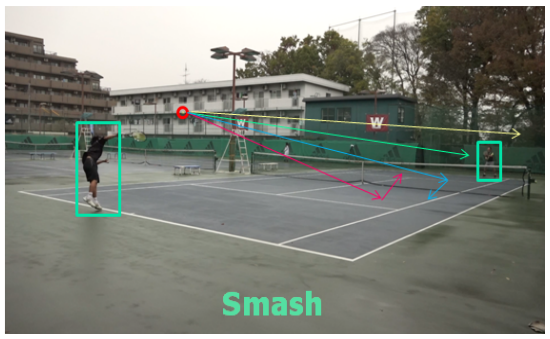
Adaptive Mixture System Model and Ball-feature Noise Elimination for Tennis Ball 3D Position Tracking

修士課程卒業　王 源

➢ Research Background

Tennis Game Analysis



3D ball tracking

Game data
- ➢3D ball position
- ➢3D ball velocity
- ➢3D ball trajectory
- ➢…

Game analysis
- ➢Score judgment
- ➢Player evaluation
- ➢…

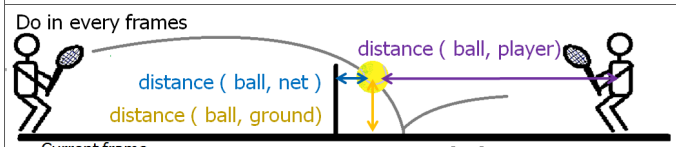
Challenge in Tennis Ball Tracking		
	Volleyball tracking	Tennis ball tracking
Ball size	Common (26 ~ 27 cm / 14*14 ~ 30*30 pixels)	Small (6 ~ 6.5 cm / 3*3 ~ 11*11 pixels)
Move speed	Common speed (about 30 pixels / frames)	High speed (about 85 pixels / frames) & Abrupt motion change
Occlusion	Partial occlusion	Complete occlusion
Video shooting environment	Indoor	Outdoor (weather & camera height limitation & camera parameters set)
Background	Complex Background (Noise which owning similar features)	

Target: 3D ball tracking with high success rate in tennis game analysis.

➢Proposals

Proposal 1: Adaptive Miture System Model

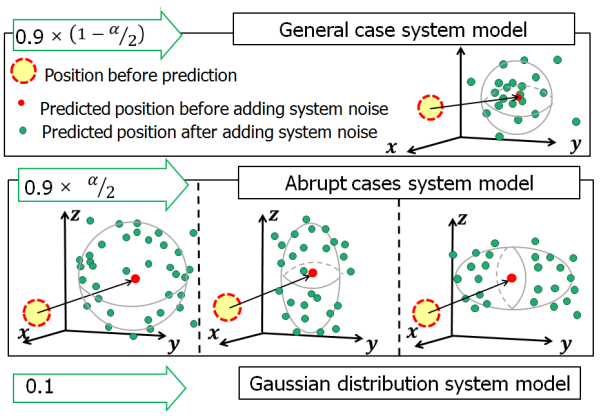
P1: Motion Prejudgment Method



Conditions	Smash	Bounce	Hit the net	General
1. distance < threshold¹	Be near to player	Be near to ground	Be near to net	✗
2. Δ distance < 0	Go close to player	Go close to ground	Go close to net	✗
3. Next state step height < threshold² (net height)			Future height lower than net	✗

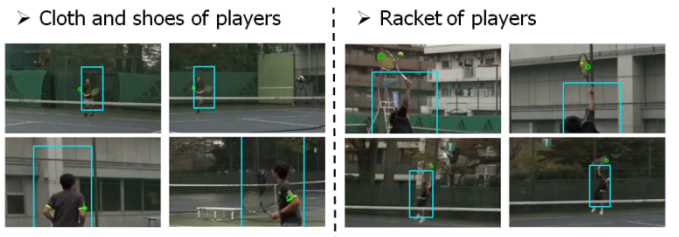
- distance(ball, reference) = $\sqrt{(X_{ball}-X_{reference})^2+(Y_{ball}-Y_{reference})^2+(Z_{ball}-Z_{reference})^2}$
- threshold¹ is different in different cases prejudgment; threshold² only used in "hit the net" case.

P1: Adaptive Mixture System Model

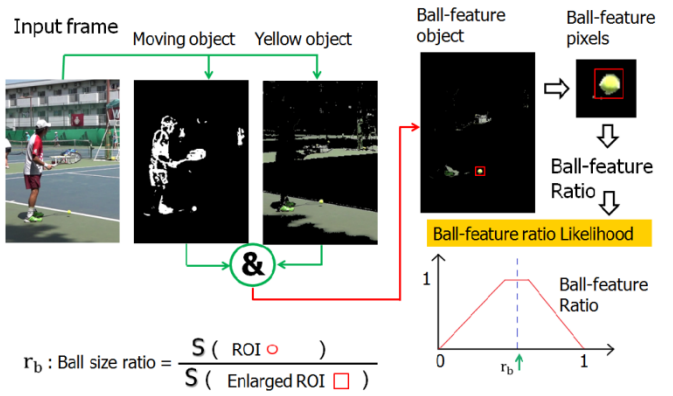


Proposal 2: Ball-feature Noise Elimination

P2: Ball-Feature Noise



P2: Ball-feature ratio likelihood



➢ Experiment result:

Experiment Environment		Sequence set 1	Sequence set 2
Parameters of sequence	Camera number	4	
	Resolution	1920 × 1080	
	Frame rate	60 fps	
	Weather	Cloudy	Sunny
Game	Record date	December 3, 2015	August 6, 2015
	Total frames	3940	2839

Evaluation Method

Success camera: Projected circle completely covers or covers part of the ball.

Success frame: At least 3 cameras out of 4 are success cameras.

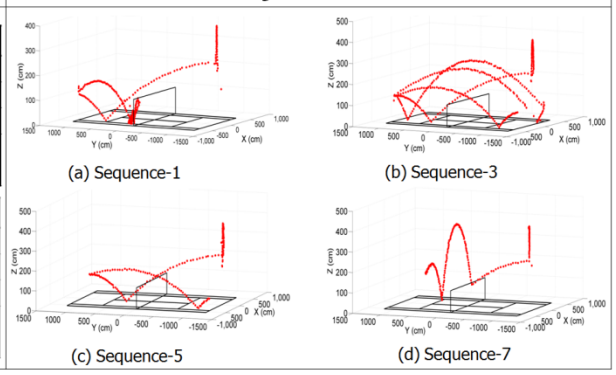
$$tracking\ success\ rate = \frac{\sum success\ frame}{\sum frame} \times 100\%$$

Experiment Results

Tracking result (cloudy weather)			
Method	Proposal 1	Proposal 1&2	Previous work
Success frame number	3197	3476	2108
Total frame number	3940		
Success rate	81.14%	88.22%	53.50%
Improvement	27.64%	34.72%	

Tracking result (sunny weather)			
Method	Proposal 1	Proposal 1&2	Previous work
Success frame number	2029	2582	1547
Total frame number	2839		
Success rate	71.47%	90.95%	54.49%
Improvement	16.98%	36.46%	

Results 3D Trajectories From Set 1



➢ Conclusion:

With adaptive mixture system model and ball-feature noise elimination (ball-feature ratio likelihood), the tracking success rate of tennis ball reaches 88.22% and 90.95% for cloudy day sequence and sunny day sequence.

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