EECE 5639- Homework 4

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Question 1

(a)

$$\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{bmatrix} \begin{bmatrix} p \\ q \\ 1 \end{bmatrix} \tag{1}$$

(b) There are 8 degrees of freedom for this transformation.

(c) 4 point correspondences are required for this transformation.

(d) Yes. If more points are available, the caliberation necessary for improving the accuracy can be done more precisely with linear least squares.

(e) Invarients include concurrency, collinearity, order of contact, tangent discontinuities and cusps, cross ratio of 4 collinear points and measurements in a canonical frame.

(f) Invarients include parallelism, ratio of areas, ratio of lengths on collinear or parallel lines.

(g) If both sets have the vanishing point at infinity, then the building is franto parallel.

Question 2

```
% create the image
image = zeros(8,8);
image(6,1) = 1;
image(7,2) = 1;
image(8,2) = 1;
image(6,3) = 1;
image(2,2) = 2;
image(6,2) = 2;
image(2,4) = 2;
image(6,6) = 2;
image(4,7) = 2;
image(5,7) = 2;
image(6,8) = 2;
image(3,2) = 2;
image(2,3) = 4;
image(4,3) = 2;
image(6,7) = 4;


%create the patch
template = zeros(3,3);
template(1,1) = 1;
template(1,3) = 1;
template(2,2) = 1;
template(3,2) = 1;
template(1,2) = 2;
```

1. Calculation of SSD

```
% calculation of SSD
f = image;
g = template;
ssd = zeros(8,8);

for i = 2:7
    for j = 2: 7
           var  = (f(i-1, j-1) - g(1,1)).^2 + ...
                + (f(i-1, j) - g(1,2)).^2+ ...
                + (f(i-1, j+1) - g(1,3)).^2 + ...
                + (f(i, j-1) - g(2,1)).^2 + ...
                + (f(i,j) - g(2,2)).^2 + ...
                + (f(i,j+1) - g(2,3)).^2 + ...
                + (f(i+1,j-1) - g(3,1)).^2 + ...
                + (f(i+1,j) - g(3,2)).^2 + ...
                + (f(i+1,j+1) - g(3,3)).^2;
       ssd(i,j) = sum(sum(var));
    end
end


ssd(1,:) = 0;
ssd(:,1) = 0;
ssd(8,:) = 0;
ssd(:,8) = 0;

disp("SSD is:");
disp(ssd)
```

```
SSD is:
     0     0     0     0     0     0     0     0
     0    24    28    24    12     8     8     0
     0    16    12    16     8    12     8     0
     0     8     8    12     8    16     8     0
     0    10     7     9    12    28    20     0
     0     9    12     9    12    24    20     0
     0     0     7     7     8    12     8     0
     0     0     0     0     0     0     0     0
```

2. Calculation of correlation

```
cross_correlation_score = imfilter(image,template);
cross_correlation_score(1,:) = 0;
cross_correlation_score(:,1) = 0;
cross_correlation_score(8,:) = 0;
cross_correlation_score(:,8) = 0;
disp("Cross Correlation score");
disp(cross_correlation_score);
```

```
Cross Correlation score

     0     0     0     0     0     0     0     0
     0     4     4     2     0     0     0     0
     0    10    14     8     2     0     2     0
     0     4     4     0     0     0     4     0
     0     4     5     2     0     4    10     0
     0     3     1     0     0     4     8     0
     0     8     4     1     2     8    12     0
     0     0     0     0     0     0     0     0
```

3. Calculation of Normalized Cross Correlation

```
normalized_image = zeros(8,8);
normalized_template = zeros(3,3);

for i=2:7
    for j=2:7
      denominator = f(i-1, j-1) .^2 + ...
                  + f(i-1, j) .^2 + ...
                  + f(i-1, j+1) .^2 + ...
                  + f(i, j-1) .^2 ...
                  + f(i,j) .^2 ...
                  + f(i,j+1) .^2 ...
                  + f(i+1,j-1) .^2 ...
                  + f(i+1,j) .^2 ...
                  + f(i+1,j+1) .^2;
       denominator = sqrt(denominator);
       normalized_image(i,j) = (f(i,j) / denominator);
    end
end

denominator = sqrt(g(1,1).^2 + g(1,2).^2 + g(1,3).^2 + g(2,1).^2 ...
    + g(2,2).^2 + g(2,3).^2 + g(3,1).^2 + g(3,2).^2 + g(3,3).^2);

normalized_template(2,2) = g(2,2)/denominator;

normalized_cross_correlation = imfilter(normalized_image,template);

disp("Normalized Cross Correlation");
disp(normalized_cross_correlation);
```