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Writer identification using texture features: A comparative study☆

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ABSTRACT

A texture-based approach for writer identification of multiple scripts on a single platform is presented in this paper. Potential texture descriptors, namely Local Binary Pattern (LBP), Local Phase Quantization (LPQ), Discrete Wavelet Transform-based Local Extrema Pattern (DWT + LEP), Discrete Wavelet Transform-based Directional and Local Extrema Pattern (DWT + DLEP), Center Symmetric Local Binary Co-occurrence Pattern (CSLBCoP), and Local Tri-Directional Pattern (LTriDP) have been analyzed for identifying the writers. Comparative study for Latin, Arabic, and Devnagri databases was performed, with the Devnagri database contributed by us. The study shows high writer identification rates of 97.62% for IAM dataset using LBP features and Support Vector Machine (SVM) classifier, 95.60% for KHATT database using k-Nearest Neighbor (kNN), and 65.80% for Devnagri scripts using LPQ features and kNN classifier.

1. Introduction

For centuries, numerous graphologists, psychologists, palaeographers, and forensic experts have dedicated their time and energy for carrying out research in the field of handwriting analysis. With exponential advances in tools and technologies, automated systems have been designed for computerized analysis of handwriting [1,2]. Although these tools fetch many advantages such as fast computation of features, efficient usage of search space, visualization, automated segmentation tools, etc., they are still unable to fully replace the human expertise. There exist numerous classical problems that owe their solutions to effective handwriting analysis like the prediction of neurological disorders, spotting of keywords in handwritten fragments, writing styles categorization, prediction of writers' demographics, identification of individuals based on their handwritten documents, etc. [3].

Writer identification generally refers to the task of identifying the author of a given query document based on its match with the known authorship of the handwritten documents present in the database under consideration [4]. It has found numerous utilities in varied applications like signature verification [5], historic document categorization [6], forensic document analysis [7], etc. Based on the kind of written samples considered in the study, these methods can be broadly categorized as offline or online writer identification methods [1,8]. In offline writer identification, the written samples are in the form of digitized images, whereas in online approach, the dynamic information like pen pressure, order of hand strokes, the writing trajectory, etc. are considered using specialized devices [9]. If the same text written by the users is used in the training as well as in the evaluation phases of the system, it is referred to as text-dependent else categorized as text-independent. Text-independent systems are more demanded in real time scenarios [10].

Any writer identification approach initiates with the extraction of features from the samples present in the reference database. These features could be extracted either from the textural or the structural properties of the handwritten documents [11,12]. In

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texture-based approaches, each writing sample is considered as a different kind of textural pattern and features are extracted based on either the whole document or its different portions. Although many textural features have been proposed in the literature, only few like Local Binary Pattern (LBP) [1,13], Local Phase Quantization (LPQ) [14], etc. have been evaluated in the literature in this aspect. The efficacy of other texture descriptors like Discrete Wavelet Transform-based Local Extrema Pattern (DWT + LEP) [15], Discrete Wavelet Transform-based Directional and Local Extrema Pattern (DWT + DLEP) [16], Center Symmetric Local Binary Co-occurrence Pattern (CSLBCoP) [17], Local Tri-Directional Pattern (LTriDP) [18], etc., needs to be evaluated in this respect. The structural-based approach considers the process of segmenting the handwritten documents based on its structural properties like inter-word as well as intra-word distances, the inclination of the writing, average line height, etc. The proposed prototypical model is an offline text-independent approach for the writer identification problem based on texture features.

1.1. Motivation

The cruciality of the writer identification problem and lack of a uniform platform for comparing the writer identification accuracy for multiple scripts inspired us to propose a prototypical model towards this end. Six textural features were chosen from existing state-of-the-art features depending upon their capability to discriminate the writers via capturing the local patterns based on their neighborhood, multi-resolution property, the co-occurrence of pixel pairs, etc. [15,16]. In our study, we have considered three kinds of scripts, i.e., Latin, Arabic, and Devnagri (one of the popular indian scripts), given their importance [19–21]. As no standard Devnagri dataset was available and realizing its importance, we made an effort towards collecting a substantial amount of data for carrying out this study. The performance of writer identification was tested with different combinations of well-known classifiers and textural descriptors. The results were analyzed along with their dependency on the various parameters considered in the framework and the best performing scenarios were put forward for the multiple scripts on a common platform.

1.2. Our contribution

In this paper, an effort was made for providing a uniform platform for comparing the writer identification accuracy for multiple scripts considering some of the textural features from the existing state-of-the-art features. To attain this objective, we did a thorough study of the existing approaches and found the lacking aspects in this domain. We found that, firstly, no standard Devnagri dataset existed despite the importance and popularity of the Devnagri script. Secondly, although a lot of approaches have been proposed for writer identification of Arabic scripts in the literature, most of them performed it with the Institut fur Nachrichtentechnik (IFN)/ Ecole Nationale d'Ingenieurs de Tunis (ENIT) database which is comparatively a smaller database than the King Fahd University of Petroleum and Minerals Handwritten Arabic TexT (KHATT) which consists of variants of information. The selection of appropriate and fast performing textural features from the existing ones that would better represent the writer information was another challenge. A bunch of six textural descriptors was chosen considering their discriminatory properties. Lastly, we tested the accuracy with different well-known classifiers to investigate the best performing scenarios of writer identification for the multiple scripts considered in the study. In summary, we made the following contributions:

- Collected a substantial amount of Devnagri script samples written by different writers to contribute a Devnagri Dataset to enable the writer identification problem for the same.
- Performed the writer identification task on a large Arabic database, i.e., KHATT that was lacking in the literature for most of the state-of-the-art approaches.
- Selection of six computationally efficient textural descriptors from existing state-of-the-art features and confirming the power of LBP and LPQ in distinguishing the patterns based on co-occurrences of pixel pairs and local patterns existing in the handwritten documents.
- Analyzed the performance of writer identification by considering different well-known classifiers and reported the best performing scenarios for each script.

The rest of the paper has been organized as follows: Section 2 discusses the related work, Section 3 describes the different databases considered in the experimental studies, Section 4 presents the prototypical framework for writer identification. Experimental results with detailed analysis are discussed in Section 5 and conclusion along with the scope of future work is enumerated in Section 6.

2. Related work

Writer identification forms the basis for solving many classical problems of forensics. Hence, it is very challenging and active research area in the field of computer vision and pattern recognition. To identify the writer of a document, we need to identify appropriate features to represent the handwriting, design algorithms to identify handwriting, represent features using the basic methods as well as the derived ones and a comparative evaluation with the existing state-of-the-art approaches.

Based on the level of feature extraction, the writer identification approaches can be categorized as operating at the character level, word level, line level, paragraph level, or document level. For operating at the character level, the features are extracted based on the slant, height, area, pen-input features, structural features, directional features, fuzzy directional features, gradient, structural, concavity features, etc. For the word level operation, morphological features, edge-based