Matching algorithm with CP-decomposition

Geonwoo Ban

Pusan National University
Department of Statistics

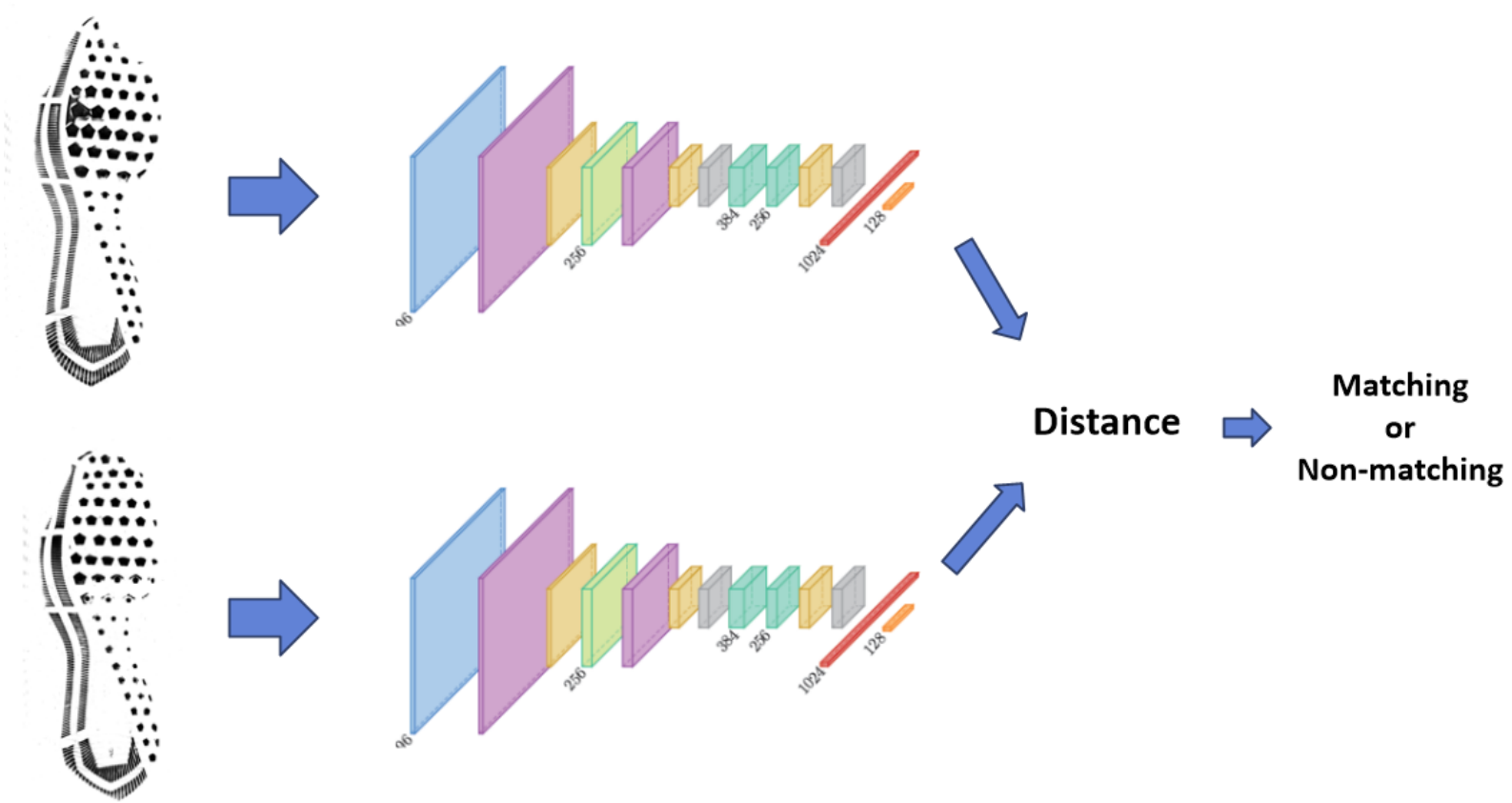
2022-05-19

List

- Image matching
  - Matching algorithm
- CP-decomposition
  - Footprint image decomposition
  - Restored footprint image
- Experiment
  - Rank 1 CP-decomposition
  - CP-decomposition matching algorithm
  - Compare with descriptor method

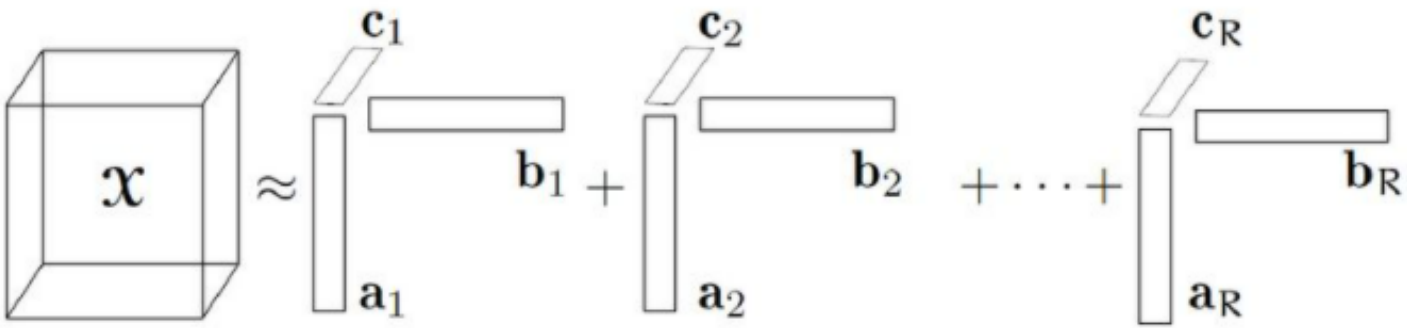
Image matching

Matching algorithm with deep learning



CP-decomposition

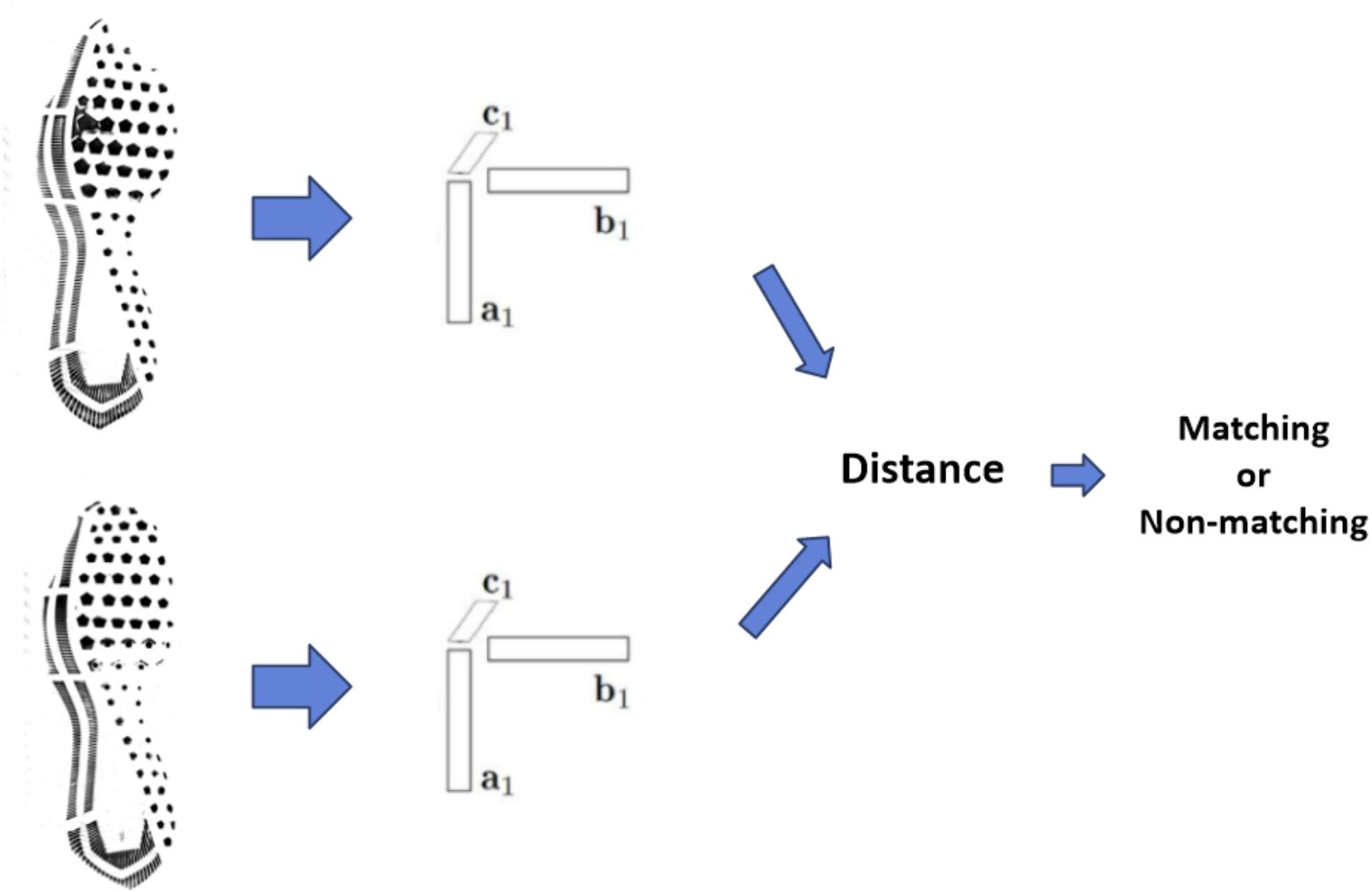
Basic concept



$$x_{ijk} \approx \sum_{r=1}^{R} a_{ir} b_{jr} c_{kr}$$

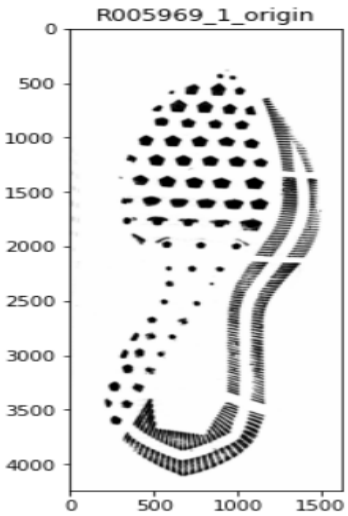
CP-decomposition

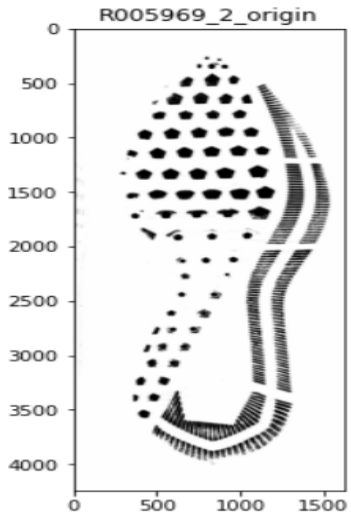
Footprint image decomposition

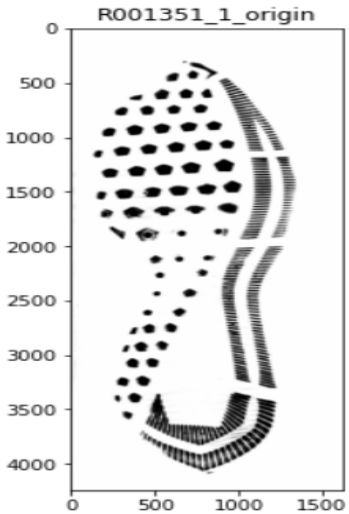


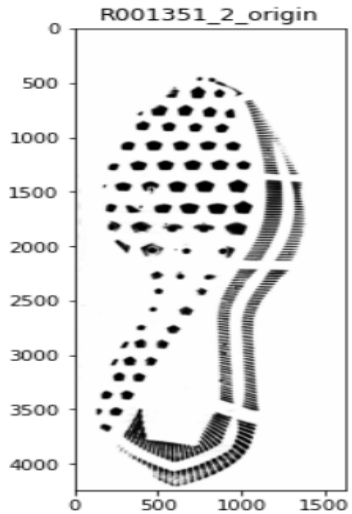
Restored footprint image

Original



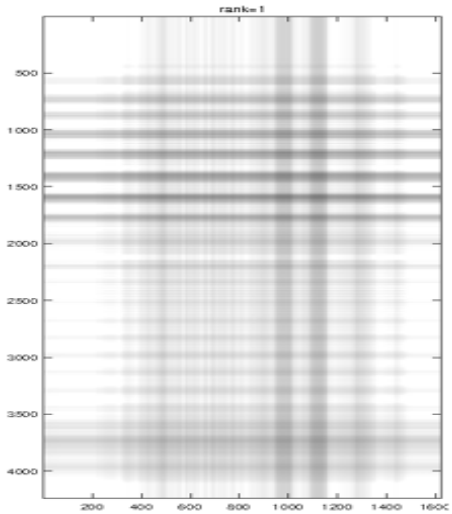


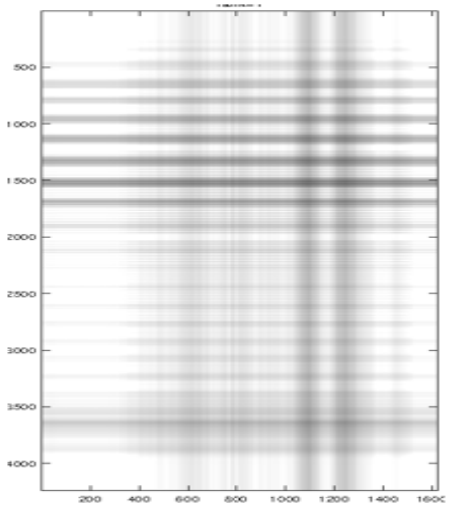


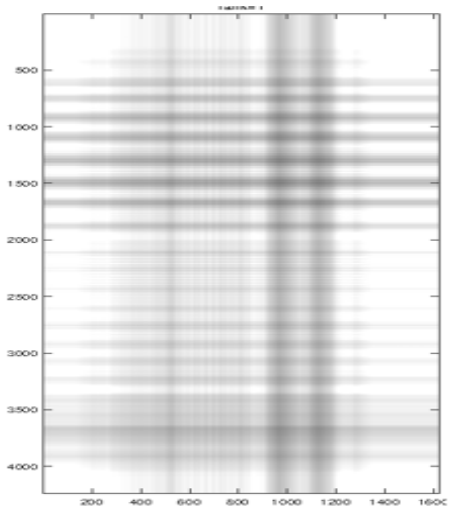


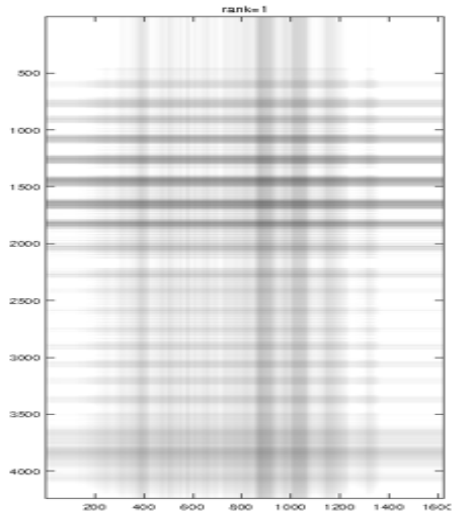
Restored footprint image

Rank 1



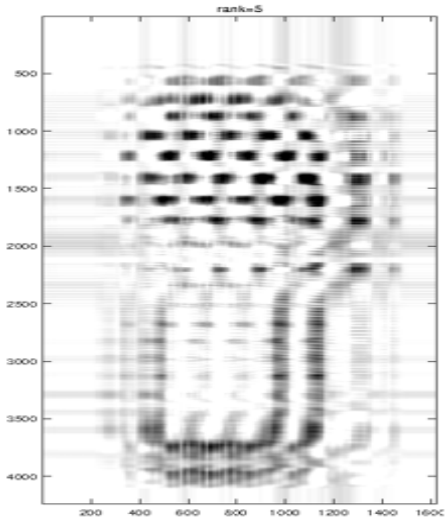


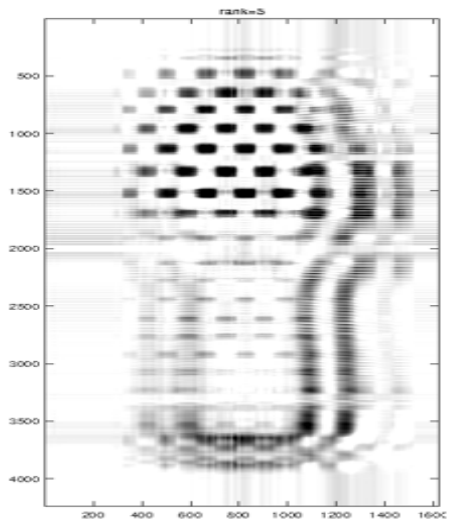


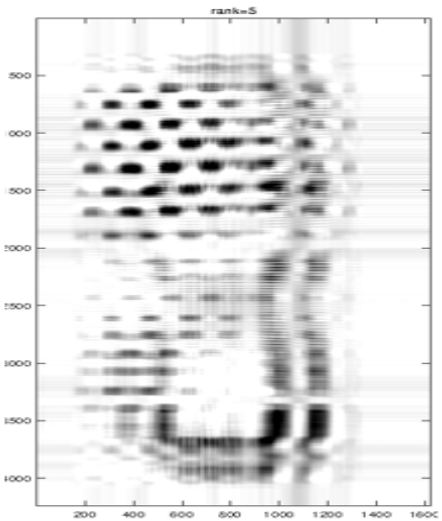


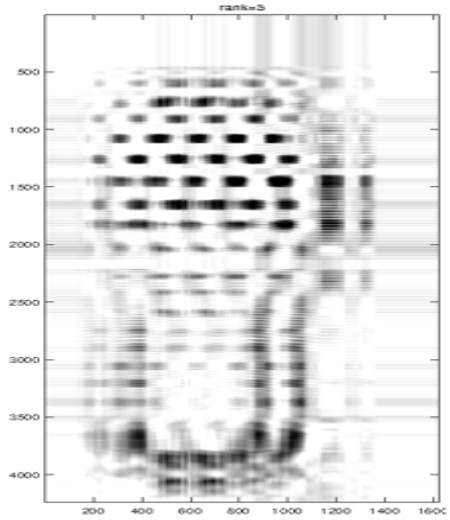
Restored footprint image

Rank 5



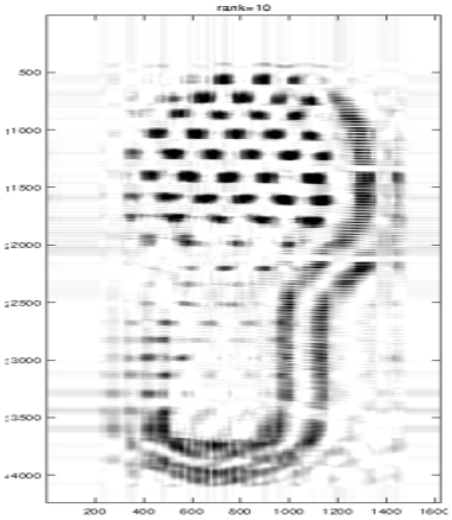


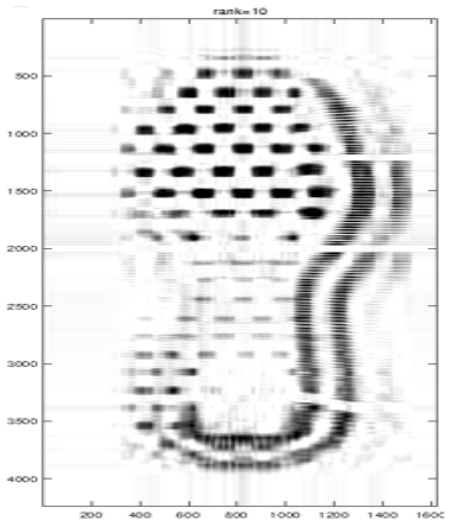


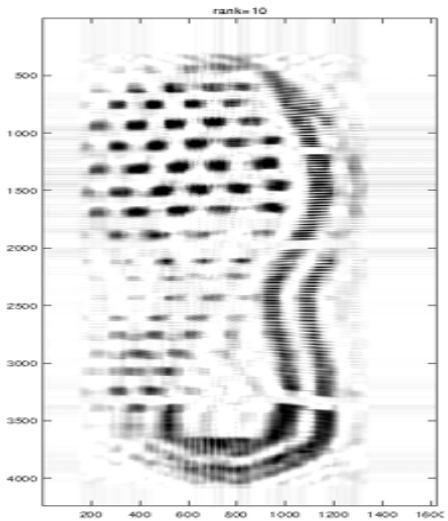


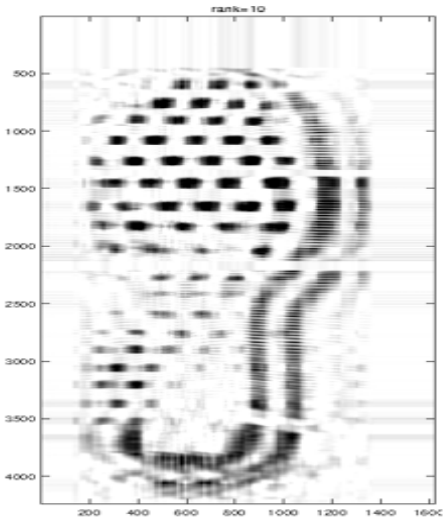
Restored footprint image

Rank 10



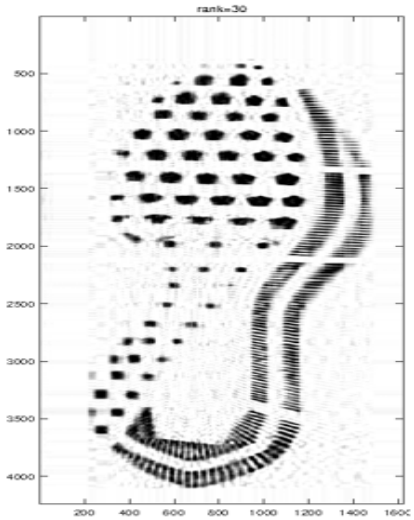


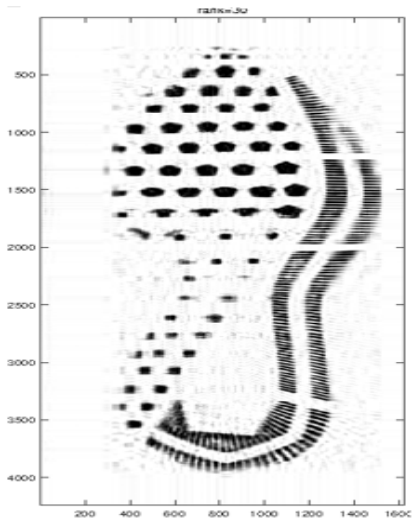


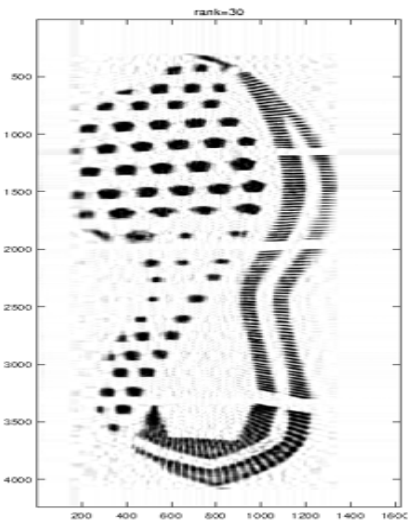


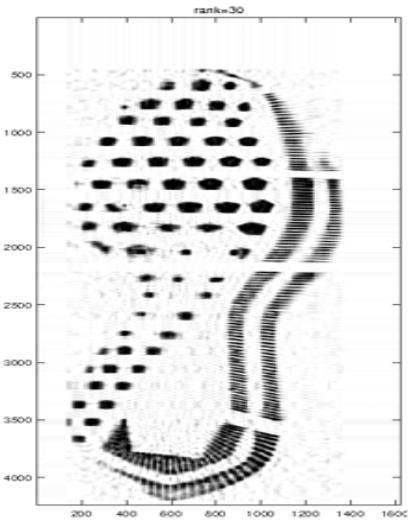
Restored footprint image

Rank 30









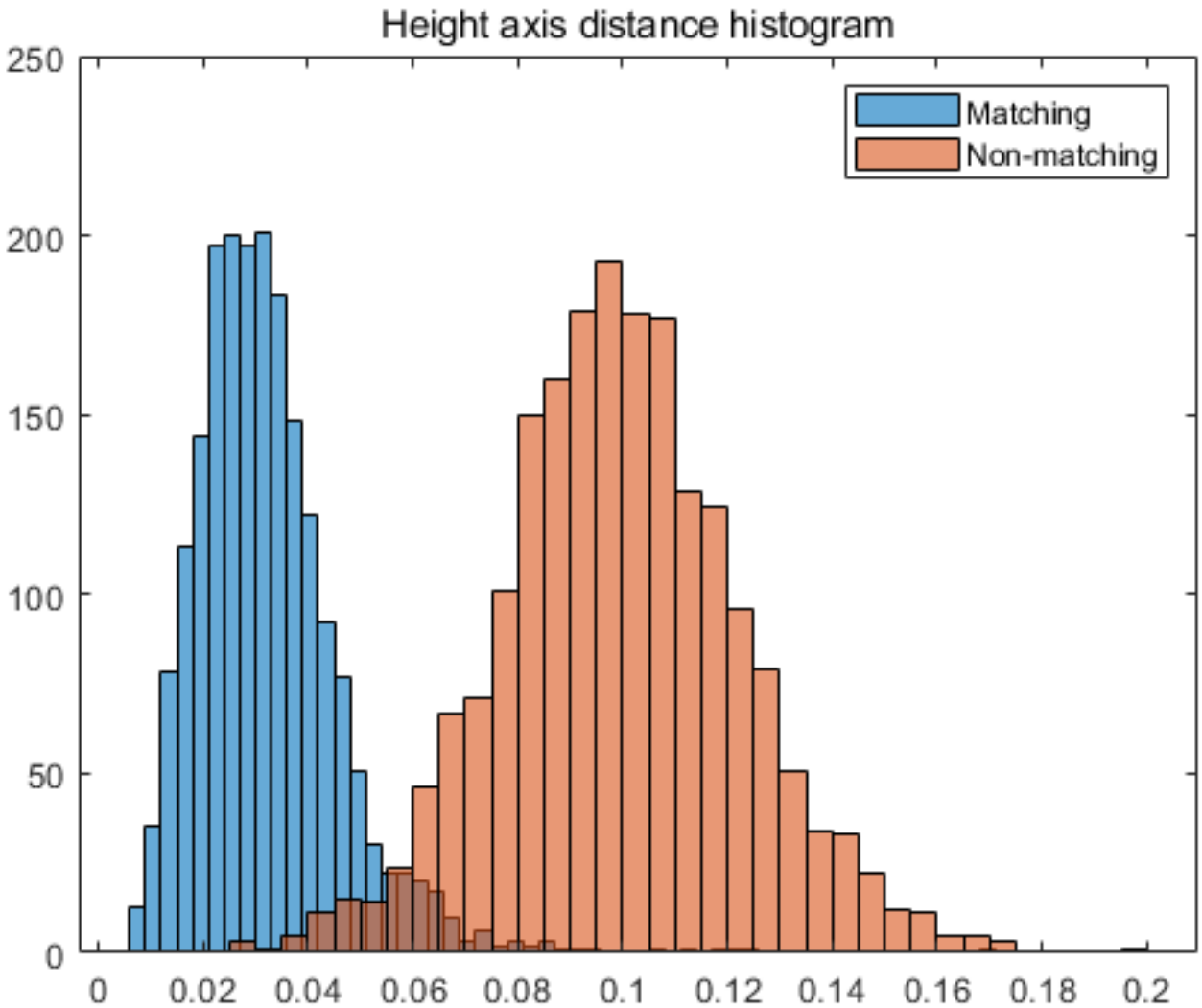
Experiment

Data

- Everspry footprint data
- 2,000 matching pairs vs 2,000 non-matching pairs
- Alignment $\rightarrow$ check
- Resized to 224×224
- Rank 1 CP-decomposition
- Image $\rightarrow$ 3 vectors
  - a1 : Height vector
  - b1 : Width vector
  - c1 : color vector
- Distance(L2-norm)
  - d1 : L2-norm of a1 vectors
  - d2 : L2-norm of b1 vectors
  - d3 : L2-norm of c1 vectors
  - TW : Sum of d1, d2 and d3

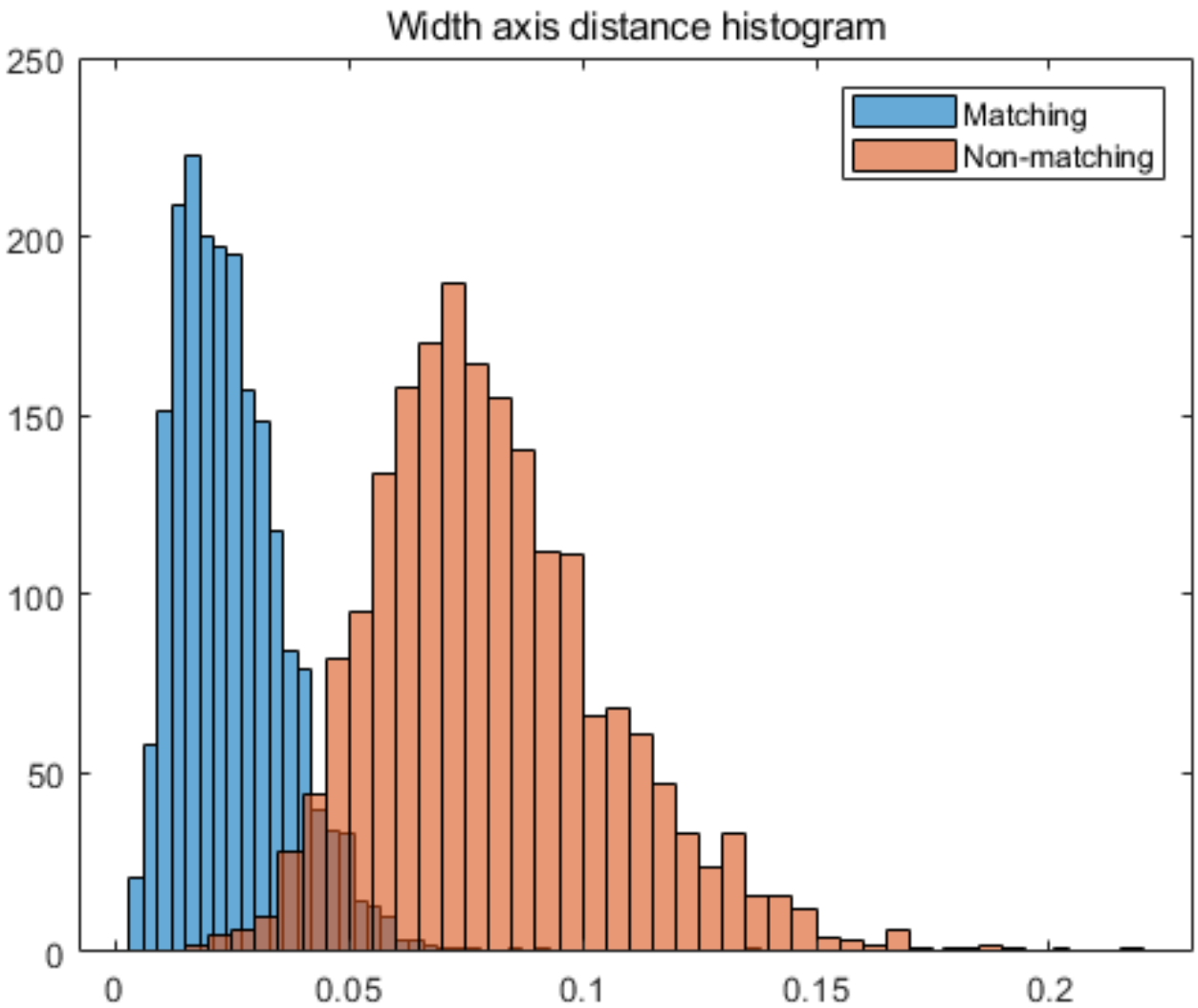
Experiment

Histogram(d1)



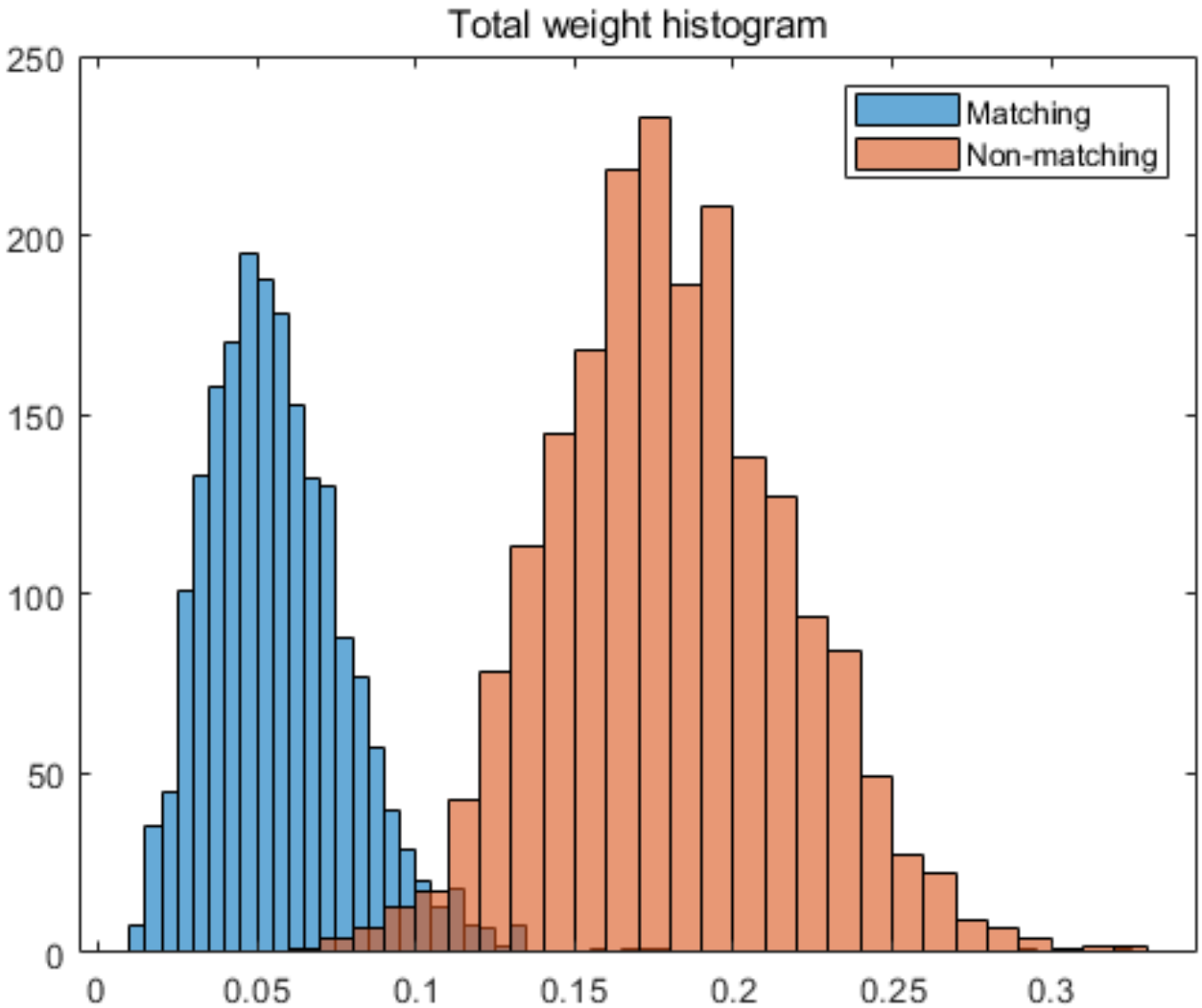
Experiment

Histogram(d2)



Experiment

Histogram(TW)



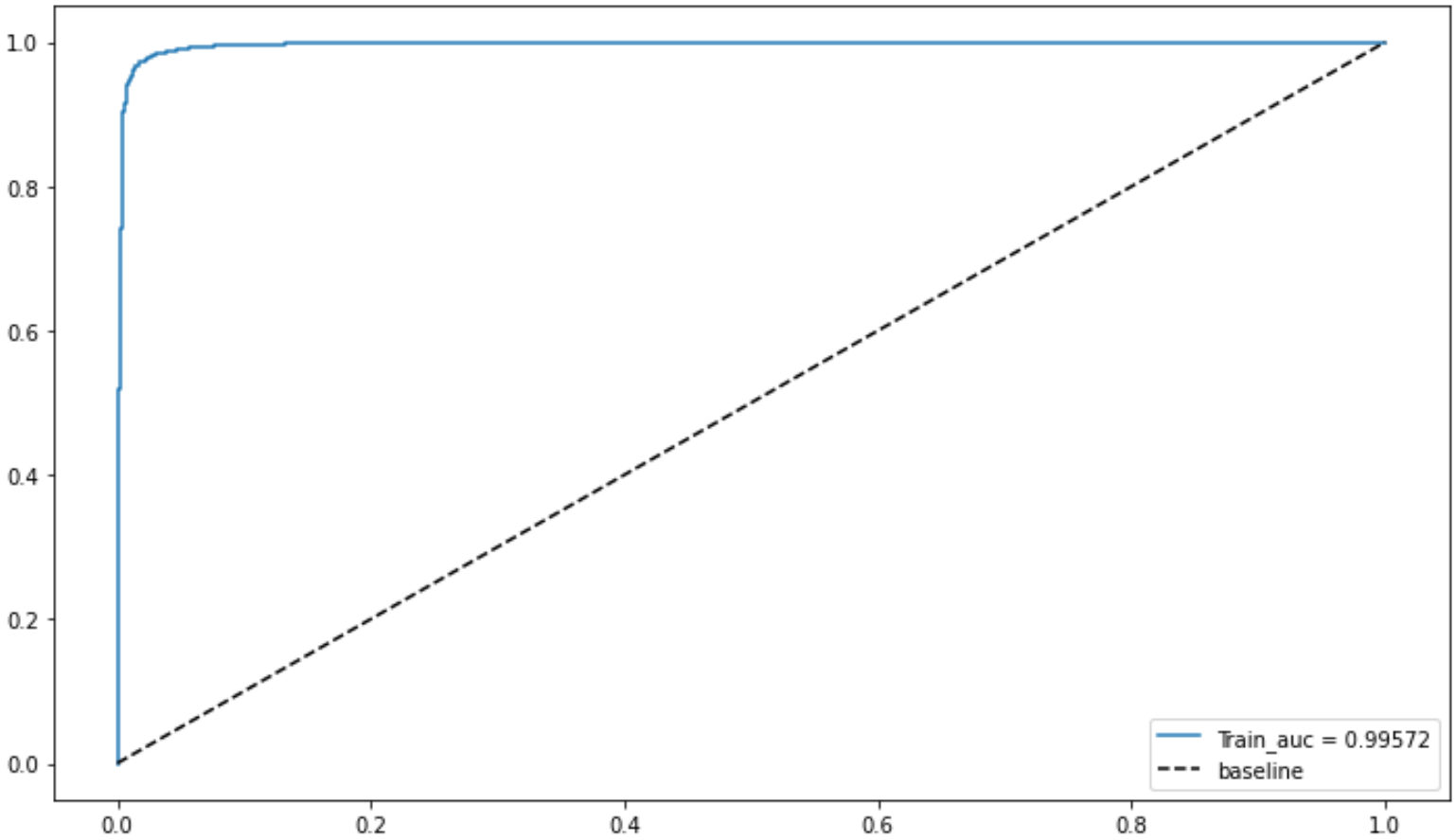
Experiment

The optimal point

- Measurement for classification $\rightarrow$ **TW**
- Find the optimal point for classification

Experiment

Left upper = the optimal point



Experiment

Ways

1. maximize $(TPR - FPR)$
2. maximize $(TPR + TNR)$
3. $TPR + FPR \simeq 1$

Chosen ways

1. maximize$(TPR + TNR)$

$\because FPR = 1 - TNR \rightarrow$ way 1 = way 2

2. $TPR + FPR \simeq 1$

Experiment

Process

Input : norm of decomposed vector pair

- step 1) Min-max scaling with the **train set** to plot ROC curve.
- step 2) Find two candidate cut-off points on ROC curve.
  - 1) maximize($TPR + TNR$)
  - 2) $TPR + FPR \simeq 1$
- step 3) Choose the better point to use the **validation set** with classification measures.
  - 1) Accuracy $= \frac{TP+TN}{TP+FP+TN+FN}$
  - 2) Recall $= \frac{TP}{TP+FN}$
  - 3) Specificity $= \frac{TN}{TN+FP}$
- step4) Calculate general performance with the **test set**.

Experiment

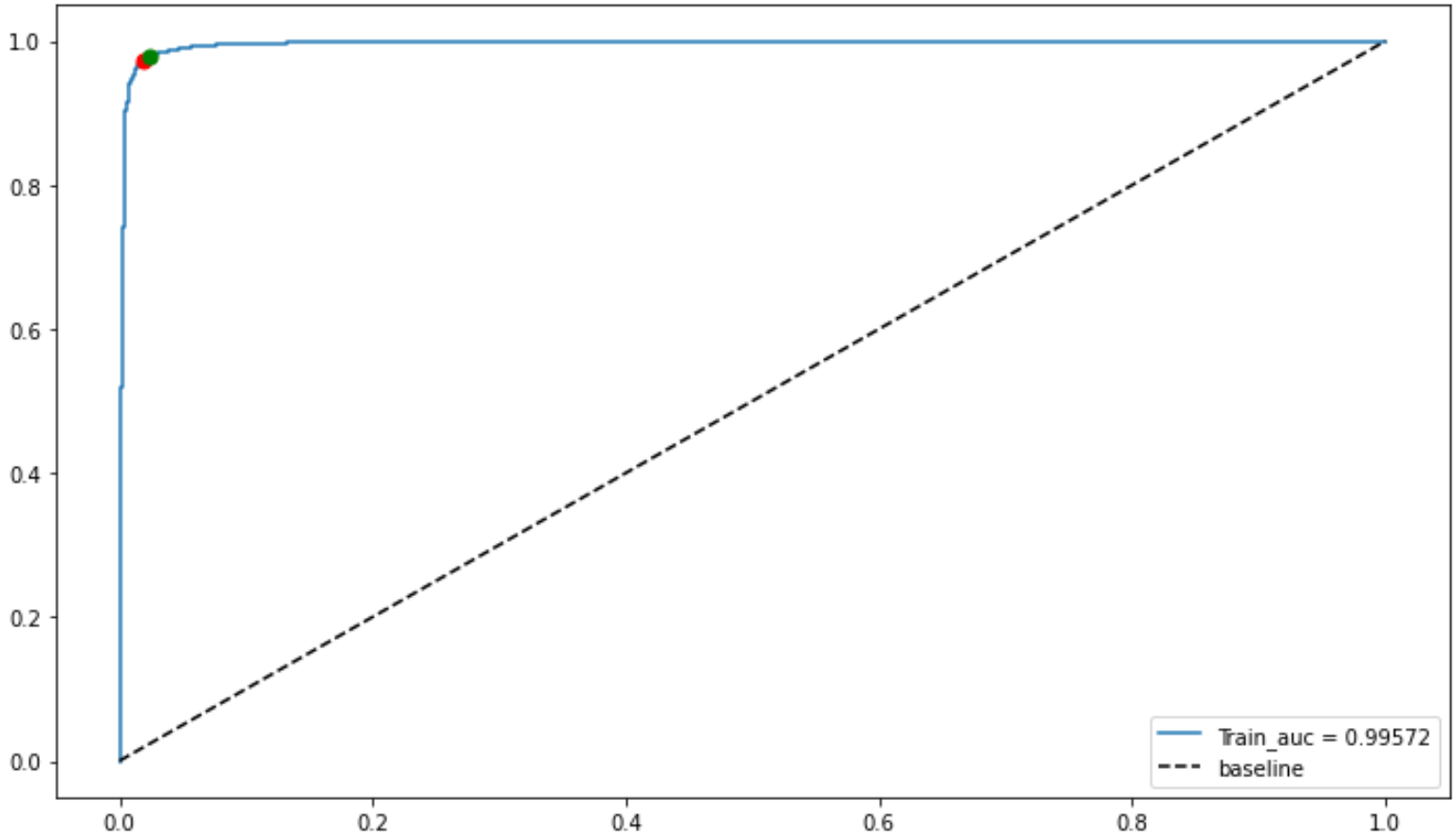
step1

	d1	d2	norm	label
0	0.042624	0.021934	0.064558	0
1	0.028146	0.027882	0.056029	0
2	0.024677	0.014908	0.039585	0
3	0.039464	0.023737	0.063201	0
4	0.023993	0.021579	0.045571	0
...	...	...	...	...
3995	0.046316	0.051611	0.097927	1
3996	0.085854	0.054567	0.140421	1
3997	0.055624	0.058244	0.113868	1
3998	0.104781	0.096818	0.201599	1
3999	0.061951	0.085333	0.147285	1

0	0.081303
1	0.155488
2	0.054586
3	0.163227
4	0.067733
	...
3995	0.345240
3996	0.706195
3997	0.757723
3998	0.409596
3999	0.452294

Experiment

step2



- method1(red) : 0.1127, method2(green) : 0.1107

Experiment

step3

Validation	Accuracy	Recall	Specificity
Method1	0.9765	0.9765	0.9705
Method2	**0.9773**	**0.9805**	**0.9740**

Experiment

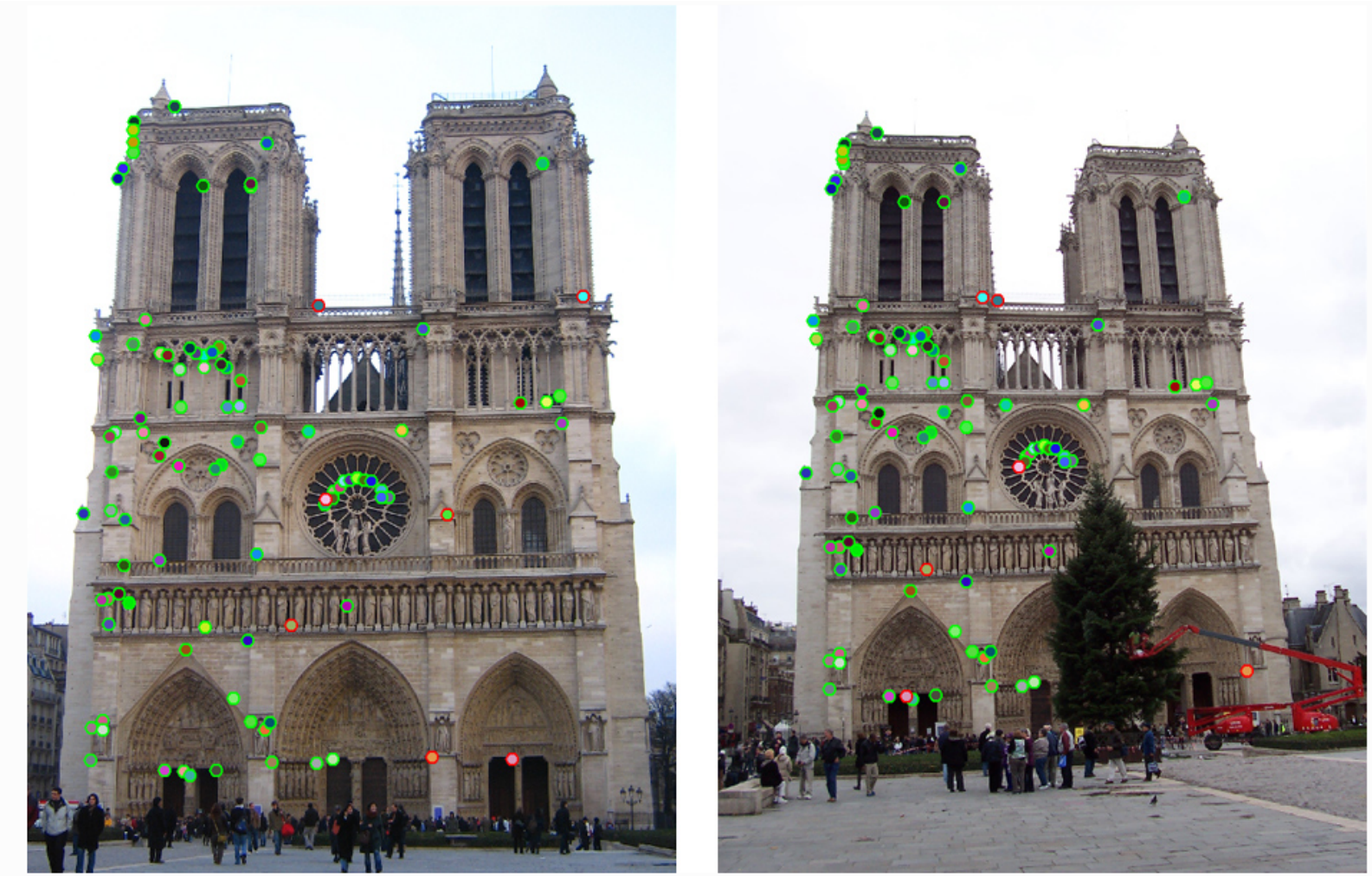
step4

Test	Accuracy	Recall	Specificity
Method2	0.9735	0.9765	0.974

Experiment

Comparison method

- Use image descriptors(Harris, SURF, SIFT, BRISK, ORB and FAST)



Experiment

Descriptor dataset

	SURF_Location	SURF_Feature	SIFT_Location	SIFT_Feature	BRISK_Location	BRISK_Feature	FAST_Location	FAST_Feature
0	118.14190	1.866757	702.8141	5987.205	145.58560	634.982327	604.3364	691.003654
1	293.39580	2.571002	493.1164	5198.918	315.41560	776.806158	431.0917	636.572622
2	394.15090	3.480249	568.0880	6089.463	116.18280	640.419124	642.0845	592.685139
3	436.86560	7.279379	1143.9950	8378.478	381.02250	627.591131	495.3411	769.329759
4	331.90300	3.121050	1202.7280	5843.481	382.48290	786.034772	330.9722	664.069473
...	...	...	...	...	...	...	...	...
3995	1044.39300	3.581189	1397.8900	8864.790	417.06220	598.587447	316.4314	645.091262
3996	715.76900	6.845936	966.9949	7136.091	548.60520	736.468216	812.0153	826.091037
3997	262.30190	3.313372	514.8018	5263.430	87.87259	550.433351	319.5481	725.317340
3998	522.48550	3.917512	1813.5840	7530.857	554.12220	761.749788	739.4476	792.050120
3999	27.99572	4.208055	133.9072	4536.682	445.89550	776.799690	154.9125	750.378960

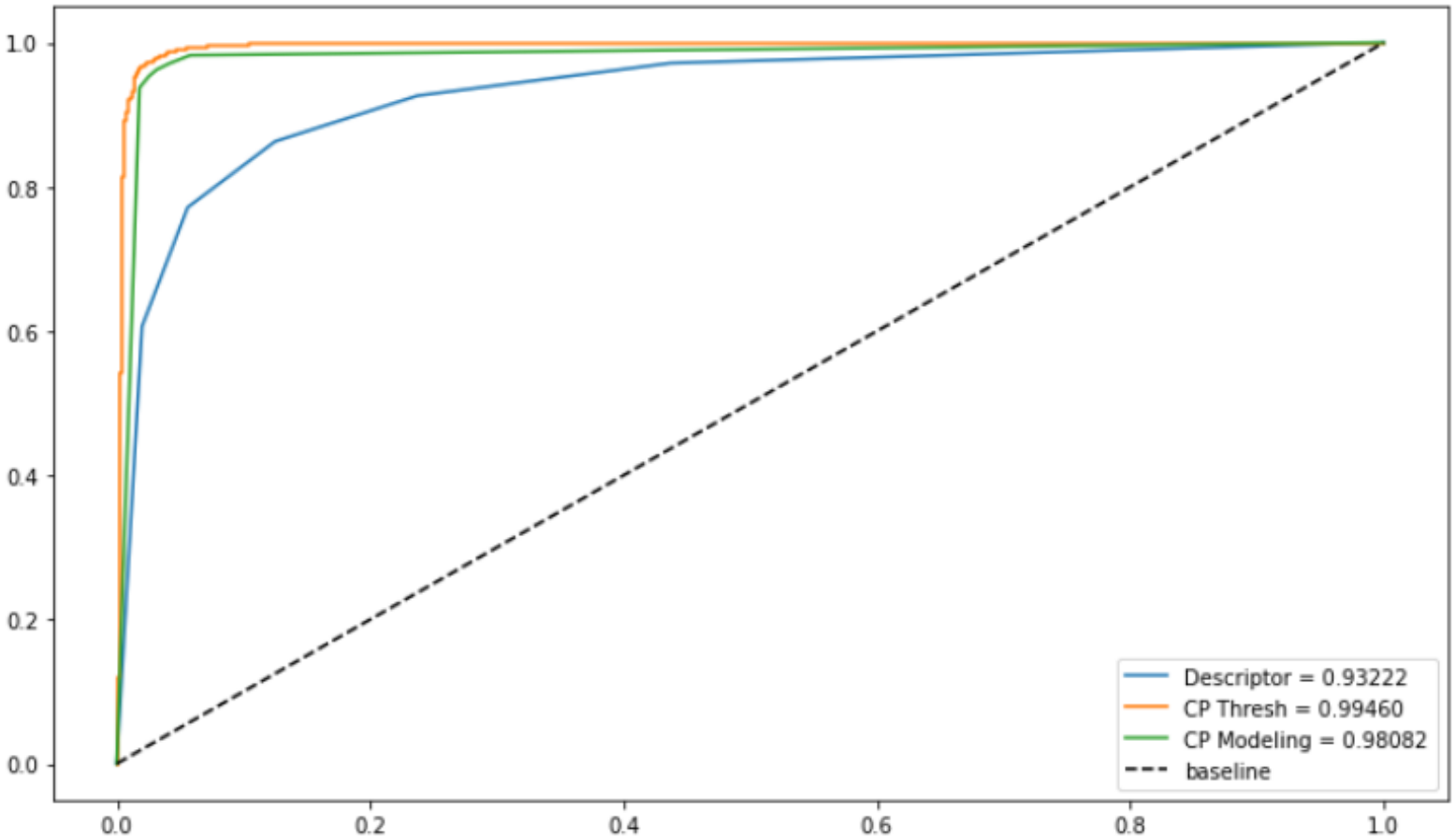
Experiment

CP-decomposition vs Descriptors

1. CP-decomposition $\rightarrow$ Find Threshold $\rightarrow$ Classification
2. Modeling random forest with descriptor dataset
3. Modeling random forest with norm of decomposed vectors

Experiment

CP-decomposition vs Descriptors



Summary

- The rank 1 CP-decomposition method can describe the footprint image.
- The CP-decomposition method is better than the descriptor comparison method.
- Need to understand more about CP-decomposition.
- Need to use different decomposition methods.