**PART A: Theory**



A picture containing person, indoor

Description automatically generated

An image of a checkerboard pattern is captured using the OAK-D Lite camera. The known focal length for the camera is 3.37 millimeter and the length from the camera to the actual object is 644 millimeters. The image resolution is , which means that the image center lies at . However, we obtain and as 540 and 332 respectively. This shows that the image center does not coincide with our pre-set principal point. As estimated, it is offset by . We know that the camera matrix can be parameterized as:

Diagram

Description automatically generated

For the intrinsic matrix, we can calculate by using the formula below:

Text

Description automatically generated

In the formula, and are the focal length, s is the skew factor, and are the offset values. Therefore, we can generate the intrinsic matrix as:

For the extrinsic matrix, we need to compute the translation and rotation of the image compared to the expected position by using formula:

Table

Description automatically generated with low confidence

As we known, the image has rotation through y-axis within 15 degrees (i.e., ). Therefore, we can generate the rotation matrix along y-axis as:

We can also generate the translation matrix by applying the offset values:

In general, the extrinsic matrix can be generated as:



For finding the homography, we choose another image of the same plane but within a different angle of view:

A person holding a piece of paper

Description automatically generated with medium confidence

Assume is a point from the first image and is the corresponding same point in the second image. Then, we can say that these two points are related by an estimated homography as:

We can further parametrize the matrix as:

Text

Description automatically generated

In such case, we can evaluate the overall homography matrix as:

Text

Description automatically generated

By choosing a set of four points in the first image: [684, 530], [728, 529], [685, 574], [728, 572], we can find their corresponding points in the second image: [661, 591], [704, 592], [660, 633], [702, 634]. Therefore, we can obtain the homography matrix by implementing a homography calculation function from cv2 as:

Graphical user interface, text, application

Description automatically generated

**PART B: MATLAB Prototyping**

I = imread("./captured\_images/1651007099257.jpg");

imshow(I);

% Get image coordinates

[x y] = ginput(2)

x = 2×1

320

892

y = 2×1

430

406

% Get focal length of OAK-D Lite from DepthAI

f = 1.6574233e+03;

% Distance between object and chessboard

z0 = 644;

% Calculate real world coordinates from image coordinates

x0 = z0 \* (x(1) / f)

x0 = 124.3376

x1 = z0 \* (x(2)/ f)

x1 = 346.5910

y0 = z0 \* (y(1) / f)

y0 = 167.0786

y1 = z0 \* (y(2) / f)

y1 = 157.7533

% Print out the distance of object

distance = sqrt((x1-x0)^2 + (y1 - y0)^2)

distance = 222.4490

**Validate:**

The actual object distance is 166 millimeters.

**PART C: Application development**

Link to the github repository:

https://github.com/annieee6446/CSC-8830-Computer-Vision-HW1