網媒所碩一　薛博文　R11944005

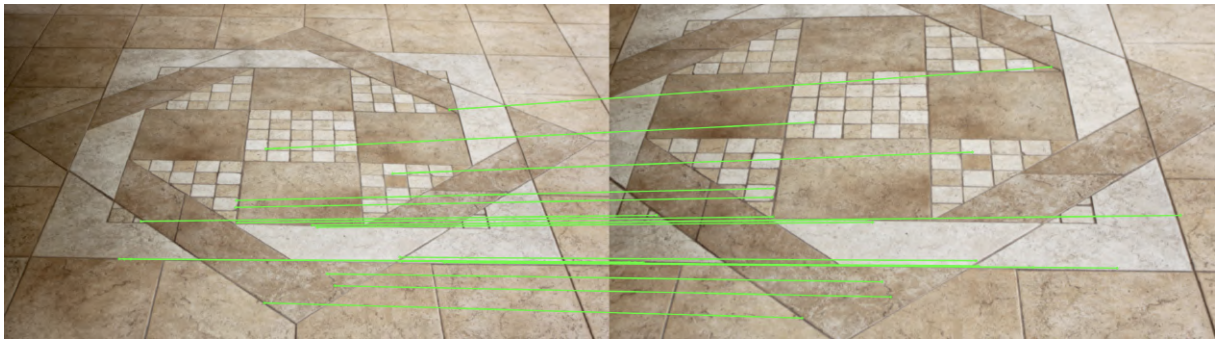
Problem 1: Homography Estimation

1. Sample k Correspondences

Image Pair 1 - Result

(a) keypoint sample, k=4

(b) keypoint sample, k=8

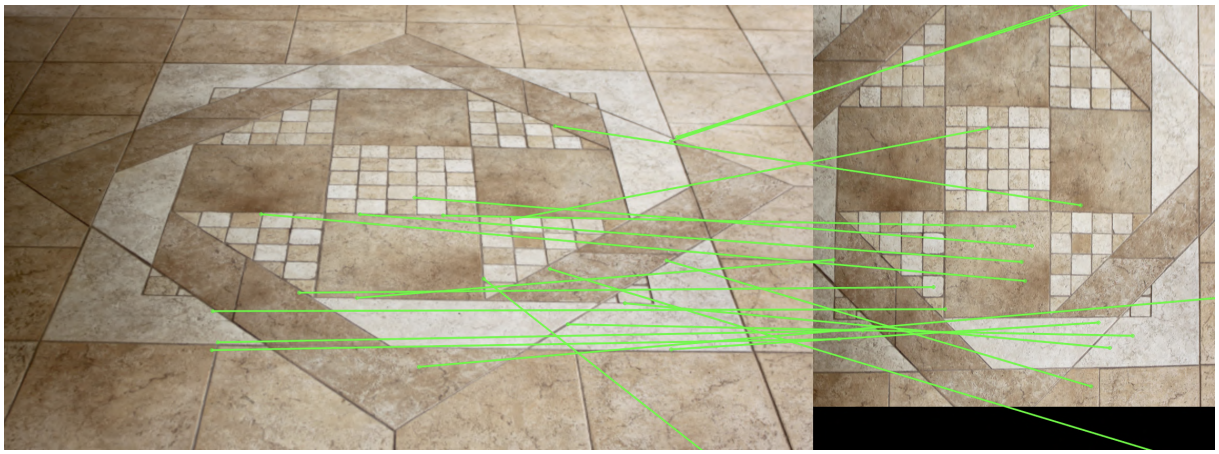


(c) keypoint sample, k=20

Image Pair 2 - Result

(a) keypoint sample, k=4

(b) keypoint sample, k=8

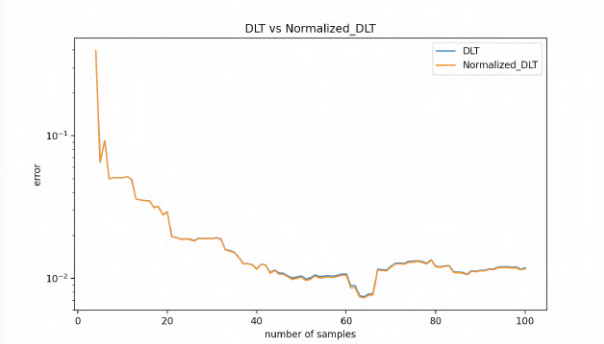


(c) keypoint sample, k=20

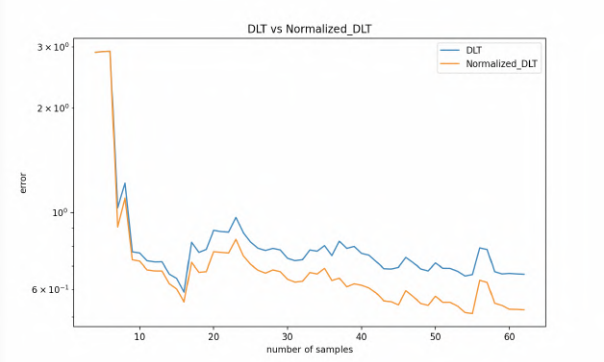
2. Methodology

1. Feature selection
    - Use SIFT to find the local features.
    - Use BFMatcher to find the correspondences.
2. Remove the outliers
    - Ratio test: Remove the the keypoints that greater than 0.75.
    - Random sample consensus(RANSAC): Use linear regressor to further remove the outliers. In the following section, we will see that RANSAC dramatically decrease the error.
3. Homography estimation
    - Direct linear transform(DLT): DLT is used to calculate the transformation matrix H.
    - Normalized DLT: Normalize the keypoints (translate + scale) can be helpful in the derivation of the transformation matrix H.
4. Find the reprojection error
    - Use groundtruth data to calculate the error(2-norm MSE).

3. Comparison between DLT and Normalized-DLT methods



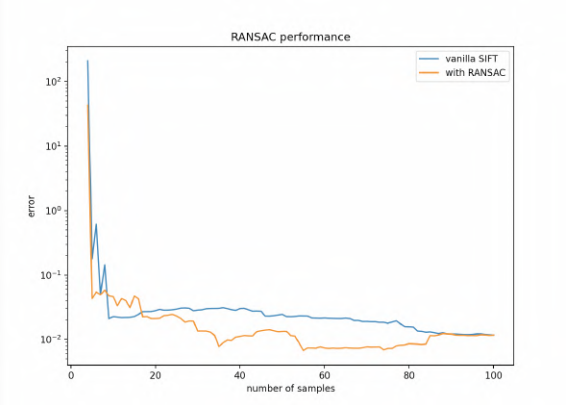
(a) Image pair 1



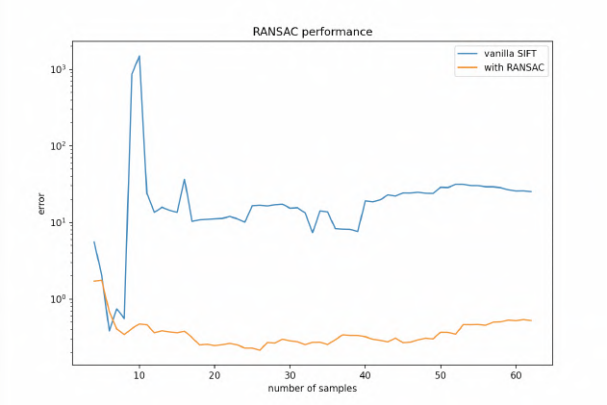
(b) Image pair 2

- As we can see, DLT method is almost as good as Normalized-DLT in the first image pair. However, normalized-DLT method is way better than DLT in the second pair images which is hugely different in the perspective.
- Visualization plots are shown as above in the log scale.

4. BONUS method: Random sample consensus(RANSAC)



(a) Image pair 1



(b) Image pair 2

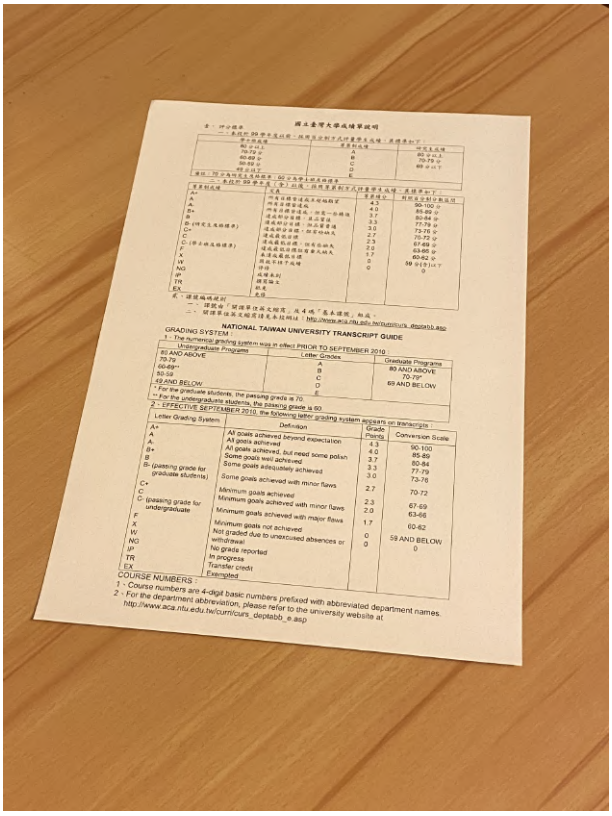
- We can manually remove some outliers or choose some points that is easy for the feature detector to predict correspondences. However, the result(error) is still not good enough by doing that. To further improve the performance, I use RANSAC with a linear regressor to remove the outliers.
- As we can see, RANSAC can dramatically decrease the error(error < 10 for k $= 4$, error < 1 for k > 4) , especially in the second image pair which outliers presents frequently.
- Visualization plots are shown as above in the log scale.

5. Further Discussion

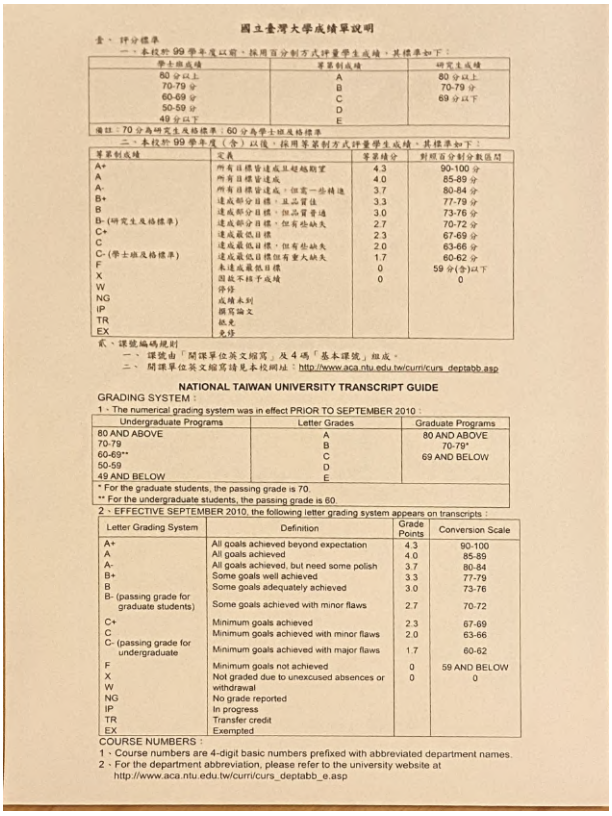
- As we see in the previous paragraph, DLT+SIFT can obtain good result for the application that perspective of two images is close enough(e.g. Image pair 1). The result converges easy by choosing more keypoints.
- On the other hand, if the perspective is hugely different(e.g. Image pair 2), technique like RANSAC can be very helpful. Remove the outlier not only improve the performance directly, it also makes Normalized-DLT more robust. Since outlier can be harmful to the process of normalization. (Normalization is useless if there are many outliers.)

Problem 2: Document rectification

1. Result



(a) source image



國立臺灣大學成績單說明

壹、評分標準

一、本校於 99 學年度以前，採用百分制方式評量學生成績，其標準如下：

學士班成績	等第制成績	研究生成績
80 分以上	A	80 分以上
70-79 分	B	70-79 分
60-69 分	C	69 分以下
50-59 分	D	
49 分以下	E	

備註：70 分為研究生及格標準；60 分為學士班及格標準

二、本校於 99 學年度（含）以後，採用等第制方式評量學生成績，其標準如下：

等第制成績	定義	等第積分	對照百分制分數區間
A+	所有目標皆達成且超越期望	4.3	90-100 分
A	所有目標皆達成	4.0	85-89 分
A-	所有目標皆達成，但需一些精進	3.7	80-84 分
B+	達成部分目標，且品質佳	3.3	77-79 分
B	達成部分目標，但品質普通	3.0	73-76 分
B-(研究生及格標準)	達成部分目標，但有些缺失	2.7	70-72 分
C+	達成最低目標	2.3	67-69 分
C	達成最低目標，但有些缺失	2.0	63-66 分
C-(學士班及格標準)	達成最低目標但有重大缺失	1.7	60-62 分
F	未達成最低目標	0	59 分(含)以下
X	因故不核予成績	0	0
W	停修		
NG	成績未到		
IP	撰寫論文		
TR	缺席		
EX	免修		

貳、課號編碼規則

一、課號由「開課單位英文縮寫」及 4 碼「基本課號」組成。

二、開課單位英文縮寫請見本校網址：http://www.aca.ntu.edu.tw/curri/curs_deptabb.asp

NATIONAL TAIWAN UNIVERSITY TRANSCRIPT GUIDE

GRADING SYSTEM：

1、The numerical grading system was in effect PRIOR TO SEPTEMBER 2010：

Undergraduate Programs	Letter Grades	Graduate Programs
80 AND ABOVE	A	80 AND ABOVE
70-79	B	70-79*
60-69**	C	69 AND BELOW
50-59	D	
49 AND BELOW	E	

* For the graduate students, the passing grade is 70.
** For the undergraduate students, the passing grade is 60.

2、EFFECTIVE SEPTEMBER 2010, the following letter grading system appears on transcripts：

Letter Grading System	Definition	Grade Points	Conversion Scale
A+	All goals achieved beyond expectation	4.3	90-100
A	All goals achieved	4.0	85-89
A-	All goals achieved, but need some polish	3.7	80-84
B+	Some goals well achieved	3.3	77-79
B	Some goals adequately achieved	3.0	73-76
B- (passing grade for graduate students)	Some goals achieved with minor flaws	2.7	70-72
C+	Minimum goals achieved	2.3	67-69
C	Minimum goals achieved with minor flaws	2.0	63-66
C- (passing grade for undergraduate	Minimum goals achieved with major flaws	1.7	60-62
F	Minimum goals not achieved	0	59 AND BELOW
X	Not graded due to unexcused absences or withdrawal	0	0
W	No grade reported		
NG	In progress		
IP	Transfer credit		
TR	Exempted		
EX			

COURSE NUMBERS：

1、Course numbers are 4-digit basic numbers prefixed with abbreviated department names.

2、For the department abbreviation, please refer to the university website at http://www.aca.ntu.edu.tw/curri/curs_deptabb_e.asp

(b) output image

2. Methodology

1. Preprocess the image: gray, blur etc.
2. Use Canny edge detector to find the edges.
3. Use dilate, erode to minimize the noise.
4. Find the contour of the input image.
5. Find the corners of the input image.
6. Correspond the corners of the input image to the corners of result image.
7. Find the homography. (In the same way as problem1)
8. Transform the image, and do bilinear interpolation.

3. How to Run the code

1. For problem 1, use the following line to execute the code.
   python 1.py images/1-0.png images/1-2.png groundtruth_correspondences/correspondence_02.npy
2. For problem 2, use 'python 2.py' to execute the code, the program will automatically choose 4-corners and the output will present in the folder with the name tmp.jpg.
3. Environment

```
python==3.7
numpy==1.19.5
opencv_python==4.6.0.66
scikit_image==0.15.0
skimage==0.0
```

4. Other people's contribution

1. Thanks to classmate 信承 to give me the idea that draw the matching points to visualize the correspondence. That helps me a lot in choosing good matching points.
2. Thanks to friend(not in this class) 雅晴 to give me the idea on how to find the corner of image.