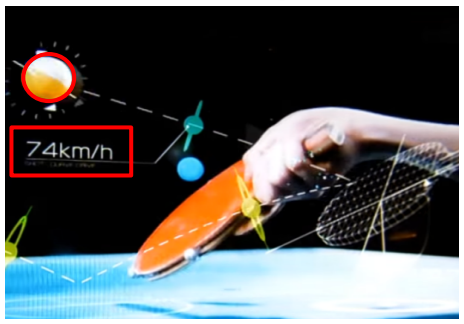
Multi-peak Estimation for Real-time 3D Ping-Pong Ball Tracking with Double-queue Based GPU Acceleration

修士課程卒業　鄧 紫薇

Research Background



Ping-pong TV contents [1]

Target:
Real-time 3D ping-pong ball tracking with high success rate

3D ball tracking
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Data
- 3D ball position
- 3D ball velocity
- 3D ball trajectory

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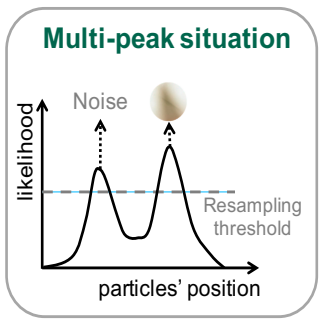
Application
- TV contents
- Player evaluation
- Tactic analysis…

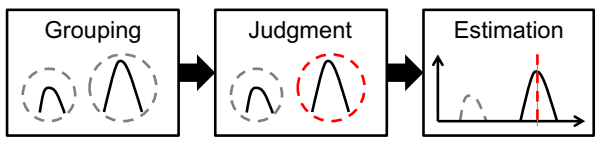
	Tennis ball	Ping-pong ball
Ball size	radius: 6 ~ 6.5 cm 3x3 ~ 11x11 pixels	radius: 2 cm 6x6 ~ 9x9 pixels
Moving speed	High About 85 pixel/f	High About 150 pixel/f
Ball color	Yellow	White
Similar noise	Player's shoes	Players' arm Players' jersey Passerby's shoes

Challenges:
- Undistinguishable color feature
- Similar noises in the complex background

Proposals

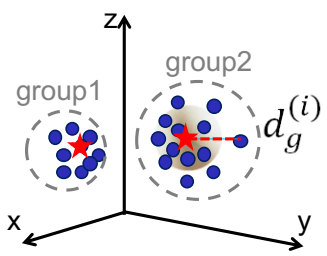
Multi-peak estimation





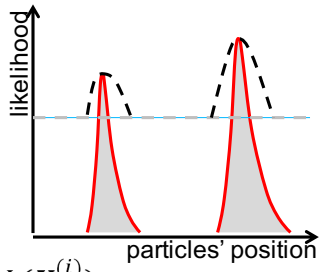
Merit:
- Robust for both single-peak and multi-peak situations

Best group judgment



weighting

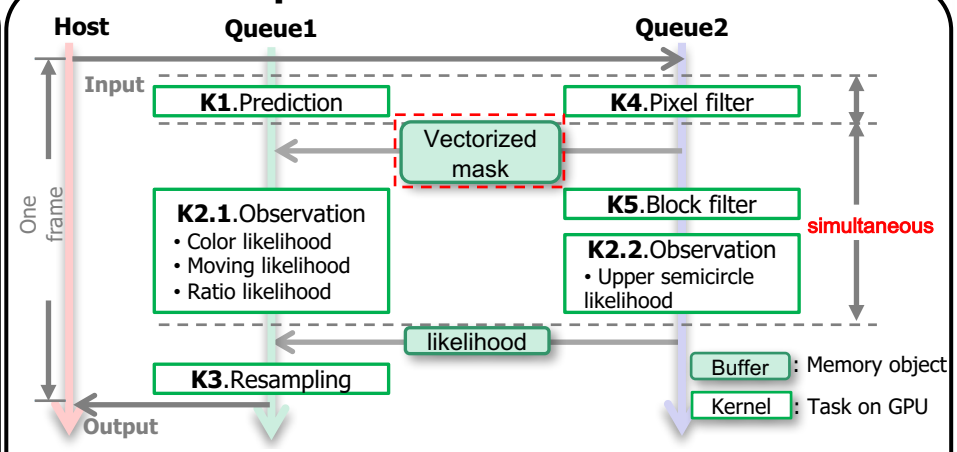
$$\kappa_g^{(i)} \propto \frac{1}{d_g^{(i)}}$$



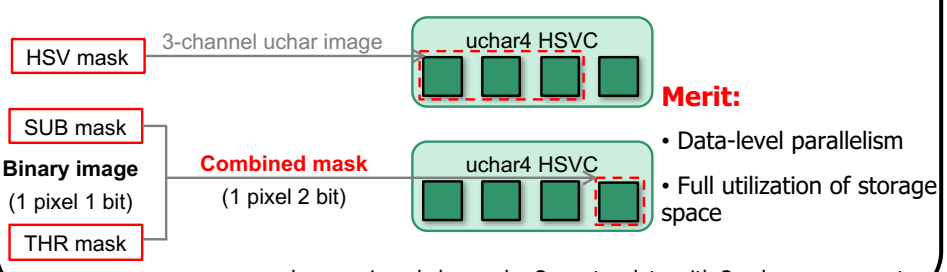
$$L_{group}\left(\mathbb{G}_k^g\right) = \sum_{i=0}^{i<s_g} \kappa_g^{(i)} \cdot L\left(X_k^{(i)}\right)$$

Best group: The group with the largest L_{group}

Double-queue based GPU acceleration



Vectorized mask data combination



Merit:
- Data-level parallelism
- Full utilization of storage space

uchar: unsigned char. uchar3: vector data with 3 uchar components.

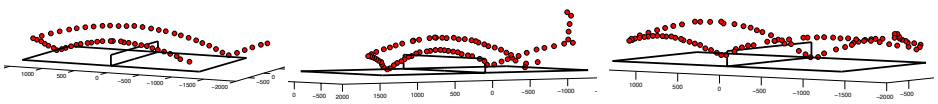
Experiment results

Ping-pong sequence parameter			
Resolution	1920x1080	Round	14
Frame rate	60fps	Smash case	122
Shutter speed	1000	Total frame	3913

Camera perspectives

Test work	9216 Particles			
	Frame work	FW+P2+P3	FW+P1+P2+P3	GPU version
Success frame	1246	3796	3897	3877
Success rate	31.84%	97.01%	99.59%	99.08%
Time (ms/f)	610	869.8	870	8.8

FW: Frame work
P2: Upper semicircle likelihood
P1: Multi-peak estimation
P3: Smash-failure-specific system model



3D trajectory results

Conclusion

This work proposes a multi-peak estimation method, upper semicircle likelihood and smash-failure-specific system model in the algorithm design, obtaining 99.59% tracking success rate based on 14 ping-pong sequences shot in an official match. Two proposals in GPU acceleration are put forward to reduce the time cost to 8.8 ms/f, reaching the real-time requirement.

[1] http://www.panasonic.com/jp/corporate/wonders/wondersolutions/kaiseki.html

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