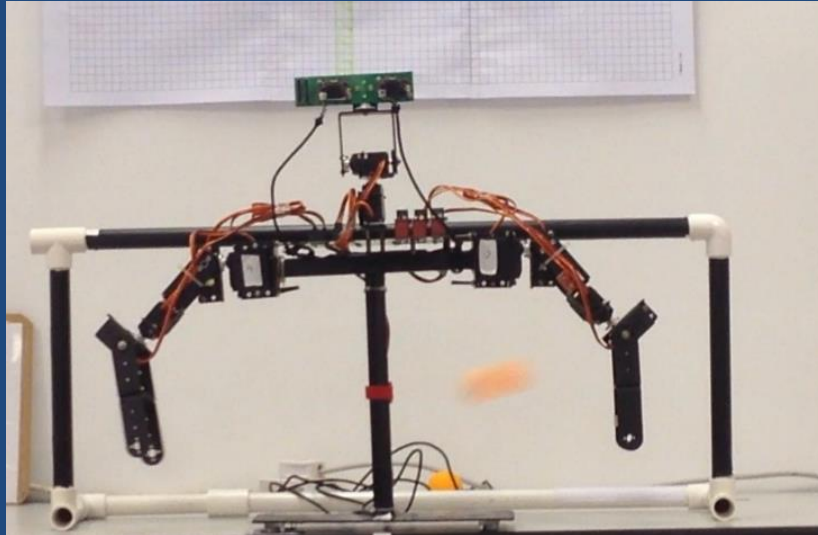


**Goalkeeping against a thrown table tennis ball with
low-cost real-time stereoscopic vision and a servo-motor-based robotic arm system**

by Yuen Hei Chit Adrian

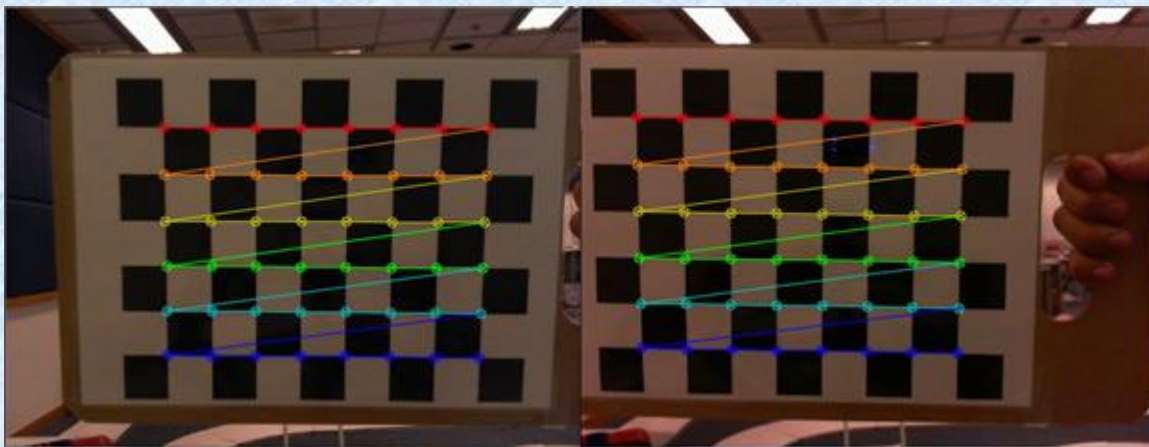
Advised by Professor Shing-Chi CHEUNG

Objective: Develop a robot goalkeeper!!

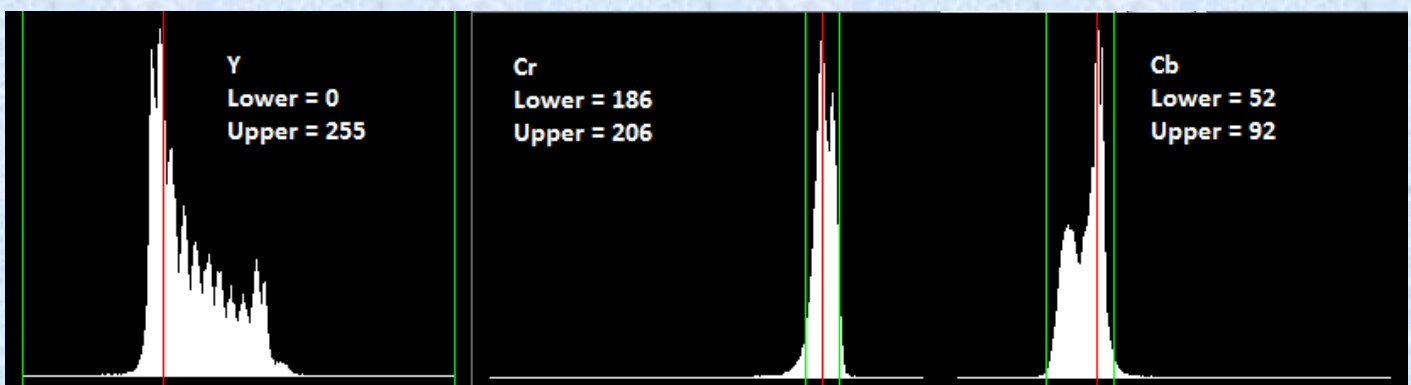


Calibration

Two webcams were used to provide stereoscopic vision to the robot. Their intrinsic and extrinsic parameters need to be estimated prior to object detection. Multiple views of a planar pattern were obtained and used to calibrate the cameras.

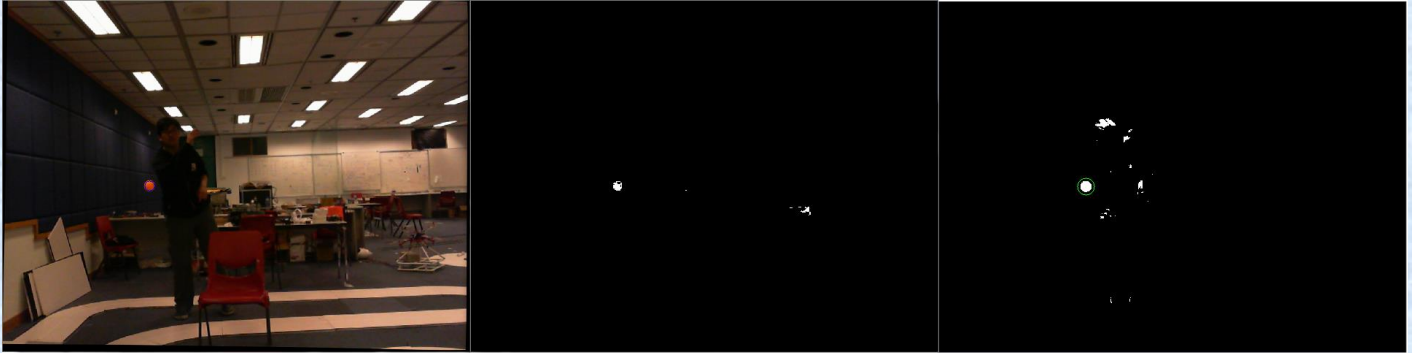


The color information of the ball is also needed in object detection. Views of the ball from the cameras were obtained and the histograms of the views in the YCrCb color space were analyzed to obtain bounds for color segmentation.



First step: Object Detection

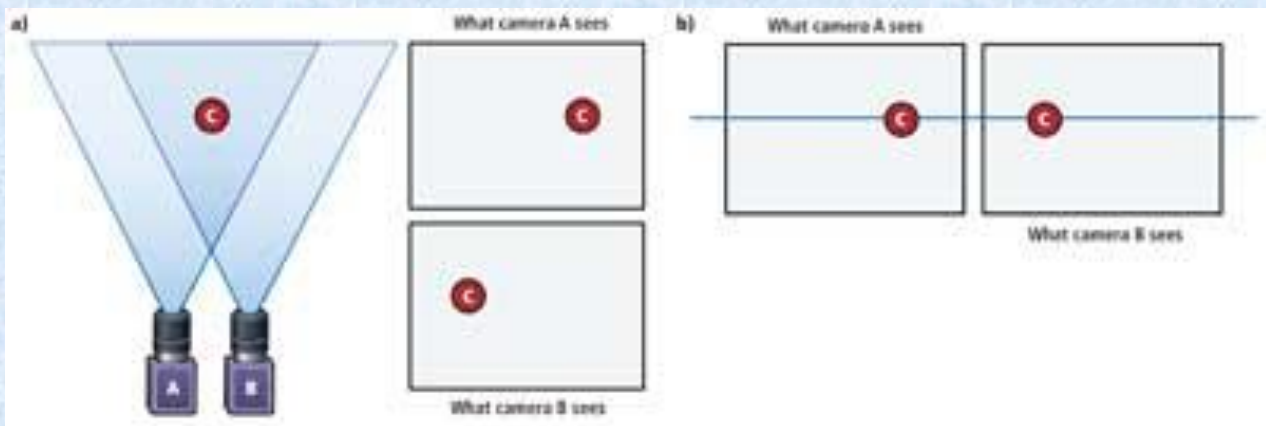
Object detection of a source image (left) is done in two steps: background subtraction to obtain a “motion mask” (right) and color segmentation with prior calibration to obtain a “color mask” (middle). Then, region growing was performed on “motion mask” with “color mask” to obtain “ball mask”. If “ball mask” is not all zero, a ball is detected.



The rationale of the algorithm is based on the observation that points in a “color mask” is often a subset of those in a “motion mask” due to non-uniform illumination of the ball.

Second step: Triangulation and prediction

Applying object detection on left and right camera views yields two “ball masks”. A minimum enclosing circle is fit onto the points in each “ball mask” to obtain the center of radius of the ball in each camera view. Triangulation is performed to determine the estimated 3D position of ball. The flight dynamics of the ball and the coordinate of the ball at the robot motion plane is estimated. The robot moves accordingly.



Testing: Throw all the balls!!



Conclusion

A robot goalkeeper has been developed in this project. It uses different techniques in object detection, tracking and trajectory prediction to estimate the ideal robot pose to goalkeep against a table tennis balls.