Question 5

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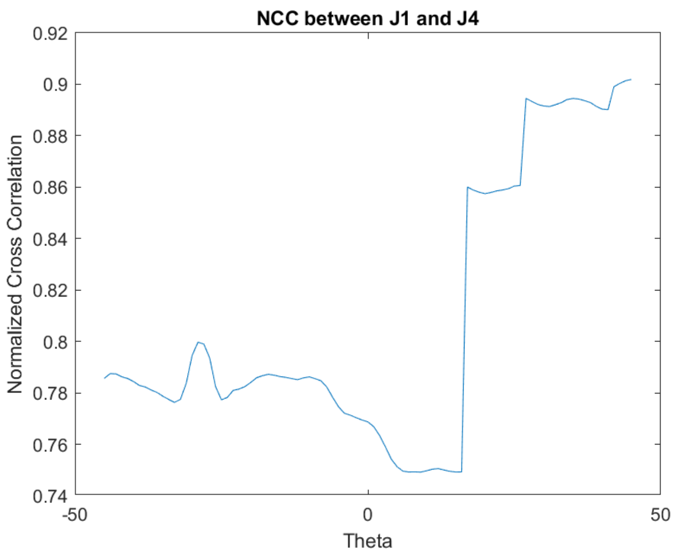
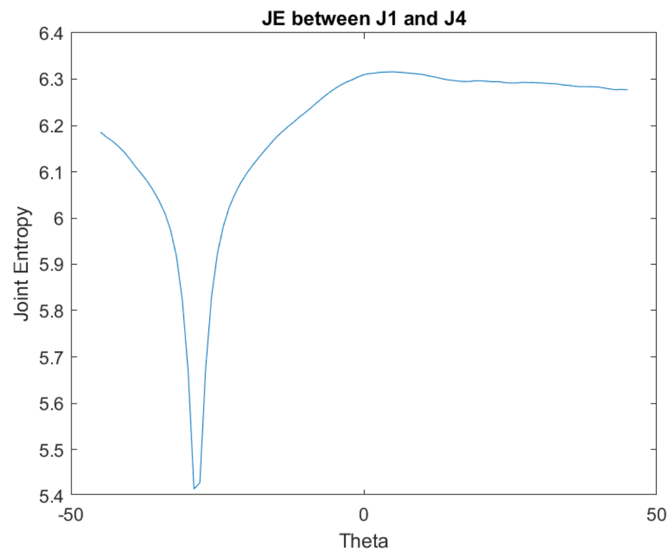
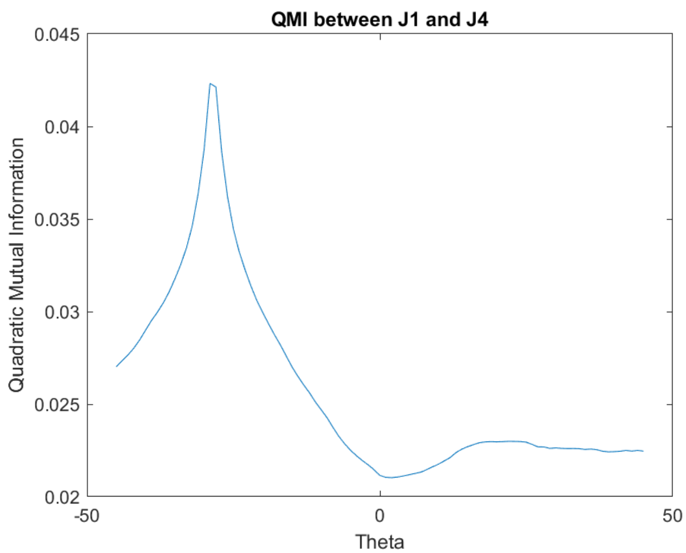
Que 5. (c)



Normalized Cross Correlation



Joint Entropy



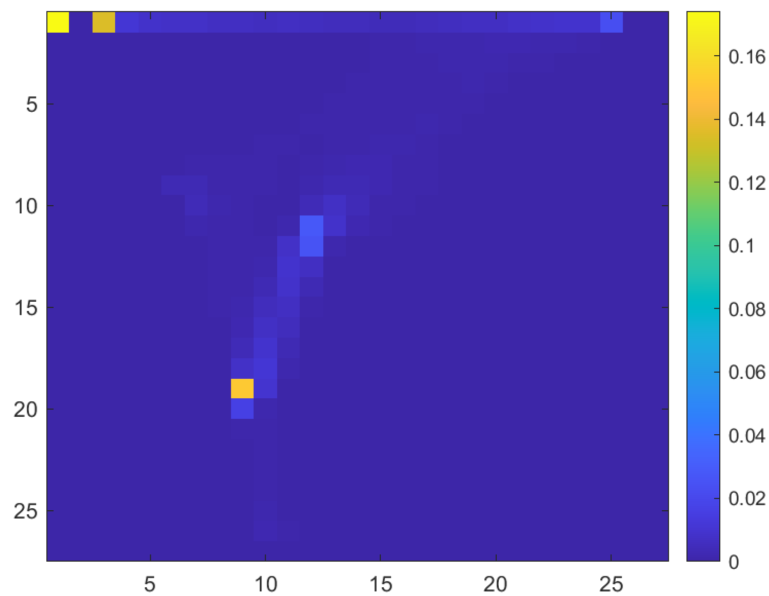
Quadratic Mutual Information

Figure 1: Nearest neighbour interpolation

(d)

- We select the angle θ that maximizes the **NCC (Normalized Cross-Correlation)**. According to the plot, NCC peaks at $\theta = 45.0°$, but this is evidently not the correct rotation angle. Although there is a local maximum at $-29°$, it is not the global maximum. This suggests that NCC may not be a reliable measure for all types of image alignment.
- We choose the angle θ that minimizes **JE (joint energy)**. The plot indicates that the minimum of JE occurs at $\theta = -29°$, which is close to the expected value. Given that the initial rotation was 28.5° (with counterclockwise as positive) and the step size for θ is 1°, we have determined the answer with a precision of up to 1 degree.
- We select the angle θ that maximizes **QMI (Quadratic Mutual Information)**. According to the plot, the maximum of QMI occurs at $\theta = -29°$, which is near the expected value. Given that the initial rotation was 28.5° (with counterclockwise as positive) and the step size for θ is 1°, we achieved a precision of up to 1 degree in our result

(e) The optimal rotation according to JE, is $-29°$.



(f) When two random variables, I_1 and I_2, are independent, their joint probability distribution $P_{I_1,I_2}(i_1, i_2)$ equals the product of their marginal distributions $P_{I_1}(i_1)$ and $P_{I_2}(i_2)$:

$$P_{I_1,I_2}(i_1, i_2) = P_{I_1}(i_1)P_{I_2}(i_2).$$

Thus, the greater the magnitude of the difference between $P_{I_1,I_2}(i_1, i_2)$ and $P_{I_1}(i_1)P_{I_2}(i_2)$, the stronger the dependence between the variables. Consequently, the images are more dependent (or correlated) when the QMI, given by

$$\text{QMI} = \sum_{i_1}\sum_{i_2}\left(P_{I_1,I_2}(i_1, i_2) - P_{I_1}(i_1)P_{I_2}(i_2)\right)^2,$$

is larger. Therefore, image alignment is achieved when their QMI is maximized.