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CS516 - Computer Vision

Prof. Russell Butler

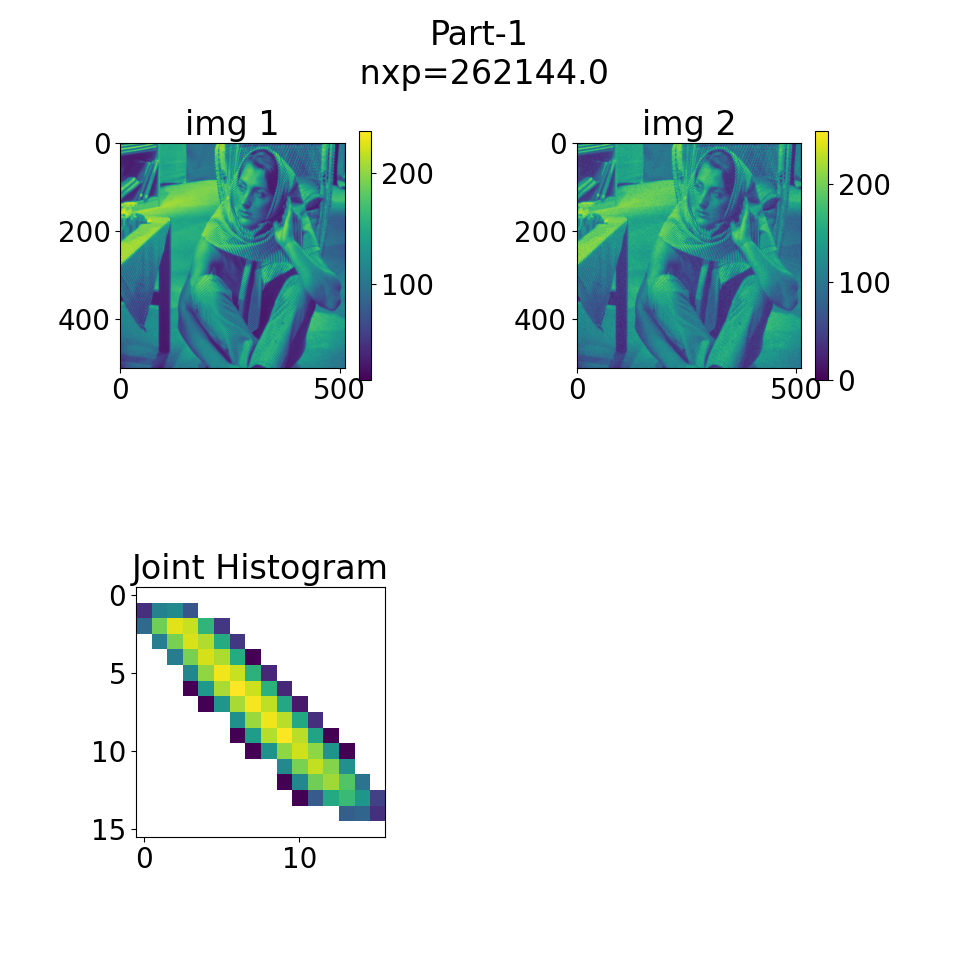
Students

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**Part 1: Joint histogram 10/100**

* Completed all.
* We have not shown all the images output in this pdf but it’s written in code.



**Part 1(C) Observation:**

* I1 and J1 are similar in terms of both grayscale and position, as a result, most points in the histogram center around the line `y = x`, with minor deviations due to the "blurred effect". I2 and J2 are also perfectly aligned with respect to pixel positions, but have slightly different grayscale intensities, therefore, we observe a line with a different slope and intercept, while the data points are still closely clustered. I3/J3 and I4/J4 show the images of two different people. Since the images are less similar to each other, data points in the histogram are more scattered around. This pattern is also observed in the last two pairs of images where a slice of brain is shown. However, the details of the brain are greyed out in J5 and J6 using a constant intensity around 100. Consequently, many data points overlap on the vertical line `x = 100`, where the grayscale intensity on the y axis ranges from roughly 10~140, corresponding to the intensity within the brain as in I5 and I6.

**Part 2 (similarity criteria 20/100):**

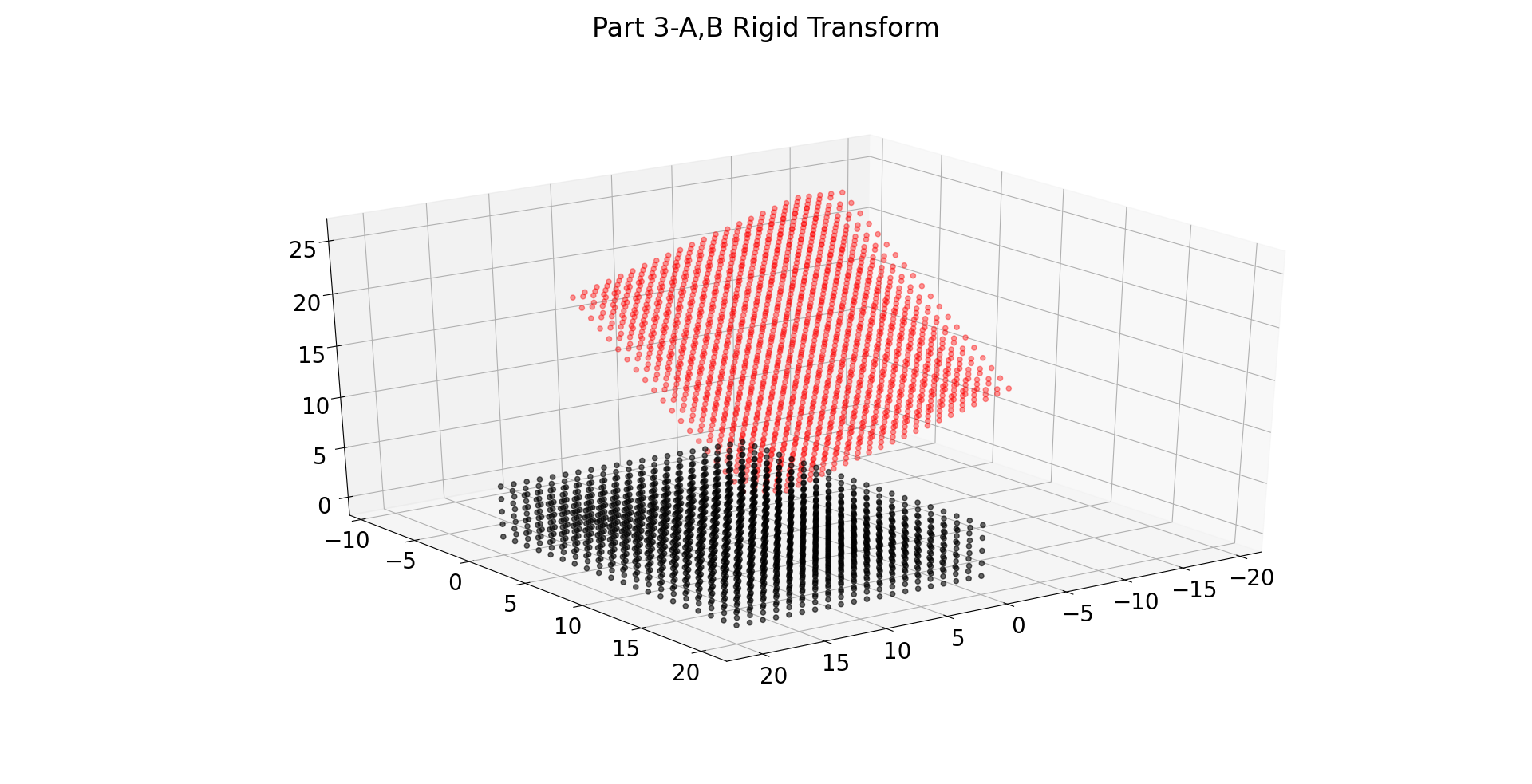
* completed all parts.
* No output to show in this question.
* The more similar two images are, the larger the mutual information value is. The first two pairs of images share a lot of similarity, so the mutual info values are higher. The second pair only differs in grayscale intensity, so this pair has the highest mutual info. In the first pair, J2 is a little blurred, so the mutual info drops a bit. All other pairs have a significantly lower mutual info because they are much less similar.
* The Pearson correlation coefficient fails to detect any non-linear relationship, so it's does not give us

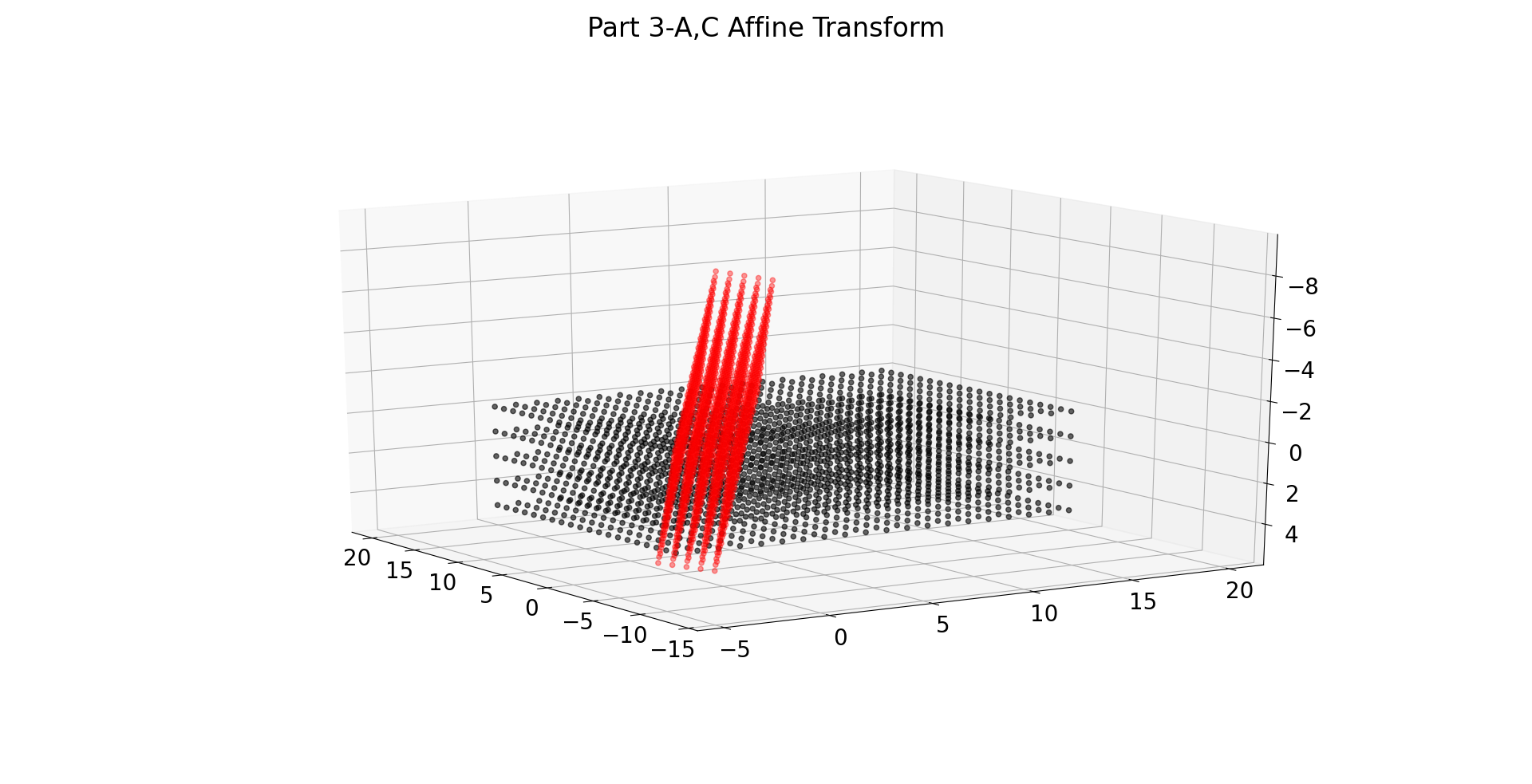
very useful information. For example, both the third and the fourth pair have different images, so the pearson coefficient should be similar, but it turns out that they differ a lot simply due to random shapes or noise.

* The squared sum difference is also not a good metric when it comes to image similarity. For example, while the first two pairs of images are very similar, its ssd is very high. The next two pairs of images are not similar at all, but they have a much much lower ssd. In fact, if we transform an almost black image into a almost white image, the difference on each pixel will be very large, despite the similarity of the two images, the corresponding ssd will still be a tremendous number.

**Part 3 (spatial transforms 20/100):**

* Completed all parts.



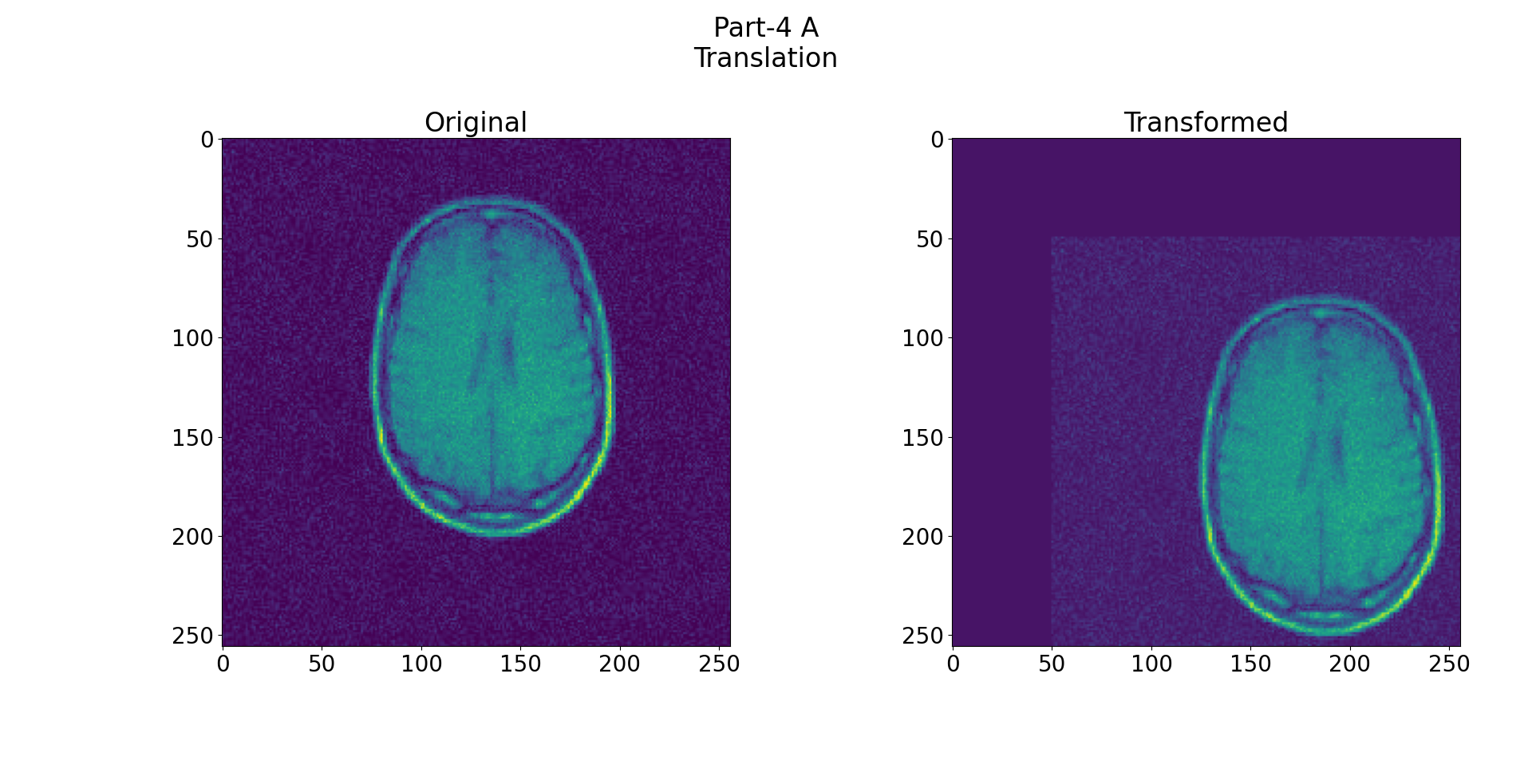


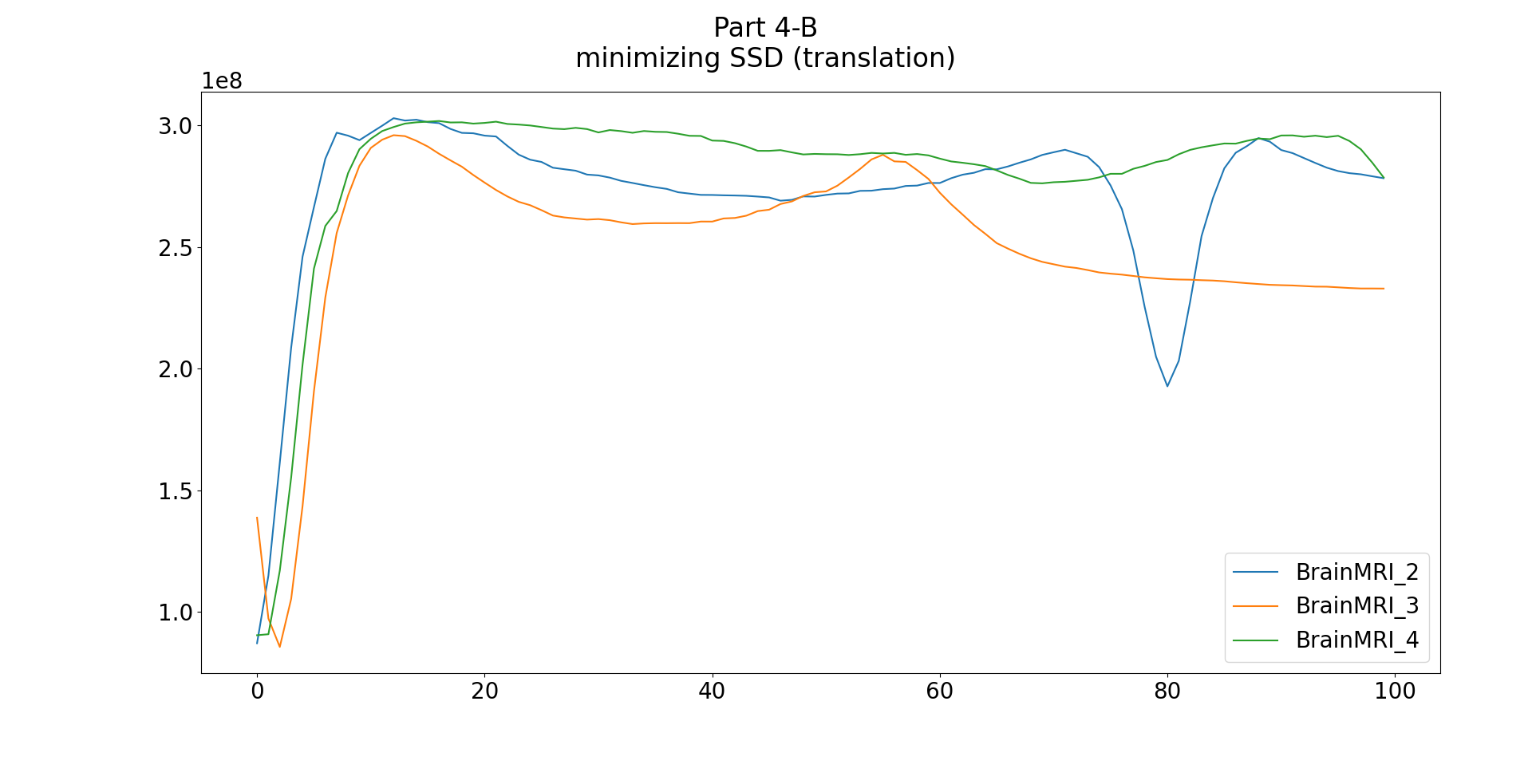
**Part 3(D) :**

* The rightmost column only has the translation parameters, so m1 translates an image by 10 pixels on both x, y and z axis. Excluding the rightmost column and the last row, all other parameters are within the topmost 3 x 3 sub-matrix. In particular, values on the diagonal in this 3 x 3 matrix can be a mix of rotation and scaling. Note that 0.9045 appears twice on the first and third row, this can happen if and only if there's a rotation around the y axis with angle theta, where cos(theta)=0.9045, and no rotations around the x or z axis. Besides, the number in the middle is not 1, so it must be a scaling factor which is 0.8750. The other four numbers not on the diagonal represent the mix of shear and rotation parameters. So, x in the z direction and y in the x direction are sheared by a factor of -0.3847, y in the z direction and z in the x direction are sheared by a factor of 0.2939. Similarly, both x and z in the y direction are also sheared, to compute the factors, we need to divide -0.1840 and 0.3090 by positive and negativesin(theta), respectively. In sum, this matrix contains translation, rotation, scale and shear.
* Following the same idea, we can infer that m2 has a translation of -3 on the x axis, 1.5 on the y axis, a rotation of 90 degrees around the y axis, plus some scaling and shearing. m3 is more complex where no elements in the sub-matrix equals to each other or zero, it could be a mix of only scale and shear, or a rotation around all three axes, or both, we need to solve a list of joint math equations to get the answer.

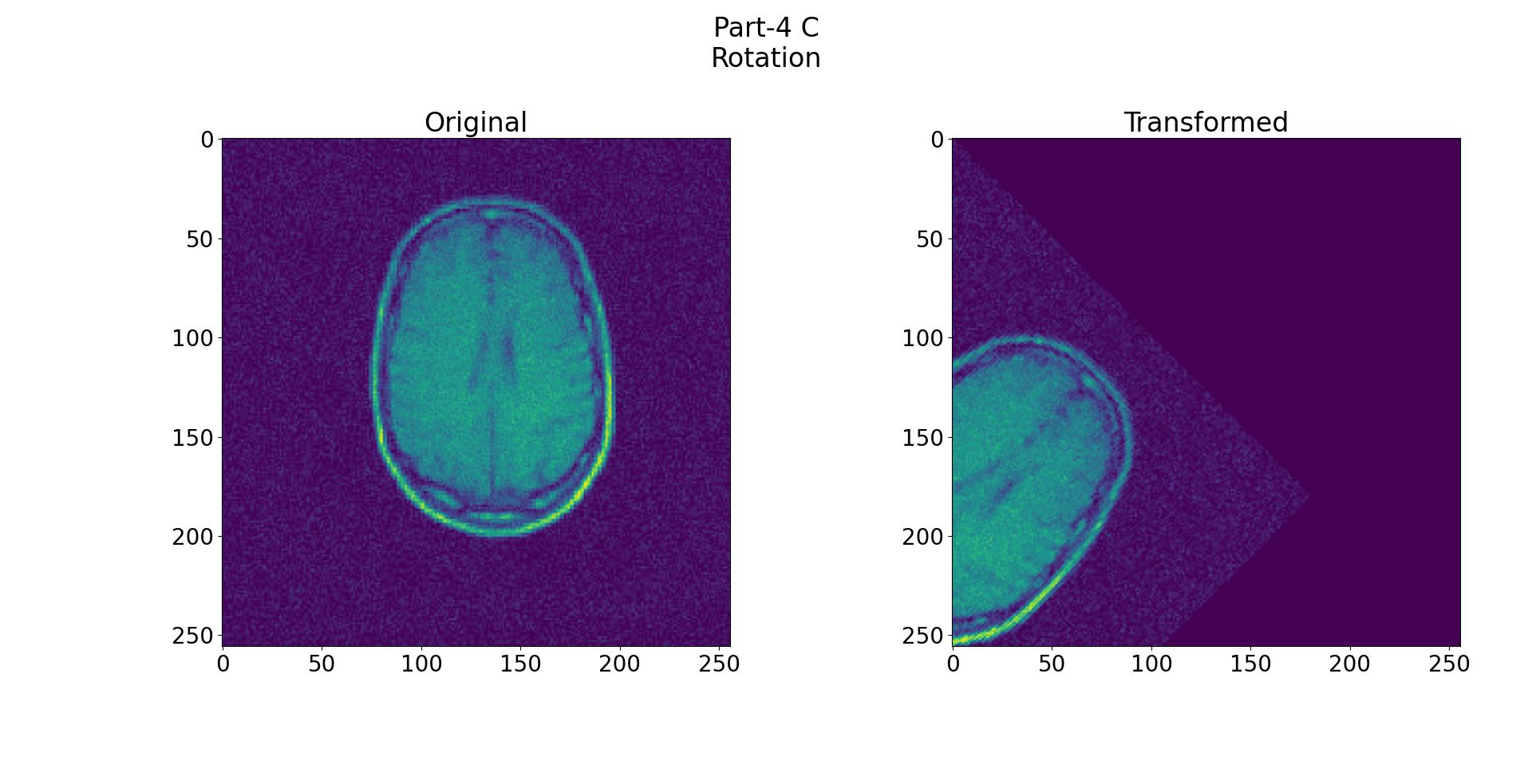
**Part 4: simple 2d registration 40/100:**

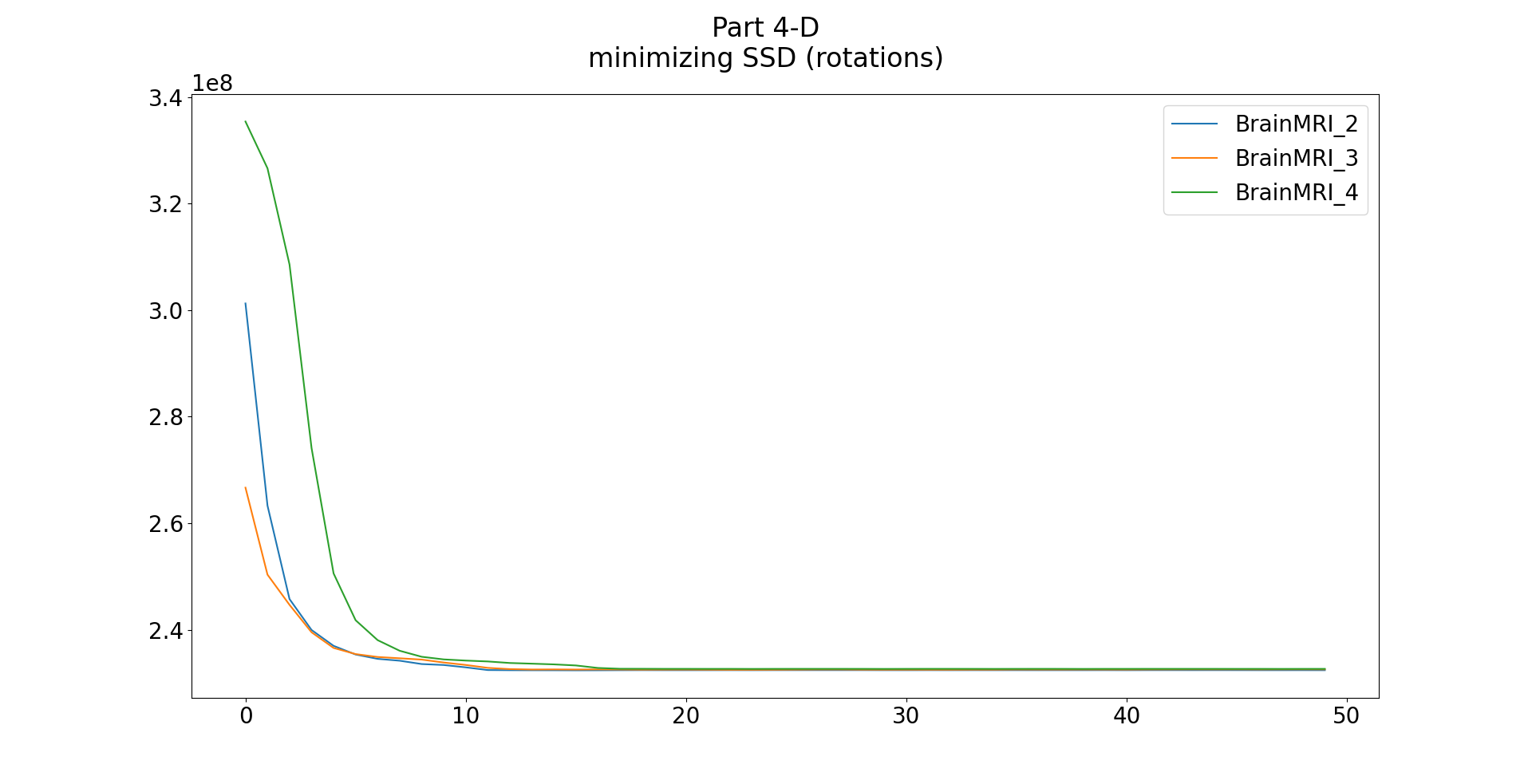
* Expect 4-E all other parts completed.





* Image “BrainMRI\_2.jpg” SSD curve is decreasing because it perfectly adjust with “BrainMRI\_1.jpg” in addition to that after each iteration translated image causes SSD to minimize, whereas in "BrainMRI\_3.jpg" and "BrainMRI\_4.jpg” not.





**Part 5: practical application: 20/100 (10%, +10% bonus):**

* We tried
  + **$ flirt -in tof.nii -ref t1.nii -out tof\_in\_t1.nii**
  + With