Question 2

CS663 (Digital Image Processing) Assignment 1

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Question 2

Problem 1

You are viewing the following graph from a research paper. Unfortunately, from the graph, the (x, y) values at only a few points can be observed. You need to obtain the (x, y) values at many other points. Hence you can do the following: you extract the image from the paper, and open it through MATLAB which provides a function called impixelinfo. This function gives you the (x, y) coordinates of any spatial location pointed by your mouse. However, the coordinate system of the graph and that of MATLAB will be different. Describe a procedure to convert from MATLAB's coordinate system to the coordinate system of the graph. This will help you obtain the (x, y) coordinates in the coordinate system of the graph. Support your answer with suitable equations. There is no need to write any code for this. [15 points]

Section 1

Procedure of Coordinate Conversion

As the graph's y-axis and x-axis are fairly vertical and horizontal, we can assume that both coordinate systems are not much rotated with respect to each other. Otherwise, we will have to find the rotation parameter θ also, for a more general case.
Let (x, y) be the coordinate of a point on the graph image, and (x', y') be its corresponding coordinate from MATLAB `impixelinfo` function.
As both the coordinate systems differ by translation + scaling, we use the following transformation model -

Motion Model 1

$$x = ax' + b$$
$$y = cy' + d$$

Now, the aim is to find the values of a, b, c, d, which we can find by sampling those points whose graph coordinate we can see from picture and then their MATLAB coordinate can be accessed by `impixelinfo` function.

So, among the points whose graph coordinates are known to us, say I first pointed a point with its graph coordinates being (x_1, y_1) and its MATLAB coordinates are (x_1', y_1').
Similarly, I chose another point with graph coordinates as (x_2, y_2) and MATLAB coordinates (x_2', y_2').
Putting these values into our motion model, we get -

Solving

$$x_1 = ax_1' + b \tag{1.1}$$

$$x_2 = ax_2' + b \tag{1.2}$$

Subtracting equation 1.1 from 1.2, we get

$$a = \frac{x_2 - x_1}{x_2' - x_1'}$$

Putting a in equation 1.1, we get

$$b = x_1 - \frac{x_2 - x_1}{x_2' - x_1'} x_1'$$

$$b = \frac{x_1 x_2' - x_2 x_1'}{x_2' - x_1'}$$

□

Similarly, solving for c and d,

Solving

$$y_1 = cy_1' + d \tag{1.3}$$

$$y_2 = cy_2' + d \tag{1.4}$$

Subtracting equation 1.3 from 1.4, we get

$$c = \frac{y_2 - y_1}{y_2' - y_1'}$$

Putting c in equation 1.3, we get

$$d = y_1 - \frac{y_2 - y_1}{y_2' - y_1'} y_1'$$

$$d = \frac{y_1 y_2' - y_2 y_1'}{y_2' - y_1'}$$

□

Now, we have found the values of a, b, c, d.

Hence, we can get the graph coordinates (x, y) of any point of the given graph by -

1. Getting their MATLAB coordinates (x', y') through `impixelinfo` function
2. Then using the transformation formulae that we have derived -

Formulae

$$x = \frac{x_2 - x_1}{x_2' - x_1'} x' + \frac{x_1 x_2' - x_2 x_1'}{x_2' - x_1'}$$

$$y = \frac{y_2 - y_1}{y_2' - y_1'} y' + \frac{y_1 y_2' - y_2 y_1'}{y_2' - y_1'}$$