NTU 2021 Spring Final Project Report

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A. Paper Title

Rectangling Panoramic Images via Warping

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B. Motivation

Because the limitation of digital camera, a digital image can only have a limited field of view(FOV) and less description of the scene even than human eyes. We are interested about how to make the scene more descriptive, for example, panorama. In addition, a panorama can be used to be a surrounding background in a 3D scene. Consequently, we want to research how to stitch images to get a panoramas and optimize the result by rectangling panoramic images via warping.

C. Problem Definition

1. How to find the feature points of an image and stitch those images according to these feature points.
2. Because the fluctuations of the camera when taking photos and

there may be some errors when matching the feature points, we often can't directly get a perfect rectangular result, however, we always desire our images to be rectangular.

3. Cropping the images to the maximum rectangle will lose a lot of information. We need to find a better method to warp the image to a rectangle region appropriately without visible distortions by human eyes.

D. Algorithm

Part 1. Stitching

1 Find the feature points of all input images.
   1.1 If distance < threshold: good key points
   1.2 Good key points -> pair
2 Match the feature points of two consecutive images and merge them all into a big panorama by OpenCV SIFT package.
   2.1 Draw a line between them
   2.2 Match the key point pair

3 Run RANSEC algorithm to eliminate detecting errors of SIFT. Calculate the offset and stitch the image by alpha blending.

Part 2. Local warping

Seam Carving Algorithm

1 Finding the longest seam at the image border. In our example, we only need to consider horizontal seam.

2 Calculate the energy map of the picture, and then find a path of minimum sum of energy by dynamic programming. Because this path may not go through the whole image, this seam is so called "partial seam".

3 Clone the image pixel along partial seam. Repeat this procedure until

the image is seamless.

Part 3. Global warping

1 Draw meshes and warp it back to the original image.
  1.1 Use lsd file on github
    1.1.1 Line Segment Detector
    1.1.2 https://github.com/theWorldCreator/LSD
2 **energy function**:

$$\mathrm{E}(\mathrm{v},\{\theta_{\mathrm{m}}\}) = E_s(V) + \lambda_L E_L(\mathrm{V},\{\theta_{\mathrm{m}}\}) + \lambda_B E_B(V)$$

3 shape preservation

  3.1 將網格座標代入矩陣，進行一些矩陣計算

    3.1.1 pseudoinverse

    3.1.2 一次微分（$\frac{d(x^T A)}{dx} = A$，$\frac{d(Ax)}{d(x^T)} = A$）

    3.1.3 二次微分（$\frac{d(x^T Ax)}{dx} = (A + A^T)x$）

4 line preservation: detect line segment (LSD)
5 boundary constraints

  5.1 用 cvxopt (convex optimization 之 package) 限制邊界點的移動方向

$$\begin{aligned} \min_x \quad & \tfrac{1}{2}x^\top Px + q^\top x \\ \text{subject to} \quad & Gx \preceq h \\ & Ax = b \end{aligned}$$

  5.2
6 **alternating algorithm**:

$$\min_{\theta_m} \sum_{j \in bin(m)} \left\| C_j(\theta_m e_{q(j)} \right\|^2$$

7 fix theta and update V: 根據 cvxopt 和矩陣微分，來求更新後的網格座標

8 fix V and update theta:

8.1 將 theta 量化成 50 個角度

8.2 計算 warping 前後，直線之旋轉角度：bilinear quadrilateral interpolation

9 repeat 大約 7 次

10 最終將圖片大小 rescale

E. Expected Results

Image 1: Campus

After stitching: sift_campus.png

After local warping: seg_campus.png

After global warping: ./result_campus/result.png

Image 2: Garden

After stitching: sift_garden.png

After local warping: seg_garden.png

After global warping: ./result_garden/result.png

Image 3: Grail

After stitching: sift_grail.png

After local warping: seg_grail.png

After global warping: ./result_grail/result.png

F. Discussion

1 執行時間稍長

1.1 stitching: 3 min
1.2 local warping: 10 ~ 15 min
1.3 global warping: 10 ~ 15 min

2 global warping 的部份，論文的一些細節沒寫清楚，參數的選擇很多，且結果好壞有點主觀，沒找到一項標準來選擇好的參數。

3 有時候 global warping 反而扭曲了部分原本正常的區域

G. References

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LSD - Line Segment Detector

https://github.com/theWorldCreator/LSD

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常用矩陣微分公式
https://www.itread01.com/content/1549269003.html

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