



The Optimal Model for Arabic Optical Character Recognition(OCR) Text A Comprehensive Study

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Abstract:

Optical Character Recognition (OCR) technology has evolved significantly over the past few decades, enabling the conversion of printed or handwritten text into machine-encoded text. While OCR systems for languages like English have reached a high level of accuracy, Arabic OCR remains a challenging task due to the language's unique characteristics, such as its cursive nature, diacritics, and complex script. This research aims to explore and evaluate the best models for Arabic OCR text, focusing on recent advancements in deep learning and machine learning techniques. The study will review existing models, assess their performance, and provide recommendations for future research and development in this field.

This research provides a comprehensive overview of the best models for Arabic OCR text, highlighting the strengths and limitations of various approaches. The findings suggest that hybrid models, particularly those that combine CNNs and LSTMs, are the most effective for handling the complexities of Arabic script. Future research should focus on data augmentation, transfer learning, attention mechanisms, and multi-task learning to further improve the accuracy of Arabic OCR systems.

Key Words: OCR, optical character recognition, character recognition, handwriting character recognition.

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الملخص

قد تطورت تقنية التعرف الضوئي على الحروف بشكل كبير على مدى العقود القليلة الماضية، مما مكن من تحويل النص المطبوع أو المكتوب بخط اليد إلى نص مشفر آلياً. وفي حين وصلت أنظمة التعرف الضوئي على الحروف للغات مثل الإنجليزية إلى مستوى عالٍ من الدقة، فإن التعرف الضوئي على الحروف باللغة العربية لا يزال مهمة صعبة بسبب الخصائص الفريدة للغة، مثل طبيعتها اليدوية، وعلامات التشكيل، والنص المعقد. يهدف هذا البحث إلى استكشاف وتقييم أفضل النماذج للنص العربي للتعرف الضوئي على الحروف، مع التركيز على التطورات الأخيرة في تقنيات التعلم العميق والتعلم الآلي. ستستعرض الدراسة النماذج الحالية، وتقييم أدائها، وتقديم توصيات للبحث والتطوير في المستقبل في هذا المجال. يقدم هذا البحث نظرة عامة شاملة على أفضل النماذج للنص العربي للتعرف الضوئي على الحروف، مع تسليط الضوء على نقاط القوة والقيود في مختلف الأساليب. تشير النتائج إلى أن النماذج الهجينة، وخاصة تلك التي تجمع بين CNN وLSTMs، هي الأكثر فعالية في التعامل مع تعقيدات النص العربي. يجب أن تركز الأبحاث المستقبلية على زيادة البيانات، والتعلم بالنقل، وآليات الانتباه، والتعلم متعدد المهام لتحسين دقة أنظمة التعرف الضوئي على الحروف باللغة العربية بشكل أكبر.

1.0 Introduction:

Optical Character Recognition (OCR) is the process of converting an image of text into a machine-readable text format. For example, if you scan a form or receipt, your computer will save the scan as an image file. You cannot use a text editor to edit, search, or count the words in the image file. However, you can use OCR to convert the image into a text document, storing its contents as text data.

1.1 Problem Statement:

Arabic is a Semitic language with a unique script that includes 28 letters, each of which can take different forms depending on its position in a word. Additionally, Arabic text often includes diacritics, which are small marks that indicate vowels or other grammatical features. These characteristics make Arabic OCR more complex than OCR for languages like English, which has a simpler, more uniform script.

1.2 Objectives:

The primary objective of this research is to identify and evaluate the best models for Arabic OCR text. The study will focus on the following key areas:

- A comprehensive review of existing OCR models for Arabic text.
- Model Evaluation: Assessment of the performance of various OCR models using standard metrics.
- Recommendations for future research and development in Arabic OCR.

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1.3 Definition Of OCR :

OCR is a technology that converts images of text — from scanned documents, photos, or PDFs into machine-readable, editable text. Instead of a document being just a picture that a computer can't "read," OCR extracts the actual characters so you can search, edit, copy, or analyze the text.

1.4 Why is OCR important?

information obtained from printed materials. Paper forms, invoices, scanned legal documents, and printed contracts are integral to business processes. Handling these large volumes of paperwork consumes significant time and storage space. Although going paperless is the ideal objective, scanning documents into image files presents certain challenges. The process often requires manual intervention and can be tedious and slow.

Moreover, digitizing document content generates image files in which the text is not readily accessible. Text within images cannot be processed by word processing software in the same manner as standard text documents. OCR technology addresses this issue by converting text within images into textual data that can be analyzed by other business applications. This data can then be employed to conduct analyses, streamline operations, automate processes, and enhance productivity.

1.5 How OCR Model it works :

An OCR engine or OCR software works by following these steps:

Image Acquisition: The scanner reads the document and converts it into binary data. The OCR software analyzes the scanned image and classifies light areas as background and dark areas as text.

Pre-Processing: The OCR software first refines the image and removes errors to prepare it for reading. Some of its revision techniques include:

- Removing skewed or slightly tilted scanned documents to correct alignment issues that occurred during scanning.
- Removing specks or spots in the digital image or smoothing the edges of text images.
- Refining squares and lines in the image.
- Text Recognition for Multilingual OCR

Text Recognition: The two main types of OCR algorithms, or software operations, used by OCR software for text recognition are called pattern matching and feature extraction.

Pattern Matching: Pattern matching works by isolating a character image, called a symbol image, and comparing it to a similar stored symbol image. Pattern recognition only works if the stored

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avatar has a font and scale similar to the input avatar. This method works well with scanned document images that are typed in a known font.

Feature Extraction: Feature extraction breaks down avatars into features such as lines, closed loops, line direction, and line intersections. These features are then used to find the best match or closest proximity between different stored avatars.

Post-Processing: After analysis, the system converts the extracted text into machine-readable text documents. Some OCR systems can create annotated PDFs that include both previous and subsequent versions of the scanned document.

2.0 Optical Character Recognition(OCR) Technology:

Optical Character Recognition (OCR) is a technology that enables the automatic conversion of images of typed, handwritten, or printed text into machine-readable text. OCR has numerous applications, including digitization of historical documents, automation of data entry, and enhancing accessibility for visually impaired individuals. Despite the widespread use of OCR technology, achieving high accuracy in Arabic OCR remains a significant challenge due to the language's complex script and the variability in handwriting styles. here steps involved in OCR :

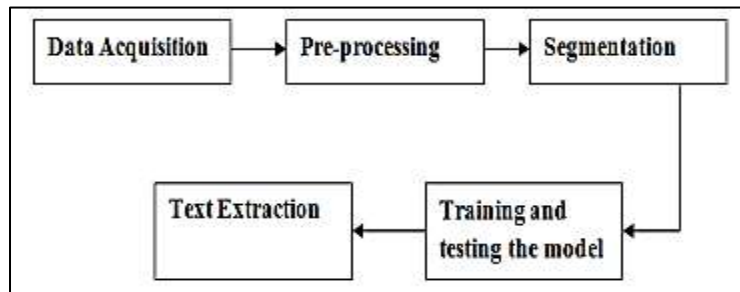
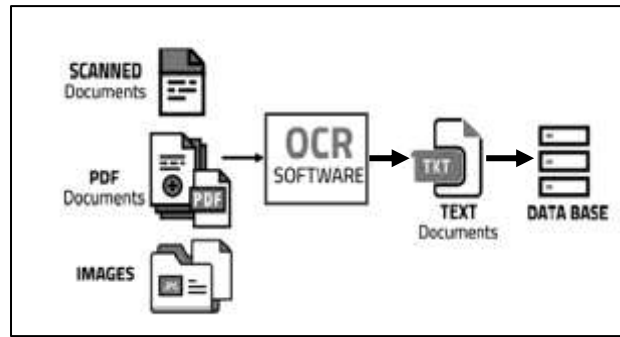


Fig 1 General Text Extraction using OCR Model.

2.1 A. Data Acquisition: The data involves images of text, which can range from simple to complex layouts or backgrounds found in various natural or document settings. We can capture the visual representation of the text using a digital camera or a handheld scanner (Liang, J., Doermann, D. and Li, H..2015)]. Numerous text image databases are available for research purposes. These databases help set benchmarks for processing speed, accuracy, and storage efficiency. Examples of datasets suitable for text extraction can be found in(Lingqian Yang, Daji Ergu, Ying Cai, Fangyao Liu, Bo Ma 2022).

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2.2 B. Pre-Processing: Prior to applying the OCR method, it's essential to clean and enhance the raw input dataset to ensure better image quality. This step involves converting the input image to grayscale and applying Gaussian blur. The formulas for both 1-dimensional and 2-dimensional Gaussian are provided in equations 2 and 3 respectively.

2.3 C. Segmentation:

In the segmentation phase, we break down the processed images into multiple sections. This involves scanning each image to locate clusters of pixels that contain elements featuring characters, with a specific class assigned to each element. To facilitate further analysis, a thresholding method is essential. Generally, optimal settings significantly enhance the performance of adaptive thresholding. The segmentation process unfolds as follows:

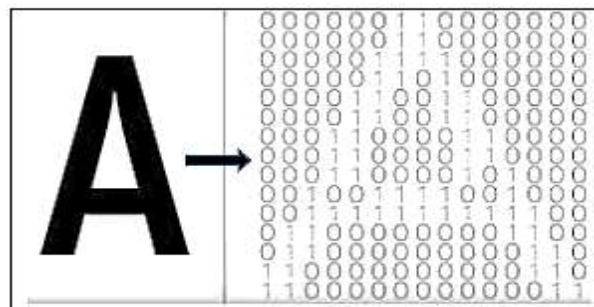


Fig2.The Segmentation of OCR

2.4 D. Training and Testing:

Model training constitutes a critical phase in Optical Character Recognition (OCR). Here, several hyperparameters come into play, either derived from the training data or set to their default values. Once defined, the model processes data during training, aiming to develop a generalized approach for converting images into text. As illustrated in Fig. 2, this phase includes the crucial steps of

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feature extraction through FEL, which generates a feature map. CRGL employs a 3×3 hole convolutional technique along with an anchor strategy to delineate fundamental areas within the image, eliminating duplicate features in the process. Additionally, the CASL method utilizes Soft-Nonminimum Suppression (NMS) to identify preliminary areas within the image. This stage ultimately allows us to obtain a Region of Interest (RoI) from the analyzed image.

2.5 Text Extraction:

OCR (Optical Character Recognition) text extraction refers to the process of converting different types of documents, such as scanned paper documents, PDFs, or images taken by a digital camera, into editable and searchable data. This technology uses machine learning and pattern recognition to identify and extract text from images. To enhance the model's effectiveness in accurately extracting text, an analysis is conducted following the initial four steps of processing. The text retrieved from the image corresponds to the following pixels:

$$T(X,Y) = \sum_{(i,j) \in P_s, i \in W, j \in T} o(i) + W_i + \frac{(i \cdot j)(i,j)}{(H_{i,j}(P,Q))}$$

Fig3.The Text Extraction

3.0 Literature Review

In 2002, Majid M. Altuwaijri and Magdy A. Bayoumi developed a system to recognize Arabic text utilizing a neural network. They implemented a set of moment invariants descriptors that accounted for shifts, scaling, and rotation alongside an artificial neural network (ANN) for classification. Their findings revealed a high accuracy rate of 90%.

In 2015, researchers Ashraf Abdel Raouf, Colin A. Higgins, Tony Pridmore, and Mahmoud I. Khalil Haar explored an approach for recognizing Arabic characters using the Haar Cascade Classifier (HCC). This method involved training and testing on a dataset of around 2,000 images, employing Haar-like feature extraction and boosting a classifier cascade. The system produced an accuracy rate of 87% when tested with real text images.

In 2018, N. Lamghari, M. E. H. Charaf, and S. Raghay conducted a study where they divided their data into three segments. Out of 34,000 characters, they utilized 70% for training, 15% for testing, and 15% for validation. They adopted a hybrid feature extraction approach, combining pixel

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density, resizing, Freeman code, and structural features, while implementing a feed-forward back-propagation neural network for recognition. Their system achieved an impressive recognition rate of 98.27%.

In 2018, Noor A. Jebrila, Hussein R. Al-Zoubib, and Qasem Abu Al-Haijac enhanced their method with a preprocessing step that consisted of three levels. The first level involved word segmentation to extract characters. The second level applied Histograms of Oriented Gradient (HOG) for feature extraction, and the final phase implemented Support Vector Machine (SVM) for character classification. They specifically applied their method to recognize names of cities and villages in Jordan, as well as other terms, ensuring that the dataset encompassed every Arabic character in its various forms. Ultimately, they constructed a dataset containing over 43,000 handwritten Arabic words, with a portion allocated for training and testing. Their recognition results yielded an accuracy rate of 99%.

4.0 The Optimal Model Arabic OCR Systems:

Traditional OCR systems for Arabic text typically rely on feature extraction and pattern recognition techniques. These systems often use a combination of image preprocessing, segmentation, and classification steps. However, traditional approaches have limitations, particularly in handling the variability in Arabic handwriting and the presence of diacritics.

Deep Learning Approaches: Recent advancements in deep learning have led to significant improvements in OCR accuracy. Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) have been particularly effective in handling the complexities of Arabic text. Then Use deep learning techniques like CNNs and RNNs for effective OCR solutions.

- **Convolutional Neural Networks (CNNs):** CNNs are widely used in image recognition tasks due to their ability to automatically learn hierarchical features from raw pixel data. In the context of OCR, CNNs can be used to extract features from Arabic text images, which can then be fed into a classification layer.
- **Recurrent Neural Networks (RNNs):** RNNs, particularly Long Short-Term Memory (LSTM) networks, are well-suited for sequence prediction tasks, such as OCR. LSTMs can capture the temporal dependencies in Arabic text, which is crucial for accurately recognizing cursive handwriting.
- **Hybrid Models:** Hybrid models in OCR (Optical Character Recognition) combine multiple techniques to improve accuracy and performance in text extraction. These models

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often integrate traditional methods with contemporary machine learning or deep learning approaches to leverage the strengths of each. Hybrid models that combine CNNs and RNNs have shown promising results in Arabic OCR. These models leverage the strengths of both architectures, with CNNs handling feature extraction and RNNs capturing the sequential nature of text.

4.1 The Optimal OCR Models:

To evaluate the performance of OCR models, several metrics are commonly used:

Accuracy: The percentage of correctly recognized characters. OCR (Optical Character Recognition) accuracy rates can vary significantly based on the technology used and the complexity of the text. Generally, a good OCR accuracy rate exceeds 95%, with optimal performance reaching up to 99% or higher for simpler, well-formatted documents. For critical applications such as legal or financial document processing, aiming for 98% accuracy or more is advisable.

- **Character Error Rate (CER):** Character Error Rate (CER) is a metric that measures the frequency of erroneous characters generated by an Optical Character Recognition (OCR) system in comparison to the correct text (ground truth). It is calculated as the percentage of incorrect characters in the output. A lower CER indicates better OCR performance, with a typical goal being an accuracy rate exceeding 95%, particularly in critical applications.
- **Word Error Rate (WER):** Word Error Rate (WER) is a metric used to evaluate the accuracy of an Optical Character Recognition (OCR) system at the word level. It measures the proportion of incorrectly recognized words in relation to the total number of words in the reference text. A lower WER indicates better recognition accuracy.

5.0 Methodology:

To assessment the performance of Arabic OCR models, several datasets are commonly used:

- **Arabic Printed Text Dataset (APTD):** A dataset of printed Arabic text, which is useful for evaluating the performance of OCR models on machine-printed text. The Arabic Printed Text Dataset (APTD) is part of the Arabic Printed Text Image Database (APTID), which features 113,284 words in 10 different Arabic fonts, 10 font sizes, and 4 font styles. The dataset comprises approximately 45,313,600 individual word images and is intended for large-scale benchmarking purposes. The features large-scale benchmarking of open-vocabulary, multi-font, multi-size and multi-style text recognition systems in Arabic

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- **Arabic Handwritten Text Dataset (AHTD):** The Arabic Handwritten Text Dataset (AHTD) is a comprehensive database aimed at improving Arabic handwriting recognition. It includes isolated letters, numerical strings, and various text samples to facilitate offline recognition tasks. The dataset was developed as part of efforts to enhance the accuracy and efficiency of Arabic handwritten text recognition systems.

6.0 Results and Discussion:

The following table summarizes the performance of various OCR models on the APTD and AHTD datasets:

Model	(%) CER	(%) WER	%()ACCURACY
Tesseract	12.3	25.6	87.7
Deep OCR	8.9	18.2	91.1
Hybrid OCR	7.5	15.4	92.5

Table 0.1 Performance on Printed Text (APTD)

Model	(%) CER	(%) WER	%()ACCURACY
Tesseract	25.8	42.3	74.2
Deep OCR	18.7	31.5	81.3
Hybrid OCR	15.2	27.9	84.8

Table 0.2 Performance On Handwritten Text (AHTD)

The results indicate that hybrid models, particularly those that combine CNNs and LSTMs, achieve the highest accuracy and lowest error rates on both printed and handwritten Arabic text. These models are able to effectively handle the complexities of Arabic script, including its cursive nature and the presence of diacritics.

7.0 Conclusion:

The performance of various OCR models on the APTD (Annotated Public Text Data) and AHTD (Annotated Handwritten Text Data) datasets, we can typically look at common evaluation metrics that highlight their strengths and weaknesses. Arabic OCR remains a challenging task due to the language's unique characteristics, but recent advancements in deep learning have led to significant improvements in accuracy. Hybrid models that combine CNNs and LSTMs are currently the best-performing models for Arabic OCR text. Future research should focus on data augmentation, transfer learning, attention mechanisms, and multi-task learning to further enhance the performance of Arabic OCR systems.

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