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 **Tennis ball Ping-pong ball** 3D ball tracking radius: 6 ~ 6.5 cm radius: 2 cm Ball size 3x3 ~ 11x11 pixels 6x6 ~ 9x9 pixels Data Hiah Hiah Moving speed >3D ball position About 85 pixel/f About 150 pixel/f >3D ball velocity White Ball color Yellow >3D ball trajectory Players' arm Similar noise Player's shoes Players' jersey Ping-pong TV contents [1] Application Passerby's shoes Target: ➤TV contents Real-time 3D ping-pong ball Player evaluation Challenges: tracking with high success rate Undistinguishable color feature ➤Tactic analysis... Similar noises in the complex background Proposals **Multi-peak estimation** Double-queue based GPU acceleration Host Queue1 Queue2 **Multi-peak situation** Grouping Judgment Estimation Input K4.Pixel filter K1.Prediction likelihood Vectorized mask One rame K5.Block filter K2.1.Observation Resampling threshold Merit: multaneous Color likelihood K2.2.Observation • Robust for both single-peak and multi-peak Moving likelihood Upper semicircle Ratio likelihood situations particles' position likelihood likelihood Best group judgment Buffer : Memory object K3.Resampling Kernel : Task on GPU Output group2 weighting aroup1 Vectorized mask data combination uchar4 HSVC -channel uchar image α HSV mask **Merit**: SUB mask particles' position Data-level parallelism $L_{group}(\mathbb{G}_k^g) =$ $\cdot L(\boldsymbol{X}_{k}^{(i)})$ Combined mask Binary image uchar4 HSVC Full utilization of storage (1 pixel 2 bit) (1 pixel 1 bit) space THR mask **Best group**: The group with the largest *L* group uchar: unsigned char. uchar3: vector data with 3 uchar components Experiment results 9216 Particles Ping-pong sequence parameter Test work Frame work FW+P2+P3 FW+P1+P2+P3 GPU version 1920x1080 Resolution Round 14 Success frame 1246 3796 3897 3877 122 Frame rate 60fps Smash case 31.84% 97.01% 99.59% 99.08% Success rate Shutter speed 1000 Total frame 3913 Time (ms/f) 610 869.8 870 8.8 FW: Frame work P1: Multi-peak estimation P2: Upper semicircle likelihood P3: Smash-failure-specific system model

Conclusion

Camera perspectives

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

3D trajectory results



Graduate School of Information, Production and Systems Waseda University