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Pattern Recognition by Graphs: Application to Printed Tifinagh Character

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Abstract
Writing is one of the most essential medium to communicate with people. This is why we created character recognition systems to facilitate man-machine interaction. Most methods of character recognition existing require lot of pre-processing. Based on the idea that any form is apprehended by the human perception, we present a structural approach to recognition of Tifinagh characters (alphabet used by the Amazighe, mainly Tuareg). After using pre-processing techniques, we uses graphs representation as a model for offline recognition of printed Tifinagh characters. This representation allows extracting the basic form of an independent letter and recognizes it. The proposed approach shows its effectiveness against problems such as size and orientation resulting performance gain, also in term of its speed.

Keywords
Character Recognition, Graphs Representation, Tifinagh Characters, Structural Approach, Recognition System

I. Introduction

Optical Character Recognition (OCR) is a computer procedure that converts an image of printed text into a text file, which means get the text in image of printed text and save it in a readable text file fortreatment and enrichment. The image can come as appliance of online and offline devices. Online devices work with a pen and include displays, tablets and graphics tablets. These tablets can provide temporal order of the points are the lines of text. Some tablets provide additional information, including speed and pressure In addition, offline devices include scanners flat type, manual and paper. They make an image substantially in the form of raster pixels.

Amazighe is a Chamito-Semitic language derived from ancient Berber. It includes a variety of dialects present from Morocco to Egypt, passing through Algeria, Tunisia, Mali, Niger and Libya. Several research studies have been performed on the computerization of Tifinagh characters. This research is concentrated in Morocco and Algeria. In Morocco there are three research centers: Sultan MoulaySlimane University in Beni Mellal, Ibn Zuhr University in Agadir, and Royal Institue of Amazigh Culture (IRCAM) in Rabat, Morocco.

Lately a lot of research has been done on OCRTifinagh.In their Articles, Essaady and all [1] adopted an analytical approach in which they used finite automata as method of recognition and Freeman coding as feature extraction method. Bencharef and all [2] used a Riemannian metric as a feature. This is because these metrics descriptors are reliable toward change scale, the existence of noise and geometric distortions. El Ayachi and all [3, 4], shows two methods of recognition. Both methods use the Multilayer Neuron Networks and Dynamic Programming for the classification, Moments invariants&Walsh transform for feature extraction. In their work neural networks combined with Walsh transform showed fairly interesting results. Bencharef and all [5], in a second work, have merge several feature extraction methods (Hu Moments, Zernike Moments, Legendre Moments, Texture, GIST, Walsh) and several classification methods (Nearest Neighbour, Multiclass SVM, Bayesian Networks, Neural Networks), as a result they got an excellent recognition rate but a large processing time. All methodologies adopted in this work give good results, but it require lots of pre-processing which makes these systems long enough to automate a set of scripts.

Hence the idea of Hebb [6] that any form is apprehended by the human visual perception, not as a whole, but in parts, and that the organization and the relative spatial positions of its parts play an important role in learning and recognition. Structural descriptions are based on a decomposition of forms into simple elements. In our OCRTifinagh system,we adopted a structural approach in which graphs are used as a model representation.

II. Tifinagh characters Recognition system

A. Characteristics of Tifinagh

Ya	Yab	Yag	Yag^{w}	Yad	Ya□□
					
1	2	3	4	5	6
Yey	Yef	Yak	Yak^{w}	Yah	Ya□
					
7	8	9	10	11	12
Ya□□	Yax	Yaq	Yi	Yaj	Yal
					
13	14	15	16	17	18
Yam	Yan	Yu	Yar	Ya□	Ya□
					
19	20	21	22	23	24
Yas	Ya□	Yac	Yat	Ya□	Yaw
					
25	26	27	28	29	30
Yay	Yaz	Ya□			

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Fig. 1: Officials Characters Tifinagh (IRCAM)

Tifinagh alphabet is used by Berbers, mainly Tuaregs. It was formerly a consonantal alphabet. This alphabet has undergone modifications and variations inevitable since its origin until today. The Tifinagh characters normally written from left to right and vertically from top to bottom. Fig. 1 illustrates Tifinagh characters proposed by IRCAM (Research Institute for Amazighe Culture). it is composed of thirty-three characters representing consonants and vowels.

B. Character Recognition System

A Character Recognition System (CRS) accepts the output from a device online or offline as input data, processes it and produces output data understandable.The system is based on three major steps: pre-processing, Feature extraction and classification, as shown in Fig. 2.

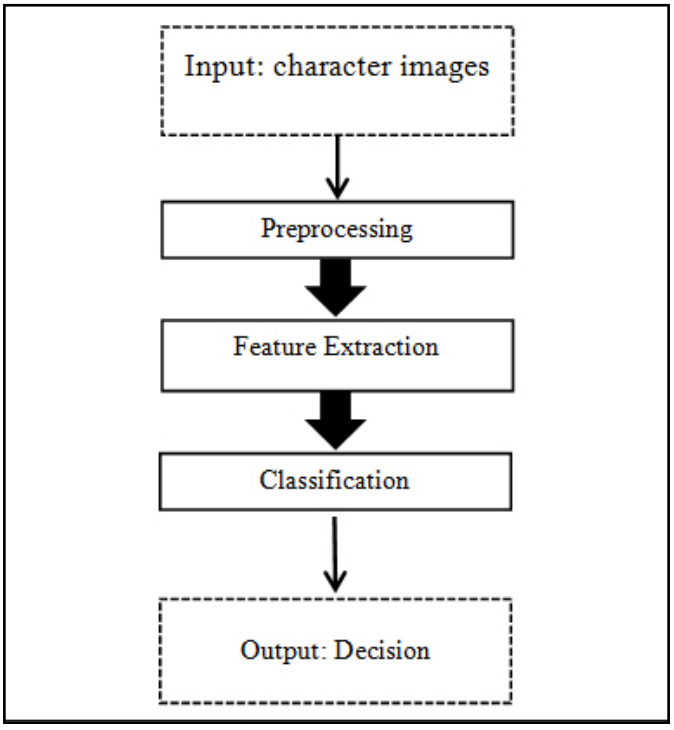

Fig.2 : Character recognition system

Pre-processing phase aims to reduce the amount of data to keep only relevant information. It is called low-level treatment. The extraction of the primitive phase allows to make from the representation of the image a synthetic description of the pattern to be recognized in a multidimensional space.
The classification phase is the phase of recognition of the character or word. This step implies the existence of a learning data base. The description of the character to be recognized is compared with the descriptions of the base character.

C. Tifinagh character recognition system

It represent a set of methods and algorithms we used for each step of character recognition system. Figure 3 shows theTifinagh characters recognition system.

1. Pre-processing

In order to automate the handwriting recognition, we must prepare images to be processed. Preliminary steps, which are necessary for recognition, are the binarization and skeletonization.

a. Binarization

It is the first step of pre-processing, it main to convert the scanned image into a binary image. However, binarization is an operation that produces two classes of pixels.In general, they are represented by black pixels and white pixels.

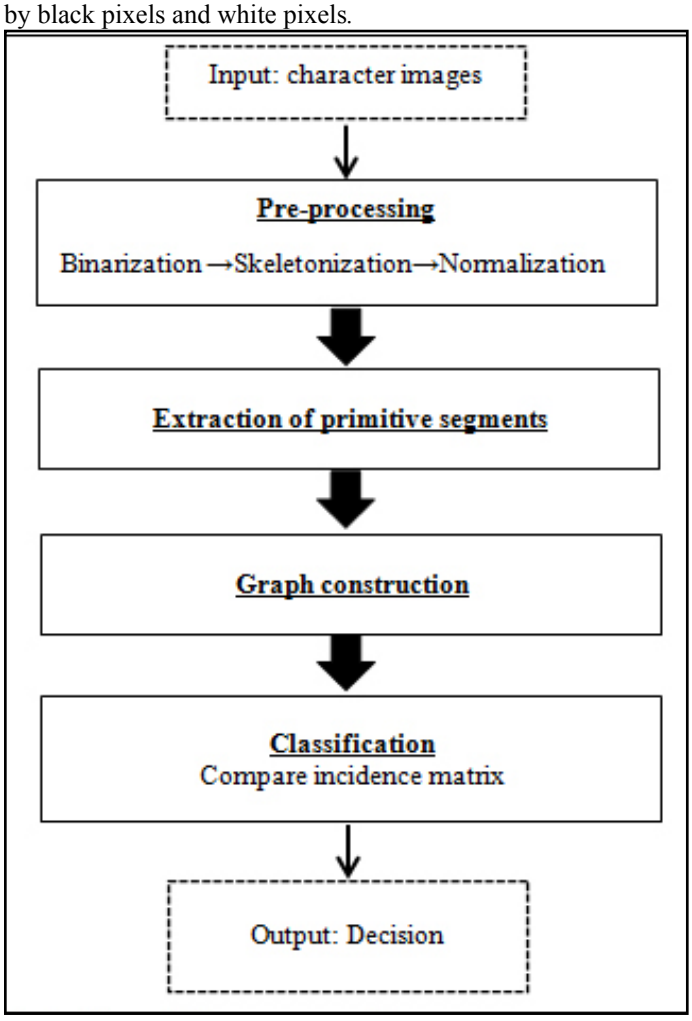

Fig. 3: Adopted Character recognition system

b. Skeletonization

It is used to obtain a thickness equal to one of the writing line and thus be reduced to a linear writing. The skeleton must preserve the shape, connectivity, topology and end of the route, and should not introduce parasitic elements.

c. Normalization of the position

The goal is to improve the processing time by removing unwanted areas. To do that we calculated the horizontal and vertical histograms to detect the first white pixel at top, bottom, left and right.

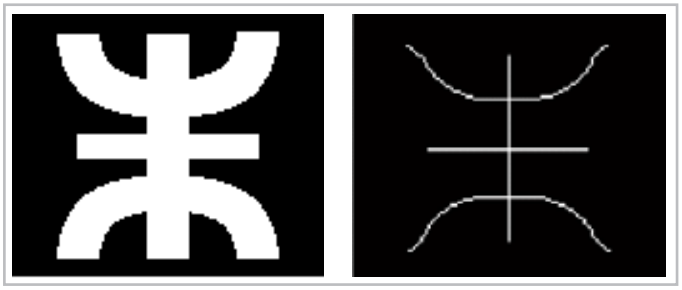

Fig. 4:Example of skeletonization

We have used the algorithm of Zhang and Wang [7] due to its strength and speed. This is a parallel algorithm in a single iteration that produces perfectly skeletons 8-connected and which operates the collisions. Figure 4 illustrate the results obtained by using Zhang&Wang algorithm.
This algorithm removes all pixels that are not part of the skeleton. For pixel P1 we use 4*4 neighbours. Figure 5 illustrate an example of the neighbours of pixel P1 used to determine if it is a skeleton pixel or not.

P10	P11	P12	P13
P9	P2	P3	P14
P8	P1	P4	P15
P7	P6	p5	P16

Fig. 5: Pixel p1 and its neighbours

A pixel p1 removed if the following conditions are satisfied:
- P1=1
- 2≤B(P1)≤6 where B(P1) is number of P1 white neighbours
- A(P1)=1 where A(P1) is number of 01 pattern starting from p2
- P2*P4*P8=0 or P11=1
- P2*P4*P6=0 or P15=1

d. Extraction of primitive segments

Once the skeleton of a character obtained, we need to extract the primitive segments that is to say a simple as possible geometrically element constituting grapheme which is schematically represented by a skeleton. That is to extract singular points (Fig. 6). Can be divided into three type minutiae points [8]:
- End Points
- Intersection Points
- Inflection Points

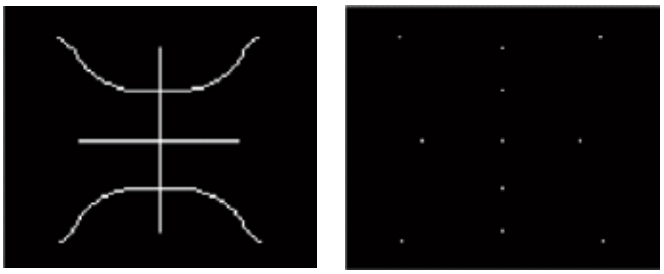

Fig. 6: Example of singular points

Intersection and end pointsdetection

This step does not pose a major problem since it's based on the study of the neighbours of each point. End points have only one 8-neighbor and the intersection points at least three. One method is to scan the image and check if the neighbours of each point corresponds to a boolean mask characteristic of an intersection or end. Thus the intersection points correspond to the following masks:

$$\text{With rotation of 45 °}\begin{cases} I^1 = \begin{matrix} 1 & 0 & 1 \\ x & 1 & 0 \\ 0 & x & 1 \end{matrix} \\ I^2 = \begin{matrix} 1 & 0 & 1 \\ 0 & 1 & 0 \\ x & 1 & x \end{matrix} \\ I^3 = \begin{matrix} 1 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 1 \end{matrix} \end{cases}$$

Where the symbol x represents 1 or 0, and the end points are obtained, meanwhile, with the following masks:

$$\text{With rotation of 45 °}\begin{cases} F^1 = \begin{matrix} 1 & 0 & 0 \\ x & 1 & 0 \\ 0 & 0 & 0 \end{matrix} \\ F^2 = \begin{matrix} 1 & x & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{matrix} \end{cases}$$

Inflection points Detection

After detecting the end points and intersection, the skeleton may be divided into a set of primitives whose concavity is not necessarily strict. The inflection points are calculated so primitive by primitive. By definition, an inflection point is where the curvature of the curve vanishes (with special management segment portions). A simple way is to use an interpolation then find places where$D = (x'' * y' - x' * y'') = 0$. The de Casteljau algorithm [8] is quite appropriate as smooth breaks. However, the use of all points of the control points as primitive involves too noisy and approximation leads to interference detections. Using a polygonization Ramer [8] leads to a smoothing of the curve. With this, the number of control points is limited, thereby improving the results.

2. Graph construction

A graph G is a pair G = (N, A), which represents N nodes or vertices and A represents the arcs or edges. The graphs of the most common structures are not topologically complete.

Graphs are considered as a set of very powerful structural data for the representation of objects. In a graph representation, vertices represent objects or parts of objects. The arcs represent the relationships between the objects or parts of objects they can be oriented or non-oriented (that is to say a vertex directed to another). The graph associated with the matrices, such as matrices of impacts, contains information about the connectivity graph.

An impact matrix M is a matrix of size n * m, such that:

$$\begin{cases} n = |N| \ the\ number\ of\ nodes \\ m = |A| the\ number\ of\ edges \end{cases}$$

an element $e_{i,j}$ (i= {1,…, n} et j= {1,…, m}) of the matrix M

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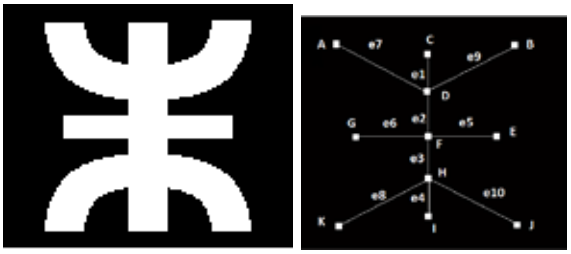
an element $e_{i,j}$ (i= {1,…, n} et j= {1,…, m}) of the matrix M can have two values:

$$\begin{cases} e_{i,j} = 1 \ \ if\ the\ arc\ j\ is\ incident\ to\ top\ i \\ e_{i,j} = 0 \ if\ no \end{cases}$$

The degree of the graph is the number of edges incident to vertices, this means that for an undirected graph the degree is twice the number of arcs as each arc is incident to two vertices. The degree of a vertex is the number of arcs incident to the top.

Convert the image into a graph is critical because the graph should represent the characteristics of the letter to a large extent. The distance between two nodes must be high enough to represent the characteristics of the letter properly and also small enough to not take a lot of memory. This task has been carried out in extracting singular points. From these points we can construct the appropriate graph (Fig. 7).



Original image Image graph representation

Fig. 7: Image graph representation

III. Classification and Results

The training set consists of the total images incidence matrix reference [9]. The similarity test is made by comparing the incidence matrix of the test image with those of the reference images. The first step is to verify the number of nodes which means that we are using an exact graph matching method. This method affect the recognition rate but the CPU time is good.

	e1	e2	e3	e4	e5	e6	**e7**	**e8**	**e9**	**e10**
A	0	0	0	0	0	0	1	0	0	0
B	0	0	0	0	0	0	0	0	1	0
C	1	0	0	0	0	0	0	0	0	0
D	1	1	0	0	0	0	1	0	1	0
E	0	0	0	0	1	0	0	0	0	0
F	0	1	1	0	1	1	0	0	0	0
G	0	0	0	0	0	1	0	0	0	0
H	0	0	1	1	0	0	0	1	0	1
I	0	0	0	1	0	0	0	0	0	0
J	0	0	0	0	0	0	0	0	0	1
K	0	0	0	0	0	0	0	1	0	0

Fig. 8: Example of incidence matrix

In this experience, 2200 character images from the IRCAM database were used to form the training set, and 1100 character images were used to test the performance of identification. Some results are listed in the table below.

These results demonstrate interesting in terms of CPU time.This come from the fact that we only use singular points to represent character by graph. Also it shows effectiveness against problems such as size and orientation by using incidence matrix as a way to identify characters.Recognition rate can be improved by adding other features such as height and width of characters, and by improving the singular point detection. Results obtained are illustrated in the following table.

Table: Recognition rate, error rate and training time

		Test 1	Test 2
adopted method	training data Size	1100	2200
	The test database Size	550	1100
	Recognition rate (%)	89.21	91.01
	Error rate (%)	11.79	8.99
	Training time (s)	300.25	400

IV. Conclusion

In this article, we used graphs as representation model for recognition of printedTifinagh characters. We used singular points as information to build character, than extract incidence matrix and use it as the main feature to recognize character.

We have presented experimental results performed on the database of printed characters Amazighe (IRCAM).The results obtained are 91.01% with a computation time from 40 seconds using a database of 2200 characters.

The work done is a first step for several perspectives. We try to improve our recognition rate by changing the graph model for a better representation keeping the speed of the system. We try to extend our approach to the recognition of printed handwriting recognition characters, the recognition of words, sentences and texts**.**

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