Solution for Q6 … (By Kavya Gupta)

Instructions to run the code :-

So the code for all the 4 plots is saved in **A2Q6.m** MATLAB file saved in the main .zip file. Running it will create those 4 plots. First two plots will be for Image 2 = T2.jpg, then other two will be for Image 2 = Negative of T1.jpg

Also in the folder **Q6** in the main .zip file you will find the pics of 4 plots {**corr1.png, qmi1.png, corr2.png, qmi2.png**} which are also attached in this pdf.

Analysis of Image 1 vs Image 2 :-

1) **Correlation Coefficient Plot (corr1.png)**

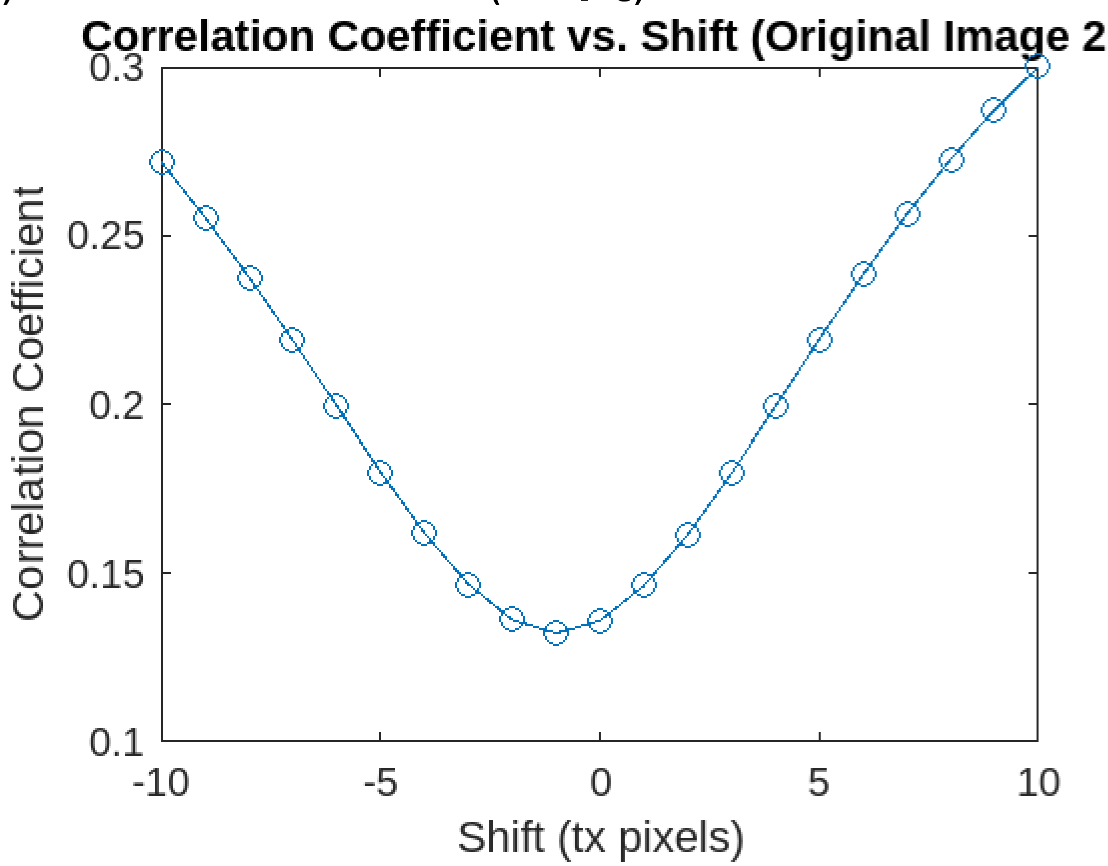

Figure 1 : Correlation Coeff. v/s tx for Original Image 2

Commentary :

It's a V-shaped graph. Surprisingly, at tx close to 0, correlation coefficient (CC) is minimum (around 0.13). It is surprising as one would expect the CC to be maximum at tx=0 because as said in the question, each point (x, y) represents the same entity and is perfectly aligned. If that was so then the correlation coefficient must have been close to 1. But we get to see the almost opposite. As tx deviates from 0, i.e. misalignment increases, then correlation coefficient is increasing 🤯, which sort of indicates that relation between images increases, which is obviously not the case.

2) **Quadratic Mutual Information (QMI) Plot (qmi1.png)**

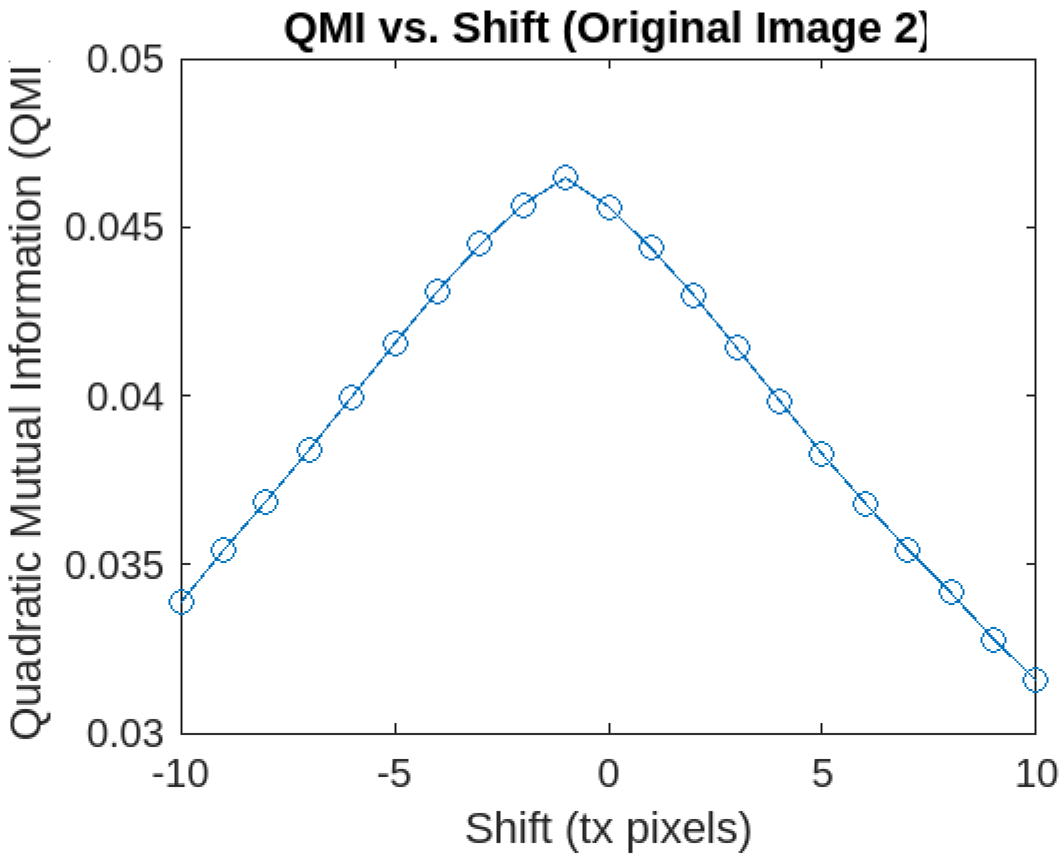

Figure 2 : QMI v/s tx for Original Image 2

Commentary :

To our relief, here the QMI works as we expected. It is max at tx close to 0 and decreases as |tx| increases. As misalignment increases, QMI decreases. Sharp change at tx close to 0.

Analysis of Image 1 vs Negative of Image 1 :-

1) **Correlation Coefficient Plot (corr2.png)**

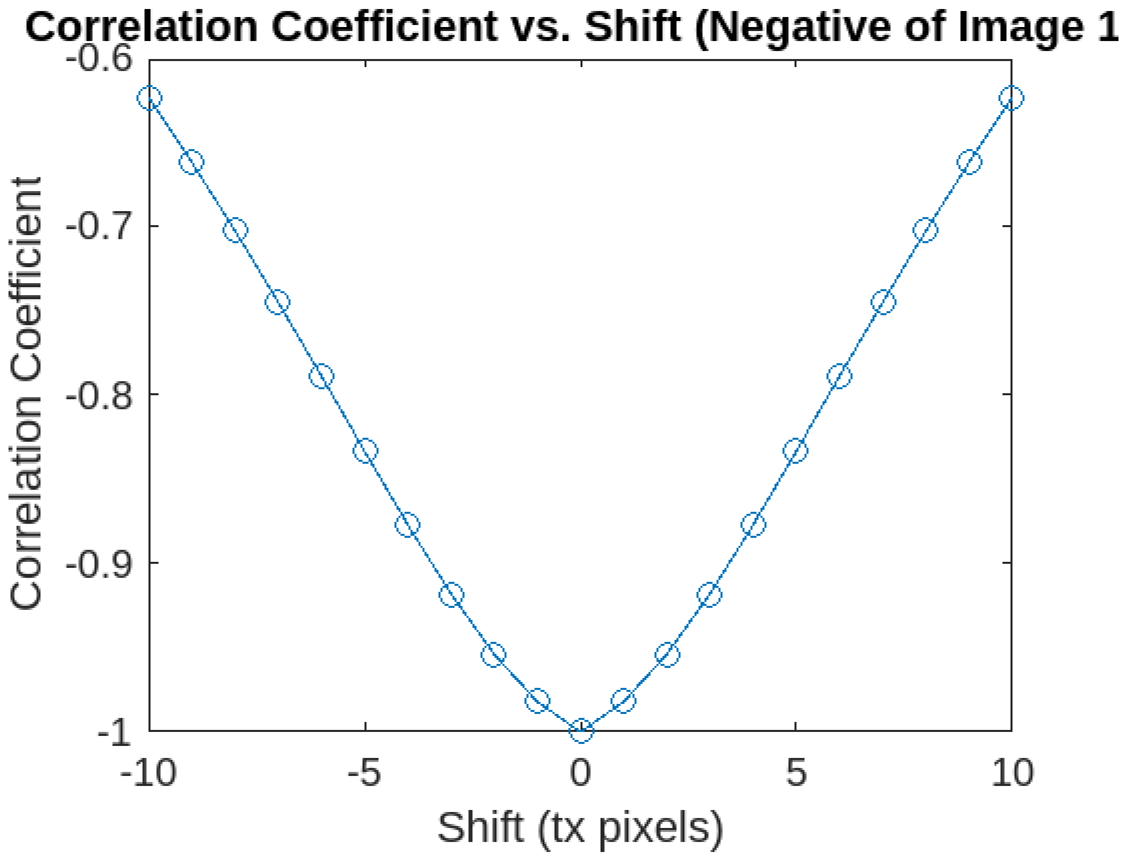

Figure 3 : Correlation Coeff. v/s tx for Negative of Image 1

Commentary :

At tx=0, the CC is -1 exact. Here, it may look like its same as first plot, but see here that all the values are completely negative, hence when I take modulus of this graph, I will get an inverted V-graph, there CC = 1 at tx=0, meaning best relation at no misalignment which is what we expected hence CC works out here well. As misalignment increases, modulus of CC decreases, which indicates lesser relation between images, hence matching our intuition.

2) **Quadratic Mutual Information (QMI) Plot (qmi2.png)**

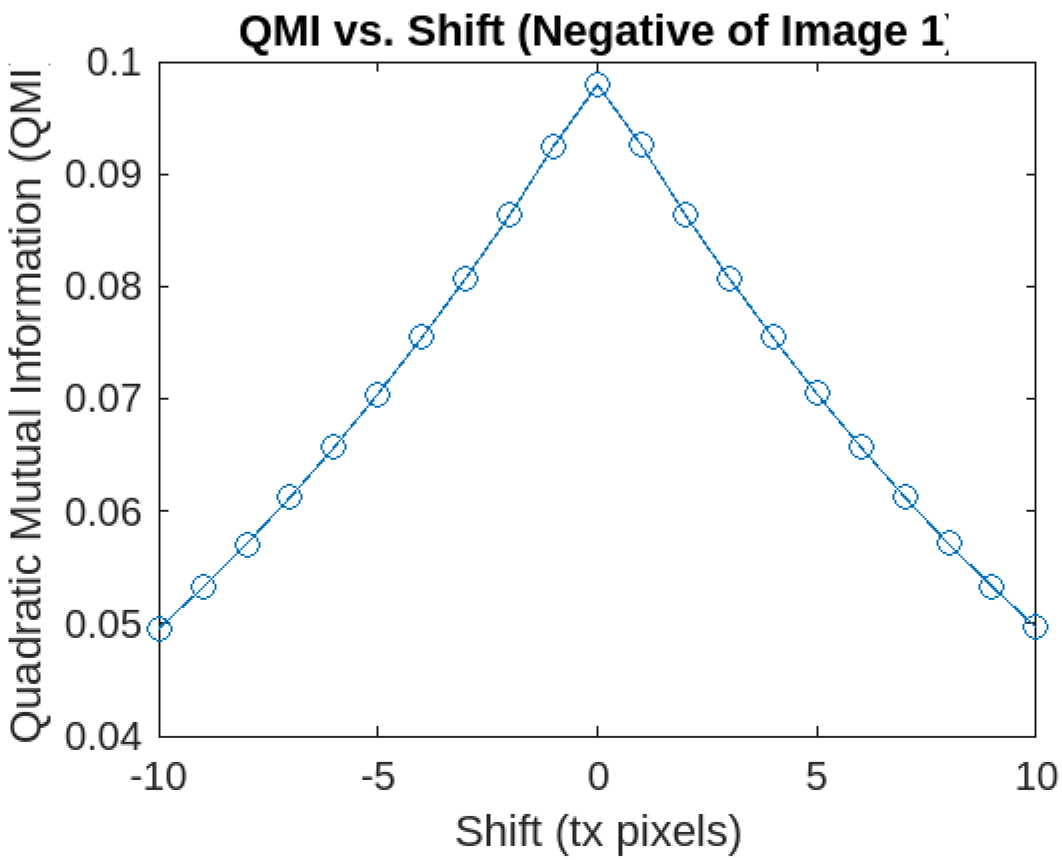

Figure 4 : QMI v/s tx for Negative of Image 1

Commentary :

Same like the first QMI graph, this is an inverted V graph. QMI max at no alignment (tx close to 0) and it decreases as misalignment increases (|tx| > 0) indicating that the images are less related, matching our intuition. In this case specifically, the graph looks nearly symmetrical.

Final Observations :-

So the Correlation Coefficient finds the relation between the images depending on the ***mean*** and ***variance*** of *all the points at the same time* **(DOESN'T MAKE USE OF FULL INFORMATION OF PDF)**.. So in certain cases it could happen that the misalignment causes changes at all the neighboring points, but it may happen the net result of all the misalignments cancels out, and we may see less change in "**mean**" even when images become more and more misaligned OR even that the **mean** starts approaching the mean of the Image 1 like in case of **corr1.png**.. That's why we see unexpected graphs.

In case of **corr2.png**, since the second image is exact negative of Image 1, we see that "**mean**" becomes exact negative and all the happenings due to

misalignment happen in one direction, hence correlation coefficient gives a very good result. As |tx| increased the “**mean**” started moving toward the original mean of Image 1, hence CC started becoming less negative.
If we take the modulus of CC, then we see that the two images were maximally correlated for tx close to 0, as we expected !! Most optimal at least misalignment in corr2.png, but not in corr1.png

This happened because here the intensities were “linearly dependent” on each other (I2 = 255 - I1), which directly affects the mean hence the CC was able to give accurate results here.

Hence Correlation Coefficient is <u>highly dependent on the variation of mean and linear relation between variables than actual distortion at each point</u>.

This is where QMI comes to save the day… <u>it is less dependent on mean and rather depends on distortion at small neighborhoods at points</u>.

We expected that there should be a maxima near 0 and QMI meets our expectations in both the graphs, meaning it rightly said that the two images were maximally correlated for tx close to 0.

This is because QMI uses the **Joint Histogram Bin method,** nearby neighbors of a point will most probability will fall into the same point as the point itself. So if any misalignment happens, the new neighbors of a point in the new misaligned image start going in different bins and hence the QMI decreases.
*It does not depend on “**mean**” at all unlike CC and gives the same nature of graph everytime* **qmi1.png, qmi2.png***, unlike CC.*
Also QMI takes square of the difference between joint pmf and marginal pmfs, hence there is no issue of **“Net Result = 0** due to canceling each other” as in CC.

It catches the linear as well as the non-linear relation between the intensities and hence gives better results….

Hence QMI is a much superior method to detect misalignments than Correlation Coefficient !!