MODULATION TRANSFER FUNCTION

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CONTENTS

OBJECTIVES

01

Measure the MTF of different cameras using the slanted edge technique

02

Understand the relationship between MTF and resolution.

METHODOLOGY

SETUP AND IMAGE CAPTURE

- Place the camera on a stand and position the Resolution Test Chart at a fixed distance.
- Ensure parallel alignment between the camera sensor plane and the slanted edge image.
- Capture multiple images of the test chart, using burst mode if available, and average the images to minimize noise.

DATA PROCESSING

- Open the slanted edge image using MATLAB.
- Obtain intensity profiles of a line crossing the edge (LE).
- Derive the line (d(LE)/dx).
- Perform Fourier transform of this derivative (FFT[d(LE)/dx]).

FREQUENCY ANALYSIS

- Extract the modulus of the FFT of the derivative (abs(FFT[d(LE)/dx])).
- Keep only the positive half of the modulus.
- Calibrate the scale of the Fourier Transform plot using the scale bar from the image.

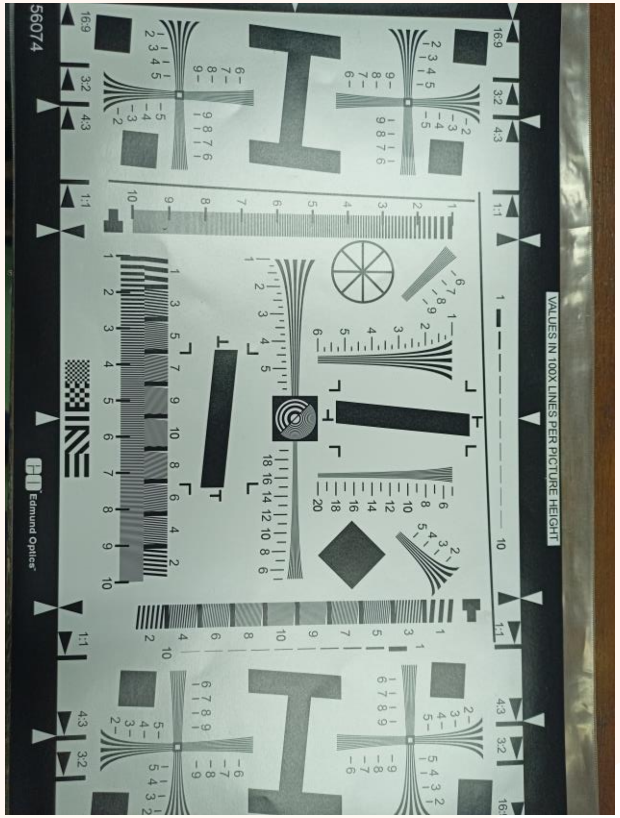
SPATIAL FREQUENCY MEASUREMENT

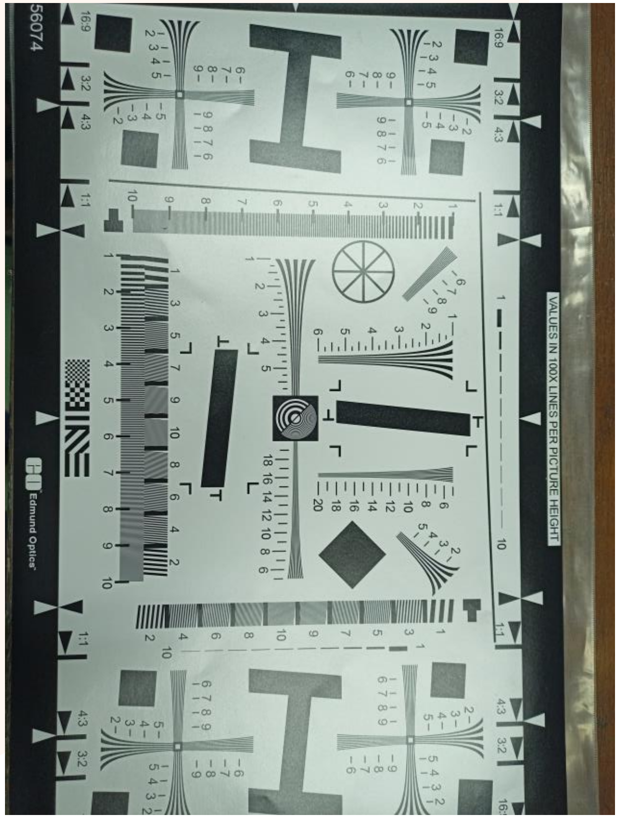
- Express spatial frequency in cycles/mm or line pairs (lp)/mm.
- Repeat steps for several lines across the edge and average the results.

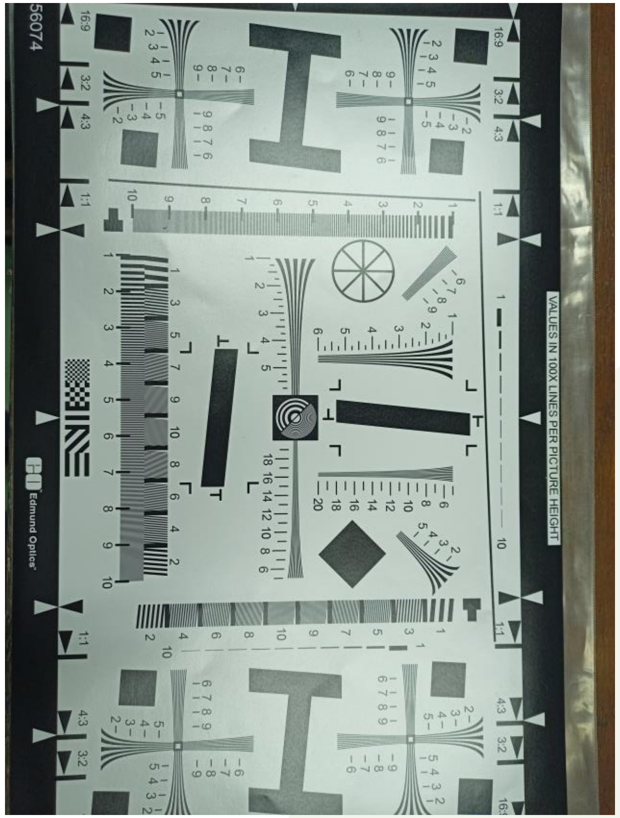
NORMALIZATION AND RESOLUTION CALCULATION

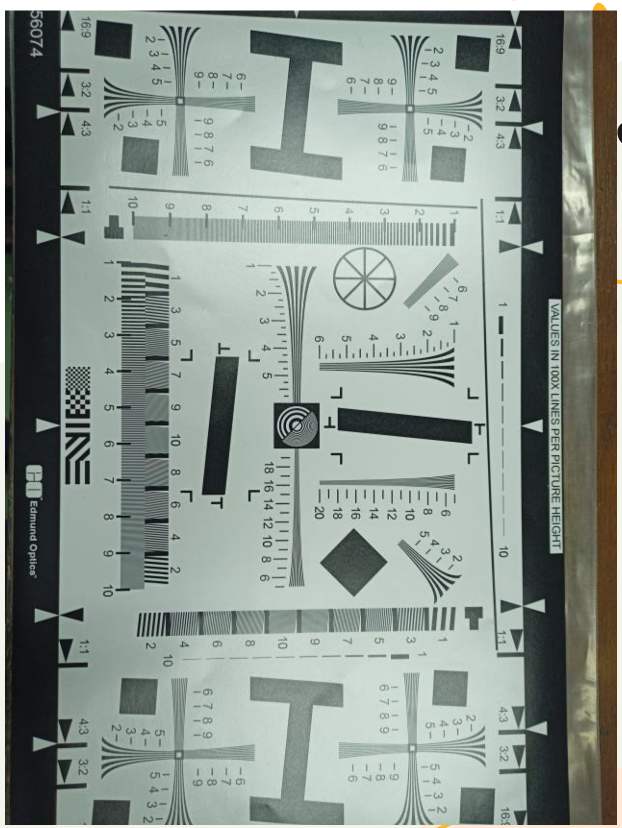
- Normalize the average MTF to 1.0.
- Identify the point where MTF is at 0.5; this represents the camera's resolution in lp/mm.
- Observe line pair images to pinpoint the stage at which the camera loses detail or experiences a phase flip.

SAMPLE IMAGES USED





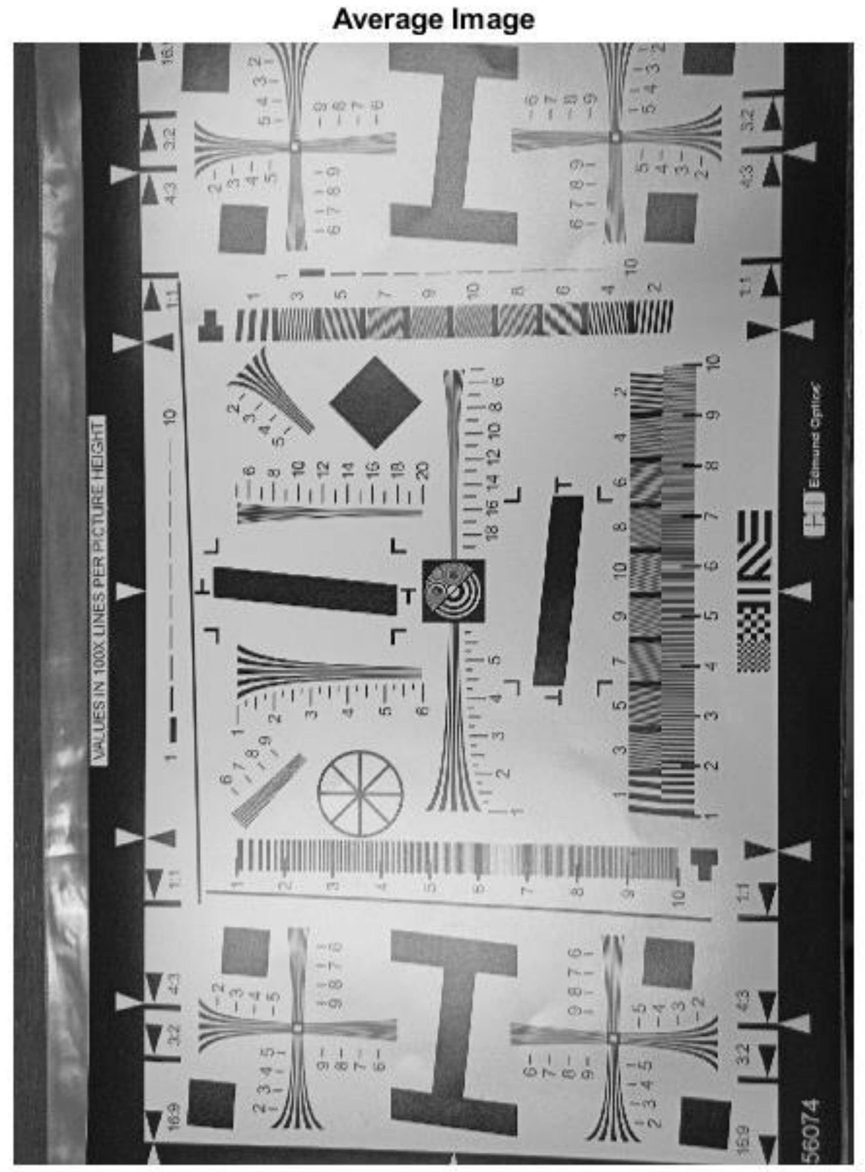


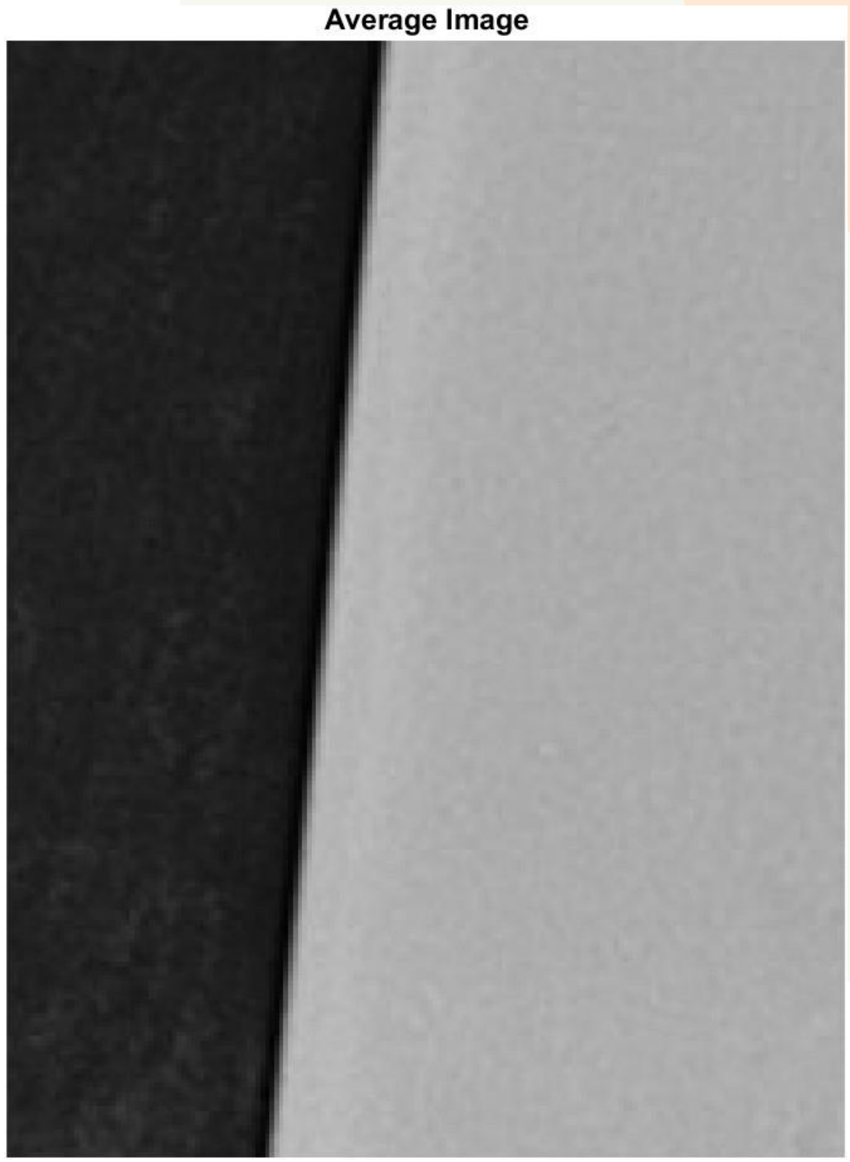


CODE AVERAGING THE 4 IMAGES

```
img_folder = 'C:\Users\User\Documents\MATLAB\167-Activity 4\MTF';
file_extension = '.jpg';
file_list = dir(fullfile(img_folder, ['*', file_extension]));
num_images = numel(file_list);

% Initializing a variable to store the total image
total_image = zeros(size(imread(fullfile(img_folder, file_list(1).name))));

% Looping through each image file
for i = 1:num_images
    image_name = file_list(i).name;
    image = imread(fullfile(img_folder, image_name));
    if size(image, 3) == 3
        image = rgb2gray(image);
    end
    total_image = total_image + double(image);
end

% Calculating the average image
average_image = uint8(total_image / num_images);
J = imrotate(average_image, 90)
```

RESULTING AVERAGE IMAGE

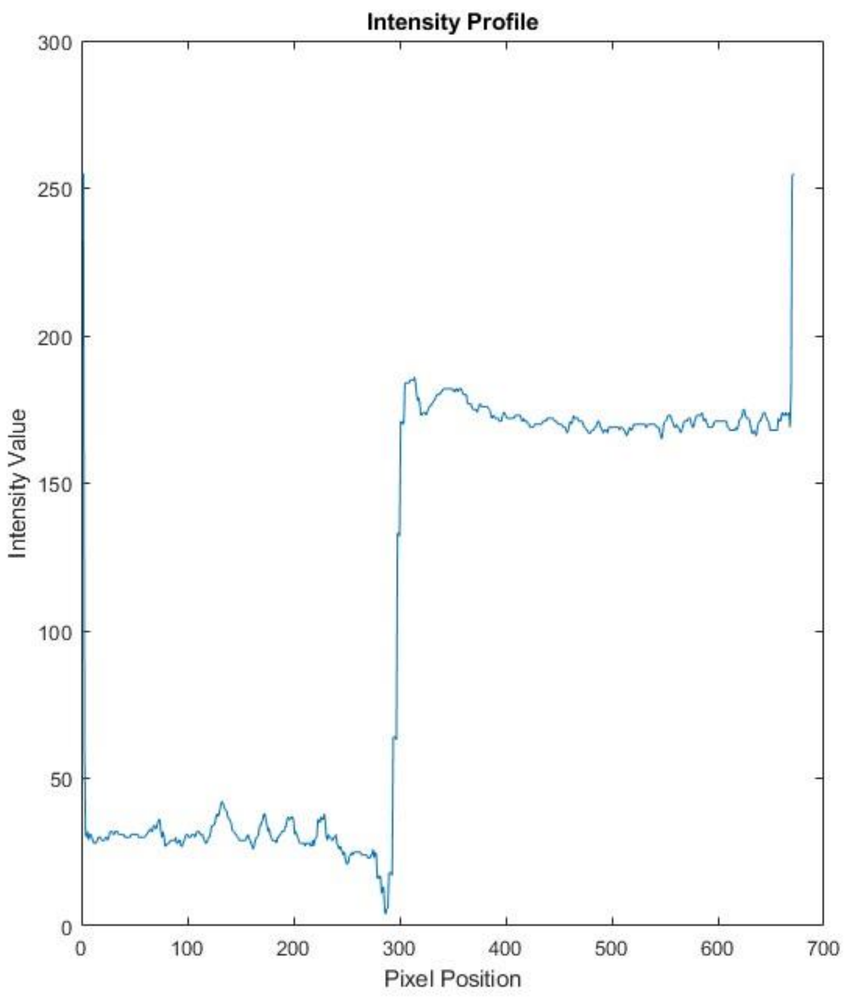




For me to be able to get the slanted image, I zoomed in the first image and saved as picture, as seen in the second photo.

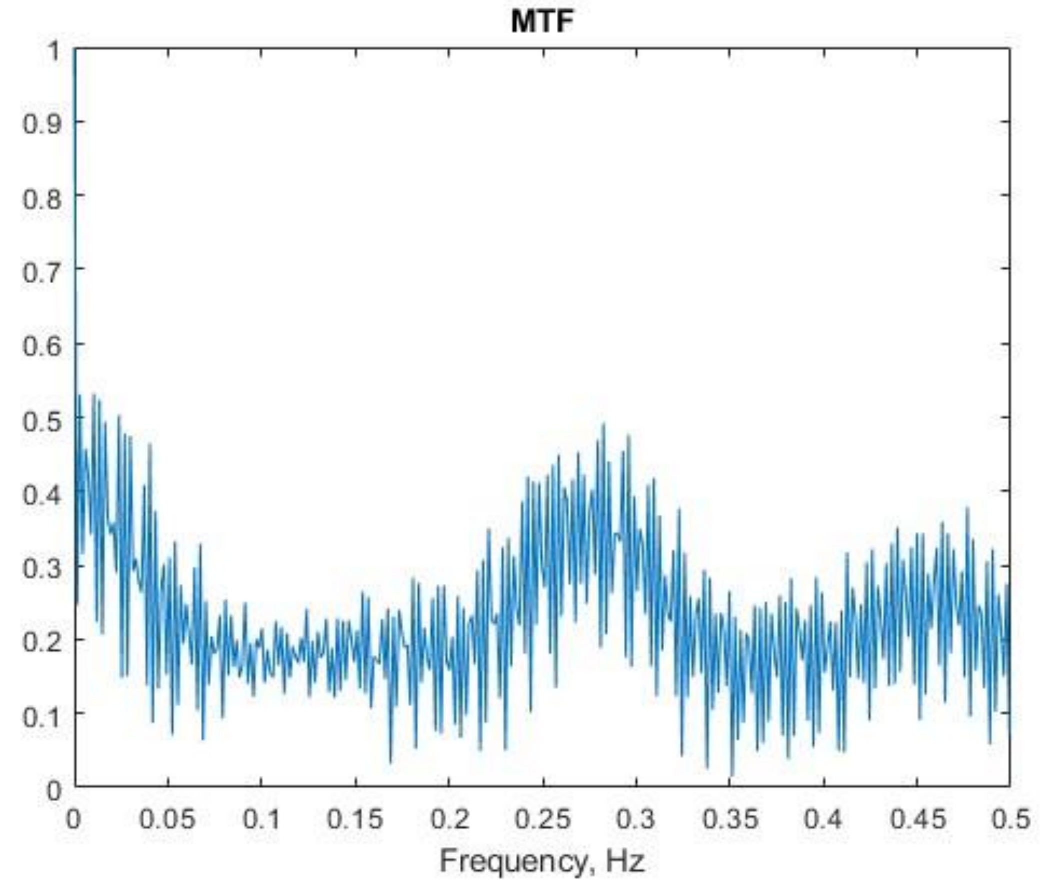
OBTAINED INTENSITY PROFILE

```
slantedImage = imread(['C:\Users\User\Documents\MATLAB\167-Activity 4\slant.jpg']);
slantedImage = rgb2gray(slantedImage);
rowIdx = 100;
% Extracting the intensity profile
intensityProfile = slantedImage(rowIdx, :);
plot(intensityProfile);
title('Intensity Profile');
xlabel('Pixel Position');
ylabel('Intensity Value');
```



MEASURING THE MTF

```
% Taking the derivative of the intensity profile
derivativeProfile = diff(intensityProfile);

% Taking the FFT of the derivative profile
FFT_derivative = fft(derivativeProfile);

% Calculating the MTF
MTF = abs(FFT_derivative) / max(abs(FFT_derivative));

% Setting up frequency axis
dx = 1;
N = length(intensityProfile) - 1;
Fmax = 1 / (2 * dx);
df = 1 / ((N - 1) * dx);
frequencyAxis = 0:df:Fmax;

K = length(frequencyAxis);

% Displaying the MTF
plot(frequencyAxis(1:K), MTF(1:K));
xlabel('Frequency, Hz');
title('MTF');
```



REFLECTION

I was not able to fully complete the objectives of this activity, but I did try my best to code and complete the activity. I faced some challenges, but I learned a lot from the experience. I think I deserve a grade of **90** for making an effort to finish this activity and I promise to make a better activity next time. Special thanks to Mark Danganan for helping me with the codes.

THANK YOU!