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

**Research Background**

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

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

**Proposals**

**Multi-peak estimation**

- Merit:
  - Robust for both single-peak and multi-peak situations
- Best group judgment
- \[ L_{group}(C_k^g) = \sum_{i=0}^{k_g(i) < d_g(i)} k_g(i) \cdot L(X_k^i) \]
- **Best group:** The group with the largest \( L_{group} \)

**Double-queue based GPU acceleration**

- Host
- Queue1
- Queue2
- **K1. Prediction**
- **K4. Pixel filter**
- **K2.1. Observation**
  - Color likelihood
  - Moving likelihood
  - Ratio likelihood
- **K5. Block filter**
- **K2.2. Observation**
  - Upper semicircle likelihood
- **K3. Resampling**
- **Buffer**
- **Memory object**
- **Kernel**
- **Task on GPU**

**Experiment results**

| Ping-pong sequence parameter | Resolution | Frame rate | Shutter speed | Round | 14 |
|------------------------------|------------|------------|---------------|-------|----|
| Tennis ball                  | 1920x1080  | 60fps      | 1000          | Smash case | 122 |
| Ping-pong ball               | 3x3 ~ 11x11 pixels | High About 85 pixel/f | High About 150 pixel/f |

**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](http://www.panasonic.com/jp/corporate/wonders/wondersolutions/kaiseki.html)

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