Biometrics Final Project

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Introduction

For this project, we have implemented a simple system for identifying the author of a handwriting sample. Given a handwriting sample that has already been segmented into its composite words, the system extracts features from those words using the Fourier Transform. In order to classify a handwriting sample, these features are used to compare the words in the sample to words in a training set. For each word in a sample, the classifier finds the training word to which it is most similar and votes for that word's writer. The writer who gets the most votes from a sample is assigned as its author.

Feature Selection

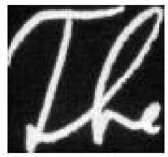
I focused primarily on feature extraction. Features are extracted from individual words. First the colors in the word image are inverted. The words are all in black pen, but they are easier to process in white. The discrete cosine transform of the word image is taken and only the lowest frequencies are kept. The idea of keeping the lower frequencies comes from work described in [1], and the fact that there is not much high frequency content in the word images to begin with. During the classification process, these features are compared using normalized cross correlation.

Originally, I tried a more complicated feature extraction process. Each word was split into several equal sized (except perhaps on the right end) vertical windows. These windows were then transformed using either the Fourier or Gabor transform. The results of these transforms were used as the features for the word.

The intuition behind this more complicated approach is that the most information on handwriting can be found in individual characters, rather than words. The windows are a way of approximating the ability to segment words into characters. However, the process of extraction and comparison is extremely slow for these features.

In view of these problems, the Fourier Transform of an entire word is a much more appealing feature. It is also accurate. The Gabor Transform of the entire word was tried as well, but was not as accurate. This is to be expected since this transform acts locally on different portions of the signal to which it is applied.

Additionally, the windows used do not really represent characters. To truly compare characters, a scale invariant character detector would be required in order to find and separate different characters. The development of such a detector would be a significant effort. In addition, assuming that such a detector was developed, the issue of the complexity of the character based representation would remain. It seems unlikely that this representation could scale to datasets with either large writing samples or many writers.



Three words and their Fourier Transforms.

Data

The dataset used is a subset of the IAM Handwriting Database. It is maintained by the Research Group on Computer Vision and Artificial Intelligence of the Institut fur Informatik und angewandte Mathematik at the University of Bern. The entire dataset consists of samples taken from 657 different writers.

The writing samples were collected by giving people forms with a sentence to be copied at the top, scannign the form, and then extracting the handwritten portion. The samples were further segmented into lines and then into words. Our project uses the words exclusively. Each word can uniquely be identified by the form that it came from, its line number within the form, and its position on that line.

While the database contains samples from 657 people, most people have very few forms assigned to them. The average for the entire set is 2.34 forms per person. The highest number of forms that a person in the dataset has written is ten. There are thirteen such people. There are 93 individuals who have authored at least five. Our work was done using the thirteen people who have ten forms each.

A better study could likely be formed using the 93 people who have at least five forms, as five writing samples per person would furnish several hundred words each. In total, the thirteen people who each have at least ten forms comprise 9184 words in total. Taking two forms each from the 93 who each have at least five furnishes around 14500 words. Given our limited hardware resources, we therefore chose to work with the smaller subset. The IAM Handwriting Database is described in greater detail in [2].

Conclusion

The classifier is tested using three forms for each of the thirteen writers. Of these three, two are used for training and one is used for testing. Results for the Fourier Transform features are 100% accuracy on this thirteen class problem, while the accuracy of these features at predicting the writer of a word is 43.47%.

The reason that we are able to achieve such high accuracy on the writing samples despite the low acuracy among the words themselves is the voting system that considers the contribution of each word in the sample equally. Although a word will be incorrectly identified more often than not, the likelihood that an individual incorrect writer will gain as many votes as the actual writer is low.

We are happy with our result in classifying the author of a given handwriting sample. However, it would be interesting to see how this scheme performs when there are more authors to choose between. With a combination of better algorithms, a faster language, and better hardware, this would be possible. We also would like to find better features (perhaps by developing a character detector) for writer prediction given a single word. An accuracy of just 43.47% on this task leaves much room for improvement.

References

1. R. Plamondon, G. Lorette, Automatic signature verification and writer identification - the state of the art, *Pattern Recognition*, Vol. 22, No. 2, pp. 107-131, 1989.
2. U.V. Marti, H. Bunke, The IAM-database: an English sentence database for oine handwriting recognition, *International Journal of Document Analysis and Recognition*, Vol. 5, pp. 39-46, 2002.