

INTRODUCTION

PCAST and OSAC have identified handwriting as one of the areas that would benefit from research into the scientific validity of the comparisons performed by forensic document examiners.

OBJECTIVES

- Design a study to validate conclusions expressed by forensic document examiners.
- Quickly and effectively pair handwritten documents with various levels of visual correspondence.
- Develop an automated *score* indicating the level of dissimilarity between two documents.
- Explore open-source and proprietary methods of producing scores.
- Compare the resulting document pairs between different methods.

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DATA

The *NIJ dataset* was collected on lined white paper using a ballpoint ink pen and then scanned.

- Collected handwriting samples from 33 different individuals
- 2 different styles for each individual: cursive and print
- 6 different phrases from the *London Letter* written in each style
- 5 replicates of each phrase

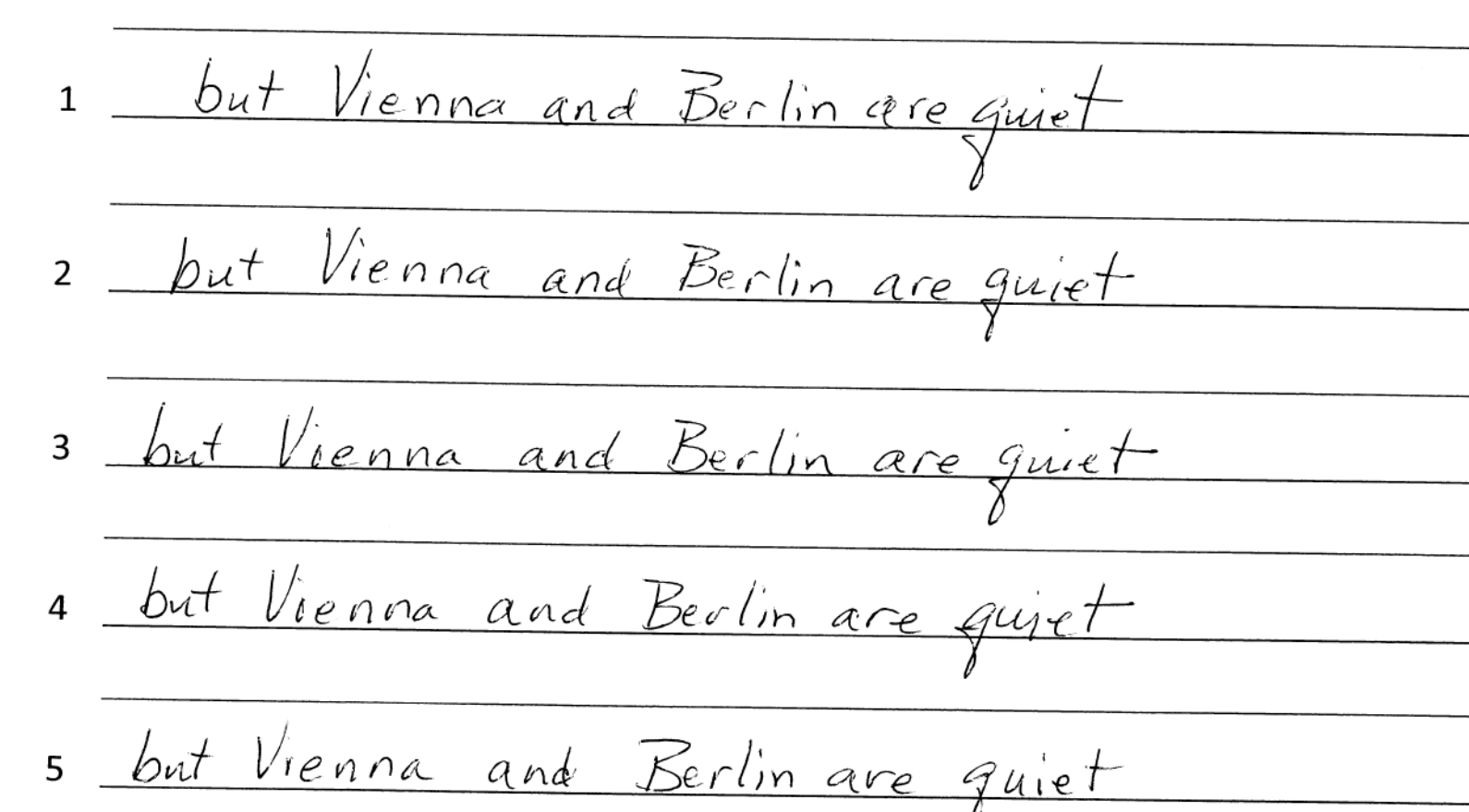


Figure 1: Print handwriting sample

SIFT METHODS

SIFT (Scale-Invariant Feature Transform) is an algorithm designed to identify key points in an image regardless of the orientation and size [1]. For this project, SIFT was implemented using OpenCV in the C++ language. Overview of using SIFT to produce a score between two samples of handwriting is provided below:

Create the codebook:

- Start with a *training set* of images
- Detect the important *features* in each image
- Use the SIFT algorithm to compute the matrix of *descriptors* for all the features
- Use the k-Means algorithm to *cluster* the descriptors
- Use the BOW algorithm to create the *codebook* from the clusters

Compute the scores:

- Start with a *test set* of images
- Detect the important *features* in each image
- Use the SIFT algorithm to compute the matrix of *descriptors* for all the features
- Use the codebook and the k-NN algorithm to find the *encoded vector* for each image
- Compute the *Euclidean distance* between all of the encoded vectors

FLASH ID METHODS

FLASH ID is a software developed by Sciometrics, LLC to quantify features of handwriting [2]. For this project, FLASH ID was used to produce a score vector for each writing sample, which were used to compute a single score for a pair of writing samples. This nonstandard score was developed for this project.

Using FLASH ID:

- Start with a *base set* of images
- Assign some writers from the FBI 100 to the *reference set*
- Use FLASH ID to get a *score vector* [2] (one score for each reference set writer) for each writing sample in the NIJ dataset

Using R:

- Compute the *Euclidean distance* between all pairs of score vectors
- Separate the distance scores into *within* or *between* writer
- Separate distance scores by phrase
- *Rank* the scores (higher score = two writing samples are more dissimilar)

RESULTS

Scores are only comparable within system, writing style, and phrase. Example pairs from SIFT (Figures 2-5) and FLASH ID (Figures 6-9) scores are given below:

Our London business is good
Our London business is good

Figure 2: Same writer, low score=0.056

Our London business is good
Our London business is good

Figure 3: Different writer, low score=0.049

Our London business is good
Our London business is good

Figure 4: Same writer, high score=0.124

Our London business is good
Our London business is good

Figure 5: Different writer, high score=0.178

Our London business is good
Our London business is good

Figure 6: Same writer, low score=1.535

Our London business is good
Our London business is good

Figure 7: Different writer, low score=1.619

Our London business is good
Our London business is good

Figure 8: Same writer, high score=8.57

Our London business is good
Our London business is good

Figure 9: Different writer, high score=12.67

An example of a pair from different writers and a comparison of the SIFT and FLASH ID scores (star position on number line) and ranks (number on star) for that pair are given below:

but Vienna and Berlin are quiet
but Vienna and Berlin are quiet



Figure 10: Pair with high visual similarity

Figure 11: Scores & rank for the pair

CONCLUSION

- These methods can be extended to perform forensic identification of source
- FLASH ID scores seem to give better rankings in this particular case
- But, we know the SIFT methods have room to improve:
- Considering replacing SIFT with SURF or using a combination of SIFT & SURF
- Looking at different scoring metrics to replace the Euclidean distance

REFERENCES

- [1] D. G. Lowe, "Object recognition from local scale-invariant features," *Proceedings of the 7th IEEE International Conference on Computer Vision*, Kerkyra, Greece, 1999, pp. 1150-1157 vol.2.
- [2] Miller, et al. (2017), A Set of Handwriting Features for Use in Automated Writer Identification, *J Forensic Sci*, 62: 722-734. doi:10.1111/1556-4029.13345