REAL OBJECT DIMENSIONS FROM IMAGES

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Abstract

The objective is to determine real object dimensions from images using OpenCV Java Library. Implemented two approaches – *Reference Object Method* and *Stereo Vision method*.

The Reference Object Method uses an object of known dimensions called reference object in the image. Assume one of the corners of the reference object to be the world origin and represent the other corners using the known dimensions of the object. Preprocess the image, detect the reference object in the image and get the vertices of the minimum bounding rectangle. Using the pixel points of the vertices and the corresponding world coordinates, calculate the Extrinsic Matrix of the image using *solvePnP()* method of OpenCV Library. Project the world coordinates to the camera coordinate system using the determined Extrinsic Matrix to get Z. Detect other objects in the image and re-project their pixel points to the camera coordinate system. Multiply with the determined Z to get the actual camera coordinates. Use distance formula to calculate the real object dimensions.

$$distance=\sqrt{(x2-x1)^2+(y2-y1)^2}$$

The Stereo Vision Method uses two images of the scene captured by the same camera. Take a picture of the required scene and translate the camera to a known distance (baseline distance) horizontally to capture the second picture of the same scene. Preprocess the images and find the disparity map of the images using *compute()* method of *StereoSGBM* class in OpenCV library. Detect the objects in the left image and get the vertices of the minimum bounding rectangles. Using the disparity map, find the disparity corresponding to each of the vertices. Use the below formula to calculate Z:

$$Z = (focal\ length * base\ line\ distance) / disparity$$

Re-project these vertices to camera coordinate system using inverse intrinsic matrix and multiply with the determined Z. Use distance formula to calculate the real object dimensions.

The Reference Object Method could determine the object dimensions with high accuracy (99% to 100%) for objects lying on the same X-Y plane as the reference object. The accuracy drops as the object distance from the reference object increases along the Z-axis. The Stereo Vision Method, on the other hand, could determine the Z accurately but the accuracy of the determined dimensions dropped in the cases where the object detection method used couldn't get the exact vertices of the objects in the image.

Keywords: stereo, estimate depth, opencv, disparity

Contributions

For Reference Object Method:

- Detected objects in the images and their bounding rectangle vertices.
- Calculated Extrinsic Matrix of the image.
- Calculated depth (Z) to the reference object.
- Re-projected vertices of the other objects to camera coordinate system using inverse intrinsic matrix and the determined Z.
- Calculated object dimensions using distance formula.
- Analyzed results.

For Stereo Vision Method:

- Detected objects in the images and their bounding rectangle vertices.
- Computed disparity map of the two images.
- Calculated depth (Z) using focal length, disparity and baseline distance.
- Re-projected vertices of the detected objects to camera coordinate system using inverse intrinsic matrix and the determined Z.
- Calculated object dimensions using distance formula.
- Analyzed results.

Implementing this project gave an opportunity to explore the OpenCV Java library to estimate real object dimensions from images using two different methods – Reference Object Method and Stereo Vision Method. Learned to implement methods related to the project to detect objects in an image, calculate extrinsic matrix of an image using world coordinates and corresponding pixel points, estimate distance of any object to the camera using stereo vision, estimate distance to an object of known dimensions in the image, compute disparity map of two images and use it along with focal length and baseline distance to calculate depth and analyze the results to identify causes of the slight error in calculated real object dimensions. In addition, I explored the OpenCV library further to learn to detect key points in two stereo images, to extract descriptors of these key points, to find matching points and to use corresponding points in two stereo images to calculate fundamental matrix.

I plan to take this project forward to improve object detection in images to get a more accurate result in Stereo Vision Method. Also, I would like to explore the possibilities of improving the accuracy of the Reference Object Method to compute the dimensions of objects lying outside the same X-Y plane by considering the depth of the reference object along with its length and breadth when assuming the reference object world coordinates.