EE 146: Computer Vision

Buddy Ugwumba SID: 862063029

Lab 2: Threshold & Segmemtation

Date: 01/12/2022

```
clf

% Original RGB images
    % textured images
    ashy_Larry = imread("Ashy_Larry.jpeg");
    rocky_Road = imread("Rocky_Road.jpeg");
    % non-textured images
    love = imread("love.jpeg");
    unique = imread('unique.jpeg');
% Grayscale of Images
    % textured images
        ashy_gray = rgb2gray(ashy_Larry);
        rocky_gray = rgb2gray(rocky_Road);
        % non-textured images
        love_gray = rgb2gray(love);
        unique_gray = rgb2gray(unique);
```

```
% Execute the Otsu function for each grayscale texture and non-texture
% image then test the threshold value acquired from the function with
% matlabs internal function

% Texture image 1
ashyHist = imhist(ashy_gray);
[ashyQ, ~, ~, ~, ~] = OtsuMethod(ashyHist)
```

```
ashyQ = 146
```

```
algoTest(ashy_gray, ashyQ)
```

```
value = 145.5686
ans =
"0.29634%"
```

```
% Texture image 2
rockyHist = imhist(rocky_gray);
[rockyQ, ~, ~, ~, ~] = OtsuMethod(rockyHist)
```

```
rockyQ = 62
```

```
algoTest(rocky_gray, rockyQ)
```

```
value = 61.2392
ans =
"1.2423%"
```

```
% Non-Texture image 1
loveHist = imhist(love_gray);
[loveQ, ~, ~, ~, ~] = OtsuMethod(loveHist)
```

```
loveQ = 118
```

```
algoTest(love_gray, loveQ)
```

```
value = 117.4588
ans =
"0.46074%"
```

```
% Non-Texture image 2
uniqueHist = imhist(unique_gray);
[uniqueQ, ~, ~, ~, ~] = OtsuMethod(uniqueHist)
```

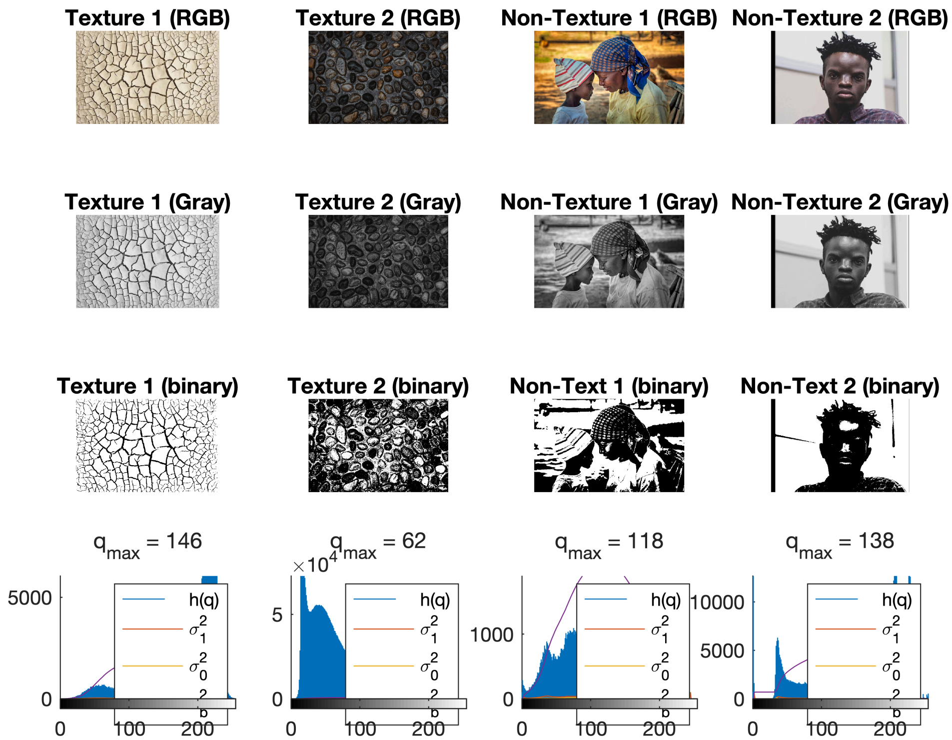
```
uniqueQ = 138
```

```
algoTest(unique_gray, uniqueQ)
```

```
value = 137.5373
ans =
"0.33645%"
```

```
% Create subplots of images
        % Original images
        subplot(4,4,1), imshow(ashy_Larry), title('Texture 1 (RGB)')
        subplot(4,4,2), imshow(rocky_Road), title('Texture 2 (RGB)')
        subplot(4,4,3), imshow(love), title('Non-Texture 1 (RGB)')
        subplot(4,4,4), imshow(unique), title('Non-Texture 2 (RGB)')
        % Gray images
        subplot(4,4,5), imshow(ashy_gray), title('Texture 1 (Gray)')
        subplot(4,4,6), imshow(rocky_gray), title("Texture 2 (Gray)")
        subplot(4,4,7), imshow(love_gray), title("Non-Texture 1 (Gray)")
        subplot(4,4,8), imshow(unique_gray), title("Non-Texture 2 (Gray)")
        % Binarized image with Otsu threshold
        subplot(4,4,9), imshow(imbinarize(ashy_gray, ashyQ/256)), title("Texture 1 (bi
            xlabel("q_{max} = " + ashyQ);
        subplot(4,4,10), imshow(imbinarize(rocky_gray, rockyQ/256)), title("Texture 2
             xlabel("q_{max} = " + rockyQ);
        subplot(4,4,11), imshow(imbinarize(love_gray, loveQ/256)), title("Non-Text 1 (
             xlabel("q_{max} = " + loveQ);
        subplot(4,4,12), imshow(imbinarize(unique_gray, uniqueQ/256)), title("Non-Text
             xlabel("q_{max} = " + uniqueQ);
        % histogram of original image, foreground variance, background
```

```
        % variance, variance between foreground and background
        subplot(4,4,13), hold on, imhist(ashy_gray),
            [~, ~, ~, sigmaforeground, ~] = OtsuMethod(ashyHist);
            plot(sigmaforeground),
            [~, ~, ~, ~, sigmabackground] = OtsuMethod(ashyHist);
            plot(sigmabackground),
            % Encountered an area when calculating the variance between
            % decided to output the vectors of the variance functions and
            % found that the foreVec was 255*1. I do not know why this is I
            % followed thee formula, but made the necessary adjustments
            % because matrices are not indexed at 0. To solve this problem
            % I appended a zero value at the end of foreVec
            % fore =  foregroundVariance(ashyHist, ashyQ);
            % back = backgroundVariance(ashyHist, ashyQ)
            [~, ~, sigmabetween, ~, ~] = OtsuMethod(ashyHist);
            plot(sigmabetween),
            legend('h(q)', '\sigma_{1}^{2}',...
            '\sigma_{0}^{2}', '\sigma_{b}^{2}'), hold off
        subplot(4,4,14), hold on, imhist(rocky_gray),...
            [~, ~, ~, sigmaforeground, ~] = OtsuMethod(rockyHist);
            plot(sigmaforeground),
            [~, ~, ~, ~, sigmabackground] = OtsuMethod(rockyHist);
            plot(sigmabackground),
            [~, ~, sigmabetween, ~, ~] = OtsuMethod(rockyHist);
            plot(sigmabetween),
            legend('h(q)', '\sigma_{1}^{2}',...
            '\sigma_{0}^{2}', '\sigma_{b}^{2}'), hold off
        subplot(4,4,15), hold on, imhist(love_gray),...
            [~, ~, ~, sigmaforeground, ~] = OtsuMethod(loveHist);
            plot(sigmaforeground),
            [~, ~, ~, ~, sigmabackground] = OtsuMethod(loveHist);
            plot(sigmabackground),
            [~, ~, sigmabetween, ~, ~] = OtsuMethod(loveHist);
            plot(sigmabetween),
            legend('h(q)', '\sigma_{1}^{2}',...
            '\sigma_{0}^{2}', '\sigma_{b}^{2}'), hold off
        subplot(4,4,16), hold on, imhist(unique_gray),...
            [~, ~, ~, sigmaforeground, ~] = OtsuMethod(uniqueHist);
            plot(sigmaforeground),
            [~, ~, ~, ~, sigmabackground] = OtsuMethod(uniqueHist);
            plot(sigmabackground),
            [~, ~, sigmabetween, ~, ~] = OtsuMethod(uniqueHist);
            plot(sigmabetween),
            legend('h(q)', '\sigma_{1}^{2}',...
            '\sigma_{0}^{2}', '\sigma_{b}^{2}'), hold off
```



This algorithm is very powerful for finding the optimal threshold value for an image. Since the mean is precalcuated, the Otsu method passes over the grayscale histogram 3 times. 0(K) makes the Otsu method very fast compared to other algorithms mentioned in the literature. Knowing the threshold value of an image allows us to segment the foreground from the background. Segmentation of the two backgrounds aids in computer vision by distinguishes objects in a picture.

```
function [mu0, mu1, N, K] = MakeMeanTable(grayscaleHistogram)
    K = size(grayscaleHistogram,1);
    % Create Mean Table of the Histogram
    n0 = 0;
    s0 = 0; % Sum of pixel values?
    % Tabulate background means mu0(q)
    % Create a vector to store the means of the background
    mu0 = zeros(256, 1);
    for q = 1:K
        for r = 1:size(grayscaleHistogram,2)
        n0 = n0 + grayscaleHistogram(q,r);
        s0 = s0 + q*grayscaleHistogram(q,r);
            if n0 > 0
                mu0(q,r) = s0/n0;
            else
                mu0(q,r) = -1;
            end
        end
    end
```

```
    N = n0;
    % Tabulate foreground means
    n1 = 0;
    s1 = 0;
    % Create a vector to store the means of the foreground
    mu1 = zeros(256, 1);
    for q = K-1:-1:1
        for r = 1:size(grayscaleHistogram,2)
            n1 = n1 + grayscaleHistogram(q+1,r);
            s1 = s1 + (q+1)*grayscaleHistogram(q+1,r);
            if n1 > 0
                mu1(q,r) = s1/n1;
            else
                mu1(q,r) = -1;
            end
        end
    end
end

% Write a function to execute the Otsu method on the texture and
function [qMax, sigmaBetweenMax, sigmaBetween, sigmaForeground, sigmaBackground] = Otsu
    % This function takes as its input a grayscale histogram and returns the
    % optimal threshold value or -1 if no threshold is found
    % MakeMean Tables(h)
    [mu0, mu1, N, K] = MakeMeanTable(grayscaleHistogram); % When there are multiple arg
    sigmaBetween = zeros(256,1);
    sigmaForeground = zeros(256,1);
    sigmaBackground = zeros(256,1);
    sigmaBetweenMax = 0; % Set the maximum between class variance to 0
    qMax = -1; % Set the max threshold value to -1
    n0 = 0;
    % Examine all possible threshold values q
    for q = 1:K-1
        for r = 1:size(grayscaleHistogram,2)
            % Sum up the number of pixels
            n0 = n0 + grayscaleHistogram(q,r);
            n1 = N - n0;
            if n0 > 0 && n1 > 0
                sigmaBetween(q,r) = (1/(N.^2))*n0*n1*(mu0(q,r) - mu1(q,r))^2;
                sigmaForeground(q,r) = 1/n1*(q - mu1(q,r))^2*grayscaleHistogram(q,r);
                sigmaBackground(q,r) = 1/n0*(q - mu0(q,r))^2*grayscaleHistogram(q,r);
                % Maximize sigma^2_b
                if sigmaBetween(q,r) > sigmaBetweenMax
                    sigmaBetweenMax = sigmaBetween(q,r);
                    qMax = q;
                end
            end
        end
    end
end

% Function to check error
function [error] = algoTest(grayscaleHistogram, experimentalValue)
```

```
[counts, ~] = imhist(grayscaleHistogram);
value = otsuthresh(counts);
value = (value*100*256)/100
% The value is normalized, convert it to an indexed value
error = (abs(value-experimentalValue)/value)*100+"%";
end
```