# Handwritten Arabic Word Spotting Using Speeded Up Robust Features Algorithm

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***Abstract*- Optical Character Recognition (OCR) of Arabic text from manuscripts images is virtually impossible, this is due to the semi-cursive nature of Arabic script which is very difficult to explore by algorithms and image processing methods.**

**In this paper, we present a method of exploration and research in content of Arabic manuscript images. It's about characterizing segmented handwritten words with a set points of interest by providing a means of identification and research in these manuscripts. Each word segmented and described by key features will be compared to query words.**

**The results of this method are encouraging in comparison with other methods, especially when it comes to the same of handwritten style used in the text.**

**Keywords: Arabic calligraphy; Arabic Manuscripts; Computer Vision; Cultural heritage; Detector / Descriptor; Image / Text format; Word Segmentation; Word Spotting.**

## I. Introduction

The ancient Arabic manuscripts has preserved in libraries constitute a patrimonial heritage seen by minorities of researchers. Transcription or annotation of digitized Arabic manuscripts requires a considerable effort to duplicate their contents to the formats recognized by the machine. Transcription or manual annotation therefore requires the reproduction of large quantities of information (elements) included in these images. Most often, these elements (words, calligraphy...) have repeated several times in the same manuscript with the same style of writing. The idea is to automate the transcriptions or annotations with the comparison of the elements of manuscripts, to avoid the redundancy of these objects during the entry. Comparing elements (content) from ancient Arabic manuscripts is not a simple process. This requires a robust method that adapts to geometric variations, brightness variations, scale changes and rotations. Transcription and automatic annotations are therefore meaning to facilitate access to these manuscripts, minimizing the reproduction and search time in these manuscripts. Several works on binarization have led to a significant loss of information, leading to a difficulty in recognizing handwriting. To solve this problem, we carried out a prospective study on the scale space theory. We applied this theory on grayscale images of Arabic manuscripts to extract useful information from the corresponding scales. These will be like signatures corresponding to the elements to be compared. This phase must ensure maximum reliability when extracting the overall elements features because the subsequent use based on this extraction.

In this article, we will present a new method that facilitate access to the content of images. This method based on the invariant local detectors and descriptors at (scale, rotation, brightness variations) for the detection of this information in the Arabic manuscripts. The information sought in manuscripts, most often are words that repeat several times in the same image. This method uses Word Spotting technique by allowing matching between the handwritten words of the query images with the target images. To allow the identification and indexing of handwriting. We interested to Speeded Up Robust Features algorithm (SURF) [1] (invariant local descriptors / detectors) for extracting and detecting the features of handwritten elements. This algorithm is widely used in computer vision to find and describe the interest points in the 2D images. The features extraction in the manuscripts elements by this algorithm consists to find the same points in the target images taken in different view and scales. Authors of this algorithm demonstrate that it is the fastest compared to other algorithms. Our method therefore consists in finding the occurrences of the same manuscript elements (writing or drawing produced by copyists) to access the contents of the old manuscripts.

## II. Related Work :

The most recent methods for searching words in images rely on the Word Spotting technique. Several works have addressed the problem of the recognition of cursive writing and the indexing of manuscripts:

The first authors of the Word Spotting method based on interest regions of words composed of characters [2], [3], [4], [5], [6], [7]. They deal with the recognition and indexing of words using character patterns or using probabilistic detection of candidate regions of characters. The classification of these

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regions interest based on the Hidden Markov Models (HMM) approach [8] or Dynamic Time Warping (DTW).

The results of these methods are interesting considering the variations of the word models. In [9], the authors developed a system of word search in medieval manuscripts. This system based on the HMM method and on Neural Networks (NN).

However, these methods suffer from considerable manual effort when producing annotations or transcription.

Recent works based on the measurement of similarity between words using generic shape descriptors [10]. Another descriptor of forms based on Histogram of Oriented Gradients (HOG) [11] allows the detection of handwritten words in [12].

In [13], [14], [15], [16], [17] they used the descriptors of interest points SIFT [18] [19] to describe the form of words. The main features used in the words detection in documents are excellent. These interests point of detectors widely used in computer vision but the detection time in these documents can be improved.

Several methods have been proposed in computer vision to detect objects in natural images. These methods also based on interest points. We can classify these methods into three categories: Contour approach, model-based approach and local extrema detection approach. The contour approach allows the detection of corners by exploiting the geometrical properties of the image. The model-based approach is done by mapping the intensity function with a theoretical model of this function and the interest points considered. The intensity approach allows the detection of local extrema by characterizing the points of strong variations in light intensity of image.

### 2.1 Contour approach (corner detection)

One of the first detectors of interest points is the detector of H.Moravec [20]. It is sensitive to noise and responds vigorously to contours. C. Harris and M. Stephen [21], have improved the Moravec corner detector principle. The Harris detector is invariant to rotation and translation, but it is resistant to changes in illumination. Several improvements have been made to the Harris algorithm by Schmid and Mohr [22]. P.Montesinos [23] generalizes this detector to color images. Y.Dufournaud [24] shows that it is possible to make it robust to changes in image resolution. In Mikolajczyk [25] consists in extracting the interest points at different scales with a Gaussian smoothing of different sizes based on the Harris detector. Then, to keep only the points for which the Laplacian is a local maximum in the scale space. The Harris affine region detector then makes it powerful to affine transformations [26].

### 2.2 Approach based on the theoretical model of signal

The research carried out by Schmid [20] shows that the theoretical model of the signal method aims to obtain a sub-pixel accuracy by approaching the signal to a theoretical model. Such methods applied to very specific types it is the detection of corners. On the other hand, these methods can't detect points in circles for example.
Rohr [27] [28] models the junctions of several lines by the convolution of a binary model with a Gaussian in order to model the blur. In the case of a corner, the model parameters are: The angle defining the orientation of the symmetry axis, the angle defining the opening of the corner, the gray levels, the position of the point and the blur. These parameters adjusted so that the theoretical signal is as close as possible to the observed signal. This approach uses a minimization in the sense of the least squares which generates a high precision in the detection of the corners.
R.Deriche and T.Blaszka [29] have improved the Rohr method with the replacement of the Gaussian function by the exponential function in order to speed up the processing time.
P.Brand and R.Mohr [30] propose the evaluation of the localization quality by a theoretical model which is adjusted to the signal using an affine transformation. For this evaluation, they test: alignment, 3D reconstruction and calculation of epipolar geometry. The tests validate an accuracy of 0.1 pixel.

R. Deriche and G. Giraudon [31] [32] [29] have improved the accuracy of detection using a theoretical model for a corner. This model theoretically analyzes the behavior of different detectors. They show that there is a relation between the position of the true characteristic to be detected and the responses in the scale space.

### 2.3 Intensity approach (local extrema detection)

This approach considers the local extrema as points of interest. In the literature, we note several methods that detect points of interest with satisfactory results.
Lindeberg [33] proposed a method called "automatic scale detection" to detect the characteristic scale of each point in a scale space. The characteristic scale of a peak is the scale at which the magnitude of the Laplacian is maximum. The scale characteristic of a peak point is the scale at which the greatest dominant curvature of the associated local surface is maximum in the corresponding principal direction.
Lowe [18] [19] proposes the SIFT (Scale Invariant Feature Transform) method. He uses the Difference Of Gaussian (DOG) to detect extrema, local minima which will be considered points of interest. This approach consists in detecting points that are stable and invariant in the scale space.
Mikolajczyk. K, Schmid [34] present a new invariant detector named Harris-Laplace. This detector keeps only the interest points which are extrema near of their characteristic scales.
H.Bay , T.Tuytelaars and V. Gool [1] developed an algorithm called Speed Up Robust Features (SURF). This algorithm resembles the algorithms of SIFT [19] and Mikolajczyk [34].
H. Bay [1] showed that algorithm is faster and more robust compared to that of Lowe [19] and Mikolajczyk [34]. B. Bagasi and L. A. Elrefaei[40] proposed a comparative study between the local features of BRISK[41] and SURF in the field of image extraction by content. This study deals with the search for images by similarity. The correspondence between the images is made on full pages of the Arabic manuscripts without segmentation, which allows only similar pages to be found.

## III. Proposed method

We find that marketed OCRs (Optical Character Recognition) don't recognize the content of manuscripts. They aren't made for indexing or recognition of structures. They designed to recognize characters printed in code (ASCII). However, for Arabic printed characters they still have recognition problems.

We present a method for the characterization of images of Arabic manuscripts. In the same way, as in the field of the recognition of Latin texts. This is the design and organization of a model based on local descriptors invariant for transcription and

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recognition of Arabic handwritten text. This model must include all the primitives of the text Arabic such as the identification of elements like words, pseudo-words, isolated characters, or graphic areas ... This method based on the Word Spotting technique by considering each element to be looked for as a query in a target image which must be segmented in turn into words, pseudo-words ...

To this end, in the context of this research, the manuscripts that we process in digitized images, their content is difficult to identify by recognition algorithms. For this reason, the manuscripts must be annotated or transcribed manually. These methods provide a means for accessing the content of these manuscripts images.

Our goal is to improve these methods by automating them by adding the Word Spotting technique. This involves associating a signature with each element to be transcribed or annotated. It characterizes the elements in the manuscripts by offering a means to identify the redundancies of these elements

### *3.1 Principles of proposed method:*

Schematic diagram of proposed method for identification of manuscript elements illustrated in following figure:

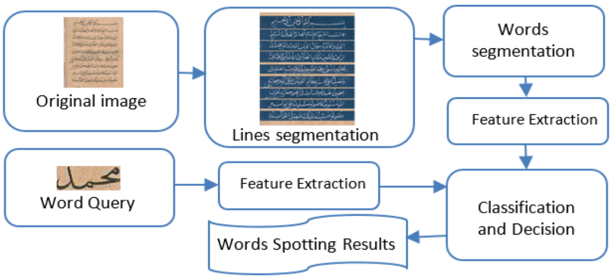


Fig. 1. Process of proposed method

#### *3.1.1. Acquisition and pre-processing*

Digitization is a first step that allow the conversion of a manuscript into images. We used a professional scanner to scan our manuscripts in different sizes and formats. Scanned images stored in raw format in folders. This gives huge images. This kind of scanner integrates algorithms such as compression to lighten the capacity of images. It also incorporates calibration and resolution settings ... A series of pre-processing can be applied to images such as: Contrast enhancement, straightening, curvature correction, detail emphasis and spreading of levels. These processing can improve the quality of the images and also their segmentation...

Fig. 2. Scanned image [35] left and right after pre-processing

#### *3.1.2. Lines segmentation*

Line segmentation [39] is necessary to locate the position of words for Word Spotting method. In this case, we will extract the lines using grayscale images. For this purpose, we will transform the image into a 1D signal. This transformation facilitates line detection despite some overlaps. Among the algorithms that are known for performing this task, we can cite the projection algorithm [36] which uses grayscale images. In [37], the authors apply the projection algorithm to binary images. This last method is effective for printed text. In this case, we notice exceptional spacing between the lines which facilitates the segmentation. The projection function *f(y)* that we have applied for a gray level image of intensity *I(x, y)* is as follows:

$$f(y) = \sum_{x=0}^{w} I(x, y) \tag{1}$$

The projection profile f (y) of the image I for the line x is illustrated in Fig. 4. Additional high frequency noise may affect this function. In this case, it is necessary to smooth this signal with the aid of a filter. As in [37] we can perform a convolution with a Gaussian filter (2) in order to eliminate the high frequency noise in the signal of the function (1).

$$p(y) = f(y) * g(y, \sigma) \tag{2}$$

with $$g(y, \sigma) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{y^2}{2\sigma^2}} \tag{3}$$

The projection profile in the following figure is the result of the horizontal projection of the gray level image. It provides various characteristics: on the main lines (minima), on the background of the image (maxima) and on the heights of the lines. The tray observed in the curve represents the image background, which explains the variations in the intensity caused by the image texture are negligible.
The relative (local) extrema can be computed with the derivative of the function p (y).

$$\frac{dp(y)}{dy} = 0 \tag{4}$$

- maxima = image background
- Minima = baseline detection
- Line heights = maximum of the character height

After extracting the local extrema, we can deduce the locations of the lines (Fig 4.a). The image on the right shows the segmentation of the lines (Fig.4.b).

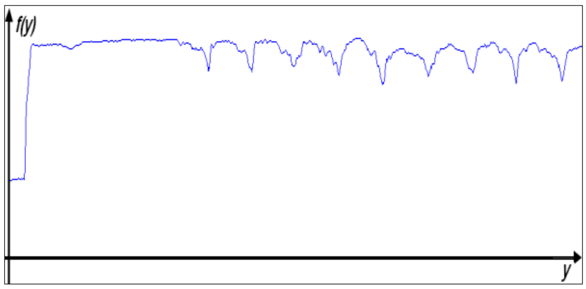


Fig. 3. Line projection profile

#### *3.1.3. Word segmentation*

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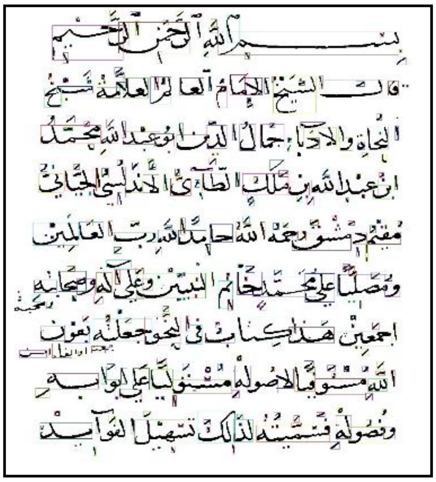
Our goal is to extract all the information in each pseudo-word to facilitate the task to the processing algorithms. For this purpose, we apply the labeling of the binary image for the extraction of the related components. Due to the bimodal character of the histogram of the processed images, this binarization operation is carried out by applying a global thresholding method of the raw image obtained after acquisition. We have opted for the optimal thresholding method of Otsu [38 It is common for the binary image obtained to be affected by a binary noise, linked to a background non-uniformity of the image. This noise is easily suppressed by the application of a binary morphological filter.

A morphological dilation of the binary image allows the fusion of the isolated characters and the pseudo-words. The projection at each line provides the words. The main problem with this technique is its sensitivity to overlapping words. Detection of the related components at the level of each line in the binary images to also locate the words. This method is sensitive to noise. On the other hand, it's effective even if word-level overlaps exist. The following figure (Fig.4.c.) shows an example of segmentation of the elements (isolated characters, pseudo words and words ...)

**a.** lines detection **b.** lines segmentation



**c.** Words and elements segmentation

Fig. 4. Segmentation Results

*3.1.4. Feature extraction*

Arabic calligraphy is a millenary art that has developed refined rules. The glyph forms of the Arabic letters vary per position of the letter in the word (initial, median, final and isolated). In addition, the Arabic text contains the diacritical marks and marks used to mark the vowels. The latter must be filtered, otherwise the quality of segmentation and recognition decreases.

Several studies have found in Arabic manuscripts that calligraphers respect the rules of writing. Indeed, we have taken an example of the occurrence of words.

These words are taken from a page of a manuscript. They look similar with multiple occurrences on the same page. In the same way, a letter is repeated several times with and sometimes isolated. We explored a collection of the same copyist who uses a same font. We have noticed an enormous redundancy in the forms of handwriting. We note that calligraphers respect the same standards and rules of writing. This is demonstrated by the presence of many manuscripts using known fonts (Andalus, Kufi, Naskh, Thuluth ...).

Several approaches in the literature can be applied to extract the characteristics of Arabic handwriting. We justify the choice of such a detector of characteristics (of a letter, a word, a graphic zone ...) by its efficiency and by its response time. However, we have noticed that the contour approach and the theoretical model approach of the signal cannot be effective in our case, since they use the detection of corners. The same handwritten character of the same size does not have a stable outline thus, we adopted the intensity approach using local extrema detection. This approach based on key points. It recognized in the literature for its efficiency and its computationally optimized time. SURF points offer these two advantages. Moreover, following their wide use in the literature, numerous variants and improvements have been developed.

As part of the Word Spotting method of detecting words at the level of Arabic handwriting, all types of manuscripts must be considered. However, some documents, such as manuscripts with different colors but with identical intensities, require the use of color to ensure correct key points extraction. The second possible variation concerns the relationship between the reliability and the algorithmic cost of the detector. Indeed, the SIFT detector extracts robust and fewer points but at the cost of additional calculations. In this case the use of SURF detectors to extract feature elements (isolated characters, pseudo words or words) can be effective is faster compared to other detectors.

*3.1.4 Classification, matching and decision*

We therefore opted for SURF interest points. The comparison between two interest points can be done with several methods. Choice of such a method can be made per processing costs. Interest points characterized by their properties. The comparison can therefore be carried out in two stages:

The first step of comparison between two points is carried out by examining the signs of traces of the Hessian matrix. The sign of the trace of the Hessian matrix thus represents the sign of the Laplacian and the meaning of blobs.

The second step of the comparison consists in calculating the distance between the descriptor vectors of the two interest points.

The most commonly used comparison methods based on correlation and on the calculation of vector distances. The distance between two vectors v and u of the two descriptors of interest points can be calculated with the Euclidean distance or with the Mahalanobis distance.

## IV. EXPERIMENTAL RESULTS

The proposed method allows to extract features of the handwritten objects. Indeed, the manuscripts characterized by the physical support (almost uniform texture) and the ink used.

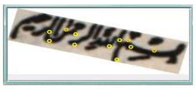
The latter generates significant variations in the luminous intensity. Our documents presented as a 2D image.

SURF algorithm detects more interest points characterizing the writing than points characterizing the physical medium. Because the physical medium generates very small variations of luminous intensity.

### *4.1 Words detection*

In the following figure, we show invariance of words luminosity variation, the scales changes, the rotations and the geometrical variations. The detection of a set of words that can be considered as a single graphic area is identifiable by interest points. We thus demonstrate that the texture effect is negligible because we can compare binary images with that in color or grayscale.

***Table1.*** *Results comparison for invariance*

| Invariance | Query | Target Image | Matching points |
|---|---|---|---|
| At rotation and scaling |  |  | 11 |
| Illumination |  |  | 46 |

### *4.2 Application Development*

Objective of this application is to produce a tool for facilitates access to digitized Arabic manuscripts. This application is a tool for searching and indexing images documents. For this purpose, we have developed a text identification application whose main interest is to exploit the Word Spotting technique for searching words in manuscripts. We have exploited the robustness of the SURF algorithm with respect to the invariance of its interest points to luminosity variation, rotations, scale changes and geometric variations. Our application divided into two essential parts:

The first, allows the comparison of the word features of the query image with target images containing segmented words. It consists of finding the occurrences of a word in images of the same document and designating their locations in the pages. The word features in the image based on the invariant interest points. The results of these comparisons are satisfactory despite some errors which are due to the low resolution of some images that form the pages of the manuscript.

The second compares the features of query words with those that stored in folders. The degree of similarity offers us searched words with their equivalent in ASCII code. In case of the absence of the word searched, the application proposes the addition of the word image and its equivalent in text mode to feed the base of words.

This application can also help in the transcription or automatic annotation of Arabic manuscripts. It can be used in the phase of detecting the similarities between words. The following figure shows the graphical interface of this application. The extraction of the global features of the query image and compared with those of those that included in images.

The results of matching with the Word Spotting method give many occurrences of the name "Mohamed محمد" equal to twice. We used three types of query images (color, grayscale and binary) and we got the same result. Therefore, this method can be applied to a set of images of the same manuscript, which makes it possible to search all the occurrences of the query word.

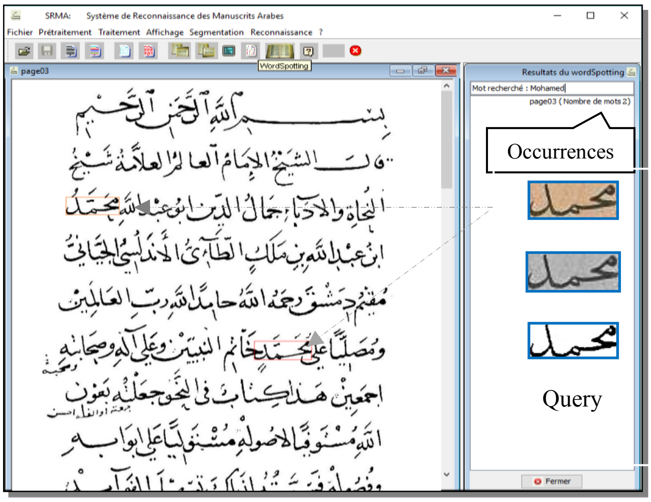



Fig. 5. Word Spotting application

## V. Conclusion

In this paper, we presented a reference method for words identification in Arabic manuscripts. It has been found that the methods developed to date for identification of Arabic manuscripts do not allow reliable recognition of manuscript elements (characters, pseudo-words, words ...).

Our method relies on interest points. It is adapted to a wide variety and variety of writing and fonts. Feature extraction (interest points) of the manuscript elements is done using SURF invariant local detectors and descriptors. In addition, we notice that the false points belonging to the texture, diverge thanks to the small variations of contrast due to the physical supports like the old paper and the parchment ...

We tested our method on several Arabic manuscripts of the national library in Rabat, some of which degraded. The results are excellent despite some rejections because of the complexity of the handwriting (exaggerated reconciliations of handwritten elements).

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