CS172 Assignment 2: Image Registration

ShanghaiTech University 2024 Fall Computer Vision I

This assignment is due on Dec.15 2024 at 11.59 pm

For all assignments this semester, you have a total of 7 slip days. However, you can only use up to 4 slip days for a single assignment. If you need additional time due to unforeseen circumstances, please email the TA (wangwq2023@shanghaitech.edu.cn) for approval. If you submit late without a valid reason, we will deduct some points accordingly.

🚨 Plagiarism Warning

This is an individual assignment. **Plagiarism is strictly prohibited** . Any form of copying or uncredited code-sharing will be treated as an academic violation. The code you submit must be **entirely your own**. You are encouraged to discuss concepts with your peers, but you must write the code yourself. Submissions will be checked for plagiarism using automated tools.

Consequences of plagiarism may include:

- Receiving zero points for this assignment.
- Facing further disciplinary actions as per your institution's academic policies.

📘 Introduction

Image registration is the process of aligning corresponding points on two or more images. These images can be taken at different times, or they may come from different sensors, perspectives, scales, and so on. Image registration has widespread applications in fields such as medical imaging, remote sensing, machine vision, and computer vision.

In this assignment, you will accomplish two different task of image registration, image stitching and deformable image registration.

❗ Note

Learning to organize your code independently is also a crucial skill. Therefore, for this assignment, we will only inform you of the objectives that need to be achieved, without providing a specific code framework. Everything will be left for you to decide on your own.

📝 Part 1: Image Stitching

In this part, you are required to take some photos within the campus and stitch these photos together to create a panoramic picture.

Step 1: Take images

You are required to create two panoramic images, each one composed of three photos stitched together, therefore, you will need to take a total of six photos across two different scenes within the campus.

Step 2: Calculate correspondences

Calculate correspondences between two images using LightGlue, which is a lightweight feature matcher published in ICCV 2023.

Note that you are not required to train LightGlue by yourself, you can directly use the pretrained model provided in the GitHub repository.

Step 3: Calculate homography

Using the correspondences obtained in the previous step, calculate the homography between two images.

Step 4: Image warping and stitching

Utilize the homography matrix obtained in the previous step to warp the images and then stitch the wrapped images together. In practice, this step may involve a lot of optimization processing to make the stitched image look better. However, for the simplicity of the assignment, you only need to use the average value of the pixels for the overlapping parts.

Note that the result of stitching might not necessarily be a rectangle. To make it into a rectangular image, the parts without pixels can simply be set to black. Additionally, when warping an image, the resulting pixel coordinates are often not integers, hence interpolation is necessary.

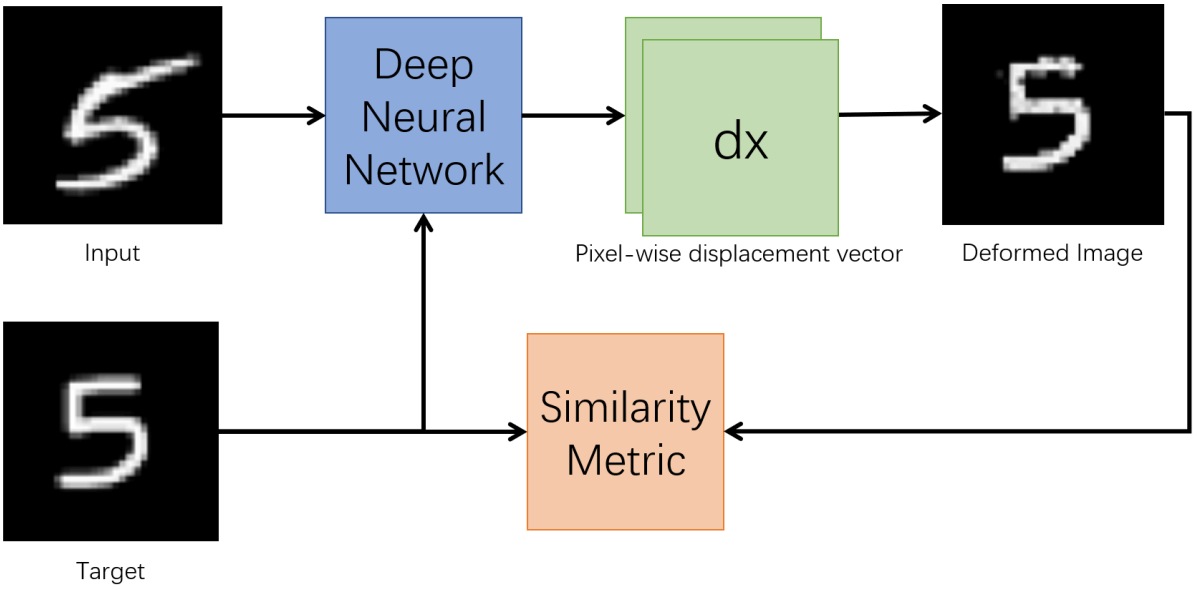
📝 Part 2: Deformable Image Registration

In the first part of this assignment, you utilized homography matrices to perform image stitching. While this method works well for images taken from the same scene with planar surfaces or relatively small perspective changes, it has its limitations. Homography transformation assumes a planar scene and cannot effectively handle more complex scenarios involving non-rigid deformations, such as those encountered with biomedical images, or objects that have undergone significant rotation, scaling, or shape changes. Therefore, in the second part of this assignment, you will explore Deformable Image Registration, an advanced technique capable of aligning

images that have undergone complex transformations or deformations. This method will allow you to accurately register images even when they exhibit significant non-rigid transformations.

Although deformable image registration is often applied in the biomedical field, for the sake of simplicity, in this part you will use the MNIST handwritten digits dataset to perform deformable image registration on handwritten digits.

The pipeline of method you need to implemented is shown as below. All the details (e.g. network architecture, loss function) are leave for you to decide on your own.



Hint: The pixel-wise displacement vector predicted by deep neural network may not lead to a valid position, so interpolation is necessary as that in image stitching. However, since you are training a neural network, the whole process need to be differentiable, which is required by the back propagation of gradient. You may find the function `torch.nn.functional.grid_sample()` helpful. For the detail, you can read Spatial Transformer Networks.

Submission

Please submit the following files :

- A report in `pdf` format to **BlackBoard**. The template of report is available on **BlackBoard**.
- Submit a `zip` file (`ChineseName-StudentID.zip`) of your entire project directory (**Without dataset and mode weights !!!**) to ShanghaiTech EPAN. There should be a README about how to reproduce your result with your code.

Repeat!

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Good luck, and have fun with the assignment!