Layman Description

Features of "Training- and Segmentation-Free Intuitive Writer Identification with Task-Adapted Interest Points"

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In our paper at IGS 2015 “Training- and Segmentation-Free Intuitive Writer Identification with Task-Adapted Interest Points”, we presented a novel method for writer identification that allows for translation of the results comprehensible to human experts in document examination on the one hand, and fast to compute and performant on the other.

We proposed a statistical analysis of the distribution of stroke segments and compound strokes handwriting is composed of. We define stroke segments as short sections of a continuous stroke, while compound strokes are composed of several stroke segments or strokes, up to a full character or word. This allows a multi-scale analysis which takes into account details as well as the overall appearance of the handwriting.

To fix ideas, let us draw the analogy of our problem to the domain of making and using maps, more specifically to topography. Topography is a detailed graphic representation (map) of a landscape’s surface. In a topographical map all visible landscape features, such as peaks, depressions, valleys, rivers …, are recorded, whereas flat areas are featureless in such a map.

Now let us consider an image of a handwriting sample as a topographical map: The ink intensity (how dark the ink trace is) corresponds to the elevation at a given location, leading to a relief representation, c.f. Figure 1 (c): 3D plot of the image (Figure 1(a)). Elevation changes (changes in ink intensity) can equally be depicted as contour lines (see Figure 1 (b); where a contour line is a line connecting places of equal elevation.

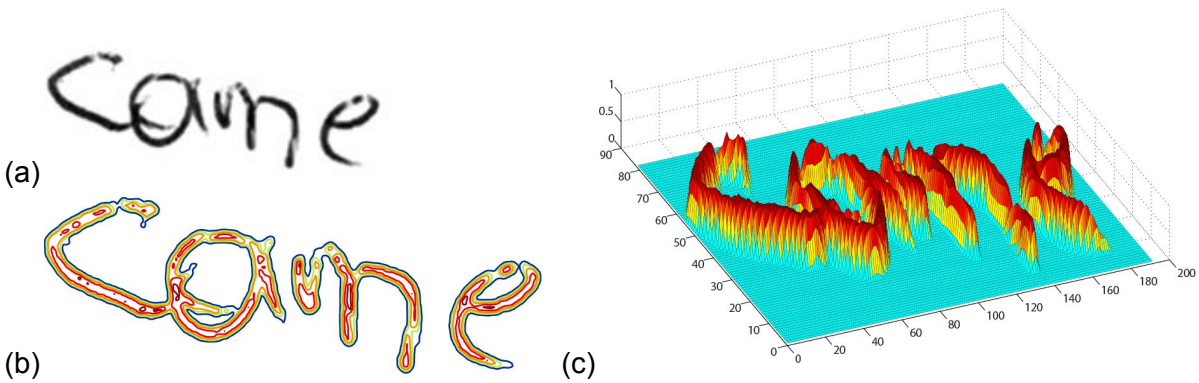


Figure 1. (a) image, (b) contour lines, (c) 3Dplot

Employing this interpretation, we assume that a writer creates a characteristic topographical map, where repeating structures (landscape features) are occurring with a certain probability, i.e. the writer creates a characteristic distribution of structures.

In order to determine this characteristic distribution pattern, we first identify distinctive points in our handwriting map in a similar fashion to a hiker who identifies distinct landscape features on the map to help the orientation while hiking. We call these points *points of interest* or simply *interest points*. Note that those points do not necessarily correspond to key points in the creation process of the handwriting sample, such as positions of velocity, pressure, or curvature changes.

In order to quantify the characteristic distribution, we then describe each interest point with two elementary characteristics:

1) its orientation (on the map that would correspond to the compass points), which describes the direction of the fastest drop in elevation (e.g. consider the Eiger Northface - its orientation naturally is North).
2) its scale, which describes the extent of the interest point (e.g. how narrow a ridge is)

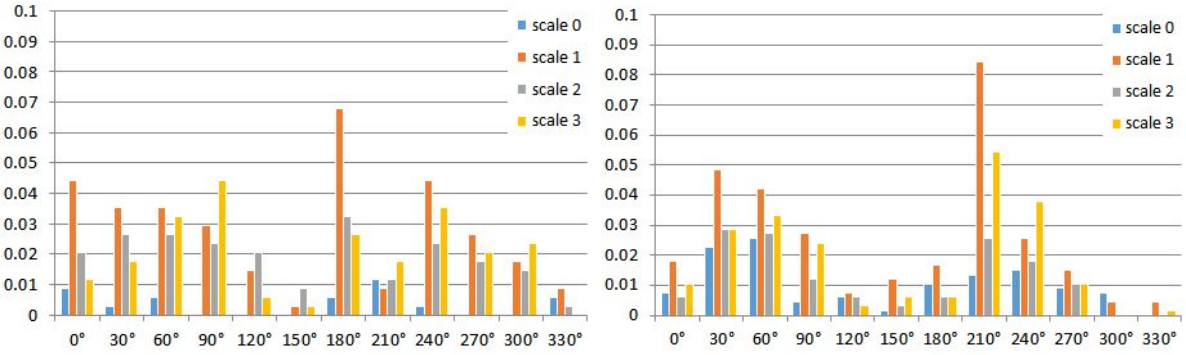
We use a table with a fixed set of orientations and scales, where we count the co-occurring characteristics. Thus, we can compute a probability distribution of those characteristics (not the absolute number) to identify a writer.

To fix ideas, let us consider two concrete handwriting samples of *writer A* and *writer B*:

(a) handwriting of writer A (b) handwriting of writer B

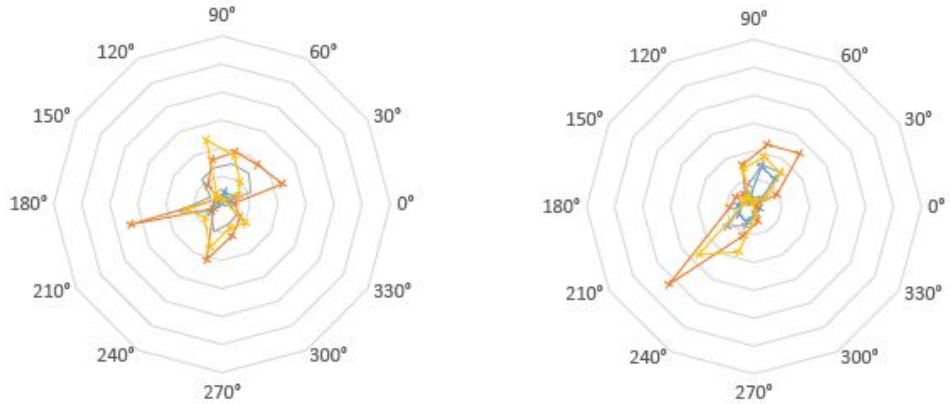
Figure 2. Samples of handwriting of the two different writers

Their handwriting generates the characteristic distributions shown in Figure 3 (a) and (b) respectively (only the smallest four scales are shown for reasons of simplicity). Note that each tick (e.g. 0°) corresponds to an interval, i.e. 0° means that all orientations 0°-29.99° are accumulated in this “bucket”. Each scale is coded with a colour. Observe how the distribution of each scale, but also within each scales differs from writer to writer. A more natural illustration of orientations is a polar plot (c.f. Figure 4), which can be understood as a visual fingerprint of the handwriting. In the polar plot the orientations are denoted as angles, and the probability is the distance from the center.



(a) distribution of *writer A* (b) distribution of *writer B*

Figure 3. Orientation distribution of two different writers at four different scales. The tick marks on the X-axis (degrees) correspond to intervals of 30° each, i.e. 0° means that all orientations 0°-29.99° are collected in this tick.



(a) distribution of *writer A* (b) distribution of *writer B*

Figure 4. The orientation distribution of four scales visualized as polar plot

Each scale encodes different characteristics of the handwriting: while the smallest scales (smaller than the stroke-width) encode sub-stroke properties, scales equal to the stroke width represent the strokes themselves, and larger scales capture bigger compound structures.

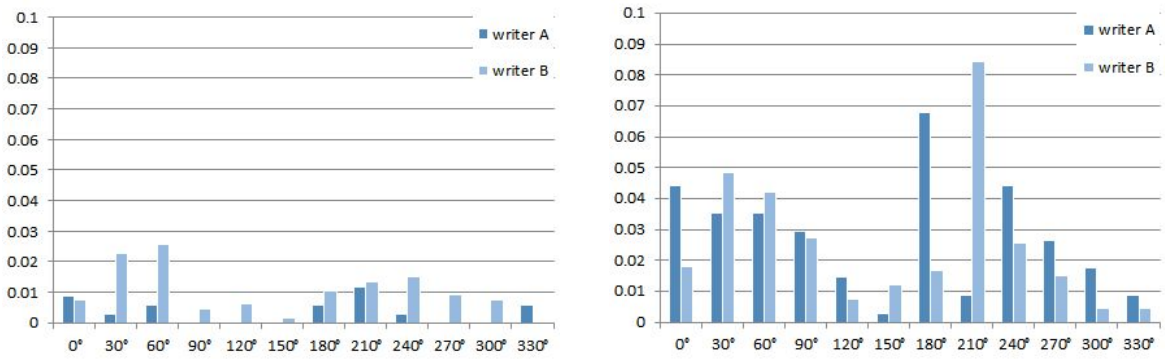
The scales which cover the width of a stroke allow us to estimate the general slant and uniformity of the writing as they directly correspond to strokes. Note that the slant is encoded as peaks across scales orthogonal to the actual slant (the orientation of an interest point is the direction of the fastest drop in elevation, i.e. it is orthogonal to the stroke orientation).

However, the orientation captures several properties of the script; thus, the peaks might be deviated from the overall slant, and different scales capture different properties of the script.

Let us make this information more accessible by directly comparing two scales of each of the two writers A and B: Figure 5 shows the interest point orientations (at two respective scales (a) and (b)) of both writers. Note the distinct differences in the probability distribution between the two writers:

Figure 5 (a) This scale corresponds to interest points smaller than the stroke width. The relative amount[1] of scale-0 interest points is higher for writer B than writer A, and has a peak around 30-90°. Furthermore, interest points are distributed over all orientations at this scale for writer B, whereas the distribution for writer A is less uniform.

Figure 5 (b) This scale covers the stroke width. From the distinct peaks for each writer A and B we can deduce information about the slant of the handwriting. The peaks around 0 and 180 degrees for writer A indicates handwriting with little slant, whereas the peaks at 30 and 210 degrees for writer B indicate slanted handwriting. Furthermore, we can deduce that the handwriting of writer A is more round than writer B's, and writer B uses very parallel strokes.



(a) distributions for scale 0 (b) distributions for scale 1

Figure 5. Interest point orientations comparison of two handwritings at two different small scales

[1]As the feature is a probability distribution, this corresponds to the ratio of the interest points found on this scale and for a specific orientation to the entire number of interest points found for this writer