Image Registration Report

QUESTION 1: What is the effect of increasing/decreasing the number of chosen control points in registration accuracy?

Results: The results are illustrated in Figure 1-4.

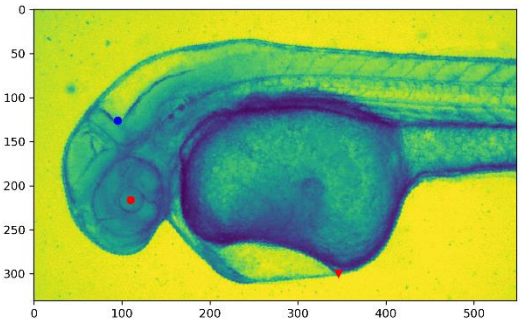

Figure 1

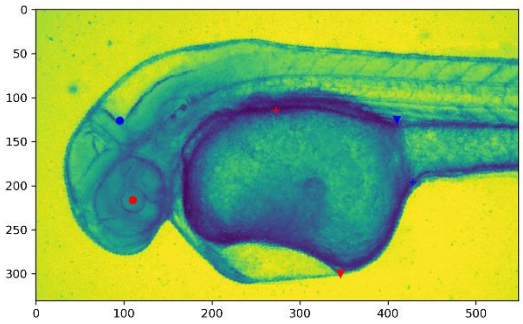

Figure 2

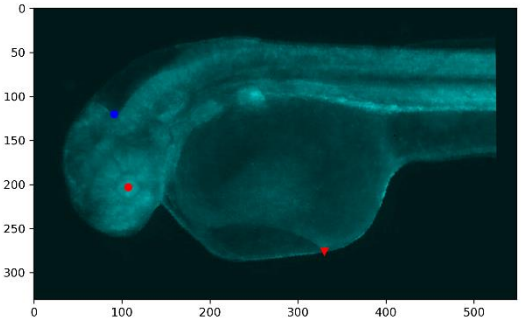

Figure 3

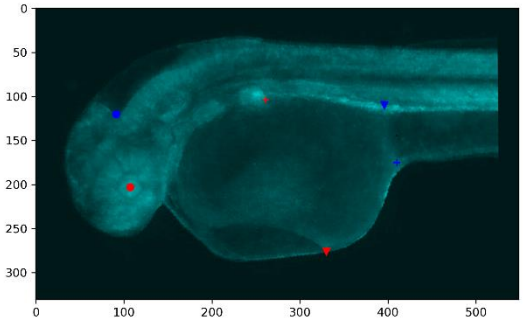

Figure 4

Answer: The figures illustrate the impact of varying the number of control points on registration accuracy. The first column shows the results when only three control points are used, positioned along the left and bottom edges. This configuration provides higher accuracy in these areas but results in noticeable misalignment on the upper right side, failing to meet the registration requirements for the entire image.

In contrast, the second column adds three more control points, placed in the middle and right regions. This additional placement significantly improves the registration accuracy across the image, as seen in the aligned overlay with minimal offset—only a slight misalignment remains at the far-right edge. Overall, increasing the number of control points leads to more precise alignment, meeting the registration requirements more effectively.

QUESTION 2: How would you evaluate the accuracy of your registration?

Code: The codes are illustrated in Figure 5-7.

```
from skimage.metrics import mean_squared_error

mse_value_original = mean_squared_error(img_vis, img_cfp_gray)
mse_value_transformed = mean_squared_error(img_vis, warped_image_gray)
print(f"original Mean Squared Error(MSE): {mse_value_original:.4f}\n"
      f"transformed Mean Squared Error(MSE): {mse_value_transformed:.4f}")
```

Figure 5

```
from skimage.metrics import structural_similarity as ssim

ssim_value_transformed, _ = ssim(img_vis, warped_image_gray, full=True,
data_range=1)
print(f"{ssim_value_transformed:.4f}")
```

Figure 6

```
from skimage.metrics import peak_signal_noise_ratio as psnr

psnr_value = psnr(img_vis, warped_image_gray, data_range=1)
print(f"{psnr_value:.4f}")
```

Figure 7

Result: The results are illustrated in Table 1.

	Three control points	Six control points
Mean Squared Error (MSE)	0.3468	0.3824
Structural Similarity Index Measure (SSIM)	0.1823	0.1442
Peak Signal-to-Noise Ratio (PSNR)	4.5987	4.1743

Table 1

Answer: From a visual inspection, the registration accuracy appears to improve significantly after adding three additional control points. To objectively evaluate the accuracy of this registration, I applied three metrics from the "skimage.metrics" module: Mean Squared Error (MSE), Structural Similarity Index Measure (SSIM), and Peak Signal-to-Noise Ratio (PSNR). Generally, a lower MSE and a higher PSNR or SSIM value indicate better alignment between images. Surprisingly, however, the results in Table 1 show an opposite trend. After adding three control points, the values suggest a worse registration outcome: MSE increased, SSIM decreased, and PSNR dropped slightly, contrary to the visual impression of improved alignment.

Upon further analysis, I suspect this discrepancy may be due to differences in the grayscale intensity distributions of the original and transformed images. With more control points, more pixels overlap, and thus the local variations and subtle differences between the images become more pronounced, leading to larger metric discrepancies in MSE, SSIM, and PSNR.

This unexpected outcome raises questions about the reliability of these metrics in capturing perceived visual improvements. I am keen to discuss this with our module tutor or lecturer to better understand why these metrics contradict the visual assessment and explore potential solutions.