Fusing High- and Low-Level Features for Handwritten Word Recognition

Alessandro L. Koerich, Alceu S. Britto Jr., Luiz E. S. Oliveira & Robert Sabourin

Department of Computer Science (PPGla)
Pontifical Catholic University of Paraná (PUCPR)
Curitiba, PR, Brazil

École de Technologie Supérieure (ÉTS)
Université du Québec
Montréal, QC, Canada

ABSTRACT
This paper is focused on the combination of features extracted from different representation spaces, namely, words and characters with the aim of improving the handwritten word recognition performance. To achieve such a goal, two categories of features are considered: high level features including, global, histogram and segmentation features are extracted from word segments and generate variable-length feature vectors; low features that represent different discriminant characteristics of the handwriting are extracted from character hypotheses and generate fixed-length feature vectors. Both feature vectors are combined at classification level through the combination of the confidence scores produced by the classifiers. The classifier that accounts for the high level feature vectors is based on hidden Markov models (HMM) and it provides a list of the N-best word hypotheses, their a posteriori probabilities and character hypotheses segmented from such word hypotheses. The low level features are extracted at the character level and used together with a segmental neural network (SNN) character classifier.

The novelty of this approach relies on the fusion of high-level, long-range features and low-level local features through the combination of the confidence scores produced by the classifiers. The novelty also relies on the combination of classifiers that operates into two different representation spaces, i.e. word and character.

FEATURE EXTRACTION
High-level features are global features such as ascenders, descenders and loops. They are usually powerful but less robust. These features do not work very well on unconstrained handwriting, because the results of high-level feature extraction tend to be erroneous due to the large shape variations in natural cursive handwriting, especially among different writers.

On the other hand, low-level features are local features such as profiles, projections, directional contour, concavities, etc. They are usually less informative but more reliable.

CONCLUSIONS
In this paper we have presented an approach that relies on the combination of high-level long-range features and low-level local features through the fusion of classifiers output. The proposed approach combines features extracted from different representation spaces (word and character). The error rate resulting from the combination of the two feature types at classification level is significantly better than that achieved by single feature types.

In this paper we have presented a approach that combines high-level and low-level features extracted from isolated characters to reduce the word error rate. The proposed combination is effective and computational efficient. The improvements reported in this paper are significant. Hence it is logical to conclude that a fusion of different feature types at classification level is a promising research direction in handwriting recognition.