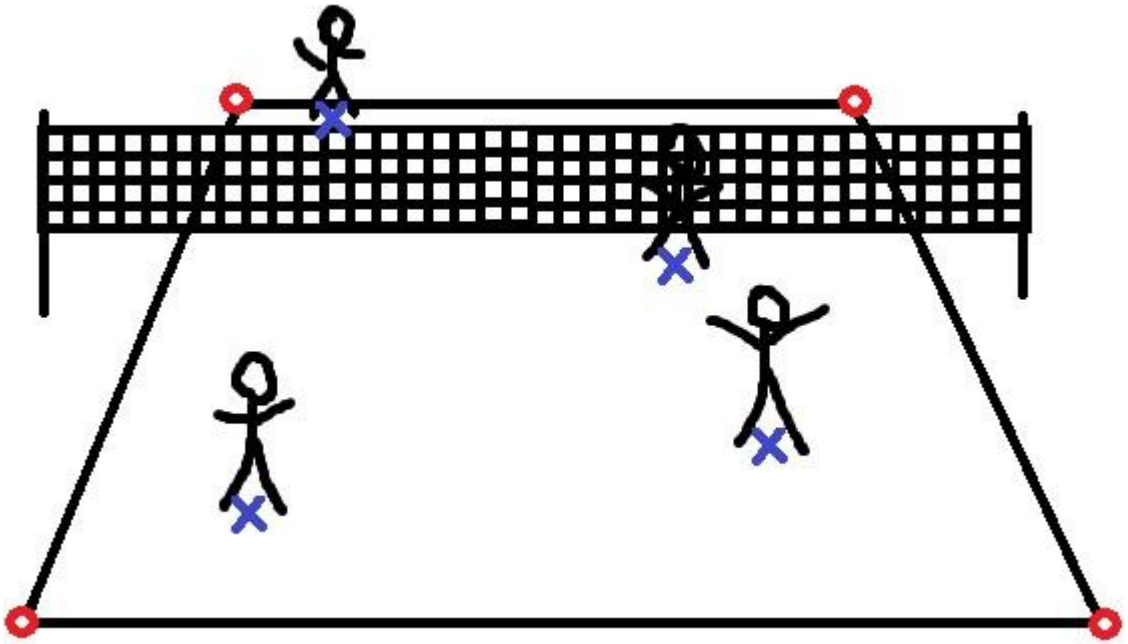
[http://tecfa.unige.ch/guides/xml/epub/test/epub-source/flash_tutorials_files/300px-HSV-color-wheel.png]

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

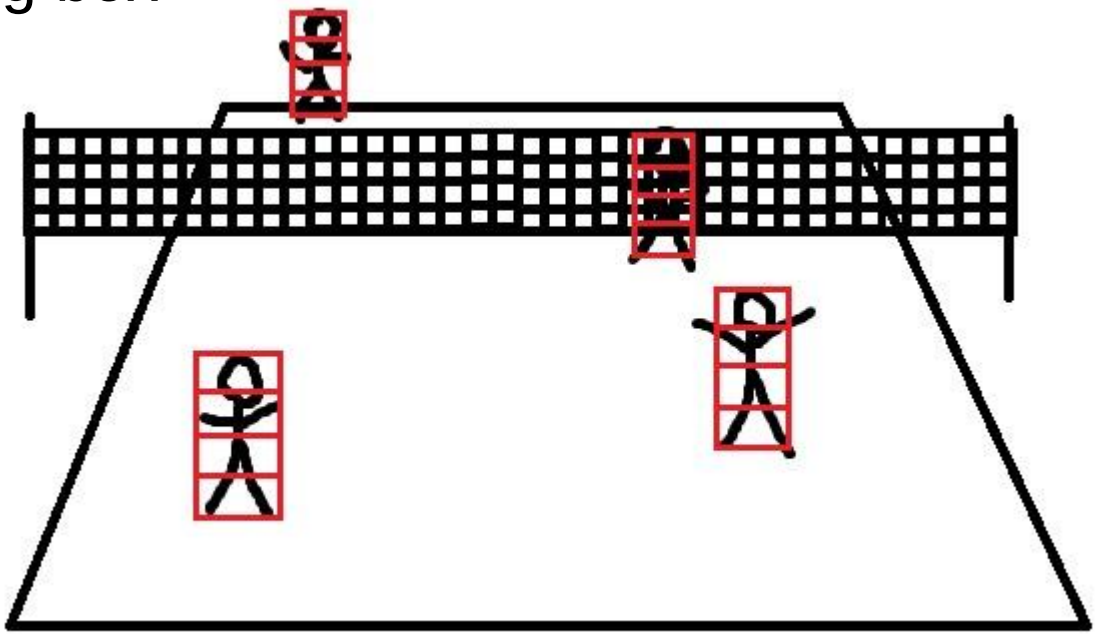
Methodology

- Calibration from initial frames of the video



Methodology

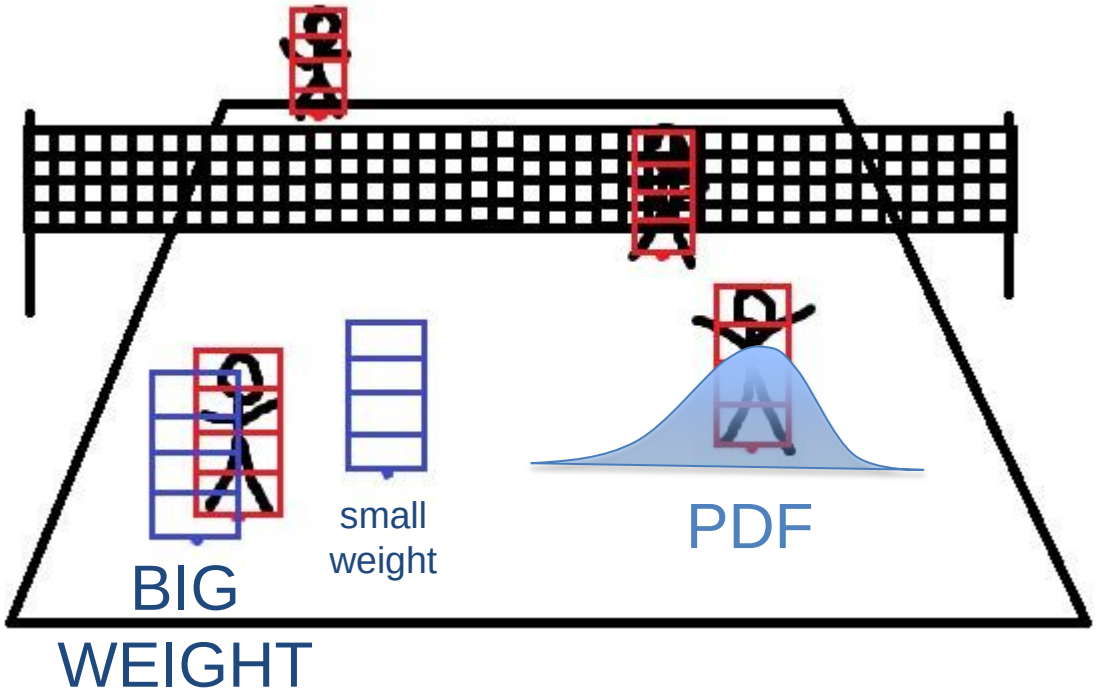
- Each player and each particle with a corresponding bounding box



- Reference color histograms for each player

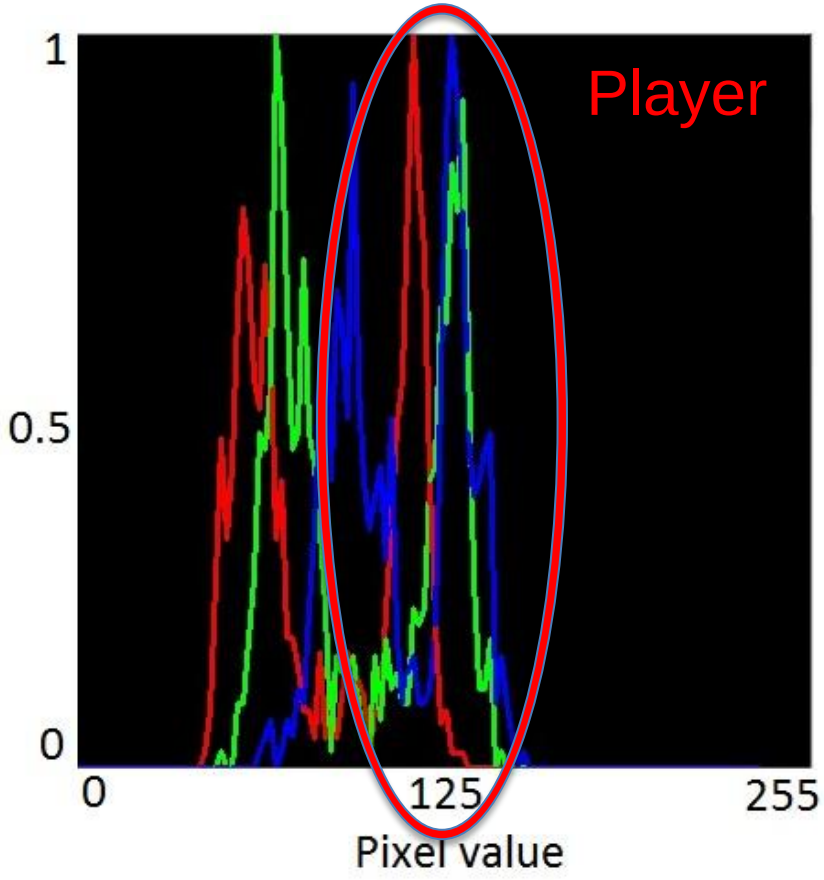
Methodology

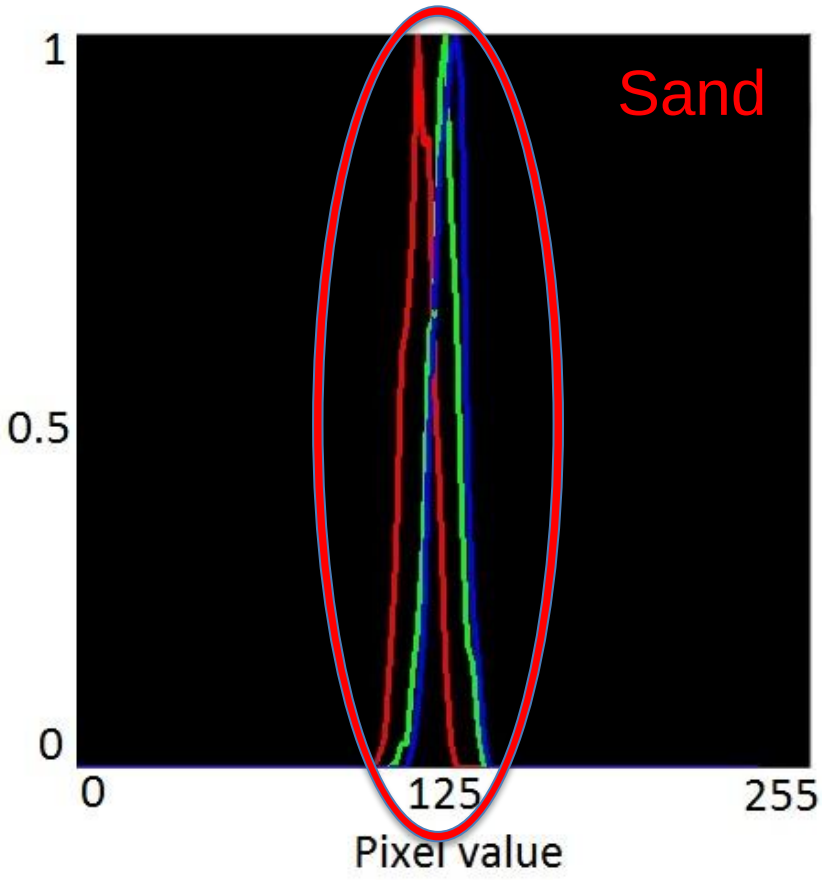
- Weight of the particles proportional to histogram similarity



Methodology

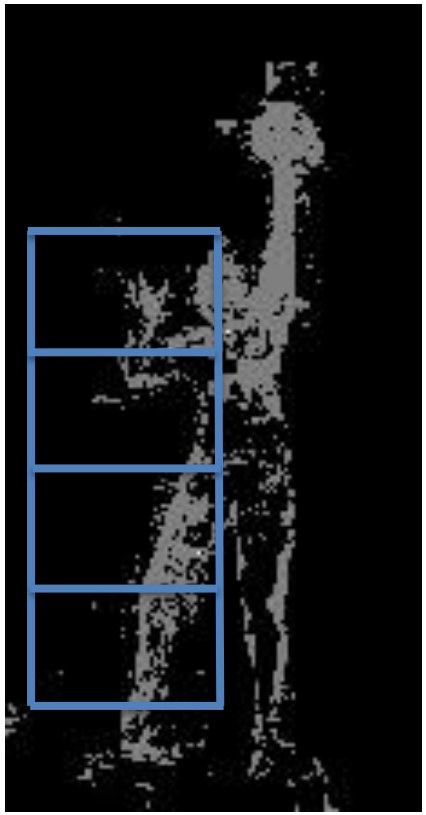
- Bhattacharyya distance used for measuring the similarity of the normalized color histograms





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

$$Pweight = Color\ weight + movement\ weight$$

- 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

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  - C istograms
  - U
  - R

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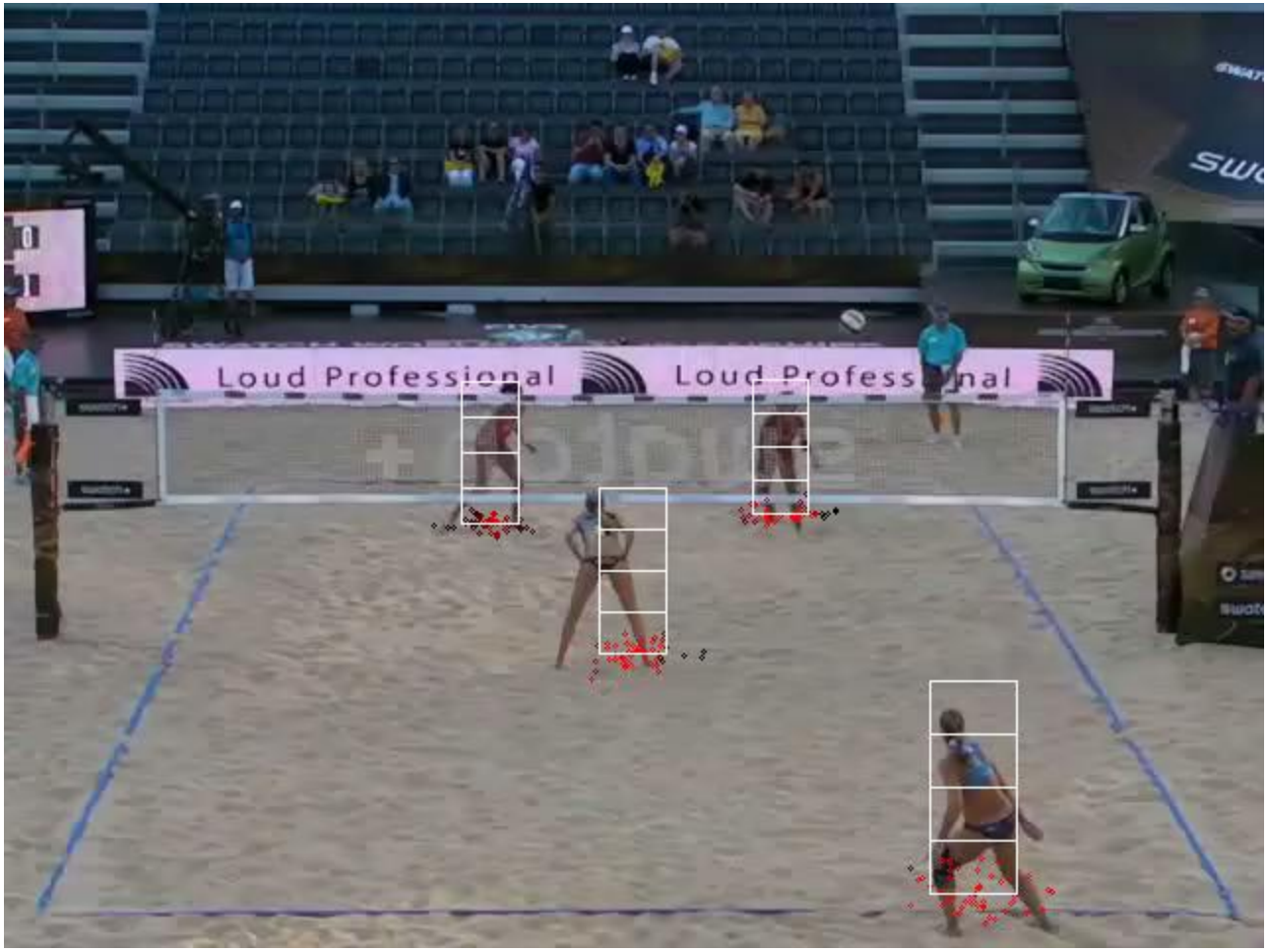
Results



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 %

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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

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Bhattacharyya Distance

$$D\left(\boldsymbol{h}^{ref}, \boldsymbol{h}^{hyp}\right) = \sqrt{1 - \sum_{b \epsilon B} \frac{\sqrt{\boldsymbol{h}_b^{ref} \boldsymbol{h}_b^{hyp}}}{\sqrt{\sum_{b \epsilon B} \boldsymbol{h}_b^{ref} \cdot \sum_{b \epsilon B} \boldsymbol{h}_b^{hyp}}}}$$

Where *B* denotes the number of histogram bins, and $\boldsymbol{h}_b$ represents the value of the *b-th* bin of the reference or hypothesized histogram

Particle Weighting

$$\omega_j^i = \frac{c}{\sum_k D_{i,j}} + \sum_k F$$

Where ω 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;