

# Digital Image Processing Project

## Target Tracking of Table Tennis Ball Using Machine Vision

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### INTRODUCTION

Target tracking is a popular research field in recent years. Our project aims to solve a certain problem in ping-pong ball detection, with high processing speed and little requirement of computational power.

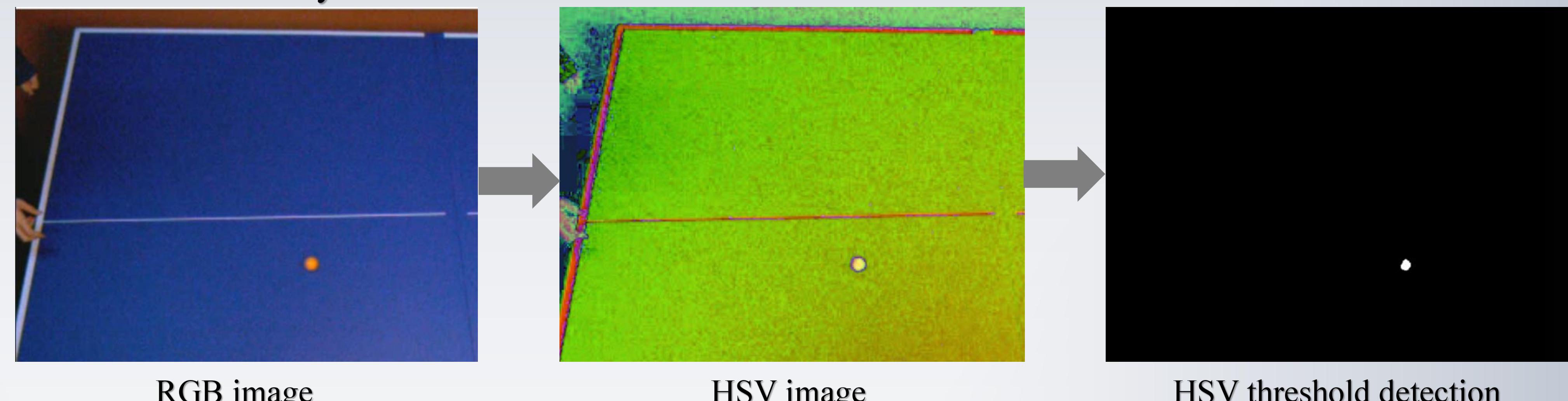
By using the traditional image processing methods such as HSV threshold detection, Canny edge detection, and Hough Circle detection, we successfully construct a ping-pong ball detection system. Based on the reconstruction this system rebuilds the 3D trajectory of the ping-pong ball with a high accuracy rate.

This project will be a complete system including a Binocular camera, image processing, ball tracking, 3D reconstruction and a 3D 3d animation interface of ping-pong ball.

### BASIC METHODS

#### HSV threshold detection

By transferring the original RGB image to the HSV color space, the different colors in the image can be more easily separated from each other. HSV means hue, saturation, and value, and it provides a more intuitive representation of the way that humans sense the colors.

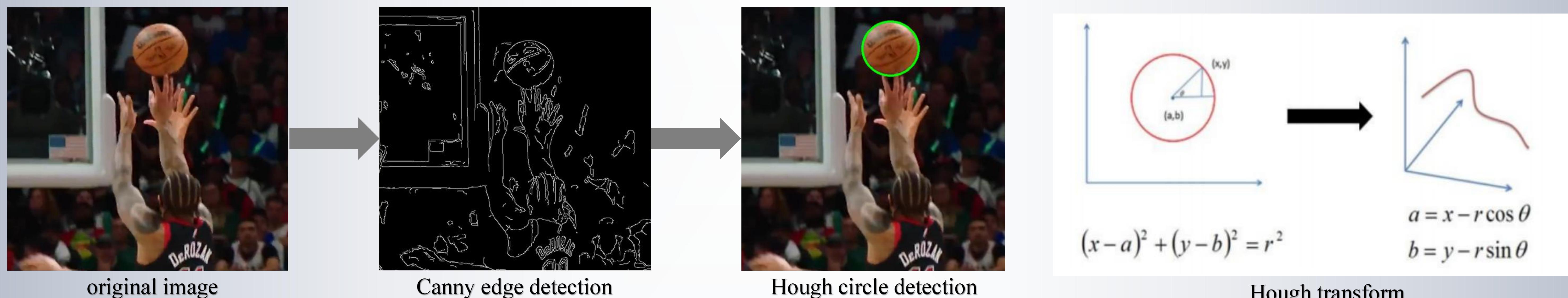


#### Edge detection

In this project, a Canny edge detector will be used in order to provide useful edge information for the following procedures. The Canny edge detection is composed of smoothing, calculation of gradient, Non-maximum suppression, and Double-Threshold detection.

#### Hough circle detection

Hough circle detection is converting a circle in the 2D image space into a point in the 3D parameter space. A circle is determined by the radius, horizontal and vertical coordinates of the center. Therefore a circle after the Hough transformation corresponds to a point in the three-dimensional parameter space (ab coordinate system). For each point in the ab coordinate system, if the cumulative junctions at one point are greater than a certain threshold, then a circle(at XY coordinate system) corresponding to this point(at ab coordinate system) in the image is detected.



### METHOD COMPARISON

The deep-Learning based methods are dominant in the field of object tracking because of their high accuracy rate and transferable applications. As a result, Object detection has achieved fast development in recent years, with successful approaches empower researchers to easily detect the object.

However, the detection of ping-pong balls is a highly specified work, with much previous knowledge like the shape, size, and color. With this knowledge, we can complete the work with traditional image processing methods.

### RESULT

A 3D reconstruction based on the HSV threshold detection, edge detection, Hough circle detection, and Binocular 3D reconstruction is successfully implemented in this project. The system can run on 8G memory, i5-9300H CPU @ 2.40GHz, and NVIDIA GTX 1660Ti with 30Hz. The reconstruction of a table tennis ball in a 3D figure is shown on the right figure. Besides, the exact trajectory and drop point detection using the trajectory will be shown in a visualization animation interface.

### OVERALL FLOW DIAGRAM

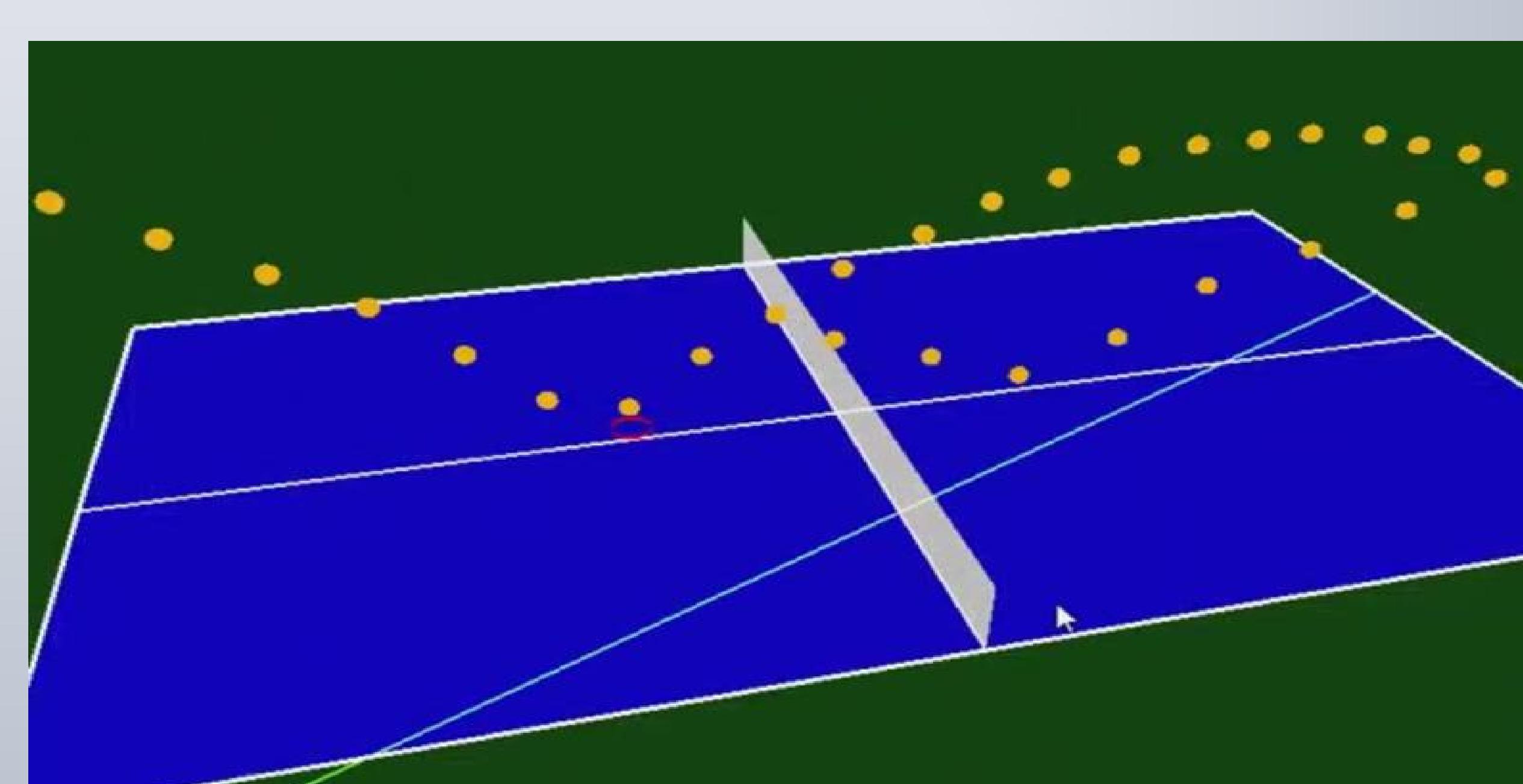
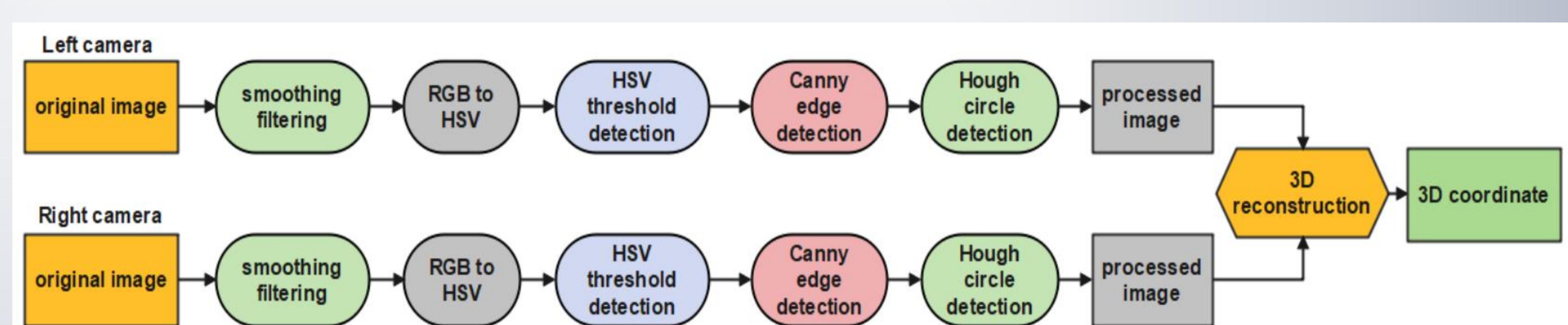


Table tennis ball 3D reconstruction