Task 2.12

```
colorintrinsics = determineIntrinsics;
ppx = colorintrinsics.ppx
```

```
ppx = 950.7278
```

```
ppy = colorintrinsics.ppy
```

```
ppy = 533.0599
```

```
fx = colorintrinsics.fx
```

```
fx = 1.4089e+03
```

```
fy = colorintrinsics.fy
```

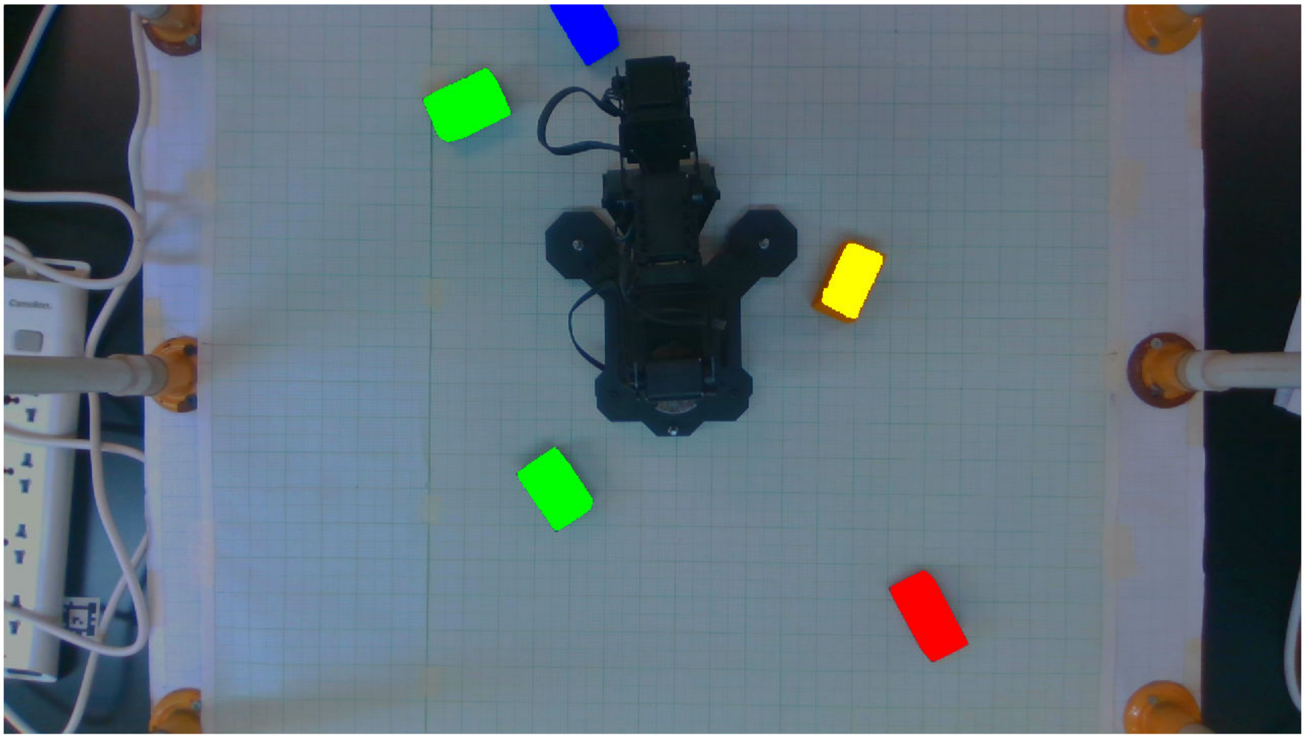
```
fy = 1.4089e+03
```

```
colorintrinsics.width;
```

Explain eacxh entry (left to do)

Task 2.13

```
% determineIntrinsics;
% Reading the image
img1 = imread("intro to rob\at3_Color.png");
imshow(img1)
```

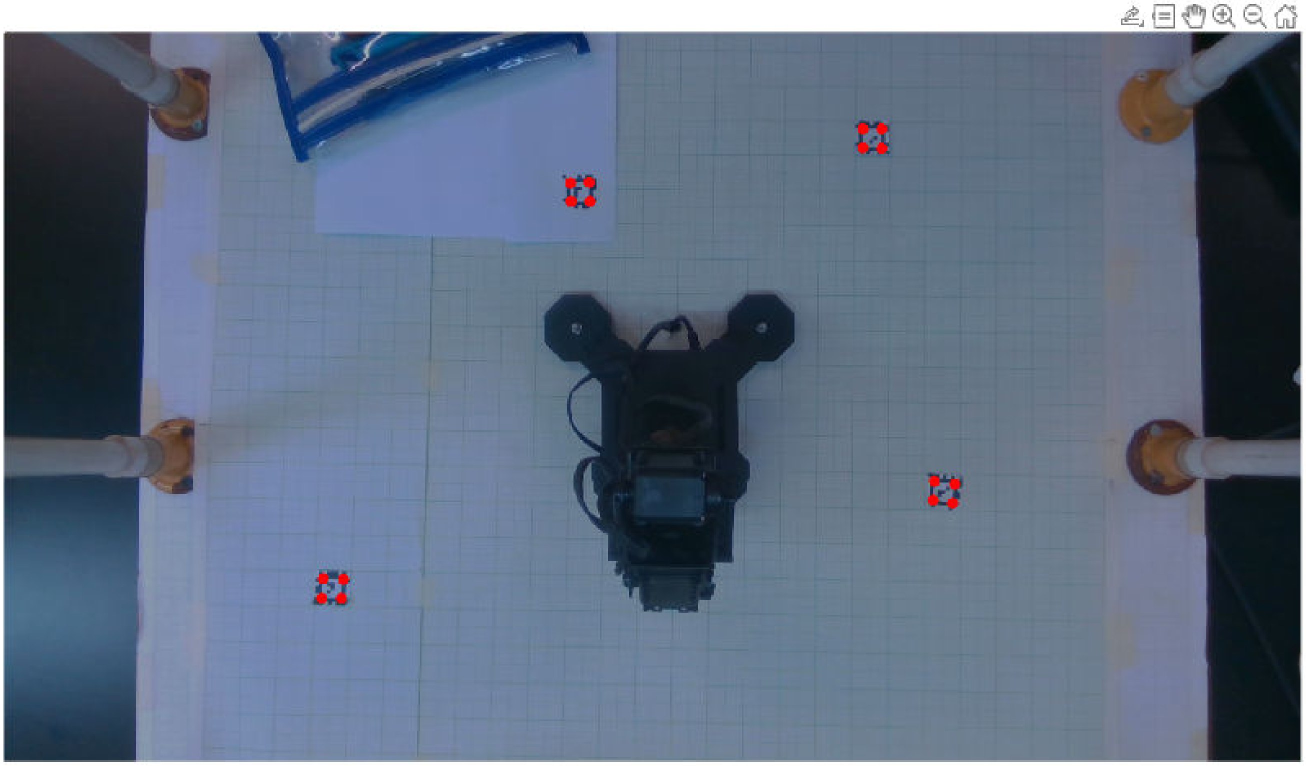


```
cam_intrinsics = cameraIntrinsics([fx fy],[ppx ppy], [1080 1920]);
```

```
[tag, loc,  pose] = readAprilTag(img1, "tagStandard41h12", cam_intrinsics, 2.3);

I = img1;
for idx = 1:length(tag)
    % Display the ID and tag family
    disp("Detected Tag ID, Family: " + tag(idx))
        % + ", " ...
        %     + detectedFamily(idx));

    % Insert markers to indicate the locations
    markerRadius = 8;
    numCorners = size(loc,1);
    markerPosition = [loc(:,:,idx),repmat(markerRadius,numCorners,1)];
    I = insertShape(I,"FilledCircle",markerPosition,ShapeColor="red",Opacity=1);
end
```

```
Detected Tag ID, Family: 0
Detected Tag ID, Family: 1
Detected Tag ID, Family: 2
Detected Tag ID, Family: 3
```

```
imshow(I)
```



```
t = pose(1).Translation
```

```
t = 1×3
  -37.7062   23.5615  114.2910
```

```
r = pose(1).R
```

```
r = 3×3
    0.0300   -0.8762   -0.4810
    0.9520   -0.1216    0.2809
   -0.3046   -0.4663    0.8305
```

```
a = pose(1).A
```

```
a = 4×4
    0.0300   -0.8762   -0.4810  -37.7062
    0.9520   -0.1216    0.2809   23.5615
   -0.3046   -0.4663    0.8305  114.2910
         0         0         0    1.0000
```

```
d = pose(1).Dimensionality
```

```
d = 3
```

```
t = pose(2).Translation
```

```
t = 1×3
```

```
   27.1565  -30.5649  114.5382
```

```
r = pose(2).R
```

```
r = 3×3
   -0.1130    0.8808    0.4598
   -0.8619    0.1433   -0.4863
   -0.4943   -0.4513    0.7430
```

```
a = pose(2).A
```

```
a = 4×4
   -0.1130    0.8808    0.4598   27.1565
   -0.8619    0.1433   -0.4863  -30.5649
   -0.4943   -0.4513    0.7430  114.5382
         0         0         0    1.0000
```

```
d = pose(2).Dimensionality
```

```
d = 3
```

```

t = pose(3).Translation
```

```
t = 1×3
   35.5280   11.9516  113.7765
```

```
r = pose(3).R
```

```
r = 3×3
   -0.8830    0.0477    0.4669
   -0.0818   -0.9952   -0.0531
    0.4621   -0.0851    0.8827
```

```
a = pose(3).A
```

```
a = 4×4
   -0.8830    0.0477    0.4669   35.5280
   -0.0818   -0.9952   -0.0531   11.9516
    0.4621   -0.0851    0.8827  113.7765
         0         0         0    1.0000
```

```
d = pose(3).Dimensionality
```

```
d = 3
```

```

t = pose(4).Translation
```

```
t = 1×3
   -8.1507  -24.5873  116.8234
```

```
r = pose(4).R
```

```
r = 3×3
    0.0029    0.9980   -0.0628
   -0.9628   -0.0142   -0.2699
   -0.2703    0.0613    0.9608
```

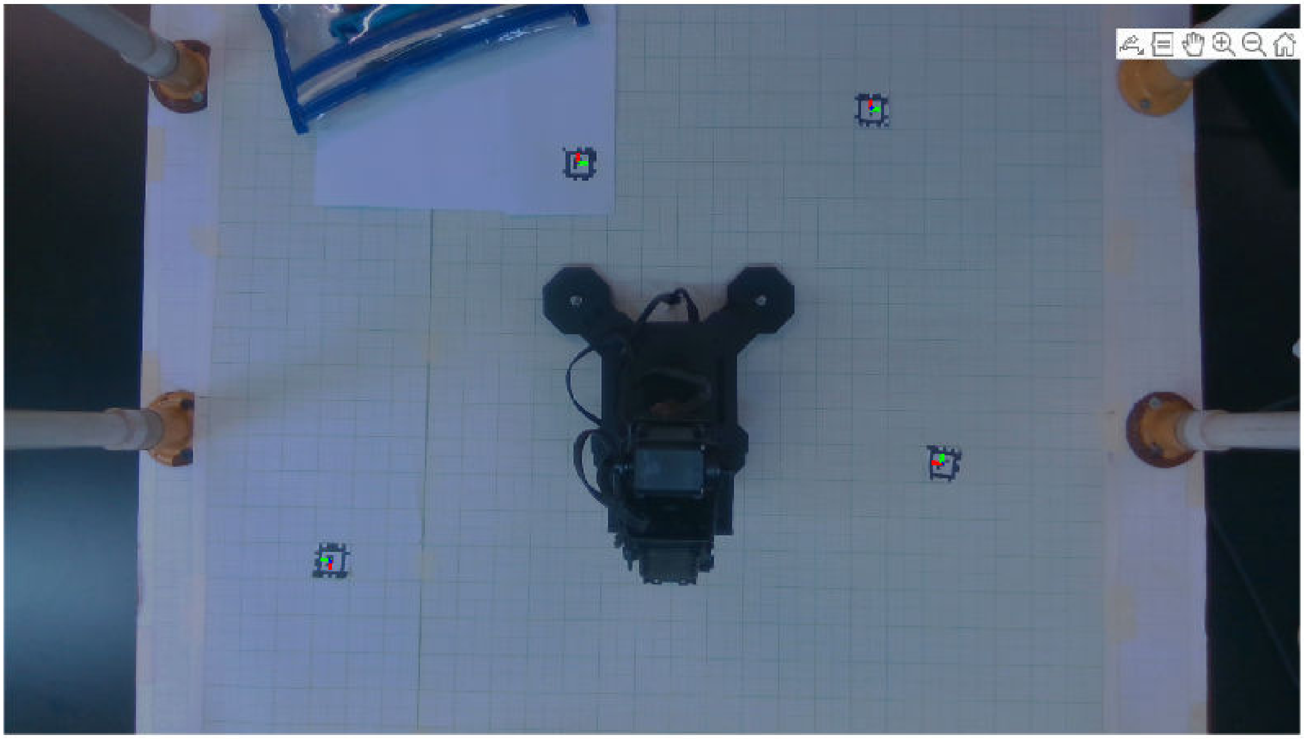
```
a = pose(4).A
```

```
a = 4×4
    0.0029    0.9980   -0.0628   -8.1507
   -0.9628   -0.0142   -0.2699  -24.5873
   -0.2703    0.0613    0.9608  116.8234
         0         0         0    1.0000
```

```
d = pose(4).Dimensionality
```

```
d = 3
```

```
tagSize = 2.3;

worldPoints = [0 0 0; tagSize/2 0 0; 0 tagSize/2 0; 0 0 tagSize/2];
I = img1;

for i = 1:length(pose)
    % Get image coordinates for axes.
    imagePoints = world2img(worldPoints,pose(i),cam_intrinsics);

    % Draw colored axes.
    I = insertShape(I,Line=[imagePoints(1,:) imagePoints(2,:); ...
        imagePoints(1,:) imagePoints(3,:); imagePoints(1,:) imagePoints(4,:)], ...
        ShapeColor=["red","green","blue"],LineWidth=7);

    % I = insertText(I,loc(1,:,i),tag(i),BoxOpacity=1,FontSize=25);
end

imshow(I)
```



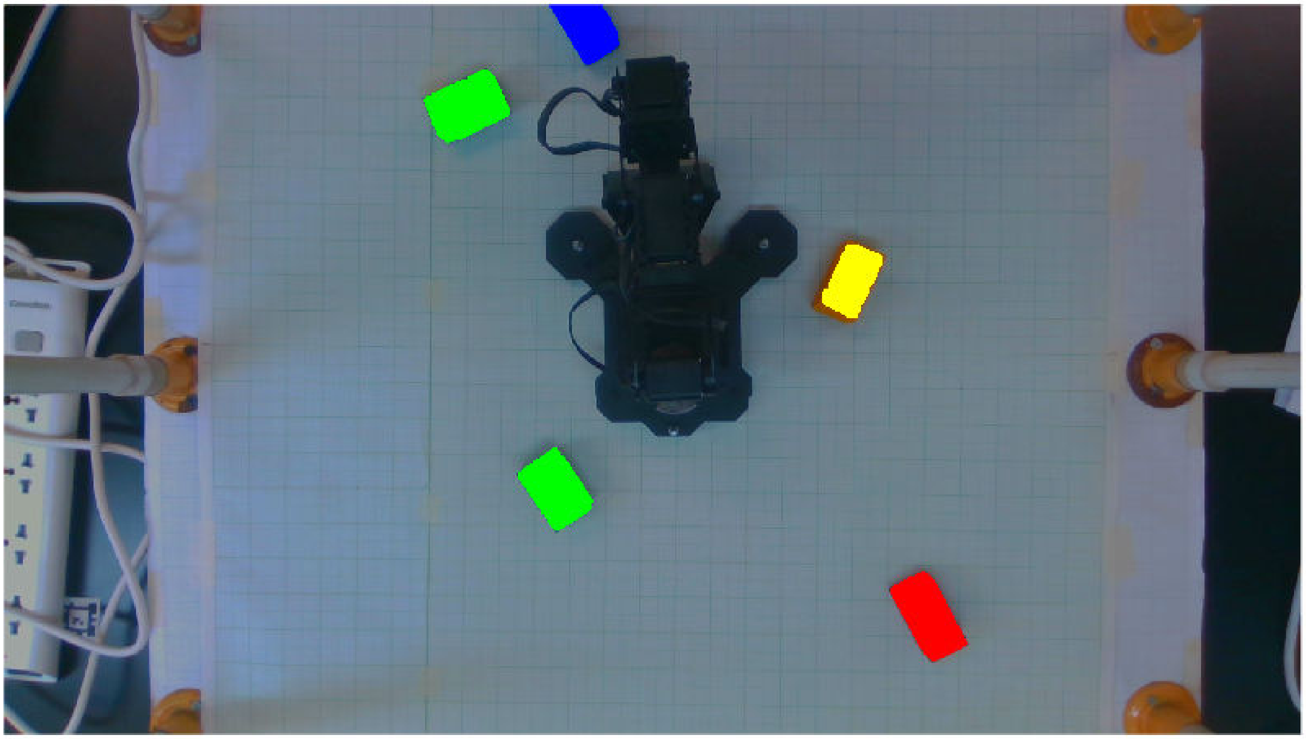
Task 2.17

Dimensions of cube 29mm x 50mm (Rectangle face)

Depth 29mm

```
center = [1920/2, 1080/2, 0]; % camera and depth intrisics se ayen ge ye

[label, rgblabel, overlayingimg, CC, poses] = segment_objects("intro to
rob\test_again_Color.png", "all", "intro to rob\test_bg_Color.png", true, center);
```

```
imshow(overlayingimg);
```



```
% pt = find_pixel_cords(center, [0, 0]);


% calculating homogenous transform
pose = poses(1, :);
cTb = homogenous_transform(pose)
```

```
cTb = 4×4
    0.9270   -0.3751         0 -274.0980
    0.3751    0.9270         0  388.8075
         0         0    1.0000         0
         0         0         0    1.0000
```

```
function T = homogenous_transform(pose)
    x = pose(1);
    y = pose(2);
    theta = pose(3);

    T = [cos(theta), -sin(theta) 0 x;
         sin(theta),  cos(theta) 0 y;
         0 0 1 0;
         0 0 0 1];

end
```

```
function [label, rgblabel, overlayimg, CC, center_pts] = segment_objects(img_path, 
color, bg_path, bgFilter, cam_center)
    % Reading the image
    img1 = imread(img_path);
    bg = imread(bg_path);

    % Convert images to double precision for accurate subtraction
    bg = double(bg);
    fg = double(img1);

    % Perform subtraction for each RGB channel
    diffR = abs(fg(:,:,1) - bg(:,:,1));
    diffG = abs(fg(:,:,2) - bg(:,:,2));
    diffB = abs(fg(:,:,3) - bg(:,:,3));

    % Normalize differences
    diffR = diffR / max(diffR(:));
    diffG = diffG / max(diffG(:));
    diffB = diffB / max(diffB(:));

    % Create binary masks for each channel using adaptive thresholds
    maskR = diffR > 0.5;  % Adjust threshold as needed
    maskG = diffG > 0.5;
    maskB = diffB > 0.5;

    % Combine masks (logical OR) to detect foreground
    bw_mask = maskR | maskG | maskB;

    % Clean the mask with morphological operations
    bw_mask = imopen(bw_mask, strel('disk', 3)); % Remove noise
    bw_mask = imfill(bw_mask, 'holes'); % Fill small gaps

    % Apply mask to each RGB channel

    % Convert back to uint8
    fg_no_bg = uint8(fg);
    for c = 1:3
        fg_no_bg(:,:,c) = uint8(fg(:,:,c) .* bw_mask);
    end
    img2 = img1;
    if bgFilter == true
        img1 = fg_no_bg;
    end

    % Converting rgb to LAB
    img1lab = rgb2lab(img1);
    [l a b] = imsplit(img1lab);

    % Converting rgb to HSV
    img1hsv = rgb2hsv(img1);
    [h s v] = imsplit(img1hsv);

    % creating empty masks
    sz = size(img1(:,:,1));
    redmask = zeros(sz);
    yellowmask = zeros(sz);
    greenmask = zeros(sz);
    bluemask = zeros(sz);

    if color == "red" | color == "all"
        redmask = h > 0.9 & s > 0.5 ;
        redmask = imfill(redmask, "holes"); % filling holes
        redmask = bwareaopen(redmask, 200); % size of actual box around 8200
        SE = strel("disk", 3); % creating a disk strel
        redmask = imclose(redmask, SE); % peroformng close operation to smoothen
edges
        % imshow(redmask);
    end
    if color == "yellow" | color == "all"
        % h extracts color, s extracts regions of yellow with ihgh saturation and v
        % ignores the dark yellow areas of the camera stand
        yellowmask = s > 0.5 & h < 0.105 & v > 0.45;
        yellowmask = imfill(yellowmask, "holes"); % as above
        yellowmask = bwareaopen(yellowmask, 200);
        SE = strel("disk", 3);
        yellowmask = imclose(yellowmask, SE);
    end

    if color == "green" | color == "all"
        greenmask = a < -10;
        greenmask = imfill(greenmask, "holes"); % as above
        greenmask = bwareaopen(greenmask, 200);
        SE = strel("disk", 3);
        greenmask = imclose(greenmask, SE);


    end

    if color == "blue" | color == "all"
        bluemask = b < -28 & v > 0.3 & l < 50;
        bluemask = imfill(bluemask, "holes"); % as above
        bluemask = bwareaopen(bluemask, 200);
        SE = strel("disk", 3);
        bluemask = imclose(bluemask, SE);
    end

    % combining masks

    allcubemask = redmask | greenmask | yellowmask | bluemask;

    % remove the small non-cube noise masked pixels from amsk
    allcubemask = bwpropfilt(allcubemask, "Area", [1000 1080*1920]);
    % find connected components
    CC = bwconncomp(allcubemask);

    % Read binary mask
    % bw = imbinarize(allcubemask);  % Ensure binary

    % Remove noise
    bw = imclose(allcubemask, strel('rectangle', [5,5]));
    bw = imfill(bw, 'holes');

    % Find connected components
    stats = regionprops(bw, 'BoundingBox', 'Orientation', 'ConvexHull', 
'PixelList');

    % Display image
    imshow(bw);
    hold on;

    % Store corners
    all_corners = [];
    center_pts = [];

for k = 1:length(stats)
    % Get convex hull points (better than bounding box)
    hull_points = stats(k).ConvexHull;

    % Perform PCA for orientation correction
    coeff = pca(hull_points);
    rotated_points = hull_points * coeff; % Align with new basis

    % Find min/max points in rotated space
    min_vals = min(rotated_points);
    max_vals = max(rotated_points);

    % Define rectangle in the transformed space
    rect_pts = [min_vals(1), min_vals(2);
                max_vals(1), min_vals(2);
                max_vals(1), max_vals(2);
                min_vals(1), max_vals(2)];

    % Transform back to original space
    rect_pts = rect_pts / coeff;

    % indetify the higher and lower of teh two points
    if rect_pts(1,2) > rect_pts(2,2)
        edge = [rect_pts(1,:); rect_pts(2,:)];
    else
        edge = [rect_pts(2,:); rect_pts(1,:)];
    end

    % Invert the y cordinates (for beter intuition)
    pt1 = find_pixel_cords([0, 1080], edge(1, :));
    pt2 = find_pixel_cords([0, 1080], edge(2, :));
    pts = [pt1; pt2];


    Y = pts(2,2) - pts(1,2);
    X = pts(2,1) - pts(1,1);
    angle = atan2(Y,X);
    % angle = acosd([X dd]);

    a = mean(rect_pts(:,1));
    b = mean(rect_pts(:,2));

    % Convert from pixel to camera cordinates
    pts = find_pixel_cords(cam_center, [a, b]);

    % finding center pts
    center_pts = [center_pts ; pts, angle];

    % finding orientation

    % Store corners
    all_corners = [all_corners; rect_pts];

    % Draw the rotated rectangle
    plot([rect_pts(:,1); rect_pts(1,1)], [rect_pts(:,2); rect_pts(1,2)], 'r-',
'LineWidth', 2);
    plot(rect_pts(:,1), rect_pts(:,2), 'bo', 'MarkerSize', 10, 'LineWidth', 2);
    plot(a, b, 'bo', 'MarkerSize', 5, 'LineWidth', 2);

    end

    hold off;

    % finding labels
    label = bwlabel(allcubemask);

    % converting labels to rgb
    rgblabel = label2rgb(label, "jet","k", "shuffle");

    % Viewing the color segmentated image
    k1 = imoverlay(img2, redmask, "red");
    k2 = imoverlay(k1, greenmask, "green");
    k3 = imoverlay(k2, bluemask, "blue");
    overlayimg = imoverlay(k3, yellowmask, "yellow");

    % overlayimg = labeloverlay(img1, label);


end



function pt = find_pixel_cords(center, image_point)
    x = image_point(1) - center(1);
    y = center(2) - image_point(2);
    pt = [x y];
end
```