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Automated Video Indexing System for Badminton Game Analysis.

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Introduction

Application of computer vision techniques to sports video contents has been paid to attention.

However, the studies are mainly focused on visualizing and archiving of sport video broadcasting

It is expected that computer vision techniques contribute to automated video analysis(segmentation, indexing) for effective coaching at sports institutes and gymnasium.

Especially in racket sports, segmentation of rally sequences is useful for effective video analysis and information sharing for improving sport performance.

Purpose

- To investigate the feasibility of an automated video indexing system for analyzing racket sports by using a single ceiling camera

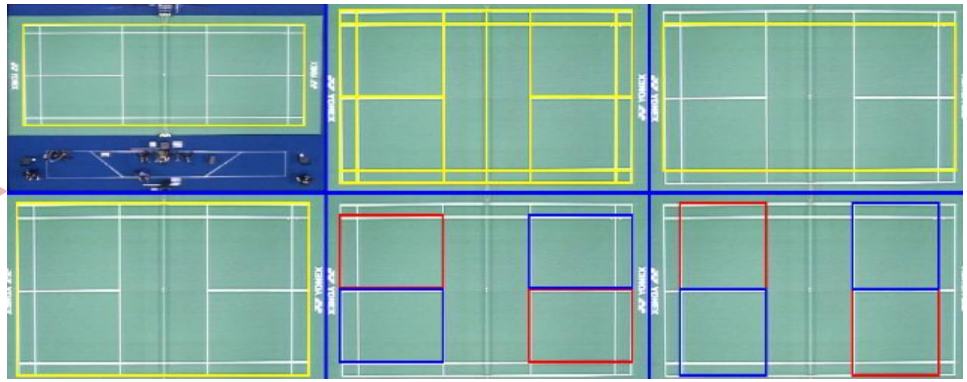
Method

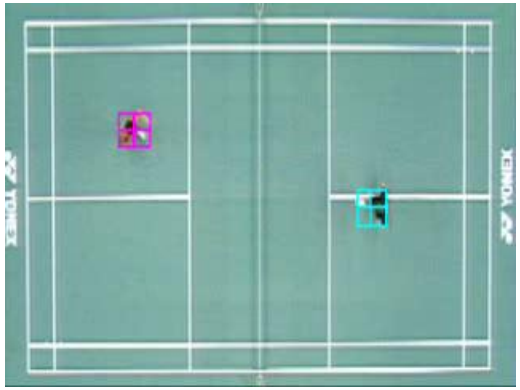
Input ; Image sequences in color acquired from a single ceiling camera mounted above the court

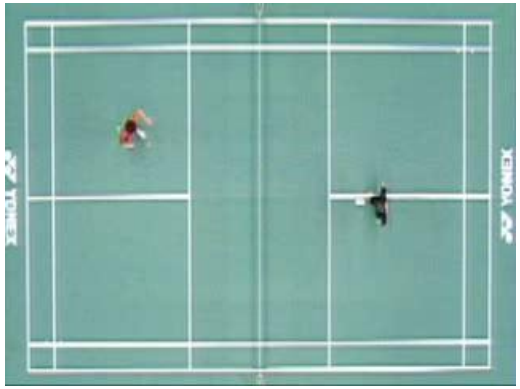
Stage 1
Segment the local badminton courts

Stage 2
Detect the players and the shuttlecock

Stage 3
Detect rally segments, deciding the current state (work or rest)







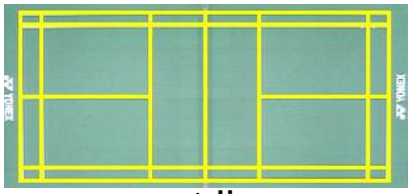
Stage1: Segmentation of Court Regions

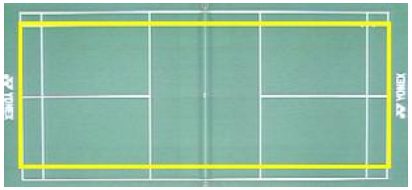
- Extraction of the white-colored court line
  - By utilizing Otsu's automatic threshold selection method and heuristics(Maximal rectangle)

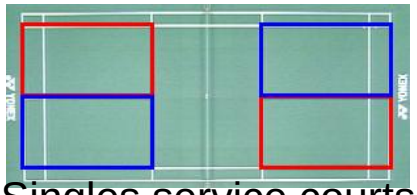
    N. Otsu, "A threshold selection method from gray-level histogram," *IEEE Transactions on System Man Cybernetics*, Vol. SMC-9, No. 1, 1979, pp. 62-66.

- Segmentation of local courts
  - By using a model of badminton generated based on the knowledge


court outline


court lines


Singles court


Singles service courts

Stage2-1: Detection and Tracking of the Players

- Background and frame subtraction and binarization of the video frame image I_t for players

$$P_t(x,y) = \begin{cases} 1, & \text{if } \max(|I_t(x,y) - B(x,y)|, |I_t(x,y) - I_{t-1}(x,y)|) > \tau 1 \\ 0, & \text{otherwise} \end{cases}$$

- Acquisition of circumscribed rectangles □ of player regions in each half court

To cope with the resulting disjoint parts of player, the neighboring or overlapped regions are merged into a target rectangle

- Tracking of the nearest similar region(magenta) across the frames

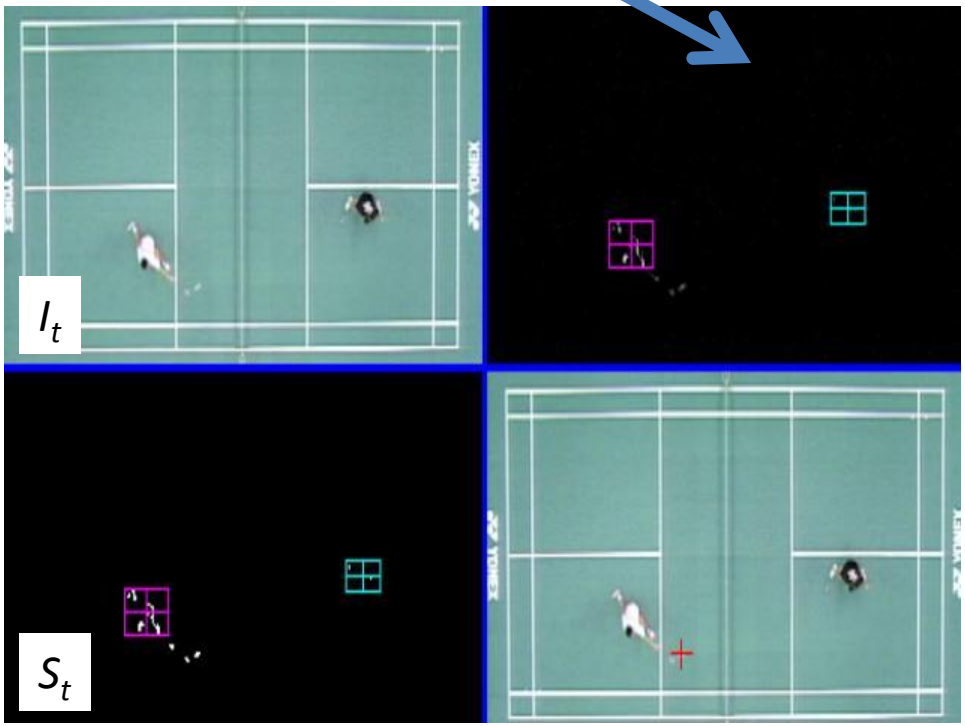
Stage2-2: Detection and Tracking of the Shuttlecock

- Background and frame subtraction and binarization of the video frame image I_t for shuttlecock

$$S_t(x,y) = \begin{cases} 1, & \text{if } \max(I_t(x,y) - B(x,y), 0) \times \max(I_t(x,y) - I_{t-1}(x,y), 0) > \tau 2 \\ 0, & \text{otherwise} \end{cases}$$

A white moving object (shuttlecock) is detected except the player regions

- Tracking of the similar white region furthest away from the player regions in each half court



Stage3: Detection of Rally Period

<u>Simple rules exploited in our method</u>

- Detection of rally start
  - The service is the first shot in each rally
    - the start point of each rally can be determined by detecting the moving shuttlecock while each player is detected in each service court during “rest” period.

- Detection of rally end
  - The shuttlecock is immobile for a time interval after it lands
    - the disappearance time of the shuttlecock can be a cue for indexing the end of each rally.

Experiment

The proposed method is applied to automatic segmentation of rally sequences in actual badminton matches.

Data set:

Data; Color image sequences of five badminton matches acquired from a single ceiling camera mounted above the court (344 rallies in total)

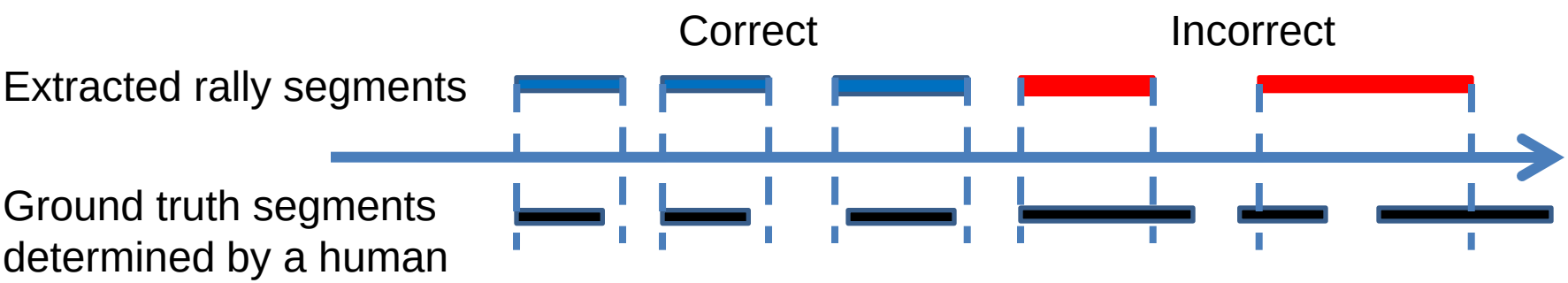
Image size; 320 x 240 pixels,

Frame rate; approx. 30 fps,

Evaluation criteria:

The segment contains the corresponding ground truth segment completely

The segment separates correctly from both adjacent ground truth segments.



Experimental Results

	Rallies	Recall(%)	Precision(%)
Match 1 (WS)	64	100	100
Match 2 (MS)	68	97.06	100
Match 3 (MS)	68	89.71	100
Match 4 (WS)	66	95.45	98.44
Match 5 (MS)	78	94.87	97.37

Computational time; about 7 msec / frame (144 fps) in average

Results of Rally Period Detection

Sample1(Two rallies)

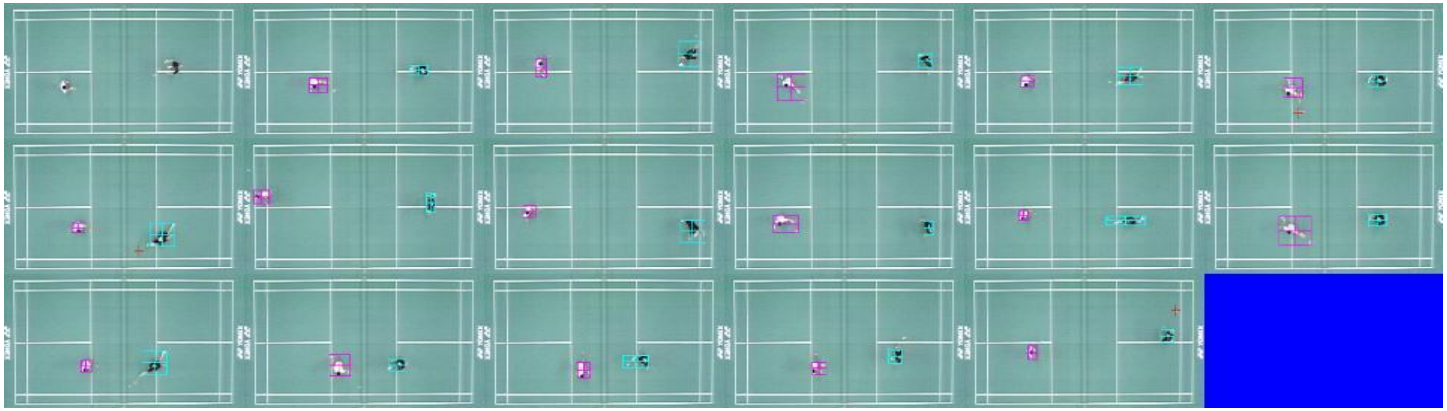
Sample2(Two rallies)

Segmented players (magenta, cyan) and shuttlecock (red) highlighted only during “work” period

Our methods of player and shuttlecock detection and tracking yield good results.

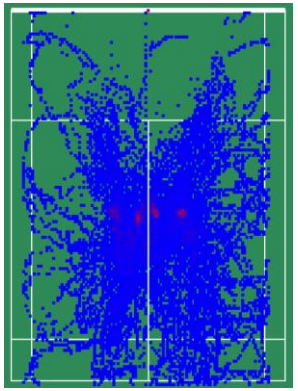
Examples of Data Presentation

Player position sequences at shot

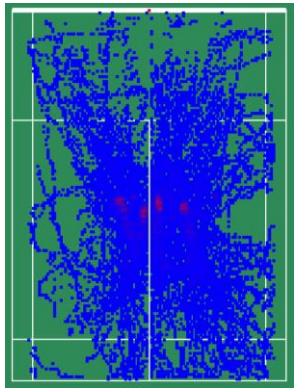


Footprint frequency distribution

Player A

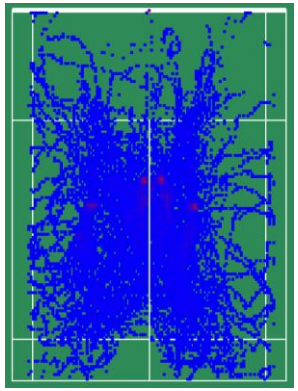


1st Game

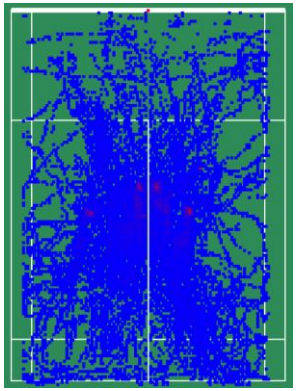


2nd Game

Player B



1st Game



2nd Game

Our system enables an immediate feedback of objective data on the spot

Conclusion

- We have proposed an automated video indexing system for analyzing badminton game
  - In a straightforward rule-based approach
  - Incorporating the players and shuttlecock detection and tracking methods
  - By using a single ceiling camera
- Promising results were obtained for actual badminton matches
- Processing time is very fast (7msec / frame)

- Our system can enable immediate feed-backing of objective data and facilitate efficient utilization of video contents handled in sports institutes etc.

Future Work

- Incorporating human motion recognition techniques for a more refined and higher-level sport video analysis
  - analysis and characterization of each player's motion, skill and tactics
- Further application to other racket and/or net sports
  - Tennis, Table Tennis, Volleyball, etc.

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