A Dual PSO-Adaptive Mean Shift for Preprocessing Optimization on Degraded Document Images

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ABSTRACT

In the two past decades, solving complex search and optimization problems with bioinspired metaheuristic algorithms has received considerable attention among researchers. In this paper, the image preprocessing is considered as an optimization problem and the PSO (Particle Swarm Optimization) algorithm was chosen to solve it in order to select the best parameters. The document image preprocessing step is the basis of all other steps in OCR (Optical Character Recognition) system, such as binarization, segmentation, skew correction, layout extraction, textual zones detection and OCR. Without preprocessing, the presence of degradation in the image significantly reduces the performance of these steps. The authors’ contribution focuses on the preprocessing of type: smoothing and filtering document images using a new Adaptive Mean Shift algorithm based on the integral image. The local adaptation to the image quality accelerates the conventional smoothing avoiding the preprocessing of homogeneous zones. The authors’ goal is to show how PSO algorithm can improve the results quality and the choice of parameters in pre-processing’s methods of document images. Comparative studies as well as tests over the existing dataset have been reported to confirm the efficiency of the proposed approach.

KEYWORDS
Degraded Documents, DIBCO Dataset, Image Preprocessing, Image Smoothing, Mean Shift, OCR System, PSO

1. INTRODUCTION

The automatic reading systems of documents are widely used to store, sort and search any important information from paper-based documents. The objective of document image analysis is to extract and recognize the textual information (using OCR system) and graphics components in the document. A typical OCR system consists of the following steps:

- **Step 1**: Image preprocessing (page’s restoration, quality improvement, noise reduction, contrast enhancement, deskewing of the document, page magnification).
- **Step 2**: Foreground/Background separation (Binarization) using global or local methods.
- **Step 3**: Component separation and segmentation, using a pyramidal analysis (extraction of the physical and logical layout of the document, text block detection, printed or handwritten recognition).
- **Step 4**: Optical recognition of text.
As described in (Gaceb et al., 2008), in general there does not exist an ideal and generic segmentation because of the difficulty of parameter choice on document images of very diverse quality. There are always several possible segmentations. We can show that the problem of segmentation is usually a poorly formulated problem. A good segmentation mechanism will be able to provide a good recognition on a wide variety of documents. Therefore, it should be able to simplify the image content without degrading it, by avoiding precipitated and irreversible choices. We note that the future of image preprocessing and segmentation is in the downstream control by using evolutionary approaches. It is in this context that the PSO algorithm was introduced to facilitate, accelerate and optimize the choice of preprocessing settings applied to images of documents. The evolution of a global optimum search is guided by the quality of binarization. Image foreground and background separation is also an essential step in a variety of image analysis, OCR and computer vision tasks (Gaceb et al., 2008).

In our study, we have chosen PSO algorithm for the following reasons; it comprises very simple concepts, and the paradigm can be implemented in a few lines of computer code. It requires only primitive mathematical operators and it is computationally inexpensive in terms of both memory requirements and execution time.

The rest of this paper is organized as follows: In section 2, we give a general overview on more methods presented in the literature, which are related to our problem, especially the preprocessing of degraded images. In section 3, we present the PSO paradigm principle, the equations and the algorithm. In section 4, we present the theoretical principle of the Mean Shift method. The section 5 describes our new approach and the contributions in terms of preprocessing of document images. This last section is organized into two parts; the first one describes an adaptive mechanism of Mean Shift (AMS) method for smoothing and filtering and the second one explains the role of PSO algorithm in the image filtering and smoothing by using an improved Mean Shift method. At the end of this paper (section 6), we present and discuss some experimental results obtained from applying our propositions on a set of images of the degraded documents from DIBCO11 Dataset before concluding the paper in section 7.

2. RELATED WORK

The physical layout of degraded documents, printed or handwritten is harder to extract due to the low quality, aging or faint typing. They include various disturbing elements such as holes, spots, writing from the verso appearing on the recto, ornamentation, or seals. Other degradations are related to the image capture quality such as blur, poor contrast and the presence of false colors using the jpeg compression. Preprocessing of a degraded image refers to all the steps of filtering, noise reduction, restoration and contrast enhancement that precede the segmentation, the detection or the recognition of the contents of this image. Another kind of techniques can be used as a preprocessing such as binarization, skew or slant detection and correction, run-length smoothing, page, blocks, lines, word or character merging. In character recognition systems, the preprocessing steps are required on degraded document to improve their quality (Alginahi, 2010), they represent the most important part in these systems (Paszkowski et al., 2007). The literature on preprocessing of degraded image document is vast and a complete review remains beyond the scope of this paper. However, here we try to give an overview of the most important preprocessing approaches.

Ramponi and Fontanot (1993) evaluate linear and a quadratic operator as noise smoothing of gray-level images of documents. Their study proves the efficiency without blurring the details of the image document. In the selective and adaptive framework there is another approach based on partial differential equations (PDE) proposed by (Perona & Malik, 1990). In these approaches the value of a pixel moves through iterations depending on the gradient vector variations, the variance of the averages is also due to the gradient vector, all of that gives these approaches better accuracy (compared to EPSF approaches (Nikolaou & Papamarkos,2009)) at ambiguous areas and therefore better preservation of edges. The PDE analysis is available in two versions: isotropic and anisotropic.
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