Asim Nabawi and **Sabri A. Mahmoud**,
"Arabic Optical Text Recognition: A Classified Bibliography."
Engineering Research Bulletin, Minufiyah University, Egypt, Vol. 23, No. 1, Jan. 2000, pp. 79-131.

Key words: Arabic Character Recognition, Arabic Cursive Characters, OCR, AOTR, AOCR, OCR, Classified Bibliography

ISSN 1110 - 1180

ENGINEERING RESEARCH BULLETIN

Volume 23
Number 1
January 2000

MINUFIYA UNIVERSITY,
FACULTY OF ENGINEERING
SHEBIN EL-KOM, EGYPT

Arabic Optical Text Recognition: A Classified Bibliography

Asim A.-F. Nabawi[1] and **Sabri A. Mahmoud**[2]

College of Computer & Information Sciences
King Saud University

Al-Manarain Establishment
for Technical Applications

Riyadh, Saudi Arabia

Abstract **A classified bibliography and a lexicographically-indexed table of 260 items of literature pertaining to the optical recognition of Arabic texts, including Hindi numerals' recognition, are provided. The limited number of items cited in this bibliography highlights two points. First, the difficulties facing researchers in collecting dispersed references pertinent to this research area, which was in the first place a major incentive to working on this paper. Second, the limited efforts and resources expended in promoting this branch of research, evident from comparing the volumes of reported OCR research works and products on Latin and other languages with those on Arabic. A keyword-based classification scheme whose results may help in locating papers of interest in a certain research subtopic is implemented. An appendix provides a classified table highlighting the features of each of the included literature items, offering a glimpse of an overall picture.**

Indexing Terms: *Arabic Optical Text Recognition Arabic Optical Character Recognition AOTR AOCR OCR Classified Bibliography*

Introduction

The authors have been collecting literature on the subject of Arabic optical text recognition (AOTR) for more than two years[3]. To the authors' knowledge, this is the first attempt to produce a classified bibliography on AOTR.

Manuscript received from Dr. Asim A.-F. Nabawi on : 3/7/1999
Accepted on : 4/12/1999
Engineering Research Bulletin, Vol 23,No 1, 2000 Minufiya University, Faculty of Engineering , Shebien El-Kom , Egypt, ISSN 1110-1180

[1] Computer Science Department, CCIS, KSU, P.O. Box 51178, Riyadh 11543, Saudi Arabia.

[2] Al-Manarain Establishment for Technical Applications, P. O. Box 53531, Riyadh 11593, Saudi Arabia.

[3] The authors would appreciate any comments, suggestions, or documents for inclusion in the next version of the bibliography, to be forwarded to the first author on his address given above.

The published work on Arabic optical text recognition is comparatively limited in number and scattered in many places. Due to this status, researchers in the field face considerable difficulties in locating reports of the previous efforts in this field. To make their task easier, and to help them concentrate on the job they need the literature for, we have expended time and effort in collecting, classifying, and producing this bibliography.

All the papers, theses, and reports that we could trace are included. The references that the authors could not lay hands on a copy of, are marked with an asterisk (*) following their entry in the AOTR bibliography. Readers should not expect the classification of such references to be as complete as that of the available references. Classifying the unavailable ones is based either on their title if the title is indicative and/or informative, or on other researcher's comments on them, if available. Farsi, Kurdi, Urdu, and historical Ottoman texts use the Arabic alphabet set with few additions or modifications. Hence few papers on the recognition of texts in Farsi and historical Ottoman could be obtained and are included. The language of all these literature items is English save 11 items in Arabic; 11 in French; two in Japanese; and only one item in Russian.

Classification Results

Readers who prefer to bunch literature items relevant to each research topic and/or subtopic in the field of Arabic optical text recognition, will find their needs satisfied in this section before the compiled AOTR bibliography. Table (1) highlights the statistics of the collected literature items. Meanwhile, readers interested in having a concise picture of each literature item in this classified collection are referred to the table given in Appendix A.

In the appendix, some symbolic information on each of the items of the bibliography are arranged in one row of the table. Some light is first shed, in Appendix A, on the classification scheme concocted to fill up the entries of that table. With the help of that scheme the symbolic information on each of these references can be decoded and made available.

Table (1) Statistics of the Literature Items of the AOTR Bibliography

Type	Available	Non-available	Sum
General Review Papers	7	3	10
Research Papers	153	61	214
Research Reports	1	11	12
Theses (Ph. D. & Master)	7	16	23
Books	0	1	1
Total Number	168	92	260

Review Papers

Two of the review papers cited in this bibliography, namely [Govindan90] and [Mantas86], are not confined to AOTR. Nevertheless, the first of them is a very informative, well-written, broad-scope review paper. The second gives a historical background and a general review of industrial recognisers and scanning devices. The two papers looked into some research works on AOTR, and included some of these works among their references. We recommend any novice to start his readings on the subject with these two papers. A recent and far more comprehensive survey paper that critically looked into the AOTR systems available in the marketplace is [AlBadr95]. [Ahmed94] has looked into the problem of the non-standard test data sets and evaluated the performance of systems and published research works in AOTR spanning more than the last two decades (1981-1992). Including the aforementioned papers, the following are the review papers cited in this bibliography, divided into two groups: 10 general review (GR) papers and 17 limited review (LR) papers.

a. General Review Papers:

[Ahmed94]; [AlBadr95]; [Amin85a]; [Ghuwar94]; [Govindan90]; [Jambi91b]; [Mantas86]; [Nouh94]; [Parhami77]; and [Shoukry89].

b. Limited Review Papers:

A limited review paper is a research paper or report that discusses and/or compares the performance of a limited number of published techniques and reports in the field. The following are papers that fall under this category.

[AbdElGwad90]; [AlOhali96]; [Amin85b]; [Amin87]; [Fakir91]; [Nouh88b]; [Ramsis88]; [SharafEldin88]; [Tikhonova92]; [Tolba87a]; [Tolba88a]; [Tolba88b]; [Tolba89]; [Tolba90]; [Yalabik88]; [Youssef89]; and [Youssef93].

Nature of Application and Hardware Implementation

There are three general points applicable at this juncture:

- First, on-line recognition techniques are generally deemed comparatively simpler than off-line techniques. This is mainly due to the availability of important temporal information inherent of on-line handwritings.
- Second, the recognition of characters is always simpler than that of cursive text, due to the attendant problems of segmenting such texts into words, subwords, and eventually in most of the cases into characters.
- Last point is that, due to variability of the human writing both in style and size, handwritten texts are far more difficult to recognise compared to machine-printed texts.

i. On-line

a. Handwritten Character Recognition

[Amin79]; [Amin80]; [Amin85b]; [Amin87]; [Amin88b]; [ElSheikh89a]; [ElSheikh90a]; [ElSheikh90c]; [ElWakil87]; [ElWakil88]; [ElWakil89]; and [Nouh87c].

b. Handwritten Cursive Text Recognition

[AbdelAzim96]; [AlEmami90]; [Amin82a]; [Amin82b]; [Amin83]; [Amin84]; [Amin85b]; [Amin85c]; [Amin87]; [Amin88c]; [ElSheikh90b]; [Nouh87c]; [Seddik89]; and [Shaheen90].

c. Handwritten Hindi Numerals Recognition

[ElSheikh90c] and [Nouh87c].

ii. Off-line

a. Printed Character Recognition

[AbuHaiba90]; [AbuHaiba91]; [Aiiah88]; [AlBaiaty86]; [AlEmami88]; [Ali89]; [AlShebeili97]; [AlTuwaijri94b]; [AlTuwaijri94c]; [AlTuwaijri95b]; [AlTuwaijri96]; [AlYousefi92]; [Badie78]; [Belghith90]; [Bouhlila88]; [ElRamly89b]; [ElRamly89c]; [ElShbiny76]; [ElSheikh88a]; [ElSheikh89b]; [Fayek92]; [Goneid87]; [Goneid88]; [Ismail93a]; [Jambi97]; [Khella94]; [Khemakhem87a]; [Khemakhem87b]; [Khemakhem88]; [Khemakhem89]; [Khemakhem93]; [Kurdy92]; [Mahdi87]; [Mahdi89]; [Mahmoud91]; [Mahmoud94]; [Nabawi94]; [Namane90]; [Nazif75]; [Nouh80]; [Nouh84]; [Nouh87b]; [Nouh87c]; [Nouh88a]; [Nouh88b]; [Nouh88c]; [Nouh88d]; [Nouh89]; [NurulUla87]; [NurulUla88a]; [NurulUla88b]; [Sabri86]; [Sanossian96]; [SharafEldin88]; [Sharkawy88]; [Taconet89]; [Tolba86]; [Tolba87a]; [Tolba87b]; [Tolba87d]; [Tolba88a]; [Tolba88b]; [Tolba89]; and [Tolba90].

b. Printed Cursive Text Recognition

[AbdelAzim87]; [AbdelAzim88]; [AbdelAzim89a]; [AbdelAzim89d]; [AbdelAzim89e]; [AbdelAzim90a]; [AbdelAzim90b]; [AbdelAzim92a]; [AbdelAzim92b]; [AbdelAzim93]; [AbdelAzim95]; [Ahmed92]; [AlBadr92]; [AlBadr93]; [AlBadr95b]; [AlBadr95c]; [AlBadr96]; [AlJabri91]; [AlJabri92]; [Allam94]; [AlOhali96]; [AlSuwaiyel91]; [Amin85c]; [Amin86]; [Amin88a]; [Amin89]; [Amin91a]; [Amin91b]; [Badie80a]; [Badie80b]; [Barber88]; [Berbar94]; [Bouhlila89]; [ElDabi90]; [ElGowely89]; [ElGowely90]; [ElKhaly90]; [ElRamly89a]; [ElSheikh88b]; [Emam93]; [Emam94]; [Fakir91]; [Fakir92]; [Fakir93]; [Fehri94]; [Ghuwar95]; [Goraine89]; [Goraine90]; [Goraine92a]; [Goraine92b]; [Goraine94]; [Guindi87]; [HajHassan85];

[HajHassan88]; [HajHassan90]; [HajHassan91]; [Hashish85]; [Hassibi93]; [Hassibi94]; [Hyder88a]; [Hyder88b]; [Ismail93b]; [Jambi90]; [Kamel90]; [Khella92]; [Khemakhem88]; [Khemakhem89]; [Khemakhem93]; [Kurdy93]; [LaPre96]; [Makhoul96]; [Margner92]; [Nouh87a]; [Nouh87c]; [Nouh88a]; [Parhami81]; [Ramsis88]; [Rashid96]; [Saleh75a]; [Saleh75b]; [Saleh77]; [Shoukry83]; [Shoukry91]; [Yalabik88]; [Youssef89]; and [Youssef93].

c. Printed Hindi Numerals Recognition

[Ali89]; [ElHamalawy88]; [Mahmoud86]; [Mahmoud87]; [Nouh87c]; [Nouh88a]; and [Parhami81].

d. Handwritten Character Recognition

[AbdElgwad90]; [AbuHaiba90]; [AbuHaiba95a]; [AbuHaiba95e]; [AbuHaiba96b]; [AlEmami88]; [Ali79]; [AlYousefi88]; [AlYousefi89]; [AlYousefi90]; [AlYousefi92]; [Badie82a]; [Badie82b]; [ElDesouky91]; [ElDesouky92]; [Nouh87c]; [Nouh93]; [NurulUla88a]; [NurulUla88b], [Rashwan94]; [SaadAllah85]; [Tolba86]; [Tolba87b]; [Tolba87d]; [Zaki86a]; and [Zaki86b].

e. Handwritten Cursive Text Recognition

[AbdelAzim89b]; [AboSamra97]; [AbuHaiba93]; [AbuHaiba94a]; [AbuHaiba94b]; [AbuHaiba94c]; [AbuHaiba95b]; [AbuHaiba95c]; [AbuHaiba95d]; [AbuHaiba96a]; [AbuHaiba96b]; [AlMuallim87]; [AlTuwaijri 94a]; [AlTuwaijri95a]; [AlYousefi92]; [Ameur93]; [Amin91b]; [Amin92]; [Badie82a]; [Badie82b]; [Jambi91a]; [Jambi92]; [Jambi93]; [Jambi95]; [Jambi96]; [Nouh87a]; [Nouh87c]; [Rahho86]; [Shoukry94]; [Zahour89]; [Zahour90]; [Zahour91]; and [Zahour92].

f. Handwritten Hindi Numerals Recognition

[Abbas86]; [AbdelAzim89c]; [Abdulla88]; [AlQaisy85]; [AlQaisy87]; [AlQaisy89]; [AlTikrity84]; [AlTikrity85]; [Assal91]; [Assal92]; [Bansal84]; [Braham92]; [Goneid92a]; [Goneid92b]; [Goneid92c]; [Mahmoud86]; [Mahmoud87]; [Nouh87c]; and [Yousef86].

iii. Multifont Recognition:

[AbdelAzim89a]; [Ahmed94]; [AlBadr92]; [AlBadr95a]; [Allam94]; [AlTuwaijri94a]; [AlTuwaijri95a]; [Amin86]; [Amin88a]; [Amin89]; [Amin91a]; [ElGowely89]; [ElGowely90]; [ElSheikh89b]; [Fayek92]; [Fehri94]; [Goraine89]; [Govindan90]; [Hassibi94]; [Kurdy92]; [Kurdy93]; [LaPre96]; [Makhoul96]; [Namane90]; [NurulUla88a]; [NurulUla88b]; [Ramsis88]; [Rashid96]; [Tolba89]; and [Tolba90].

iv. Hardware Implementation

Most of the techniques used in the AOTR field are implemented in software, availing from the high processing speeds and huge storage capacities of the new machines. Nonetheless, continuous leaping advances in both chip technology and computer architecture enable implementing some of these techniques, wholly or partly, in hardware. Parallel processing techniques and their hardware implementation have opened new vistas for realising connectionist neural nets and employing some other techniques used in the character recognition field in hardware form. [Abbas86] and [Khemakhem93].

Pre-processing and Segmentation Techniques

i. Pre-processing Techniques

The first step to be taken before processing a character is to have its image acquired using video cameras, scanners, or the like, and transformed into a digitised form suitable for recognition. The recognition efficiency depends -- in its major part -- on the quality of this digitised image and on how faithfully it represents the original image (or strictly the document in this case). Noise in such a document representation is there with any black pixel(s) representing an extraneous signal, whatever its source may be, in the digitised image.
Pre-processing techniques are used to theoretically eliminate, or practically reduce, both noise and variations in the digital image. For example, eliminating variations leads to a digital image of the handwritten character independent of the writer's personal style. The pre-processing techniques are aimed at minimising the effects of the unwanted noise and variations through using one or more of many operations. These techniques include, among others, binarization (thresholding), scaling, filtering and smoothing, thinning (skeletonization), slant normalisation, deskewing leading to baseline detection, and stroke width estimation.

a. Noise Reduction (Smoothing)

Work has been continuing on this topic since OCR systems started to be at the focus of researchers' attention. This is justified since it is a long-held view that were it not for noise with its diverse sources, the recognition of isolated printed characters would have been a trivial issue. Noise reduction techniques are numerous, with some of them more suited to either on- or off-line applications. They encompass, after binarization (thresholding) of the character image, conditioning steps like low-pass filtering and smoothing. The latter steps are needed to minimise variations that are a by-product of the image acquisition process. Image traversal

removes isolated pixels and fills gaps. Mathematical morphological operations may also be used for smoothing the character binary image.

[Abbas86]; [AbdelAzim89c]; [AbuHaiba90]; [AbuHaiba91]; [AbuHaiba93]; [AbuHaiba94a]; [AbuHaiba94b]; [AbuHaiba94c]; [AbuHaiba95a]; [AbuHaiba95b]; [AbuHaiba95c]; [AbuHaiba95d]; [AbuHaiba96a]; [AbuHaiba96b]; [Ahmed92]; [AlBadr95b]; [AlBadr95c]; [AlBadr96]; [AlBadr92]; [Ali89]; [AlShebeili97]; [AlTuwaijri94b]; [AlTuwaijri95a]; [AlTuwaijri95b]; [AlTuwaijri96]; [AlYousefi88]; [AlYousefi89]; [AlYousefi90]; [AlYousefi92]; [Ameur93]; [Amin80]; [Amin82a]; [Amin82b]; [Amin83]; [Amin84]; [Amin85b]; [Amin85c]; [Amin86]; [Amin87]; [Amin88a]; [Amin88b]; [Amin88c]; [Amin89]; [Amin91a];; [Amin91b]; [Amin92]; [Badie82a]; [Badie82b]; [Braham92]; [ElGowely90]; [ElHamalawy88]; [ElKhaly90]; [ElRamly89a]; [ElRamly89b]; [ElRamly89c]; [ElSheikh88a]; [ElSheikh88b]; [Emam93]; [Emam94]; [Fakir93]; [Fayek92]; [Fehri94]; [Ghuwar95]; [Goneid92b]; [Goneid92c]; [Goraine92b]; [Goraine94]; [HajHassan91]; [Hassibi94]; [Jambi90]; [Jambi91a]; [Jambi97]; [Khella92]; [Khella94]; [KKurdy93]; [Lapre96]; [Mahmoud94]; [Makhoul96]; [Nabawi94]; [Namane90]; [Nouh87a]; [Nouh87b]; [Nouh88d]; [Nouh93]; [NurulUla88a]; [Parhami81]; [SaadAllah85]; [Saleh75a]; [Saleh75b]; [Shaheen90]; [Shoukry91]; [Taconet89]; [Tolba89]; [Tolba90]; [Zahour89]; [Zahour91]; [Zahour92]; [Zaki86a]; and [Zaki86b].

b. Thinning (Skeletonization) & Contour Detection

This process of thinning, or reducing, the character image into a skeleton is an essential step for OCR systems that require the expression of structural relationships for the sake of recognition. Obviously these relationships reduce both the space and processing time exacted by such systems. Thinning algorithms are very convenient for OCR systems aimed at recognising handwritten text and/or characters to combat the inherent variations in the human writing styles. Clustering algorithms implementing fuzzy approaches are also used to reduce characters into skeletons, but they are slow and suitable only for isolated characters. Contour detection helps also in scaling characters into a fixed size, and then centring the character inside the box prior to the recognition stage. This is generally useful in systems sensitive to variations in character size and position, like template matching and correlation methods. It has to be born in mind that such thinning techniques should preserve the secondaries of the Arabic characters, such as dots , zigzags, and the like. This information is vital for recognising Arabic, since many characters have the same main body and can only be differentiated using these secondaries.

[Abbas86]; [AbdelAzim92a]; [AbdElgwad90]; [Abdulla88]; [AbuHaiba90]; [AbuHaiba91]; [AbuHaiba93]; [AbuHaiba94a]; [AbuHaiba94b]; [AbuHaiba94c];

[AbuHaiba95a]; [AbuHaiba95b]; [AbuHaiba95d]; [AbuHaiba96a]; [AbuHaiba96b]; [Ali89]; [Allam94]; [AlMuallim87]; [AlTiktiti85]; [AlTuwaijri94b]; [AlTuwaijri95a]; [AlTuwaijri95b]; [AlTuwaijri96]; [Ameur93]; [Amin89]; [Amin91b]; [Amin92]; [Badie82a]; [Badie82b]; [ElDesouky91]; [ElDesouky92]; [ElHamalawy88]; [ElKhaly90]; [ElRamly89a]; [ElRamly89b]; [ElRamly89c]; [ElSheikh88a]; [ElSheikh88b]; [ElSheikh89a]; [ElSheikh90a]; [ElWakil87]; [ElWakil88]; [ElWakil89]; [Emam94]; [Fakir93]; [Fehri94]; [Goneid92b]; [Goneid92c]; [Goraine89]; [Goraine92b]; [Goraine94]; [HajHassan91]; [Hassibi94]; [Jambi91a]; [Jambi92]; [Jambi93]; [Jambi95]; [Khella92]; [Khella94]; [Mahdi87]; [Mahdi89]; [Mahmoud91]; [Mahmoud94]; [Margner92]; [Namane90]; [Nouh89]; [NurulUla88a]; [Parhami81]; [SaadAllah85]; [Shaheen90]; [Tolba89]; and [Tolba90].

c. Restoration of Temporal Information from Off-line Handwritten Texts

Some research work do not fit under one of the previous subheadings but still fall under the broad banner of pre-processing. Some researchers have decided to get hold of the temporal information missing from the handwritten texts produced in off-line environments. For this purpose they suggested a new technique to extract such information from off-line texts in order to render on-line text recognition techniques applicable to off-line handwritten texts.

The advantage here is the relative ease with which on-line recognition techniques are applied compared to off-line ones. Restoration of temporal information may be achieved by skeletonizing the connected words/subwords of the text, then representing each one of them in a way suitable for extracting the needed temporal information. This information include the number of strokes, their order, and the direction of writing of each stroke.

[AbuHaiba93]; [AbuHaiba94b]; [AbuHaiba95b]; and [AbuHaiba96b].

ii. Segmentation

Although some optical character recognition (OCR) systems do not necessarily need segmentation, this stage is deemed indispensable for many OCR systems. In these latter systems, segmentation is mostly carried out directly after pre-processing. In the segmentation stage individual characters of the text words are isolated prior to recognising them.. Nevertheless, the segmentation task is naturally carried out after page decomposition into its logical elements that are not necessarily all text. Segmentation of the text elements first into words and/or subwords and then into characters (or even into strokes or primitives) is important, and is deemed a decisive step to the success of most text recognisers. A most common method used to achieve the identification of text lines, then the segmentation of each line into words and/or subwords, is the horizontal

and vertical projection histograms, respectively. Some other methods are used either to supplement this, or to succeed it in case of failure. Contour tracing, thinning, traversing an energy-like curve, skeleton tracing, and connected component labelling are some of these methods. Arabic texts in particular suffer from the presence of horizontal ligatures and vertical overlapping that aggravate both the segmentation and recognition phases.

[AbdelAzim88]; [AbdelAzim89a]; [AbdelAzim89c]; [AbdelAzim89d]; [AbdelAzim90b]; [AbdelAzim92a]; [AbdelAzim96]; [AboSamra97]; [AbuHaiba95c]; [Ahmed92]; [AlEmami90]; [AlMuallim87]; [AlOhali96]; [AlTuwaijri94a]; [AlTuwaijri95a]; [AlYousefi88]; [AlYousefi90]; [AlYousefi92]; [Ameur93]; [Amin82a]; [Amin82b]; [Amin83]; [Amin84]; [Amin85b]; [Amin85c]; [Amin86]; [Amin87]; [Amin88a]; [Amin88b]; [Amin88c]; [Amin89]; [Amin91a]; [Amin91b]; [Amin92]; [Assal92]; [Bouhlila89]; [ElDabi90]; [ElGowely90]; [ElKhaly90]; [ElSheikh88b]; [ElSheikh90b]; [ElSheikh90c]; [Emam93]; [Emam94]; [Fakir93]; [Fehri94]; [Goneid92c]; [Goraine89]; [Goraine92b]; [Goraine94]; [HajHassan85]; [HajHassan88]; [HajHassan90]; [HajHassan91]; [Hassibi94]; [Jambi90]; [Jambi91a]; [Jambi92]; [Jambi93]; [Jambi95]; [Khella92]; [Kurdy93]; [Margner92]; [Nabawi94]; [Nazif75]; [Parhami81]; [Ramsis88]; [Rashid96]; [Saleh75a]; [Saleh75b]; [Shoukry91]; [Tolba89]; [Tolba90]; [Zahour89]; [Zahour91]; and [Zahour92].

Feature Extraction Approaches

The history of optical character recognition pivots itself around the notion of how the human ability to recognise written texts can lend itself to a machine, but expectedly at a faster pace. Many approaches are available, but from an Artificial Intelligence (AI) viewpoint the template matching approach is dispensed with. Other approaches are less sensitive to noise and lend themselves more suitably to problems emanating from variability of font size and handwriting styles. Most of these approaches invariably need suitable features of every character of the learning set to be decided upon, extracted, and stored in a features' vector.
In the subsequent stage of the recognition process, these features will be used to classify, or recognise, the unknown input characters.

a. Template Matching and Correlation

This technique emulates a mechanical template by comparing a given unknown character pattern, pixel-by-pixel, to a stored set of pattern templates. The given pattern is considered to belong to the class of the stored template with a minimum distance, or error. Albeit being direct to implement, this technique suffers from hypersensitivity to distortion. Many researchers use wide variations of this technique when other employed methods fail to recognise some input characters.

[AbdelAzim88]; [AlBaiaty86]; [Nazif75]; [Nouh80]; [Nouh84]; [Nouh87b]; [Nouh88d]; and [Nouh93].

b. Statistical Distribution of Points

These features describe the given character using a set of characteristic measurements extracted from its pattern. These features include Zoning, Crossings, n-tuples, Distances and Moments, just to name some of them. Systems using such features may be automatically trained for new fonts of the character set, since they generally tolerate moderate noise and variation in the character image to some extent. They provide high speed and diminished implementation complexity. However, for such features the mask making is generally difficult.

[Abbas86]; [AbdelAzim88]; [AbdelAzim89a]; [AbdelAzim89b]; [AbdelAzim89c]; [AbdelAzim89d]; [AbdelAzim90a]; [AbdelAzim90b]; [AbdelAzim92a]; [AbdelAzim92b]; [AbdelAzim93]; [AbdElgwad90]; [Ahmed92]; [AlBadr92]; [Allam94]; [AlQaisy85]; [AlQaisy89]; [AlTikrity85]; [AlTuwaijri94a]; [AlTuwaijri95a]; [AlYousefi88]; [AlYousefi89]; [AlYouseli90]; [AlYousefi92]; [Belghith90]; [Braham92]; [ElDabi90];109; [ElHamalawy88]; [ElKhaly90]; [ElRamly89b]; [ElRamly89c]; [ElSheikh90c]; [Emam94]; [Fayek92]; [HajHassan91]; [Jambi97]; [Kamel90]; [LaPre96]; [Mahmoud86]; [Mahmoud87]; [Makhoul96]; [Nabawi94]; [Nouh88b]; [NurulUla88b]; [Ramsis88]; [Rashid96]; [Rashwan94]; [Saleh75a]; [Saleh75b]; [Saleh77]; [Sanossian96]; [SharafEldin88]; [Shoukry94]; [Tolba86]; [Tolba87a]; [Tolba87b]; [Tolba87d]; [Tolba88a]; [Tolba88b]; [Tolba89]; [Tolba90]; [Zaki86a]; and [Zaki86b].

c. Global Transformations & Series Expansion

These techniques produce features that are insensitive to global deformation such as rotation, scaling, and translation. They also help to simplify the features' vector. Many researchers have used Walsh, Fourier, Hough, 1-D slice of the character spectrum, Projections, and other transforms. Chains of direction coding have also been used in different schemes. However, these techniques sometimes require the support of using additional features to improve the recognition rates. Like the statistical features, they may also automate the recogniser training for new fonts.

[Abbas86]; [AlQaisy87]; [AlShebeili97]; [ElKhaly90]; [ElSheikh88a]; [ElSheikh88b]; [Fakir93]; [Ismail93a]; [Khella92]; [Khella94]; [Khemakhem88]; [Khemakhem89]; [Khemakhem93]; [Mahmoud94]; [Nabawi94]; and [Sharkawy88].

d. Structural (Geometrical) & Topological Features

As the name implies, these features are directly dependent on, and extracted from, the geometry, or topology, of the given character yielding its global (topological) and local (geometrical) properties. These features include, but are not restricted to, strokes, bays, loops, number of crossing

points, branching points, end points, dots, and zigzags. They are highly tolerant of distortions and variations in writing styles, but are not always easy to extract from the character images. This is simply because these features require the pattern structure to be quantifiable, a task that is not always easy. Mask generation is also difficult for these types of features.

[AbdelAzim89a]; [AbdelAzim89b]; [AbdelAzim89c]; [AbdelAzim92a]; [AbdelAzim96]; [AbuHaiba90]; [AbuHaiba94a]; [AbuHaiba94b]; [AbuHaiba94c]; [AbuHaiba95a]; [AbuHaiba95b]; [AbuHaiba95e]; [AbuHaiba96b]; [AlBadr96]; [AlEmami90]; [Ali79]; [AlMuallim87]; [AlOhali96]; [AlTikrity84]; [Ameur93]; [Amin80]; [Amin82a]; [Amin82b]; [Amin83]; [Amin84]; [Amin85b]; [Amin85c]; [Amin86]; [Amin87]; [Amin88a]; [Amin88b]; [Amin88c]; [Amin89]; [Amin91a]; [Amin91b]; [Badie82a]; [Badie82b]; [Bansal84]; [ElDesouky91]; [ElDesouky92]; [ElGowely90]; [ElRamly89a]; [ElSheikh88a]; [ElSheikh88b]; [ElSheikh89a]; [ElSheikh90a]; [ElWakil87]; [ElWakil88]; [ElWakil89]; [Fakir93]; [Fehri94]; [Ghuwar95]; [Goneid92b]; [Goneid92c]; [Goraine89]; [Goraine92b]; [Goraine94]; [HajHassan91]; [Hassibi94]; [Hyder88a]; [Hyder88b]; [Ismail93a]; [Jambi90]; [Jambi91a]; [Jambi92]; [Jambi93]; [Jambi95]; [Khella94]; [Kurdy93]; [Margner92]; [Nazif75]; [Parhami81]; [SaadAllah85]; [Shaheen90]; [Zahour89]; [Zahour91]; and [Zahour92].

Classification Approaches

The recognition system is trained using the training set(s) on the features of the elements of the character set to be recognised, then comes the classification, or recognition phase. When an unknown character (after being segmented from the text, if not originally separate) is introduced, the recognition system should extract its features. These are then compared to the stored ones, using the specific classification algorithm. Consequently, the recognition system should come out with the best possible match, which hopefully is the right character class.
Classification approaches directly represent the character recognition schemes. These recognition schemes may be broadly classified into two main streams: statistical and structural approaches. Nevertheless, in order to allow the reader to pinpoint his sought references without delay, these two streams are available as broad headings. Some other specific approaches, that may not always exactly fit under one of them, are singled out. Hybrid classifiers are always possible to improve both the system's reliability and the recognition rate.

a. The Statistical Approach

Statistical classifiers are **decision-theoretic** approaches that span a diverse number of either deterministic or probabilistic methods. The former type of methods encompasses deterministic or distance classifiers. These classifiers have to map a fixed-length features' vector into a partitioned space. This process is equivalent to clustering in the vector space, where the decision rule is mainly a non-exact matching based on distance calculations to centres of clusters. The unknown input pattern

(character) is compared, then decided upon using many techniques. These include distance classifiers (to class means), nearest-neighbour (ranging from 1-nearest neighbour to k-nearest neighbour classifiers), and Bayesian (probabilistic) classifiers. Decision-tree classifiers are also statistical in nature. They range from using simple trees to using multiple-trees in order to improve the recognition accuracy. Statistical classifiers are generally capable of being automatically trained.

[Abbas86]; [AbdelAzim88]; [AbdelAzim89a]; [AbdelAzim89d]; [AbdelAzim90a]; [AbdelAzim90b]; [AbdelAzim92a]; [AbdElgwad90]; [AlBadr92]; [AlBaiaty86]; [Allam94]; [AlQaisy89]; [AlShebeili97]; [AlTikrity85]; [AlYousefi88]; [AlYousefi89]; [AlYousefi90]; [AlYousefi92]; [ElDabi90]; [ElHamalawy88]; [ElKhaly90]; [ElRamly89b]; [ElRamly89c]; [ElSheikh88a]; [ElSheikh88b]; [ElWakil87]; [ElWakil88]; [ElWakil89]; [Fakir93]; [Fayek92]; [HajHassan91]; [Kamel90]; [Khella92]; [Khella94]; [Khemakhem88]; [Khemakhem89]; [Khemakhem93]; [Mahmoud86]; [Mahmoud87]; [Mahmoud94]; [Margner92]; [Nabawi94]; [Nazif75]; [Nouh80]; [Nouh84]; [Nouh87b]; [Nouh88b]; [Nouh88d]; [Nouh93]; [NurulUla88b]; [Ramsis88]; [Saleh75a]; [Saleh75b]; [Saleh77]; [SharafEldin88]; [Tolba86]; [Tolba87a]; [Tolba87b]; [Tolba87d]; [Tolba88a]; [Tolba88b]; [Tolba89]; [Tolba90]; [Zaki86a]; and [Zaki86b].

b. The Syntactical Approach

The syntactical or **language-theoretic** classifiers are based on the grammar concept borrowed from the theory of formal language. For some of these classifiers to be implemented, the unknown input words should be successively segmented into smaller identifiable primitives. These primitives should then be parsed according to a given set of these syntactical rules. The unknown pattern, represented by a string of primitives, is classified as being a member of a certain class if it is successfully parsed by its grammar. In some cases such a string may not be completely parsed, then a stochastic grammar using probabilities may be used to solve the problem.

[AbdelAzim89a]; [Ali79]; [Amin80]; [Amin82a]; [Amin82b]; [Amin83]; [Amin84]; [Amin85b]; [Amin86]; [Amin87]; [Amin88a]; [Amin88b]; [Amin88c]; [Amin91b]; [ElDesouky91]; [ElDesouky92]; [ElGowely90]; [ElSheikh88a]; [ElSheikh88b]; [ElSheikh90c]; [ElWakil87]; [ElWakil88]; [ElWakil89]; [Emam94]; [Fakir93]; [Fehri94]; [Goneid92b]; [Goneid92c]; [Goraine89]; [Goraine92b]; [Goraine94]; [HajHassan91]; [Kurdy93]; [SaadAllah85]; [Shaheen90]; [Zahour89]; [Zahour91]; and [Zahour92].

c. The Relational Graph-matching Approach

The **graph-theoretic** classifiers built according to this approach are sometimes called hierarchical classifiers. In such cases, characters are represented as a tree where its internal nodes are the primitives and the

leaves are the character labels. When recognition fails in the forward direction towards one of the leaves, due to missing or extraneous primitives, reverse direction recognition is there to be tried as an alternative.

The Fuzzy Approach is sometimes useful in such cases, where the fuzzy-set theory of directions is used to model unknown handwritten characters as fuzzy attributed graphs. These graphs are then compared to those of the models to arrive at the correct recognition decision. Such fuzzy techniques are more helpful when the issue at hand is the recognition of handwritten characters with their attendant problems. It is futile, or at least too disadvantageous in such cases, to depend on structural approaches. Variability of the handwriting is very difficult to anticipate, and hence to describe, when the strict mathematical constraints set by the theory of formal languages are at work.

[AbdelAzim89c]; [AbdelAzim96]; [AbuHaiba90]; [AbuHaiba94a]; [AbuHaiba94b]; [AbuHaiba95a]; [AbuHaiba95e]; [AbuHaiba96b]; [AlBadr96]; [AlEmami90]; [AlMuallim87]; [AlTikrity84]; [Ameur93]; [Amin89]; [Amin91a]; [Badie82a]; [Badie82b]; [Bansal84]; [ElRamly89a]; [ElSheikh89a]; [ElSheikh90a]; [Hyder88a]; [Hyder88b]; and [Parhami81].

d. The Neural Network Approach

Artificial Neural Networks, known as Neural Nets (NNs), are interconnected networks of simple non-linear units aimed at modelling some functions of the human brain. They are treated as black boxes and are trainable using several algorithms. Since their advent, they have been successfully applied to a wide class of problems that are otherwise difficult to deal with. This state of affairs prevails due to several reasons. They are adaptive, learn from examples, and they can also generalise.

NNs are used here for the purpose of classification. They may also be used for feature extraction and statistical clustering as well. Specialised hardware is becoming more available to apply NNs in a way more fruitful than traditional methods. Many researchers yet claim that the discriminating power of NNs is still weak and more work is needed to settle this issue. Some workers in the field are experimenting with NNs, and the interest is mounting.

[AbdelAzim95]; [AbdelAzim96]; [Ahmed92]; [AlTuwaijri94a]; [AlTuwaijri94b]; [AlTuwaijri94c]; [AlTuwaijri95a]; [AlTuwaijri95b]; [AlTuwaijri96]; [Braham92]; [Emam94]; [Hassibi94]; [Nabawi94]; [Rashid96]; [Rashwan94]; [Sanossian96]; and [Walker??].

e. The Hidden Markov Model Approach

Many researchers maintain the view that most of the problems remaining in the OCR field are still associated with thresholding and segmentation.

This is especially true, when dealing with hand-written cursive script recognition. Hidden Markov models (HMMs) qualify as a suitable tool for such situations for many reasons. Fist, they are stochastic models that can cope with noise and variations in the hand-written patterns. Next, the number of tokens representing the unknown input word may be of a variable length. Moreover, the segmentation problem may be avoided. By directly working on the grey-level image of the words, HMMs may be employed to recognise an entire connected word and/or subword at a time. According to this approach, a sequence of grey-level feature vectors is extracted using HMMs. HMMs are used to describe any of the following as the need arises: single characters, parts of a character, or several characters together. The sequence of feature vectors is (Viterbi) matched against all possible combinations of the models using dynamic programming techniques. It is worth noting that the essence of this technique is carried to character recognition from the area of speech recognition research.

[AbdelAzim89b]; [AbdelAzim89c]; [AbdelAzim92b]; [AbdelAzim93]; [LaPre96]; [Makhoul96]; and [Shoukry94].

f. Table Look-ups and Others

These are simpler classification algorithms that cannot also be categorised as falling under statistical or syntactical types of classifiers. Dictionary look-up classifiers, rule-based classifiers, and hand-crafted classifiers are examples of this type of non-hierarchical classifiers which do not use a decision tree. The table look-up, for example, requires segmenting a word into characters. Determining the frame window of each character follows, where it is divided into small windows prior to searching for appropriate features. These include end points, intersection points, corners, etc., as well as their respective locations within the character window. The aspect ratio of the character window itself is also used as a feature. The unknown character is then recognised by finding a match in the look-up table.

[AlOhali96]; [Jambi90]; [Jambi91a]; [Jambi92]; [Jambi93]; and [Jambi95].

Post-processing Techniques

As the name implies, this is the final stage in the recognition process. The recognition stage is meant for recognising the unknown input character. However, this is not always the case, since in some recognition systems primitives of the unknown characters are recognised first, and then the characters are identified in a post processing stage. Sometimes classification, or recognition, of the input character fails, thus producing either a misclassification (substitution) or, at its best, a rejection. For such cases a post-processing technique is to be applied. Some researchers opt to apply some of the other recognition techniques that were not used in the recognition stage, as a post-processing stage. Some of the post-

processing techniques are applied not to the misclassified and/or rejected character(s) but to the whole word(s) containing it(them). These techniques improve the word recognition rate via exploitation of character frequencies and probabilities, lexical rules and matrices, and table look-ups for the purpose of word proofing and correction. It has to be stressed here that the word recognition rate is generally lower than the character recognition rate, since a certain word, whatever its length is, needs correction if only one of its characters is misrecognised or rejected.

Some researchers concentrate on studying words in dictionaries, to extract probabilities of the incidence of each character with respect to other characters in available used words. These probabilities are to be used to decide the best candidate character to fill up a gap in a certain word suffering from rejections in the recognition phase. Some other techniques are there to be exploited. These, among some others, are mentioned below.

a. Spell Checking and Correction

This technique is mainly interactive, requiring manual intervention of the user to decide on the most proper substitute for a suspected word in the recognised text, from the given choices available in an appropriate dictionary.

[AbdelAzim92a]; [AbdelAzim92b]; [AlFedaghi88a]; [Goraine92b]; [Goraine94]; [Hashish92]; [Hassibi94]; [Kurdy93]; and [Mahgoub92].

b. Syntactic & Semantic Analyses

Syntactic and semantic analyses may be carried out to correct the words rejected or misclassified by the recognition stage. Lexicons, lexical matrices, and context-free grammars are some of these methods aimed at improving the word recognition rate which is generally lower than its character counterpart. Some of these analyses are stochastic in nature depending on the probability of occurrence of each character of an alphabet in conjunction with the other characters of the same alphabet. Estimates of the entropy of the language are obtained based on either letter frequencies, or word frequencies and roots count. Some other analyses use the syntax of the language in which the text is written to analyse and validate the output of the recognition system. In this case, the misrecognised or rejected words may be corrected depending on their roots, after removing prefixes and suffixes. This may be sometimes applied to all words of the recognised sentence to check their correctness, even when no misclassifications or rejections are reported.

[AbdelAzim88]; [AbdelAzim89a]; [AbdelAzim89d]; [AbdelAzim90b]; [AbdelAzim92a]; [AlJabri91]; [AlJabri92]; [AlSuwaiyel91]; [Amin84];

[Amin85b]; [Amin87]; [Amin88c]; [Amin89]; [ElGamal91]; [ElSheikh90c]; [Emam94]; [Fehri94]; [Hashish88]; [Hashish92]; [Hassibi94]; [Hyder88a], [Hyder88b]; [LaPre96]; and [Parhami81].

c. The Viterbi Algorithm

This technique may be used here, as a post-processing stage, to enhance the recognition results of systems employing other recognition strategies. This may be carried out by applying the Viterbi algorithm to words containing rejected characters, in order to correct such words.

[AlJabri92]; [AlSuwaiyel91]; and [Amin89].

Acknowledgement

The authors are thankful to King Abdul-Aziz City for Science and Technology (KACST), Riyadh, for their library service. We would like to thank Dr. Badr Al-Badr and Dr. Ibrahim Al-Kharashi of KACST and Dr. Ibrahim S. I. Abu-Haiba of King Saud University, Riyadh. We are also thankful to all other researchers and colleagues for the help they offered during the process of collecting some of the research papers cited in this classified AOTR bibliography.

Bibliography Classification Table

No.	Author's Name & Year of Publication	Nature of Appli-cation	Fonts/ Char. Sets	Pre-process. & Segm.	Feature Extrac-tion	Class-ificat-ion Method	Post proc-essing
1	**Abbas86**	9,10	--	1,2	2,3	1	--
2	**AbdelAzim87***	5	1,3	u/a	u/a	u/a	u/a
3	**AbdelAzim88**	5	1,3	4	1,2	1	2
4	**AbdelAzim89a**	5	2,3	4	2,4	1,2	2
5	**AbdelAzim89b**	8	3,4	--	2,4	5	--
6	**AbdelAzim89c**	9	--	1,4	2,4	3,5	--
7	**AbdelAzim89d**	5	1,3,4	4	2	1	2
8	**AbdelAzim89e***	5	1,3	u/a	u/a	u/a	u/a
9	**AbdelAzim90a**	5	1,3	--	2	1	--
10	**AbdelAzim90b**	5	1,3	4	2	1	2
11	**AbdelAzim92a**	5	1,3	2,4	2,4	1	1,2
12	**AbdelAzim92b**	5	1,3	--	2	5	1
13	**AbdelAzim93 ***	5	1,3	u/a	2	5	u/a
14	**AbdelAzim95 ***	5	1,3	u/a	u/a	4	u/a
15	**AbdelAzim96**	2	1,3	4	4	3,4	--
16	**AbdelGwad90**	LR,7	1,3	2	2	1	--
17	**Abdulla88**	9	4	2	--	--	--
18	**AboSamra97**	8	3	4	--	--	--
19	**AbuHaiba90**	4,7	1,3	1,2	4	3	--
20	**AbuHaiba91**	4	1,3	1,2	--	--	--
21	**AbuHaiba93**	8	3	1,2,3	--	--	--
22	**AbuHaiba94a**	8	3	1,2	4	3	--
23	**AbuHaiba94b**	8	3	1,2,3	4	3	--
24	**AbuHaiba94c**	8	3	1,2	4	--	--
25	**AbuHaiba95a**	7	3	1,2	4	3	--
26	**AbuHaiba95b**	8	3	1,2,3	4	--	--
27	**AbuHaiba95c**	8	3	1,4	--	--	--
28	**AbuHaiba95d**	8	3	1,2	--	--	--
29	**AbuHaiba95e**	7	3	--	4	3	--
30	**AbuHaiba96a**	8	3	1,2	--	--	--
31	**AbuHaiba96b**	7,8	3	1,2,3	4	3	--
32	**Ahmed92**	5	1,3	1,4	2	4	--
33	**Ahmed94**	GR	2,3	G	G	G	G
34	**Aiiah88** *	4	3	u/a	u/a	u/a	u/a
35	**AlBadr92**	5	2,3	1	2	1	--
36	**AlBadr93** *	5	1,3	u/a	u/a	u/a	u/a

GR = general review, LR = limited review, G = generally addressed, -- = not addressed, and u/a = unavailable.

No.	Author's Name & Year of Publication	Nature of Appli-cation	Fonts/ Char. Sets	Pre-process. & Segm.	Feature Extrac-tion	Classi-fication Method	Post proc-essing
37	AlBadr95a	GR	2,3	G	G	G	G
38	AlBadr95b *	5	1,3	1	u/a	u/a	u/a
39	AlBadr95c	5	1,3	1	4	3	--
40	AlBadr96	5	1,3	1	4	3	--
41	AlBaiaty86 *	4	1,3	u/a	1	1	u/a
42	AlEmami88 *	4,7	1,3	u/a	u/a	u/a	u/a
43	AlEmami90	2	3	4	4	3	--
44	AlFedaghi88a *	u/a	3	u/a	u/a	u/a	1
45	Ali79 *	7	3	u/a	4	2	u/a
46	Ali89	4,6	1	1,2	--	--	--
47	AlJabri91	5	3	--	--	--	2
48	AlJabri92	5	3	--	--	--	2,3
49	Allam94	5	2,3,4	2	2	1	--
50	AlMuallim87	8	3	2,4	4	3	--
51	AlOhali96	LR,5	1,3	4	4	6	--
52	AlQaisy85 *	9	--	u/a	2	u/a	u/a
53	AlQaisy87 *	9	--	u/a	3	u/a	u/a
54	AlQaisy89	9	--	--	2	1	--
55	AlShebeili97	4	1,3	1	3	1	--
56	AlSuwaiyel91	5	3	--	--	--	2,3
57	AlTikriti84 *	9	--	u/a	4	3	u/a
58	AlTikriti85	9	--	2	2	1	--
59	AlTuwaijri94a	8	2,3	4	2	4	--
60	AlTuwaijri94b	4	1,3	1,2	u/a	4	u/a
61	AlTuwaijri94c*	4	1,3	u/a	u/a	4	u/a
62	AlTuwaijri95a	8	2,3	1,2,4	2	4	--
63	AlTuwaijri95b	4	1,3	1,2	u/a	4	u/a
64	AlTuwaijri96 *	4	1,3	1,2	u/a	4	u/a
65	AlYousefi88	7	3	1,4	2	1	--
66	AlYousefi89	7	3	1	2	1	--
67	AlYousefi90	7	3	1,4	2	1	--
68	AlYousefi92	4,7,8	1,3	1,4	2	1	--
69	Ameur93	8	3	1,2,4	4	3	--
70	Amin79 *	1	3	u/a	u/a	u/a	u/a
71	Amin80	1	3	1	4	2	--
72	Amin82a	2	3	1,4	4	2	--
73	Amin82b	2	3	1,4	4	2	--
74	Amin83 *	2	3	1,4	4	2	--
75	Amin84	2	3	1,4	4	2	2

GR = general review, LR = limited review, G = generally addressed, -- = not addressed, and u/a = unavailable.

No.	Author's Name & Year of Publication	Nature of Appli-cation	Fonts/ Char. Sets	Pre-process. & Segm.	Feature Extrac-tion	Class-ificat-ion Method	Post proc-essing
76	Amin85a *	GR	3	G	G	G	G
77	Amin85b	LR,1,2	3	1,4	4	2	2
78	Amin85c *	2,5	1,3	1,4	4	u/a	u/a
79	Amin86	5	2,3	1,4	4	2	--
80	Amin87	LR,1,2	3	1,4	4	2	2
81	Amin88a	5	2,3	1,4	4	2	--
82	Amin88b *	1	3	1,4	4	2	--
83	Amin88c *	2	3	1,4	4	2	2
84	Amin89	5	2,3	1,2,4	4	3	2,3
85	Amin91a	5	2,3	1,4	4	3	--
86	Amin91b	5,8	1,3	1,2,4	4	2	--
87	Amin92	8	3	1,2,4	--	--	--
88	Assal91 *	9	--	u/a	u/a	u/a	u/a
89	Assal92	9	--	4	--	--	--
90	Badie78 *	4	1,3	u/a	u/a	u/a	u/a
91	Badie80a *	5	1,3	u/a	u/a	u/a	u/a
92	Badie80b *	5	1,3	u/a	u/a	u/a	u/a
93	Badie82a	7,8	3	1,2	4	3	--
94	Badie82b	7,8	3	1,2	4	3	--
95	Bansal84 *	9	--	u/a	4	3	u/a
96	Barber88 *	5	1,3	u/a	u/a	u/a	u/a
97	Belghith90 *	4	1,3	u/a	2	u/a	u/a
98	Berbar94 *	5	1,3	u/a	u/a	u/a	u/a
99	Bilal76 *	u/a	3	u/a	u/a	u/a	u/a
100	Bouhlila88 *	4	1,3	u/a	u/a	u/a	u/a
101	Bouhlila89	5	1,3	4	--	--	--
102	Braham92	9	--	1	2	4	--
103	Dewachi75 *	u/a	3	u/a	u/a	u/a	u/a
104	ElDabi90	5	1,3	4	2	1	--
105	ElDesouky91	7	3	2	4	2	--
106	ElDesouky92	7	3	2	4	2	--
107	ElGamal91 *	--	3	--	--	--	2
108	ElGowely89 *	5	2,3	u/a	u/a	u/a	u/a
109	ElGowely90	5	2,3	1,4	2,4	2	--
110	ElHamalawy88	6	--	1,2	2	1	--
111	ElKhaly90	5	1,3	1,2,4	2,3	1	--
112	ElRamly89a	5	1,3	1,2	4	3	--
113	ElRamly89b	4	1,3	1,2	2	1	--
114	ElRamly89c	4	1,3	1,2	2	1	--

GR = general review, LR = limited review, G = generally addressed, -- = not addressed, and u/a = unavailable.

No.	Author's Name & Year of Publication	Nature of Appli-cation	Fonts/ Char. Sets	Pre-process. & Segm.	Feature Extrac-tion	Class-ificat-ion Method	Post proc-essing
115	ElShbiny76 *	4	1,3	u/a	u/a	u/a	u/a
116	ElSheikh88a	4	1,3	1,2	3,4	1,2	--
117	ElSheikh88b	5	1,3	1,2,4	3,4	1,2	--
118	ElSheikh89a	1	3	2	4	3	--
119	ElSheikh89b *	4	2,3	u/a	u/a	u/a	u/a
120	ElSheikh90a	1	3	2	4	3	--
121	ElSheikh90b	2	3	4	--	--	--
122	ElSheikh90c	1,3	3	4	2	2	2
123	ElWakil87	1	3	2	4	1,2	--
124	ElWakil88	1	3	2	4	1,2	--
125	ElWakil89	1	3	2	4	1,2	--
126	Emam93 *	5	1,3	4	--	--	--
127	Emam94	5	1,3	1,2,4	2	2,4	2
128	Fakir91 *	LR,5	3	u/a	G	u/a	u/a
129	Fakir92 *	5	3	u/a	u/a	u/a	u/a
130	Fakir93	5	3	1,2,4	3,4	1,2	--
131	Fayek92	4	2,3	1	2	1	--
132	Fehri94	5	2,3	1,2,4	4	2	2
133	Ghuwar94 *	GR	G	G	G	G	G
134	Ghuwar95	5	1,3	1	4	--	--
135	Goneid87 *	4	1,3	u/a	u/a	u/a	u/a
136	Goneid88 *	4	1,3	u/a	u/a	u/a	u/a
137	Goneid92a *	9	--	u/a	u/a	u/a	u/a
138	Goneid92b	9	--	1,2	4	2	--
139	Goneid92c	9	--	1,2,4	4	2	--
140	Goraine89	5	2,3	2,4	4	2	--
141	Goraine90 *	5	3	u/a	u/a	u/a	u/a
142	Goraine92a *	5	3	u/a	u/a	u/a	u/a
143	Goraine92b	5	1,3	1,2,4	4	2	1
144	Goraine94	5	1,3	1,2,4	4	2	1
145	Govindan90	GR	2,3,4	G	G	G	G
146	Guindi87 *	5	3	u/a	u/a	u/a	u/a
147	HajHassan85	5	1,3	4	--	--	--
148	HajHassan88	5	1,3	4	--	--	--
149	HajHassan90	5	1,3	4	--	--	--
150	HajHassan91	5	1,3	1,2,4	2,4	1,2	--
151	Hashish85 *	5	1,3	u/a	u/a	u/a	u/a
152	Hashish88 *	--	3	--	--	--	2
153	Hashish92	--	3	--	--	--	1,2

GR = general review, LR = limited review, G = generally addressed, -- = not addressed, and u/a = unavailable.

No.	Author's Name & Year of Publication	Nature of Appli-cation	Fonts/ Char. Sets	Pre-process. & Segm.	Feature Extrac-tion	Class-ificat-ion Method	Post proc-essing
154	Hassibi93 *	5	1,3	u/a	u/a	u/a	u/a
155	Hassibi94	5	2,3	1,2,4	4	4	1,2
156	Hyder88a *	5	3	--	4	3	2
157	Hyder88b	5	3	--	4	3	2
158	Ismail93a *	4	1,3	u/a	3,4	--	--
159	Ismail93b *	5	1,3	u/a	u/a	u/a	u/a
160	Jambi90 *	5	1,3	1,4	4	6	--
161	Jambi91a	GR,8	G	1,2,4	4	6	--
162	Jambi91b	GR	G	G	G	G	G
163	Jambi92	8	1,3	2,4	4	6	--
164	Jambi93	8	1,3	2,4	4	6	--
165	Jambi95 *	8	1,3	2,4	4	6	--
166	Jambi96 *	8	3	u/a	u/a	u/a	u/a
167	Jambi97	4	1,3	1	2	--	--
168	Kamel90 *	5	1,3	u/a	2	1	u/a
169	Khalidov85 *	u/a	3	u/a	u/a	u/a	u/a
170	Khella92	5	1,3	1,2,4	3	1	--
171	Khella94	4	1,3	1,2	3,4	1	--
172	Khemakhem87*	4	1,3	--	u/a	u/a	u/a
173	Khemakhem87*	4	1,3	--	u/a	u/a	u/a
174	Khemakhem88*	4,5	1,3,4	--	3	1	--
175	Khemakhem89	4,5	1,3	--	3	1.	--
176	Khemakhem93	4,5,10	1,3	--	3	1	--
177	Kubba80 *	u/a	3	u/a	u/a	u/a	u/a
178	Kurdy91 *	u/a	3	u/a	u/a	u/a	u/a
179	Kurdy92 *	4	2,3	u/a	u/a	u/a	u/a
180	Kurdy93	5	2,3,4	1,4	4	2	1
181	LaPre96	5	2,3	1	2	5	2
182	Mahdi87 *	4	1,3	2	--	--	--
183	Mahdi89	4	1,3	2	--	--	--
184	Mahgoub92 *	u/a	3	u/a	u/a	u/a	1
185	Mahmoud86	6,9	3	--	2	1	--
186	Mahmoud87	6,9	3	--	2	1	--
187	Mahmoud91	4	1,3	2	--	--	--
188	Mahmoud94	4	1,3	1,2	3	1	--
189	Makhoul96	5	2,3	1	2	5	--
190	Mantas86	GR	G	G	G	G	G
191	Margner92	5	1,3	2,4	4	1	--
192	Murad84 *	u/a	3	u/a	u/a	u/a	u/a

GR = general review, LR = limited review, G = generally addressed, -- = not addressed, and u/a = unavailable.

No.	Author's Name & Year of Publication	Nature of Appli-cation	Fonts/ Char. Sets	Pre-process. & Segm.	Feature Extrac-tion	Class-ificat-ion Method	Post proc-essing
193	Nabawi94	4	1,3	1,4	2,3	1,4	--
194	Namane90	4	2,3	1,2	--	--	--
195	Nazif75	4	1,3	4	1,4	1	--
196	Nouh78 *	u/a	3	u/a	u/a	u/a	u/a
197	Nouh80	4	1,3	--	1	1	--
198	Nouh84	4	1,3	--	1	1	--
199	Nouh86a *	u/a	3	u/a	u/a	u/a	u/a
200	Nouh86b *	u/a	3	u/a	u/a	u/a	u/a
201	Nouh87a	5,8	3	1	--	--	--
202	Nouh87b	4	1,3	1	1	1	--
203	Nouh87c	1-9	3	--	--	--	--
204	Nouh88a *	4,5,6	3	u/a	u/a	u/a	u/a
205	Nouh88b	LR,4	1,3	--	2	1	--
206	Nouh88c *	4	3	u/a	u/a	u/a	u/a
207	Nouh88d	4	1,3	1	1	1	--
208	Nouh89	4	1,3	2	--	--	--
209	Nouh93	7	3	1	1	1	--
210	Nouh94	GR	3	G	G	G	G
211	NurulUla87 *	4	u/a	u/a	u/a	u/a	u/a
212	NurulUla88a	4,7	2,3	1,2	--	--	--
213	NurulUla88b	4,7	2,3	--	2	1	--
214	Parhami77 *	GR	3	G	G	G	G
215	Parhami78a *	u/a	3	u/a	u/a	u/a	u/a
216	Parhami78b *	u/a	3	u/a	u/a	u/a	u/a
217	Parhami81	5,6	3	1,2,4	4	3	2
218	Rahho86 *	8	3,4	u/a	u/a	u/a	u/a
219	Ramsis88	LR,5	2,3	4	2	1	--
220	Rashid96	5	2,3	4	2	4	--
221	Rashwan94	7	3	--	2	4	--
222	SaadAllah85	7	3	1,2	4	2	--
223	Sabri86 *	4	3	u/a	u/a	u/a	u/a
224	Saleh75a	5	1,3	1,4	2	1	--
225	Saleh75b	5	1,3	1,4	2	1	--
226	Saleh77	5	1,3	--	2	1	--
227	Sanossian96	4	1,3	--	2	4	--
228	Seddik89 *	2	3	u/a	u/a	u/a	u/a
229	Seflan75 *	u/a	3	u/a	u/a	u/a	u/a
230	Shaheen90	2	3	1,2	4	2	--
231	SharafElDin88	LR,4	1,3	--	2	1	--

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No.	Author's Name & Year of Publication	Nature of Appli-cation	Fonts/ Char. Sets	Pre-process. & Segm.	Feature Extrac-tion	Class-ificat-ion Method	Post proc-essing
232	Sharkawy88 *	4	1,3	u/a	3	u/a	u/a
233	Shoukry83 *	5	1,3	u/a	u/a	u/a	u/a
234	Shoukry89	GR	3	G	G	G	G
235	Shoukry91	5	1,3	1,4	--	--	--
236	Starner94 *	8	3	u/a	2	5	u/a
237	Taconet89 *	4	1,3	1	u/a	u/a	u/a
238	Taraghi78 *	u/a	3	u/a	u/a	u/a	u/a
239	Tikhonova92	LR	3	--	--	--	--
240	Tolba86	4,7	1,3	--	2	1	--
241	Tolba87a	LR,4	1,3	--	2	1	--
242	Tolba87b	4,7	1,3	--	2	1	--
243	Tolba87c *	u/a	3	u/a	--	--	--
244	Tolba87d	4,7	1,3	--	2	1	--
245	Tolba88a	LR,4	1,3	--	2	1	--
246	Tolba88b	LR,4	1,3	--	2	1	--
247	Tolba89	LR,4	2,3	1,2,4	2	1	--
248	Tolba90	LR,4	2,3	1,2,4	2	1	--
249	Walker?? *	u/a	3	u/a	u/a	4	u/a
250	Yacu85 *	u/a	3,4	u/a	u/a	u/a	u/a
251	Yalabik88	LR,5	3	--	--	--	--
252	Yousef86 *	9	--	u/a	u/a	u/a	u/a
253	Youssef89	LR,5	3	G	G	G	--
254	Youssef93	LR,5	3	G	G	G	--
255	Zahour89	8	3	1,4	4	2	--
256	Zahour90 *	8	3	u/a	u/a	u/a	u/a
257	Zahour91	8	3	1,4	4	2	--
258	Zahour92	8	3	1,4	4	2	--
259	Zaki86a	7	3	1	2	1	--
260	Zaki86b	7	3	1	2	1	--

GR = general review, LR = limited review, G = generally addressed, -- = not addressed, and u/a = unavailable.

Appendix A
Classification Scheme & Table of the Bibliography

The following table is set up for the benefit of those readers interested in having an overall, yet concise picture of each literature item in this AOTR bibliography. But before looking into the table, some hints on how to read each one of its rows is given here. This table has been also used as a tool for classifying the literature items collected in the AOTR bibliography. The table comprises 8 columns, the first of which is reserved for the reference serial numbers. For easy handling of the literature items they are lexicographically indexed using the first author's surname and year of publication. This surname is here concatenated with the last two digits of the publication year, followed by a lower-case character of the alphabet if there is more than one reference by the same author(s) published in the same year. The contents of the other six columns are mainly numbers whose interpretations run as follows:

Nature of Application: (Column 3)

1: On-line Handwritten Character Recognition;
2: On-line Handwritten Cursive Text Recognition;
3: On-line Handwritten Hindi Numerals;
4: Off-line Printed Character Recognition;
5: Off-line Printed Cursive Text Recognition;
6: Off-line Printed Hindi Numerals;
7: Off-line Handwritten Character Recognition;
8: Off-line Handwritten Cursive Text Recognition;
9: Off-line Handwritten Hindi Numerals;
10: Hardware Implementation.

Addressed Fonts & Character Sets: (Column 4)

1: Single-font;
2: Multifont;
3: Arabic Character set;
4: Latin Character set.

Pre-processing* and Segmentation *Techniques: (Column 5)

1: Noise Reduction (Smoothing);
2: Thinning (Skeletonization) & Contour Detection;
3: Restoration of Temporal Information from Off-line Handwritten Texts;
4: Segmentation.

Feature Extraction Methods: (Column 6)

1: Template Matching and Correlation;
2: Statistical Distribution of Points;
3: Global Transformations & Series Expansion;
4: Structural (Geometrical) & Topological Features.

Classification Approaches: (Column 7)

1: The Statistical Approach;
2: The Syntactical Approach;
3: The Relational Graph-matching Approach;
4 :The Neural Network Approach;
5: The Hidden Markov Model (HMM) Approach;
6: Table Look-ups and Others.

Post-processing Techniques: (Column 8)

1: Spell Checking and Correction;
2: Syntactic & Semantic Analyses;
3: The Viterbi Algorithm.

Notes on the Classification Table:

1. The convention of using the asterisk (*) to denote unavailable literature items in the AOTR bibliography is applicable to the second column of the classification table given here. Their corresponding rows in the table may have (u/a) to denote unavailable information.
2. As stated earlier in the abstract, few items in this bibliography are not on Arabic texts, but on either Farsi or historical Ottoman. Nevertheless, since both languages use the Arabic alphabet set with additions and/or modifications, these items will be treated here as those on Arabic texts.
3. Hindi numerals are those numerals used all over the Arab world, with the exception of the western Arab countries (west of Egypt, i.e. Libya, Tunis, Algeria, Mauritania and Morocco) where Arab numerals are used. The Hindi numerals are different from the Arab numerals used all over the western world. The Arab numerals are the ones used in reporting this AOTR bibliography.
4. The attributes single-font and multifont used in the fourth column is valid only for machine-printed characters and/or texts. The other attribute, that is being only in Arabic or in Arabic/Latin is applicable to both machine-printed and handwritten characters and/or texts, not to numerals.
5. As for columns 3, 4, 5, 6, 7, and 8, research work reported in some literature items happens to use more than one of the mentioned techniques/approaches. In such cases some of the respective entries in the table may have more than a single number with a comma separator (,) between them.
6. General and limited Review papers, denoted by (GR) or (LR) in column 3, will be classified as follows. GR papers may have, under each of the table headings, one of the following symbols:
   (G) denoting general coverage and discussion of the research topic under this heading; or
   (--) denoting the absence of any review of the topic altogether.
   LR papers, on the other hand, will be classified as stated for the other items of the bibliography.
7. The symbol (--) applies also to all other bibliography items, under any table heading, where the specific topic is not-addressed.

The AOTR Bibliography

[Abbas86] S. H. Abbas, M. I. Harba, and M. H. Al-Muifraje, Optimising the Digital Learning Network for Recognition of the Handwritten Numerals Used by the Arabs, Proc. of the Euro. conf., Paris, France, pp. 505-513 (April 1986).

[AbdelAzim87] Hazim Y. Abdel-Azim and M. A. Hashish, Automatic Recognition of Arabic Text, Proc. of the 10th Image/ITL conf., IBM Toronto Lab., Toronto, Canada (Aug. 1987). *

[AbdelAzim88] Hazim Y. Abdel-Azim and M. A. Hashish, Arabic Reading Machine, Proc. of the 10th Nat. Computer conf., King Abdulaziz University, Jiddah, Saudi Arabia, pp. 733-744 (March 1988).

[AbdelAzim89a] Hazim Y. Abdel-Azim and M. A. Hashish, Interactive Font Learning for Arabic OCR, Proc. of the First Kuwait Computer conf., Kuwait, pp. 463-486 (March 1989).

[AbdelAzim89b] Hazim Y. Abdel-Azim and M. A. Hashish, A Hidden Markov Modeling Approach to the Recognition of Signatures: A Feasibility Study, Proc. of the First Kuwait Computer conf., Kuwait, pp. 402-425 (March 1989).

[AbdelAzim89c] Hazim Y. Abdel-Azim and M. A. Hashish, Automatic Recognition of Handwritten Hindi Numerals, Proc. of the 11th Saudi Nat. Computer conf., Dhahran, Saudi Arabia, pp. 287-298 (March 1989).

[AbdelAzim89d] Hazim Y. Abdel-Azim and M. A. Hashish, Automatic Reading of Bilingual Typewritten Text, Proc. of the CompuEURO'89: VLSI and Microelectronic Applications in Intelligent Peripherals and their Applications, Hamburg, Germany, pp. 2/140-144 (May 1989).

[AbdelAzim89e] Hazim Y. Abdel-Azim, Text Recognition: Theory and Implementation, Ph.D. Thesis, Cairo University, Dokki, Giza, Egypt (1989). *

[AbdelAzim90a] Hazim Y. Abdel-Azim, A. M. Mousa, Y. L. Saleh, and M. A. Hashish, Arabic Text Recognition Using a Partial Observation Approach, Proc. of the 12th Nat. Computer conf., Riyadh, Saudi Arabia, pp. 427-437 (Oct. 1990).

[AbdelAzim90b] Hazim Y. Abdel-Azim and M. A. Hashish, Arabic Typeset: An OCR Approach, Proc. of the 5th Signal Processing conf.

(EUSIPCO'90), Barcelona, Spain, pp. 1019-1022 (Sep. 1990).

[AbdelAzim92a] Hazim Y. Abdel-Azim and A. A.-Maguid Mohammad, Automatic Reading of Arabic Text with Spell Checking Assistance, Proc. of the conf. on the Use of Arabic Language in Information Technology, Riyadh, Saudi Arabia, pp.1-12 (in Arabic) (May 1992).

[AbdelAzim92b] Hazim Y. Abdel-Azim and A. A.-Maguid, Impact of NLP Models on the Enhancement of Arabic OCR Systems, Proc. of the First Int. conf. on AI Applications, Cairo, Egypt, pp.II/284-291 (June 1992).

[AbdelAzim93] Hazim Y. Abdel-Azim, Role of NLP-Based Arabic OCR Systems in Document Imaging, Image Technology: Symposium on Image Document Processing in Office Systems, Chamber of Commerce and Industry-Headquarters, Dammam, Saudi Arabia, pp. 221-234 (1993). *

[AbdelAzim95] Hazim Y. Abdel-Azim and A. A.-Maguid, Arabic Script Recognition Using Hopfield Network, IJCA, Int. Journal of Computers and their Applications,Vol. II, No.1 (April 1995). *

[AbdelAzim96] Hazim Y. Abdel-Azim, A Hybrid Fuzzy-Neural Approach to the Recognition of Arabic Script, Proc. of the 5th Int. conf. and Exhibition on Multi-lingual Computing, University of Cambridge, England, UK, pp. 2.3.1-2.3.13 (April 1996).

[AbdElgwad90] A. O. Abd El-Gwad, M. Salem, F. Abou-Shadi, and Hesham Arafat, Automatic Recognition of Handwritten Arabic Characters, Proc. of the 25th Annual conf. on Statistics, Computer Science and Operations Research, Cairo University, Dokki, Giza, Egypt, Vol. 4, pp. 4.63-4.75 (Dec. 1990).

[Abdulla88] W. H. Abdullah, A. O. M. Saleh, and A. H. Morad, A Preprocessing Algorithm for Handwritten Character Recognition, Pattern Recognition Letters, Vol. 7, pp. 13-18 (January 1988).

[AboSamra97] Gibrael A. Abo-Samra, K. M. Jambi, H. Al-Barhamtoshy, R. Amer, and I. Al-Bidewi, A Comprehensive Algorithm for Segmenting Handwritten Arabic Script in Off-line Systems, Proc. of the 15th Nat. Computer conf., KFUPM, Dhahran, Saudi Arabia, Vol. 2, pp.769-781 (Nov. 1997).

[AbuHaiba90] I. S. I. Abu-Haiba, Use of Fuzzy Set Theory in Pattern Recognition with Application to Arabic Characters, M.Phil. Thesis, University of Bradford, Bradford, England, UK (1990).

[AbuHaiba91] I. S. I. Abu-Haiba, Sabri A. Mahmoud, and R. J. Green, Cluster Number Estimation and Skeleton Refining Algorithms for Arabic Characters, The Arabian Journal for Science and Engineering (AJSE), KFUPM, Dhahran, Saudi Arabia, Vol. 16, No. 4, pp. 519-530 (1991).

[AbuHaiba93] I. S. I. Abu-Haiba and Pervez Ahmed, Restoration of Temporal Information in Off-line Arabic Handwriting, Pattern Recognition, Vol. 26, No. 7, pp. 1009-1017 (1993).

[AbuHaiba94a] I. S. I. Abu-Haiba, Sabri A. Mahmoud, and R. J. Green, Recognition of Handwritten Cursive Arabic Characters, IEEE Trans. on PAMI: Pattern Analysis and Machine Intelligence, Vol. 16, No. 6, pp. 664-672 (1994).

[AbuHaiba94b] I. S. I. Abu-Haiba, M. J. J. Holt, and S. Datta, Processing of Off-line Handwritten Text: Polygonal Approximation and Enforcement of Temporal Information, CVGIP: Graphical Models and Image Processing, Vol. 56, No. 4, pp. 324-335 (1994).

[AbuHaiba94c] I. S. I. Abu-Haiba, M. J. J. Holt, and S. Datta, Straight Line Approximation and 1D Representation of Off-line Handwritten Text, Image and Vision Computing, Vol. 12, No. 10, pp. 649-659 (1994).

[AbuHaiba95a] I. S. I. Abu-Haiba and Sabri A. Mahmoud, Fuzzy Graphs to Recognize Handwritten Arabic Characters, The Arabian Journal for Science and Engineering (AJSE), KFUPM, Dhahran, Saudi Arabia, Vol. 20, No. 1, pp. 77-93 (1995).

[AbuHaiba95b] I. S. I. Abu-Haiba, M. J. J. Holt, and S. Datta, Restoration of Temporal Information from Static Images of Handwritten Arabic Script, Proc. of the IEEE SICSPCS'95: IEEE Singapore Int. conf. on Signal Processing, Circuits and Systems '95, Singapore (July 1995).

[AbuHaiba95c] I. S. I. Abu-Haiba, S. Datta, and M. J. J. Holt, Line Extraction and Stroke Ordering of Text Pages, Proc. of the 3rd ICDAR'95: Third Int. conf. on Document Analysis and Recognition, Montreal, Canada, Vol. I, pp. 390-393 (Aug. 1995).

[AbuHaiba95d] I. S. I. Abu-Haiba, S. Datta, and M. J. J. Holt, Processing of Text Documents: Straight Line Approximation and Lost Loop Recovery, Proc. of the 3rd ICDAR'95: Third Int. conf. on Document Analysis and Recognition, Vol. II, Montreal, Canada, pp. 1157-1160 (August 1995).

[AbuHaiba95e] I. S. I. Abu-Haiba, S. Datta, and M. J. J. Holt, Fuzzy State Machines to Recognize Totally Unconstrained Handwritten Strokes, Image and Vision Computing, Vol. 13, No. 10, pp. 755-769 (1995).

[AbuHaiba96a] I. S. I. Abu-Haiba, M. J. J. Holt, and S. Datta, Processing of Binary Images of Handwritten Text Documents, Pattern Recognition, Vol. 29, No. 7, pp. 1161-1177 (1996).

[AbuHaiba96b] I. S. I. Abu-Haiba, Recognition of Off-line Handwritten Cursive Text, Ph.D Thesis, Dept. of Electronic and Electrical Eng., Loughborough University, Loughborough, UK (1996).

[Ahmed92] Mohammad Bin Ahmed, Al-Munji Jo'aly, J. Kraifos, and S. Kaneer, Recognition of Arabic Characters Using Neural Networks for Electronic Document Processing, Proc. of the conf. on the Use of Arabic Language in Information Technology, Riyadh, Saudi Arabia, pp. 1-8 (in Arabic) (May 1992).

[Ahmed94] Pervez Ahmed and M. A. A. Khan, Computer Recognition of Arabic Script Based Text - The State of the Art, Proc. of the 4th Int. conf. and Exhibition on Multi-lingual Computing (Arabic and Roman Script), University of Cambridge, England, UK, pp. 2.1.1-2.1.10 (April 1994).

[Aiiah88] S. S. Aiiah and S. G. Yacu, Design of an Arabic Character Reading Machine, Proc. of the Computer Arabization conf., Egyptian Computer Society, Cairo, Egypt, pp. 53-69 (1988). *

[AlBadr92] Badr Al-Bader and R. Haralick, Recognition without Segmentation: Using Mathematical Morphology to Recognize Printed Arabic, Proc. of the 13th Nat. Computer conf., Riyadh, Saudi Arabia, pp. 813-829 (Nov.1992).

[AlBadr93] Badr Al-Badr, On the Recognition of Arabic Documents, Technical Report No.93-10-01, Department of Computer Science and Engineering, University of Washington, Seattle, USA (1993). *

[AlBadr95a] Badr Al-Badr and Sabri A. Mahmoud, Survey and Bibliography of Arabic Optical Text Recognition, J. of Signal Processing, Vol. 41, No. 1, pp.49-77 (Jan. 1995).

[AlBadr95b] Badr Al-Badr and R. Haralick, Segmentation-free Word Recognition with Application to Arabic, Proc. of the Int. conf. on Document Analysisand Recognition, Montreal, Canada (1995). *

[AlBadr95c] Badr Al-Badr, A Segmentation-free Approach to Text Recognition with Application to Arabic Text, Ph.D Thesis, Dept. of Computer Science & Engineering, University of Washington (1995).

[AlBadr 96] Badr Al-Bader and R. Haralick, Segmentation-Free Recognition of Arabic Text, Proc. of the 5th Int. conf. and Exhibition on Multi-lingual Computing, University of Cambridge, England, UK, pp. 2.4.1-2.4.12 (April 1996).

[AlBaiaty86] S. H. Al-Baiaty and A. H. Murad, Machine-Printed Arabic Character Recognition Using Template Matching, Proc. of the Second Int. Baghdad conf. on Computer Technology and Applications, Baghdad, Iraq, C4: pp. 1-6 (1986). *

[AlEmami88] Samir Al-Emami, Machine Recognition of Handwritten and Typewritten Arabic Characters, Ph.D. Thesis, Dept. of Cybernetics, University of Reading, Reading, England, UK (Sep. 1988). *

[AlEmami90] Samir Al-Emami and M. Usher, On-line Recognition of Handwritten Arabic Characters, IEEE Transactions on PAMI: Pattern Analysis and Machine Intelligence, Vol. 12, No. 7, pp. 704-710 (July 1990).

[AlFedaghi88a] Sabah Al-Fedaghi and Adnan Amin, Automatic Spelling Correction, Technical Report, Electrical and Computer Engineering Department, Kuwait University, Kuwait (in Arabic) (1988). *

[Ali79] Sabah A. Ali, Topological Analysis in the Design of a Machine to Recognise Handprinted Characters, Ph.D. Thesis, Brunel University, England, UK(1979). *

[Ali89] Sabah A. Ali and Mahdi S. Al-Saadoun, A Parallel Algorithm for Image Thinning, Proc. of the First Kuwait Computer conf., Kuwait, pp. 121-140 (in Arabic) (March 1989).

[AlJabri91] Abdur-Rahman Kh. Al-Jabri and A. Mirza, Characterization of Written Arabic as an Information Source, Proc. of the Third Saudi Engineering conf., Riyadh, Saudi Arabia, Vol. 2, pp. 904-909 (Nov. 1991).

[AlJabri92] Abdur-Rahman Kh. Al-Jabri and A. S. Al-Mahmoud, Error-Correction with Unstructured Redundancy: An Application to Written Arabic, Proc. of the Workshop on the Use of Arabic Language in Information Technology, Riyadh, Saudi Arabia, 18 pages (in Arabic) (May 1992).

[Allam94] May Allam, Arabic Character Recognition, Proc. of SPIE - Int. Society for Optical Engineering V2181, conf. on Document Recognition, San Jose, CA, USA, Published by Society of Photo-Optical Instrumentation Engineers, Bellingham, WA, USA. pp. 351-359 (1994).

[AlMuallim87] H. Al-Muallim and S. Yamaguchi, A Method for Recognition of Arabic Cursive Handwriting, IEEE Transactions on PAMI: Pattern Analysis and Machine Intelligence, Vol. 9, No. 5, pp. 715-722 (Sep. 1987).

[AlOhali96] Yousef Al-Ohali and Pervez Ahmed, A Software Environment for the Development and Evaluation of Arabic Character Recognition System, Proc. of the 5th Int. conf. and Exhibition on Multi-lingual Computing, University of Cambridge, England, UK, pp. 2.5.1-2.5.10 (April 1996).

[AlQaisy85] E. K. Al-Qaisy and H. L. Naser, Recognition of Arabic Numerals Using Probabilistic Functions, Proc. of Computer Processing and Transmission of the Arabic Language Workshop, Kuwait (April 1985). *

[AlQaisy87] E. K. Al-Qaisy, Recognition of Handwritten Arabic Numerals Using Fast Fourier Transform, M.Sc. Thesis, Nat. Center for Computers/ Institute of Training and Research, Baghdad, Iraq (in Arabic) (1987). *

[AlQaisy89] E. K. Al-Qaisy and H. L. Naser, Using Probabilistic Functions for the Recognition of Handwritten Arabic Numerals, Proc. of the First Kuwait Computer conf., Kuwait, pp. 109-120 (in Arabic) (March 1989).

[AlShebeili97] Saleh A. AlShebeili, Asim A.-F. Nabawi, and Sabri A. Mahmoud, Arabic Character Recognition Using 1-D Slices of the Character Spectrum, J. of Signal Processing, Vol. 56, No. 1, pp. 59-75 (Jan. 1997).

[AlSuwaiyel91] M. I. Al-Suwaiyel, On the Entropy of Arabic, Arabian J. For Science and Engineering (AJSE), KFUPM, Dhahran, Saudi Arabia, Vol. 16, No. 4B, pp. 557-563 (Oct.1991).

[AlTikrity84] M. N. Al-Tikriti and V. S. Bansal, Recognition of Handwritten Arabic Numerals Using Fuzzy Entropy, J. for Engineering and Technology, Baghdad, Iraq, Vol. 2, pp. 7-20 (1984). *

[AlTikrity85] M. N. Al-Tikriti and S. Al-Ramahi, A Fuzzy Approach for Some Arabic Handwritten Characters Computer Recognition, Proc. of Computer Processing and Transmission of the Arabic Language Workshop, Kuwait, pp. 1-14 (April 1985).

[AlTuwaijri 94a] Majid M. Al-Tuwaijri and Magdy A. Bayoumi, Arabic Text Recognition Using Neural Networks, Proc. of the IEEE ISCAS: Int. Symposium on Circuits and Systems, London, England, UK, Vol. 6, pp. 415-418 (ABS) (1994).

[AlTuwaijri 94b] Majid M. Al-Tuwaijri, R. Ayoubi, and Magdy A. Bayoumi, Skeletonization of Arabic Characters Using a Neural Network Mapped on Maspar, Proc. of WCNN, San Diego, USA, p. II-635 (June 1994). *

[AlTuwaijri 94c] Majid M. Al-Tuwaijri and Magdy A. Bayoumi, Recognition of Arabic Characters Using Neural Networks, Proc. of the ICECS'1994, Cairo, Egypt, pp. 720-725 (Dec. 1994). *

[AlTuwaijri 95a] Majid M. Al-Tuwaijri and Magdy A. Bayoumi, A Parallel Recognition System for Arabic Cursive Words, Private communication, a paper of 33 pages (1995).

[AlTuwaijri 95b] Majid M. Al-Tuwaijri and Magdy A. Bayoumi, A New Thinning Algorithm for Arabic Characters Using Self-Organizing Neural Networks, ISCAS'95 (1995). *

[AlTuwaijri 96] Majid M. Al-Tuwaijri and Magdy A. Bayoumi, A New Thinning Algorithm for Arabic Characters Using ART2 Neural Networks, Submitted to IEEE Trans. on Neural Networks (1996). *

[AlYousefi88] H. Al-Yousefi and S. Udpa, Recognition of Handwritten Arabic Characters, Proc. of the SPIE's 32nd Annual Technical Symposium on Optical and Opto-Electronics Applied Science and Engineering, San Diego, CA, USA, Vol. 974, pp. 330-336 (1988).

[AlYousefi89] H. AL-Yousefi, Recognition of Handwritten Arabic Characters, Ph.D. Thesis, Colorado State University, Fort Collins, USA (Summer 1989).

[AlYousefi90] H. Al-Yousefi and S. Udpa, Recognition of Handwritten Arabic Characters via Segmentation, Arab Gulf J. Scient. Research, Vol. 8(2), pp. 49-59 (1990).

[AlYousefi92] H. Al-Yousefi and S. Udpa, Recognition of Arabic Characters, IEEE Transactions on PAMI: Pattern Analysis and Machine Intelligence, Vol. 14, No. 8, pp. 853-857 (Aug.1992).

[Ameur93] A. Ameur, K. Romeo-Parker, and Y. Lecourtier, L'Arabe Manuscrit et sa Reconnaissance Informatique, Proc. of the Second Int. Congress on Arabic Language and Advanced Information Technologies, Casablanca, Tunis, pp. 215-232 (in French) (Dec. 1993).

[Amin79] Adnan Amin and Azzedine Kaced, Reconnaissance des Caracteres Arabes Manuscrits en Temps Reel, CRIN - Universite de Nancy I, Rapport 79- p-080 (in French) (1979). *

[Amin80] Adnan Amin, A. Kaced, J. Haton, and R. Mohr, Handwritten Arabic Character Recognition by the IRAC System, Proc. of the 5th Int. Joint conf. on Pattern Recognition, Miami, Florida, USA, pp. 729-731 (Dec. 1980).

[Amin82a] Adnan Amin and G. Masini, Machine Recognition of Cursive Arabic Words, Proc. of the SPIE's 26th Int. Symposium and Instrument Display, San Diego, California, USA, pp. 286-292 (Aug. 1982).

[Amin82b] Adnan Amin, Machine Recognition of Handwritten Arabic Words by the IRAC II System, Proc. of the 6th Int. Joint conf. on Pattern Recognition, Munchen, Germany, pp. 34-36 (Oct. 1982).

[Amin83] Adnan Amin, IRAC: Recognition and Understanding Systems, Arab School on Science and Technology, Applied Arabic Linguistics and Signal & Information Processing, Rabat, Morocco (1983). *

[Amin84] Adnan Amin, G. Masini, and J. P. Haton, Recognition of Handwritten Arabic Words and Sentences, Proc. of the 7th Int. Joint conf. on Pattern Recognition, Montreal, Canada, pp. 1055-1057 (Aug. 1984).

[Amin85a] Adnan Amin, State of the Art on Character Recognition, Arabic Language Meeting, IBM Europe, Paris, France (Jan. 1985). *

[Amin85b] Adnan Amin, Arabic Handwriting Recognition and Understanding, Proc. of Computer processing and Transmission of the Arabic Language Workshop, Kuwait, Vol. 1, pp. 1-37 (April 1985).

[Amin85c] Adnan Amin, IRAC: Un Systeme pour la Reconnaissance et la Comprehension de l'Arabe Ecrit et Imprime, Thesis of Doctorat d'Etat, CRIN, University of Nancy, France (in French) (1985). *

[Amin86] Adnan Amin and G. Masini, Machine Recognition of Multifont Printed Arabic Texts, Proc. of the 8th IEEE Int. Joint conf. on Pattern Recognition, Paris, France, pp. 392-395 (Oct. 1986).

[Amin87] Adnan Amin, IRAC: Recognition and Understanding Systems, in Descout, R. (ed.): Applied Arabic Linguistics and Signal and Information Processing, Washington, USA, pp. 159-170 (1987).

[Amin88a] Adnan Amin, OCR of Arabic Texts, Proc. of the 9th Int. conf. on Pattern Recognition, University of Cambridge, England, UK, pp. 616-625 (March 1988).

[Amin88b] Adnan Amin, A. Kaced, and J. Haton, Handwritten Arabic Character Recognition by the IRAC System, Proc. of the Computer Arabization conf., Egyptian Computer Society, Cairo, Egypt, pp. 9-11 (1988). *

[Amin88c] Adnan Amin, Machine Recognition of Handwritten Arabic Words by the IRAC II System, Proc. of the Computer Arabization conf., Egyptian Computer Society, Cairo, Egypt, pp. 12-14 (1988). *

[Amin89] Adnan Amin and J. F. Mari, Machine Recognition and Correction of Printed Arabic Text, IEEE Trans. on Systems, Man, and Cybernetics, Vol. 19, No. 5, pp. 1300-1306 (Sep. 1989).

[Amin91a] Adnan Amin and S. Al-Fedaghi, Machine Recognition of Printed Arabic Text Utilizing Natural Language Morphology, Int. J. Man-Machine Studies, Vol. 35, pp. 769-788 (1991).

[Amin91b] Adnan Amin, Recognition of Arabic Handprinted Mathematical Formulae, Arabian J. For Science and Engineering (AJSE), KFUPM, Dhahran, Saudi Arabia, Vol. 16, No. 4B, pp. 531-542 (Oct.1991).

[Amin92] Adnan Amin and H. Al-Saadoun, A New Segmentation Technique of Arabic Text, Proc. of the 11th IAPR Int. Conf. on Pattern Recognition, The Hague, Netherlands, pp. 441-445 (September 1992).

[Assal91] M. A. Assal, M. M. Kouta and B. S. Tawfik, Recognition of Handwritten Hindu Numerals, Proc. of the 4th ORMA conf., Military Technical College, Cairo, Egypt (1991). *

[Assal92] M. A. Assal, A. A. Fahmy, and A. M. Tamer, Recognition of Handwritten Hindu Numbers in Low Quality Images, Proc. of the First Int. conf. on AI Applications, Cairo, Egypt, pp.II/261-269 (June 1992).

[Badie78] K. Badie and M. Shimura, A Classification Method of Arabic Alphabets, Paper of Technical Group, TGPRL.78-56, IECE, Institute of Electronics and Comm. Eng. of Japan (in Japanese) (1978). *

[Badie80a] K. Badie and M. Shimura, Machine Recognition of Arabic Cursive Scripts, 1980 Int. conf. of Pattern Recognition in Practice, pp. 315-323, North Holland, Amsterdam (1980). *

[Badie80b] K. Badie and M. Shimura, Machine Recognition of Arabic Cursive Scripts, Paper of Technical Group, TGPRL80-42, IECE, Institute of Electronics and Comm. Eng. of Japan (in Japanese) (1980). *

[Badie82a] K. Badie and M. Shimura, Machine Recognition of Arabic Handprinted Scripts, Trans. of the IECE, Institute of Electronics and Comm. Eng. of Japan, Vol. E65, No.2, pp. 107-114 (Feb 1982).

[Badie82b] K. Badie and M. Shimura, Machine Recognition of Arabic Cursive Scripts, Pattern Recognition in Practice, in E.S. Gelsema and L. N. Kanal, (eds.), North-Holland Pub. Company, pp. 315-323 (1982).

[Bansal84] V. Bansal and M. Al-Tikriti, Recognition of Arabic Handwritten Numerals Using Fuzzy Entropy, J. for Engineering and Technology, Baghdad, Iraq, Vol. 2, No. 2, pp. 7-20 (1984). *

[Barber88] D. Barber, Automatic Analysis and Tagging of Arabic Words, in Shivtiel, A. (ed.), Proc. of the Second Leeds Symposium, Leeds, England, UK, pp. 30-35 (1988). *

[Belghith 90] A. Belghith, M. Ben Ahmed, and M. Khemakhem, Dynamic Comparison Based Parallel and Distributed Algorithms for Arabic Character Recognition, Proc. of the Second IEEE Workshop on Future Trends of Distributed Computing Systems, Cairo, Egypt (Sep. 1990). *

[Berbar94] M. A. Berbar, Character Recognition for Arabic Texts, M.Sc. Thesis, Faculty of Electronic Engineering, Menouf, Menoufiyya University, Egypt (Dec. 1994). *

[Bilal76] A. Y. Bilal, F. Saleh, A. S. Nouh, O. S. Ali, and A. Sultan, Picture Processing by Digital Computers, Part-I: The Overall System Configuration, Research Report No. CE-4/96, Research Centre, Faculty of Engineering, Riyadh (now King Saud) University, Riyadh, Saudi Arabia (June 1976). *

[Bouhlila88] K. Bouhlila, Reconnaissance de Caracteres Arabes, These de Doctorat de Specialite, Ecole Nationnale d'Ingenieurs de Tunis (in French) (1988). *

[Bouhlila89] K. Bouhlila, M. K. Hamrouni, and N. Ellouze, Method of Segmentation of Arabic Text Image into Characters, Proc. of the First Kuwait Computer conf., Kuwait, pp. 442-446 (March 1989).

[Braham92] Rafik Braham, Applications of a Binary Neural Network, Proc. of the 13th Nat. Computer conf., Riyadh, Saudi Arabia, pp.900-906 (Nov. 1992).

[Dewachi75] A. Dewachi, A Standardization of Arabic Alphabet and Numbers, Internal Report, Iraqi Nat. Computer Center, Baghdad (1975). *

[ElDabi90] Sharif S. El-Dabi, R. Ramsis, and A. Kamal, Arabic Character Recognition System: A Statistical Approach for Recognizing Cursive Typewritten Text, Pattern Recognition, Vol. 23, No. 5, pp. 485-495 (1990).

[ElDesouky91] Ali El-Desouky, Mefreh Salem, Aida Abd El-Gwad, and Hesham Arafat, A Handwritten Arabic Character Recognition Technique for Machine Reader, Proc. of the 3rd Int. conf. on Software Engineering for Real Time Systems, Cirencester, UK, pp. 212-216 (Sep. 1991).

[ElDesouky92] Ali El-Desouky, Mefreh Salem, Aida Abd El-Gwad, and Hesham Arafat, A Handwritten Arabic Character Recognition Technique for Machine Reader, Int. Journal of Mini and Microocomputers, Vol. 14, No.2, pp. 57-61 (1992).

[ElGamal91] S. S. El-Gamal, M. A. Hashish, and A. T. El-Kheshen, Arabic Lexical Knowledge Base: Design and Implementation, Proc. of Al-Azhar Engineering Second Int. conf., AEC'91, Al-Azhar University, Cairo, Egypt, pp. 112-121 (Dec. 1991). *

[ElGowely89] Khaled El-Gowely, Recognition of Multifont Photo Script Arabic Text, M.Sc. Thesis, Faculty of Engineering, Cairo University, Dokki, Giza, Egypt (1989). *

[ElGowely90] Khaled El-Gowely, O. El-.Dessouki, and A. Nazif, Multi-phase Recognition of Multifont Photoscript Arabic Text, Proc. of the 10th Int. conf. on Pattern Recognition, Vol. 1, pp. 700-702 (1990).

[ElHamalawy88] Mohamed A. El-Hamalawy and Salwa H. El-Ramly, A Novel Arabic Numerals Shapes for Optical Character Recognition, Proc. of the 13th Int. Congress for Statistics, Computer Science, Social and Demographic Research, pp. 127-130 (March 1988).

[ElKhaly90] F. El-Khaly and M. A. Sid-Ahmed, Machine Recognition of Optically Captured Machine Printed Arabic Text, Pattern Recognition, Vol. 23, No. 11, pp. 1207-1214 (1990).

[ElRamly89a] S. H. El-Ramly and M. A. El-Hamalawy, A Language-Dependent Arabic Character Recognition Approach, Proc. of the 14th Int. Congress for Statistics, Computer Science, Social and Demographic Research, Vol. 4, pp. 247-254 (March 1989).

[ElRamly89b] S. H. El-Ramly and M. A. El-Hamalawy, A New Font for Arabic Characters Simplifies Recognition Procedure, Proc. of the14th Int. Congress for Statistics, Computer Science, Social and Demographic Research, Cairo, Egypt, Vol. 4, pp. 255-261 (March 1989).

[ElRamly89c] S. H. El-Ramly and M. A. El-Hamalawy, A New Font for Arabic Characters Simplifies Recognition Procedure, Proc. of the First Kuwait Computer conf., Kuwait, pp. 398-401 (March 1989).

[ElShbiny76] A. El-Shbiny, Attempts for Simplifying Arabic Printing Characters, Proc. of the Third Saudi Arabian Computer conf., Riyadh, Saudi Arabia (1976). *

[ElSheikh88a] T. S. El-Sheikh and R. M. Guindi, Automatic Recognition of Isolated Arabic Characters, J. Signal Processing, Vol. 14, No. 2, pp. 177-184 (March 1988).

[ElSheikh88b] T. S. El-Sheikh and R. M. Guindi, Computer Recognition of Arabic Cursive Scripts, Pattern Recognition, Vol. 21, No. 4, pp. 293-302 (1988).

[ElSheikh89a] T. S. El-Sheikh and S. G. El-Taweel, Real-time Arabic Handwritten Character Recognition, Proc. of the Third Int. conf. on Image Processing and its Applications, Warwick, UK, pp. 212-216 (1989).

[ElSheikh89b] T. S. El-Sheikh and S. G. El-Taweel, Recognition of Typewritten Arabic Characters in Different Fonts, Proc. of IEE Colloquium on Character Recognition and Applications, London, England, UK, pp. 9/1-5 (Oct. 1989).*

[ElSheikh90a] T. S. El-Sheikh and S. G. El-Taweel, Real-time Arabic Handwritten Character Recognition, Pattern Recognition, Vol. 23, No. 12, pp. 1323-1332 (1990).

[ElSheikh90b] T. S. El-Sheikh and S. G. El-Taweel, Segmentation of Handwritten Arabic Words, Proc. of the 12th Nat. Computer conf., Riyadh, Saudi Arabia, pp. 389-402 (Oct. 1990).

[ElSheikh90c] T. S. El-Sheikh, Recognition of Handwritten Arabic Mathematical Formulas, Proc. of the UK IT 1990 conf., University of Southampton, Southampton, England, UK, pp. 344-351 (March 1990).

[ElWakil87] Mohamed S. El-Wakil and Amin A. Shoukry, On-line Recognition of Handwritten Isolated Arabic Characters, Proc. of the First KSU Symposium on Computer Arabization, King Saud Univ., Riyadh, Saudi Arabia, pp.109-120 (April 1987).

[ElWakil88] Mohamed S. El-Wakil and Amin A. Shoukry, On-line Recognition of Handwritten Isolated Arabic Characters, Proc. of the Computer Arabization conf., Egyptian Computer Society, Cairo, Egypt, pp. 70-82 (1988).

[ElWakil89] Mohamed S. El-Wakil and Amin A. Shoukry, On-line Recognition of Handwritten Isolated Arabic Characters, Pattern Recognition, Vol. 22, No. 2, pp. 97-105 (1989).

[Emam93] Ashraf Emam, H. Al-Khatib, M. Ismail, and E. Korany, Fast Segmentation Technique for Arabic Scripts, Proc. of the 19th Int. conf. of the Association of Muslim Scientists and Engineers (ASME), pp. 70-88 (Oct. 1993). *

[Emam94] Ashraf Emam, M. Ismail, H. Al-Khatib, and E. Korany, Character Recognition of Arabic Script, Proc. of the 4th Int. conf. and Exhibition on Multi-lingual Computing (Arabic and Roman Script), University of Cambridge, England, UK, pp. 2.1.1-2.1.10 (April 1994).

[Fakir91] Mohamed Fakir and Chuichi Sodeyama, On the Features Extraction for the Recognition of Arabic Scripts, PRU 91-94, Japan, pp. 49-56 (Dec.1991). *

[Fakir92] Mohamed Fakir and Chuichi Sodeyama, Machine Recognition of Arabic Printed Scripts, SSPR92 (1992). *

[Fakir93] Mohamed Fakir and Chuichi Sodeyama, Recognition of Arabic Printed Scripts by Dynamic Programming Matching Method, IEICE Trans. Inf. and Sys., Vol. E76-D, No. 2, pp. 235-242 (Feb.1993).

[Fayek92] M. B. Fayek and B. Al-Basha, A New Hierarchical Method for Isolated Typewritten Arabic Character Classification and Recognition, Proc. of the 13th Nat. Computer conf., Riyadh, Saudi Arabia, pp. 750-760 (Nov. 1992).

[Fehri94] M. Fehri and M. Ahmed, A New Approach to Arabic Character Recognition in Multifont Document, Proc. of the 4th Int. conf. and Exhibition on Multi-lingual Computing (Arabic and Roman Script), University of Cambridge, England, UK, pp. 2.5.1-2.5.7 (April 1994).

[Ghuwar94] M. Ghuwar and W. Skarbek, Recognition of Arabic Characters - A Survey, ICS PAS Reports, No. 740 (1994). *

[Ghuwar95] M. Ghuwar and W. Skarbek, Detection of Baseline for Arabic Text Lines Using Hough Type Transforms, Proc. of the 7th Portuguese conf. on Pattern Recognition, Aveiro, Portugal, pp. 531-533 (March 1995).

[Goneid87] A. Goneid, A. Salem, M. Tolba, and E. Shaddad, On the Sensitivity of Some Recognition Algorithms for Printed Arabic Characters, Proc. of the 12th Int. Congress for Statistics and Computer Science, Social and Demographic Research, Cairo, Egypt Vol.5, pp. 231-241 (April 1987). *

[Goneid88] A. Goneid, A. Salem, M. Tolba, and E. Shaddad, On the Sensitivity of Some Recongnition Algorithms for Printed Arabic Characters, Proc. of the 13th IFIP Congress, Tokyo, Japan (1988). *

[Goneid92a] A. Goneid, M. N. Mikhail, H. Kotkata, and A. A. Hassan, Optical Character Recognition of Arabic Handwritten Numerals, Proc. of the 3rd Int. conf. and Exhibition on Multi-lingual Computing (Arabic and Roman Script), pp. 7.1.1-7.1.10, University of Durham, UK (Dec.1992).*

[Goneid92b] A. Goneid, M. Shalaby, S. K. Hindawi, T. Nazmi, and K. Monir, A Fast Algorithm for the Recognition of Arabic Handwritten Numerals Using Topological Features, Proc. of the First Int. conf. on AI Applications, Cairo, Egypt, pp.II/253-260 (June 1992).

[Goneid92c] A. Goneid, M. N. Mikhail, H. Kotkata, and A. A. Hassan, Optical Character Recognition of Arabic Handwritten Numerals, Proc. of the First Int. conf. on AI Applications, Cairo, Egypt, pp.II/270-283 (June 1992).

[Goraine89] H. Goraine and M. Usher, Recognition of Typewritten Arabic Characters in Different Fonts, Proc. of the IEE Colloquium on Character Recognition and Applications, London, England, UK, pp. 9/1-5 (Oct. 1989).

[Goraine90] H. Goraine, Machine Recognition of Arabic Text, Ph. D. Thesis, Dept. of Cybernetics, Reading University, Reading, England, UK (December 1990). *

[Goraine92a] H. Goraine, M. Usher, and S. Al-Emami, Recognition of Isolated Arabic Words, IEEE Computer System Analysis (June 1992). *

[Goraine92b] H. Goraine, M. Usher, and S. Al-Emami, Off-line Arabic Character Recognition, IEEE Computer,Vol. 25, No. 7, pp. 71-74 (Jul 1992).

[Goraine94] H. Goraine and M. Usher, Printed Arabic Text Recognition, Proc. of the 4th Int. conf. and Exhibition on Multi-lingual Computing (Arabic and Roman Script), University of Cambridge, England, UK, pp. 2.6.1-2.6.8 (April 1994).

[Govindan90] V. K. Govindan and A P. Shivaprasad, Character Recognition - A Review, Pattern Recognition, Vol. 23, No. 7, pp. 671-683 (1990).

[Guindi87] R. M. Guindi, An Arabic Text Recognition System, M.Sc. Thesis, Faculty of Engineering, Cairo University, Dokki, Giza, Egypt (1987). *

[HajHassan85] F. Haj-Hassan, Arabic Character Recognition, Proc. of 7th Summer Session, Computers and the Arabic Language, Arab School of Science and Technology, Syria, P2.A5-1(1985).

[HajHassan88] F. Haj-Hassan, Arabic Character Recognition, Proc. of the Computer Arabization conf., Egyptian Computer Society, Cairo, Egypt, pp. 15-20 (1988).

[HajHassan90] F. Haj-Hassan, Arabic character recognition, in Computer and the Arabic Language, Hemisphere Publishing Corporation, Edited by Pierre Mackay, pp. 113-118 (1990).

[HajHassan91] F. Haj-Hassan, Arabic Character Recognition, Proc. of the Computer Arabization conf., Egyptian Computer Society, Cairo, Egypt, pp. 15-20 (1988).

[Hashish85] M. A. Hashish, A. T. El-Kheshen, and M. R. El-Ghonemy, Experiences in Isolated Arabic Word Recognition, Proc. of Computer Processing and Transmission of the Arabic Language Workshop, Kuwait, p. 80 (April 1985). *

[Hashish88] M. A. Hashish, S. S. El-Gamal, and A. T. El-Kheshen, A System Approach to the Organization of an Arabic Lexical Knowledge Base: Modelling and Visualization, Proc. of Al-Azhar Engineering Second Int. conf., AEC'91, Al-Azhar University, Cairo, Egypt, pp. 153-164 (Dec. 1991). *

[Hashish92] M. A. Hashish, Arabic Language Processing, Proc. of Workshop on the Use of Arabic Language in Information Technology, Riyadh, Saudi Arabia, 10 pages (in Arabic) (May 1992).

[Hassibi93] K. M. Hassibi, An OCR System for Machine-Printed Arabic, Symposium on Advanced Information Processing and Analysis, VA, USA (March 1993). *

[Hassibi94] K. M. Hassibi, Machine-Printed Arabic OCR Using Neural Networks, Proc. of the 4th Int. conf. and Exhibition on Multi-lingual Computing (Arabic and Roman Script), University of Cambridge, England, UK, pp. 2.3.1-2.3.12 (April 1994).

[Hyder88a] S. Hyder and A. Khoujah, Character Recognition of Cursive Scripts, Proc. of the Regional conf. on Informatics and

Arabization (IRSIT), Tunis, Vol.1, pp. 118-127 (June 1988). *

[Hyder88b] S. Hyder and A. Khoujah, Character Recognition of Cursive Scripts, Proc. of the ACM, pp. 1146-1150 (1988).

[Ismail93a] M. Ismail, Ashraf Emam, and A. El-Zoghabi, Topological and Global Features for Arabic Character Recognition, Proc. of the 19th Int. conf. of the Association of Muslim Scientists and Engineers (ASME), pp. 39-51 (Oct. 1993). *

[Ismail93b] M. Ismail and Ashraf Emam, Arabic Text Recognition for Office Automation, Proc. of the 19th Int. conf. of the Association of Muslim Scientists and Engineers (ASME), pp. 52-69 (Oct. 1993). *

[Jambi90] Kamal M. Jambi and T. Grace, A New Topological Structural Approach for the Recognition of an Isolated Arabic Word, Proc. of the conf. on Information Technology in Support of Economic Development, Khartoum, Sudan (Dec. 1990). *

[Jambi91a] Kamal M. Jambi, Design and Implementation of a System for Recognizing Arabic Handwritten Words with Learning Ability, Ph.D. Thesis, Illinois Institute of Technology, Chicago, USA (Aug. 1991).

[Jambi91b] Kamal M. Jambi, Arabic Character Recognition: Many Approaches and One Decade, The Arabian J. for Science and Engineering (AJSE), KFUPM, Dhahran, Saudi Arabia, Vol. 16, No. 4B, pp. 499-509 (Oct. 1991).

[Jambi92] Kamal M. Jambi, A System for Recognizing Handwritten Arabic Words, Proc. of the 13th Nat. Computer conf., Riyadh, Saudi Arabia, pp. 472-482 (Nov. 1992).

[Jambi93] Kamal M. Jambi, An Approach for Segmenting Handwritten Arabic Words, Proc. of the 2nd Int. Congress on Arabic Language and Advanced Information Technologies, Casablanca, Tunis, pp.233-243 (Dec.1993).

[Jambi95] Kamal M. Jambi, An Experimental Approach for Segmenting Handwritten Arabic Words, Journal of King Abdul-Aziz University, Sciences Div., Jiddah, Saudi Arabia, Vol. 7, pp.119-130 (1995). *

[Jambi96] Kamal M. Jambi, Recognition of Handwritten Arabic Words without Segmentation, Proc. of the 6th Int. conf. on Computer Theory and Applications, Alexandria, Egypt, pp.385-395 (Sep. 1996). *

[Jambi97] Kamal M. Jambi, Ibrahim Al-Bidewi, and Majid Bakkar, Investigating New Representations of Arabic Characters Based on their Contours, Proc. of the 15th Nat. Computer conf., KFUPM, Dhahran, Saudi Arabia, Vol. 2, pp. 783-795 (Nov. 1997).

[Kamel90] A. Kamel, R. R. Ramsis, and S. S. El-Dabi, Arabic Character Recognition System: a Statistical Approach for Recognizing Cursive Typewritten Text, Pattern Recognition, Vol. 23, No. 5, pp. 485-495 (1990). *

[Khalidov85] A. B. Khalidov, Arabskie Rukopisi i Arabskaya Rukopisnaya Tradiciya, Moscow, Russia (in Russian) (1985). *

[Khella92] Fakhry Khella, Analysis of Hexagonally Sampled Images with Application to Arabic Cursive Text Recognition, M.Phil. Thesis, University of Bradford, Bradford, England, UK (1992).

[Khella94] Fakhry Khella and Sabri Mahmoud, Recognition of Hexagonally Sampled Arabic Characters, Arabian J. for Science and Engineering (AJSE), KFUPM, Dhahran, Saudi Arabia, Vol. 19, No. 4A, pp. 565-586 (Oct. 1994).

[Khemakhem87a] M. Khemakhem, Reconnaissance de Characteres Imprimes par Comparaison Dynamique, These de Doctorat de Troisieme Cycle, Universite Paris XI ORSAY (in French) (June 1987). *

[Khemakhem87b] M. Khemakhem, J. L. Gauvin, and J. Rivaillier, Reconnaissance de Characteres Imprimes par Comparaison Dynamique, Proc. of AFCET Reconnaissance des Formes et Intelligence Artificielle, Antibes (in French) (Nov. 1987). *

[Khemakhem88] M. Khemakhem, Reconnaissance Global de Characteres Imprimes Arabe et Latin par Comparaison Dynamique, Proc. of the Regional conf. on Informatics and Arabization, Tunis (in French) (March 1988). *

[Khemakhem89] M. Khemakhem and M. C. Fehri, Arabic Typewritten Character Recognition Using Dynamic Comparison, Proc. of the First Kuwait Computer conf., Kuwait, pp. 447-462 (March 1989).

[Khemakhem93] M. Khemakhem, A. Belghith, and M. Ben Ahmed, Modelisation Architecturale de la Comparaison Dynamique Distribuee, Proc. of the Second Int. Congress on Arabic Language and Advanced Information Technologies, Casablanca, Tunis, pp. 313-331 (in French) (Dec.1993).

[Kubba80] G. A. Kubba, The Impact of Computers on Arabic Writing: Character Processing and Teaching, Proc. of the IFIP Congress (1980). *

[Kurdy91] Mohammad Bassam Kurdy and K. Wadouh, Transfer the Arabic OCR to Product (First Stage), Internal Report, Arab School of Science and Technology, Syria (Sep. 1991) *

[Kurdy92] Mohammad Bassam Kurdy and Ammar Joukhadar, Multifont Recognition System for Arabic Characters, Proc. of the 3rd Int. conf. and Exhibition on Multi-lingual Computing (Arabic and Roman Script), University of Durham, UK, pp. 7.3.1-7.3.9 (December 1992). *

[Kurdy93] M. Bassam Kurdy, Ammar Joukhadar, and Ahmad Wabbi, Multifont Arabic/Latin Optical Character Recognition System, Proc. of the Second Int. Congress on Arabic Language and Advanced Information Technologies, Casablanca, Tunis, pp. 245-256 (Dec. 1993).

[LaPre96] Christopher LaPre, Ying Zhao, Christopher Raphael, Richard Schwartz, and John Makhoul, Multifont Recognition of Printed Arabic Using the BBN Byblos Speech Recognition System, Proc. of the 1996 IEEE Int. conf. on Acoustics, Speech and Signal Processing ICASSP, Atlanta, GA, USA, Vol. 4 (of 6), pp. 2136-2139 (1996).

[Mahdi87] Hani M. K. Mahdi, Small Size Image Transformations and Representations, Proc. of the 12th Int. Congress for Statistics, Computer Science, Social and Demographic Research, Cairo, Egypt, Vol. 5, pp. 1-13 (April 1987). *

[Mahdi89] Hani M. K. Mahdi, Thinning and Transforming the Segmented Arabic Characters into Meshes of Unified Small Size, Proc. of the 14th Int. Congress for Statistics, Computer Science, Social and Demographic Research, Cairo, Egypt, pp. 263-276 (March 1989).

[Mahgoub92] Hossam El-Din Mahgoub and Hazem Y. Abdel-Azim, Arabic Spelling Verification and Assistance, Proc. of the conf. on the Use of Arabic Language in Information Technology, Riyadh, Saudi Arabia, (May1992). *

[Mahmoud86] M. Y. Mahmoud, M. A. El-Hamalaway, and A. A. Fahmy, A Statistical Approach for Arabic Character Recognition, Proc. of the 9th Nat. Computer conf. and Exhibition, Riyadh, Saudi Arabia,Vol. 2, pp. 13-3-1:13-3-7 (1986).

[Mahmoud87] M. Y. Mahmoud, M. A. El-Hamalaway, and A. A. Fahmy, A Statistical Approach for Arabic Character Recognition, Proc. of the 12th Int. Congress for Statistics, Computer Science, Social and Demographic Research, Cairo, Egypt,Vol. 5, pp. 243-250 (1987).

[Mahmoud91] Sabri A. Mahmoud, I. S. I. Abu-Haiba, and R. J. Green, Skeletonization of Arabic Characters Using Clustering Based Skeletonization Algorithm (CBSA), Pattern Recognition, Vol. 24, No. 5, pp. 453-464 (1991).

[Mahmoud94] Sabri A. Mahmoud, Arabic Character Recognition Using Fourier Descriptors and Character Contour Encoding, Pattern Recognition, Vol. 27, No. 6, pp. 815-824 (1994).

[Makhoul96] John Makhoul, C. LaPre, C. Raphael, R. Schwartz, and Ying Zhao, Twards Language-Independent Character Recognition Using Speech Recognition Methods, Proc. of the 5th Int. conf. and Exhibition on Multi-lingual Computing, University of Cambridge, England, UK, pp. 2.6.1-2.6.6 (April 1996).

[Mantas86] J. Mantas, An Overview of Character Recognition Methodologies, Pattern Recognition, Vol. 19, No. 6, pp. 425-430 (1986).

[Margner92] Volker Margner and Tu Braunschweig, SARAT- A System for the Recognition of Arabic Printed Text, Proc. of the 11th IAPR Int. conf. on Pattern Recognition, The Hague, Netherlands, pp. 561-564 (Sept. 1992).

[Murad84] A. H. Murad, Recognition of Arabic Characters Using Microcomputers, M.Sc. Thesis, School of Control and System Engineering, University of Technology, Baghdad, Iraq (1984). *

[Nabawi94] Asim A.-F. Nabawi and Sabri A. Mahmoud, Automatic Arabic Character Recognition Using Back-Propagation Neural Networks, J. of King Saud University, Computer and Information Sci. Division, Riyadh, Saudi Arabia, Vol. 9, pp. 1-29 (in Arabic) (1997).

[Namane90] A. Namane and M. A. Sid-Ahmed, Character Scaling by Contour Method, IEEE Trans. on PAMI: Pattern Analysis and Machine Intelligence, Vol. 12, No. 6, pp. 600-606 (June 1990).

[Nazif75] Ahmed M. Nazif, A System for the Recognition of Printed Arabic Characters, M.Sc. Thesis, Cairo University, Dokki, Giza, Egypt (1975).

[Nouh78] A. S. Nouh, A. Sultan, and R. Tolba, Picture Processing by Digital Computers, Part-III: An Approach for Arabic Character Characteristics and Recognition, Research Report No. CE-5/98, Research Centre, Faculty of Engineering, Riyadh (now King Saud) University, Riyadh, Saudi Arabia (June 1978). *

[Nouh80] A. S. Nouh, A. Sultan, and R. Tolba, An Approach for Arabic Characters Recognition, J. of Engineering and Sciences, Riyadh (now King Saud) University, Riyadh, Saudi Arabia, Vol. 6 (2), pp. 185-191 (1980).

[Nouh84] A. S. Nouh, A. Sultan, and R. Tolba, On Feature Extraction and Selection for Arabic Characters Recognition, Arab Gulf Journal of Scientific Research, Vol. 2, No. 1, pp. 329-347 (1984).

[Nouh86a] A. S. Nouh, A. Nurul-Ula, and A. Sharaf Eldin, A System for Automatic Recognition of Arabic Characters, First Progress Report No. AR-6-20, King Abdul-Aziz City for Science and Technology, Riyadh, Saudi Arabia (1986).*

[Nouh86b] A. S. Nouh, A. Nurul-Ula, and A. Sharaf Eldin, A System for Automatic Recognition of Arabic Characters, Second Progress Report No. AT-6-20, King Abdul-Aziz City for Science and Technology, Riyadh, Saudi Arabia (1986). *

[Nouh87a] A. S. Nouh, A. Nurul-Ula, and A. Sharaf Eldin, Sequential Processing of Binary Images, J. of Engineering and Sciences, King Saud University, Riyadh, Saudi Arabia, Vol. 13 (2), pp. 229-243 (1987).

[Nouh87b] A. S. Nouh, A. Nurul-Ula, and A. Sharaf Eldin, Boolean Recognition Technique for Typewritten Arabic Character Set, Proc. of the First KSU Symposium on Computer Arabization, King Saud University, Riyadh, Saudi Arabia, pp. 90-97 (April 1987).

[Nouh87c] A. S. Nouh, A. Nurul-Ula, and A. Sharaf Eldin, The Arabic Character Database System, ACDABAS, Proc of the First KSU Symposium on Computer Arabization, King Saud University, Riyadh, Saudi Arabia, pp. 98-108 (April 1987).

[Nouh88a] A. S. Nouh, A. Nurul-Ula, and A. Sharaf Eldin, An OCR Based Address Reader for Arabic Postal Systems, First Int. conf. of the Regional Institute for Informatics and Telecommunications, Tunis (March 1988). *

[Nouh88b] A. S. Nouh, A. Nurul-Ula, and A. Sharaf Eldin, Algorithms for Feature Extraction: A Case Study for the Arabic Character Recognition, Proc. of the 10th. Nat. Computer conf., King Abdulaziz University, Jiddah, Saudi Arabia, pp. 653-666 (March 1988).

[Nouh88c] A. S. Nouh, A. Nurul-Ula, and A. Sharaf Eldin, A System for Automatic Recognition of Arabic Characters, Final Report No. AR-6-20, King Abdul-Aziz City for Science and Technology, Riyadh, Saudi Arabia (1988). *

[Nouh88d] A. S. Nouh, A. Nurul-Ula, and A. Sharaf Eldin, Boolean Recognition Technique for Typewritten Arabic Character Set, Proc. of the Computer Arabization conf., Egyptian Computer Society, Cairo, Egypt, pp. 21-28 (1988).

[Nouh89] A. S. Nouh, A. Nurul-Ula, and A. Sharaf Eldin, A Proposed Algorithm for Thinning Binary Arabic Character Patterns, Proc. of the First Kuwait Computer conf., Kuwait, pp. 426-441 (March 1989).

[Nouh93] A. S. Nouh, Recognition of Constrained Handprinted Arabic Characters, Proc. of the 2nd Int. Congress on Arabic Language and Advanced Information Technologies, Casablanca, Tunis, pp. 201-214 (Dec.1993).

[Nouh94] A. S. Nouh, and A. Sharaf Eldin, Arabic Character Recognition: A Critical Survey, Proc. of the Second KSU Symposuim on Computer Arabization, King Saud University, Riyadh, Saudi Arabia, pp.1-24 (1994).

[NurulUla87] A. Nurul-Ula, A. S. Nouh, and A. Sharaf Eldin, A Variable Limb-width Matching Algorithm for Automatic Recognition of Arabic Characters, Proc. of the 10th Symposium on Information Theory and its Applications, Fujisawa, Japan, pp. 411-415 (Nov. 1987). *

[NurulUla88a] A. Nurul-Ula and A. S. Nouh, Automatic Recognition of Arabic Characters Using Logic Statements - Part I: System Description and Preprocessing, J. Engr. Science, King Saud University, Riyadh, Saudi Arabia, Vol. 14, No. 2, pp. 343-353 (1988).

[NurulUla88b] A. Nurul-Ula and A. S. Nouh, Automatic Recognition of Arabic Characters Using Logic Statements - Part II: Development of Recognition Algorithm, J. Engr. Science, King Saud University, Riyadh, Saudi Arabia, Vol. 14, No. 2, pp. 355-367 (1988).

[Parhami77] B. Parhami and F. Mavaddat, Computers and the Farsi Language: A Survey of Problem Areas, Proc. of the Information Processing'77 IFIP Congress, North-Holland, Amsterdam, The Netherlands, pp. 673-676 (1977).*

[Parhami78a] B. Parhami, Impact of Farsi Language on Computing in Iran, Mideast Computing, No. 1, pp. 6-7 (Sep. 1978). *

[Parhami78b] B. Parhami, On the Use of Farsi and Arabic Languages in Computer-Based Information Systems, Proc. of the Symposium on Linguistic Applications of Computer-Based Information Systems, New Delhi, India, Session 3, Paper 11 (Nov. 1978). *

[Parhami81] B. Parhami and M. Taraghi, Automatic Recognition of Printed Farsi Texts, Pattern Recognition, Vol. 14, No.1-6, pp. 395-403 (1981).

[Rahho86] G. Rahho, S. SaadAllah, and S. G. Yacu, Design of Bilingual Handprinted Reading Machine Using a Microcomputer, Proc. of the Second Int. Baghadad conf. on Computer Technology and Applications, Baghdad, Iraq, Vol. II, No. 5 (1986). *

[Ramsis88] R. Ramsis, S. S. El-Dabi, and A. Kamel, Arabic Character Recognition System, IBM Kuwait Scientific Center, Kuwait, Report No. KSC027 (Jan. 1988).

[Rashid96] Mosfeq Rashid, Arabic Character Recognition Using Integrated Segmentation and Recognition, Proc. of the 5th Int. conf. and Exhibition on Multi-lingual Computing, University of Cambridge, England, UK, pp. 2.1.1-2.1.10 (April 1996).

[Rashwan94] Mohsen Rashwan, Hazem Raafat, Abdulla Ismail, Hussein I. Shahein, and Mohamed El-Shafie, Improving Classification Using a Tree Structured Neural Network, J. of Intelligent and Fuzzy Systems, Vol. 2, pp. 101-114 (1994).

[SaadAllah85] S. SaadAllah and S. G. Yacu, Design of an Arabic Character Reading Machine, Proc. of Computer Processing and Transmission of the Arabic Language Workshop, Kuwait, 17 pages (April 1985).

[Sabri86] M. Sabri, Recognition of Printed Arabic Characters Using the Architectural Correspondence Technique, Proc. of the Second Int. Baghdad conf. on Computer Technology and Applications, Baghdad, Iraq, Vol. I, C.4-1 (1986). *

[Saleh75a] F. Saleh and A. Nazif, An Automatic Recognition System for Printed Arabic Characters, An Unidentified-conf. paper, 5 pages (around 1975).

[Saleh75b] F. Saleh, An Automatic Recognition System for Arabic Characters, A paper of an Unidentified-Source, 19 pages (around 1975).

[Saleh77] F. Saleh, A.-M. Y. Bilal, A. S. Nouh, O. Saad-ud-Deen, and A. Sultan, Printed Arabic Character Recognition Using a Digital Computer, Proc. of the 2nd conf. on Arabic Scientific Research, Manchester, UK (in Arabic) (1977).

[Sanossian96] Hermineh Y. Y. Sanossian, Arabic Character Recognition System Using Neural Network, Proc. of the IEEE Signal Processing Society Workshop: Neural Networks for Signal Processing, Kyota, Japan, pp. 340-348 (1996).

[Seddik89] M. Seddik and Amin A. Shoukry, On-line Recognition of Handwritten Isolated Arabic Characters, Pattern Recognition, Vol. 22, No. 2, pp. 97-105 (1989). *

[Seflan75] A. M. Seflan, The Need for a Standard Arabic Character Set, Proc. of the Second Nat. Computer conf., Riyadh, Saudi Arabia (1975). *

[Shaheen90] Samir I. Shaheen and Gibrael A. Abo-Samra, On-line Arabic Cursive Script Recognition, The Egyptian Computer J., ISSR, Cairo University, Dokki, Giza, Egypt, Vol. 18, No. 2, pp 222-240 (1990).

[Sharaf Eldin88] A. Sharaf Eldin, A. S. Nouh, and A. Nurul-Ula, Algorithms for Feature Extraction: A Case Study for the Arabic Character Recognition, Proc. of the Computer Arabization conf., Egyptian Computer Society, Cairo, Egypt, pp. 29-42 (1988).

[Sharkawy88] M. A. Sharkawy, E. M. Shaddad, and M. Tolba, Fourier Descriptors for Printed Arabic Character Recognition, Proc. of 13th Int. Congress for Statistics and Computer Science, Social and Demographic Research, Cairo, Egypt, Vol. 5, pp. 137-146 (1988). *

[Shoukry83] Amin Shoukry and Adnan Amin, Machine Recognition of Cursive Arabic Words, in Tescher, G. (ed.): Application of Digital Image Processing IV, SPIE (1983). *

[Shoukry89] Amin Shoukry, Arabic Character Recognition: State of the Art, Proc. of the 11th Saudi Nat. Computer conf., Dhahran, Saudi Arabia, pp. 382-390 (March 1989).

[Shoukry91] Amin Shoukry, A Sequential Algorithm for the Segmentation of Typewritten Arabic Digitized Text, The Arabian J. for Science and Engineering (AJSE), KFUPM, Dhahran, Saudi Arabia,Vol. 16, No. 4, pp. 543-556 (Oct. 1991).

[Starner94] T. Starner, J. Makhoul, R. Schwartz, and G. Chou, On-line Cursive Handwriting Recognition using Speech Recognition Methods, Proc. of the IEEE Int. conf. on Acoustics, Speech, and Signal Processing, Vol. V, pp. 125-128 (April 1994). *

[Taconet89] B. Taconet, and M. H. Hamza, Recognition and Restoration of Globally Degraded Printed Characters, Proc. of the IASTED Int. Symposium: Applied Informatics-AI '89, Grindlewald, Switzerland, pp. 102-105 (Feb. 1989). *

[Taraghi78] M. Taraghi, Automatic Recognition of Printed Farsi Texts, M.Sc. Thesis, Deptartment of Mathematics and Computer Science, Sharif University of Technology, Iran (1978). *

[Tikhonova92] Irina G. Tikhonova, Arabic Optical Character Recognition, Proc. of the 3rd Int. conf. and Exhibition on Multi-lingual Computing (Arabic and Roman Script), University of Durham, UK, pp. 7.2.1-7.2.7 (Dec. 1992).

[Tolba86] M. F. Tolba, S. A.-Wahab, and A. Salem, A Recognition Algorithm for Arabic Printed Characters, Proc. of the 11th Int. Congress for Statistics, Computer Science, Social and Demographic Research, Cairo, Egypt, Vol. 2 (1986).

[Tolba87a] M. F. Tolba, A. Goneid, A. Salem, and E. Shaddad, On the Sensitivity of Some Recognition Algorithms for Printed Arabic Characters, Proc. of the 12th Int. Congress for Statistics, Computer Science, Social and Demographic Research, Cairo, Egypt, Vol. 5, pp. 231-241 (April 1987).

[Tolba87b] M. F. Tolba, S. A.-Wahab, and A. Salem, A Recognition Algorithm for Arabic Printed Characters, Proc. of IASTED: Int. Symposium on Applied Informatics, Grindelwald, Switzerland, pp. 128-131 (1987).

[Tolba87c] M. F. Tolba and H. M. K. Mahdi, On the Transformation of Arabic Characters into Unified Mesh Size, Proc. of the 12th Int. Congress for Statistics, Computer Science, Social and

Demographic Research, Cairo, Egypt, pp. 129-136 (April 1987). *

[Tolba87d] M. F. Tolba, S. A.-Wahab, and A. Salem, A Recognition Algorithm for Printed Arabic Characters, Proc. of the First KSU Symposuim on Computer Arabization, King Saud University, Riyadh, Saudi Arabia, pp. 5-8 (April 1987).

[Tolba88a] M. F. Tolba, A. Goneid, A. Salem, and E. Shaddad, T he Sensitivity of Some Recognition Algorithms for Printed Arabic Characters, Proc. of the 13th IFIP Congress, Tokyo, Japan, pp. 735-743 (1988).

[Tolba88b] M. F. Tolba, S. A.-Wahab, and A. Salem, A Recognition Algorithm for Printed Arabic Characters, Proc. of the Computer Arabization conf., Egyptian Computer Society, Cairo, Egypt, pp. 5-8 (1988).

[Tolba89] M. F. Tolba and E. Shaddad, On the Segmentation and Recognition of Printed Arabic Characters, Proc. of the Second conf. on Arabic Computational Linguistics, Kuwait, pp. 490-507 (Nov. 1989).

[Tolba90] M. F. Tolba and E. Shaddad, On the Automatic Reading of Printed Arabic Characters, Proc. of the IEEE conf. on Systems, Man, and Cybernetics, Los Angles, CA, USA, pp. 496-498 (1990).

[Walker??] R. F. Walker, M. Bennamoun, B. Boashash, Comparative Results for Arabic Character Recognition Using Artificial Neural Networks, Presented at the Workshop on Signal Processing and its Applications (19??). *

[Yacu85] S. G. Yacu, Design and Implementation of English Reading Machine for the Blind and Arabic Character Recognition, M.Sc. Thesis, College of Engineering, University of Baghdad, Baghdad, Iraq (1985). *

[Yalabik88] N. Yalabik and M. Ozcilingir, Computer Recognition of Ottoman Text, Proc. of the 3rd Int. Symposium on Computer and Information Sciences ISCIS III, Cesme, Turkey, pp. 323-329 (Nov. 1988).

[Yousef86] M. I. Yousef, Recognition of Handwritten Indian Numerals, M.Sc. Thesis, School of Control and System Engineering, University of Technology, Baghdad, Iraq (in Arabic) (1986). *

[Youssef89] Youssry M. Youssef, An Expert Knowledge-Based System for Arabic OCR, Proc. of the 14th Int. Congress for Statistics, Computer Science, Social and Demographic Research, Cairo, Egypt, pp. 227-245 (March 1989).

[Youssef93] Youssry M. Youssef, Arabic Optical Character Recognition (AOCR), Al-Handasah Magazine, Kuwait, No.12, pp. 18-23 (in Arabic) (Feb. 1993).

[Zahour89] A. Zahour, B. Taconet, and A. Faure, Methode Syntaxique de Reconnaisance de l'Ecriture Arabe Cursive (A Syntactical Method for Recognition of Arabic Cursive Scripts), Proc. of the IASTED Int. Symposium: Applied Informatics-AI '89, Grindlewald, Switzerland, pp. 97-101 (in French) (Feb. 1989).

[Zahour90] A. Zahour, Une Methode de Reconnaisance de l'Ecriture Manuscrite Arabe Cursive, These de Doctorat, Universite du Havre, France (in French) (1990).*

[Zahour91] A. Zahour, B. Taconet, and A. Faure, A New Method for Recognition of Arabic Cursive Scripts, Proc. of the First Int. conf. on Document Analysis and Pattern Recognition, Saint-Malo, France, pp. 454-463 (1991).

[Zahour92] A. Zahour, B. Taconet, and A. Faure, Machine Recognition of Arabic Cursive Writing, in From Pixels to Features III: Frontiers in Handwriting Recognition, S. Impedovo and J. C. Simon (eds.), Amsterdam, Elsevier Science Publishers B.V., pp. 289-296 (1992).

[Zaki86a] F. W. Zaki, S. El-Konyaly, A. Abdel-Fattah, and Y. Enab, A New Technique for Arabic Handwriting Recognition, Proc. of the 9th Nat. Computer conf. and Exhibition, Riyadh, Saudi Arabia,Vol. 2, pp. 13.1.1-13.1.9 (1986).

[Zaki86b] F. W. Zaki, S. El-Konyaly, A. Abdel-Fattah, and Y. Enab, A New Technique for Arabic Handwriting Recognition, Proc. of the 11th Int. Congress for Statistics and Computer Science, Cairo, Vol. 2, pp. 171-180 (1986).

تَمْيِيزُ النُّصُوصِ العَرَبِيَّةِ ضَوْئِيًا: ثَبْتُ مَرَاجِعٍ مُبَوَّبَةٍ

د. عاصم عبد الفتاح نبوي
كلية علوم الحاسب والمعلومات
جامعة الملك سعود، الرياض

د. صبري عبد الله محمود
مؤسسة المنارين للتطبيقات الفنية
الرياض، المملكة العربية السعودية

ملخص:

تم جمع ٢٦٠ بحثا في مجال التمييز الضوئي للنصوص العربية، وكذا للأرقام الهندية، وتبويبها حسب موضوعاتها العلمية. وتلقي قضية قلة عدد البحوث والمراجع، في هذا المجال البحثي، الضوء على نقطتين:

النقطة الأولى هي المصاعب الجمة التي تواجه الباحثين في جمع المراجع في هذا المجال ، على أهميته، وذلك لقلة عددها وتفرقها في بطون الدوريات والحوليات ومطبوعات المؤتمرات العلمية وبعض الكتب، وهو السبب الرئيس الذي دفع الباحثين إلى بذل الجهد وتجشم المشاق لجمع وتبويب هذه المراجع تيسيرا على الباحثين العاملين في هذا المجال الحيوي الهام.

أما النقطة الثانية فهي قلة كل من الجهود البحثية والموارد المتاحة لتطوير هذا الفرع من البحوث، بشقيه النظري والتطبيقي بالمقارنة بما ينفق من أموال وما يبذل من جهود لتطوير طرائق وأساليب لتمييز النصوص المكتوبة باللاتينية وغيرها، وذلك رغم أهمية هذا الموضوع التي يتزايد إدراكها في أوساط الباحثين والتطبيقيين.

وقد استخدمنا نظام تبويب لهذه المراجع يعتمد على كلمات مفتاحية في هذا المجال البحثي، مما يساعد الباحثين على سرعة الوصول إلى أسماء المراجع المطلوبة للبحث في النقاط المتفرعة عن هذا المجال البحثي الهام. ولقد زودنا القارئ كذلك بملحق يحتوى جدولا يلقى الضوء على محتويات كل بحث، مما يعطي لمحة سريعة عن مجال ومحتوى كل من هذه المراجع على حدة.