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OCR-based text extraction: A comprehensive review

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Abstract*— Almost everything is mechanized in the digital age, and data is shared and kept digitally. Nonetheless, there are a number of circumstances in which the data is not digital, and it may become necessary to extract text from them in order to preserve it digitally. Optical character recognition (OCR) text extraction has been totally transformed by state-of-the-art technologies like text recognition software. As a result, this paper provides an overview of the idea, describes the extraction procedure, and showcases the most recent methods, tools, and research in the field. An overview of the technologies provided bythis review will be helpful to other researchers in the field.

Keywords*—Optical Character Recognition (OCR), Digital Image Processing (DIP), Text recognition, Pre-processing, Feature extraction

I. INTRODUCTION

The computerized conversion of text or creation of a digital copy of text from sources such as handwritten documents, printed text, or natural photographs is known as optical character recognition (OCR) [1]. It falls under Digital Image Processing (DIP), which is a broad category [2]. Digital image processing, or DIP, is the application of a computer algorithm to digital images. DIP is a field that is still evolving and has applications in almost every other industry, including robotics, banking, healthcare, PET sweeps, and so on. Pattern recognition, which encompasses picture recognition, handwriting recognition, and computer-aided diagnosis, is one of its main uses.

Text recognition software became necessary as the world's data volume increased at an exponential pace. Since none of this data can be physically retained, it must be preserved digitally. Therefore, OCR-based Automatic Character Recognition is used to do it. These days, OCR frameworks are typically used to extract text from any image, whether it be a natural or computer-generated one.

OCR transforms checked archives into fully accessible reports, encouraging them to be anything other than picture records. As a result, it's typically used for various tasks including information extraction. OCR eliminates the need for laborious retyping of large reports when creating digital copies of them. Material information is separated by OCR and entered properly. It enables a machine to interpret information from an image as it would appear when reading a written document and save it in a format that would make processingit easier in the future[3].Depending on the type of data, OCR frameworks can bedivided into three categories:

1. Handwritten: These are the systems that are limited to usingwritten text.
2. Machine printed: Those who just handle text that is written and subsequently printed in hard form.
    - Specific type: A number of variables, such as language and typeface, affect how well OCR functions. As a result, many OCR systems exist for certain languages, such as Urdu.

Today, OCR is primarily used for text recognition, but in 1914, it was developed to aid the blind and other individuals with special needs. It made it possible for blind persons to have writtentexts read aloud to them by a machine. Additionally, in the 1950s, when computing power was scarce and technology was less developed, the development of OCR faced several challenges related to accuracy and speed [1]. One word at a time was workedon in the early optical character versions, which required training on individual character pictures. The best OCR framework could only recognize one word per minute in its early stages.

This paper summarizes the research in OCR. The paper is structured as follows: Section II covers modern OCR Systems,

II. MODERN OCR SYSTEM

These days, many OCR engines are in use, including Tesseract, OmniPage, Google Drive OCR, and Transym. While many of them require payment, some are available without charge.

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[4] One of the most well-liked and frequently utilized engines in OCR frameworks that can be found online is Tesseract. It operates in four steps, one after the other. Itfocuses on covering a large range of languages and fonts instead of accuracy. It is discovered that tesseract provides, on average, more accuracy than Transym OCR (another open-source OCR engine), however it is not always faster.

Another popular tool for converting digital photos to editable forms is ABBYY FineReader. This software uses advanced OCR (Optical Character Recognition) technology to accurately extract text and data from scanned documents, making it a useful tool for a variety of industries and professions. Additionally, Adobe Acrobat Pro is well-known for its powerful OCR features, which allow users to easily turn scanned PDFs into searchable and editable text. These apps are essential for effectively scanning and processing documents.

With the help of contemporary wireless facilities, a device does not have to have the complete OCR system built into it; instead, it may simply transfer the data across the network where it will be worked on, and the results will be returned to the device very quickly. Online OCR is a Web-based OCR converter that can act as a full system via the internet.

III. PROCESS OF TEXT RECOGNITION USING OCR

As stated in [5], developing a completely working OCR framework entails numerous processes, however they can be broadly classified into six steps, as shown in figure 1.

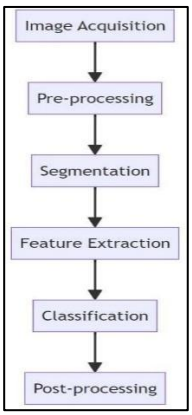

Figure 1: Steps towards Recognition in OCR

A. The image acquisition:

Image capture is the foundational step in OCR that entails obtaining a high-quality image and converting it into a format that can be processed successfully later. This includes photo quantization and compression.

B. Preprocessing

Pre-processing is crucial for achieving higher recognition rates since it makes the OCR more powerful. It begins with binarization [6] (turning a multi-tone image to black and white), followed by the image enhancement processes [7] that boost the picture's detail.

1. Spatial image filtering operations- these are commonly used to either smoothen the picture or make edges increasingly obvious. It is further divided into two parts -point processing and mask processing. Point processing is done on individual pixels while mask processing is done on a group of pixels.
2. Thresholding- it isolates the data from an unnecessary part of the image. It is normally applied to greyscale images. It can be divided into two parts: global and local. Global strategies lean toward a solitary worth cut off for the whole archive while the local methods essentially apply to explicit applications and more often than not, they don't function admirably on isolated applications.
3. Noise removal- Various kinds of noises are identified with devices that are used to capture images like a photon, lighting in the surroundings, electronics in thedevice, and so forth. Although thanks to modern technology it is possible to reduce the noise while photographing to almost insignificant levels.
4. Screw detection/correction- Natural images can often be rotated making it tough for an OCR framework to work upon it. So, these images ought to be rectified before processing further. There are various methods for it like Hough transform.

C. Segmentation

Segmentation, as the name suggests, is used to isolate the required substance from the rest of the

image.[8] It involves various steps:

1. Page segmentation- it is used to isolate content from the rest of the image, resulting in a text-only image. It can be portrayed into three general characterizations: top-down, base up, and a half and half strategies.

2. Character segmentation- it is seen as one of the chief strides in preprocessing especially in cursive contents where symbols are related together. Henceforth, there are various systems created for character division, and most by far of them are content unequivocal andmay not work with various substances.

3. Image size normalization- The outcome from the character division stage gives isolated characters that make way to next process; in this way, the detached parts get standardized in a particular size tentatively relying upon the utilization later and the feature extraction or grouping techniques utilized, at that point highlights are removed from all characters with a steady size to give information consistently.

4. Morphological processing- Sometimes, few pixels may be evacuated creating openings to certain pieces of the pictures. It is like having a few gaps where a portion of the pixels was expelled during thresholding. Then again, the inverse can likewise be valid, it may overwrite separate items which result in difficulty to isolate characters; these strong articles take after masses and are difficult to decipher. The answer to these issues is Morphological Filtering. Helpful methods incorporate disintegration and expansion, opening and shutting, delineating, and diminishing and Skeletonization

D. Feature extraction

In this step, each character is allocated a vector which atthat point represents it. Its goal is to extract a group of features, that will increase the recognition for a small number of items and produce the same feature used in different instances of the same attribute.[9] This is done using different techniques:

1. Zoning- A character is typically separated into zones of predefined size. These predefined or matrix sizes are ordinarily of the request 2x2, 4x4, and so forth. At that point, the densities of pixels or features are broken down in various zones to form the representations.
2. Projection histogram features- They measure the number of pixels in a very specific manner. There are three kinds of projection histograms – flat, vertical, and diagonal.
3. Distance profile features- They measure the distanceas the number of pixels from the merge box of theimage to the edge of the symbol. They can be taken in any direction such as up, down, left, or right.
4. Background directional distribution (BDD)- It is usedto calculate the amount of background distribution of each front pixel. Several masks are used in different directions where the average grey matter value is calculated using a specific mask.
5. The combination of various features- more than onemethod can be used together for even higher accuracy, as can be seen in Table 1.

Feature Vector	Included Features
FV1	Zoning + Profiles
FV2	BDD + Zoning
FV3	BDD + Histogram
FV4	Profiles + Horizontal and Vertical Histograms (HVH)
FV5	BDD + HVH
FV6	BDD + Profiles
FV7	BDD + Diagonal (both) histograms

Table 1. Combination of feature extraction methods

E. Classification

The feature vector that is acquired in the previous step is utilized for classification. To do the classification the information and many element vectors should be contrasted.

[10] A classifier is utilized to analyze the element vector of info and the component vector of the information bank. The choice of classifier relies on the application, preparing the set, and the number of free parameters. There are numerous strategies utilized for classification, 3 of them, which are most normally utilized are-

1. Probabilistic Neural Network (PNN) classifier- It is a classifier that employs a multi-layered feed-forwardneural

network to classify unknown patterns using probability density function.

2. Support Vector Machines (SVM) classifier- These are supervised learning techniques that may be enforced for classification or regression. It takes a collection of input and predicts to classify them within the best 2 categories. SVM classifier is trained using a set of coaching data and to categorize test statistics a model is prepared based totally upon this.
3. K- Nearest Neighbor (K-NN) classifier- It uses a model-based lesson in accordance with an unknown pattern known for a particular distance or other similar activity. It divides the thing by the votes of its neighbors. Because it looks only at a neighboringobject up to a certain level, it uses the spatial correlation of the distance function.

F. Post-Processing

It is the last advance after the arrangement. As the outcomes are not 100% right, particularly for complex dialects, Post handling procedures can be performed to improve the precision of OCR frameworks. These procedures use characteristic language preparing, geometric, and etymological setting to address blunders in OCR results. Postprocessor ought not to take a lot of time and cause new blunders.

IV. NEW TECHNIQUES

Other than the regular techniques referenced before, various strategies proposed by various researchers in the field have been investigated and are summarized below:

- A new methodology [11] to extract the text from natural images having 7 stages was proposed. Initially, the filtering process is utilized for pre- processing to improve the image. Lateral separation is done using the Thresholding method to separate the background from the required content. Then, the MSER (Maximally Stable External Region) is detected and the part which is not required is deleted. Then the stroke width calculation is applied by the stroke width variance algorithm and lastly, CNN (Convolutional neural network) is used to get the features required to spot the characters and that will be provided to the OCR to obtain the text.
- Another [12] proposed a neural network-based framework that operates based on BLSTM-Bidirectional Long Short-Term Memory that allows OCR to work at the word level. It leads to over 20% better results when compared to a regular OCR framework. It uses a method that does not require segmentation, that is one amongst the foremost common reasons for the error. Also, it found an over 9% decrease in character error compared to the more widely available OCR framework.
- [13] This technique proposed utilizing a two-advance iterative Conditional Random Field (CRF) calculation with Belief Propagation obstruction to isolate content and non-content parts and afterwards utilizing OCR on the content part to give the ideal outcome. In the case of multiple text lines, two relational graphs are used to extract different text lines and the OCR confidence is utilized as a guide while finding text containing parts.

There are a lot more techniques other than these in research. These techniques attempt to improve the overall system of OCR by increasing accuracy or working on areas that are the most common error source.

V. SOME MAJOR RESEARCH

There is a lot of application-based researches goingon using OCR. Some of them are mentioned below:

- *Text Extraction from Historical Documents*: OCR's Complete Method for Historical Texts without font knowledge. It consists of 3 steps-initially, a step that incorporates binarization and enhancement. In the second step, a high-level separation method is used todistinguish line parts, words, and letters. The KNN integration theme is adopted to incorporate the symbols of the same group. Lastly, within the third step, in each image of the new document, the same previous classification method is utilized whereas the recognition is predicated on the information extractedfrom the previous step. It results in high throughput rates of up to 95.44% [14].

- *Text Extraction from Television:* This program uses several steps. First, the hosting service is used to get the data processed. Subsequently, the OCR algorithm is employed to separate the text from the given data. Finally, output presented in the previous step is compared to expectations, and a decision is madewhether it is correct or not before issuing it. This program can be used as a practical test for TV sets [15].

- *Vehicle Identification Using Number Plate Recognition:* –OCR is used in many areas, security is one of them. This system can be used to keep track of traffic at the security entrance. First, a photograph ofthe automotive is taken and then, the number plate is separated using parts of the pictures. Afterwards, the OCR is employed to get the text from it and lastly, the details are compared to the inventory dataset to find the automobile owner's details. It makes a strong system with high reliability for security purposes [16] [17].

VI. CURRENT WORK AND CHALLENGES IN IT

Several research papers suggest potential research advancements in this area. For instance, as per [18] currently improving components like Scan goals, filtered picture quality, type of printer utilized whether ink-jet or laser, the nature of the paper, phonetic complexities, the lopsided brightening, and watermarks can impact the precision of OCR. Hence work can be done on improving the precision of OCR.

There are different issues looked by an OCR framework [19], particularly Chinese and Arabic character acknowledgment uniquely as these dialects contain muddled structures, lopsided text styles, and so on. There are various issues in the event of handwritten record pictures like the nearness of slanted, contacting or covering content lines, etc. [20] [21] therefore, new algorithms like Spiral Run Length Smearing Algorithm (SRLSA) have been under research. Additionally, since it isn't yet 100% precise, the extracted text despite everything must be crosschecked for errors, and for limited text, it is simply notworth utilizing it as it tends to be quicker to do physically compared to modern OCR systems.

Since every language and font is different from one another, there is no single method that can be applied to all to get the desired result with high accuracy [22]. In this manner, there is a great deal of research proceeding to improve the precision of the OCR framework for a specific language or font, and even for the same language, more than one method can be applied. Some examples are mentioned below:

1. Gurmukhi script- [23] There are different issues in Gurmukhi content OCR like covering characters, variable composing styles, comparability of certain characters, the unavoidable nearness of foundation commotion, and different sorts of mutilations. Likewise, when various strategies are utilized for manually written Gurmukhi content contrasting in the feature extraction strategy and classifier utilized. The distinct outcome is obtained with different strategies like with zone Density and BDD as feature extraction technique, and SVM with the RBF bit as the classifier, the highest accuracy was achieved which is95.04%.

2. Devanagari script- [24] Zoning feature extraction methods are used for Devanagari script OCR. In the zoning technique, several methods can be used. When the 4x4 grid was used for zoning, there was a significant improvement, but when 2x2, 8x8, or 16x16 grids were used for zoning, the performance was equal to the original feature value. Thus, there is a significant improvement in yield when a 4x4 grid size is used for Devanagari.

3. Arabic script- [25] It’s written from right to left and many characters may have different shapes depending on its contexts. Also, semi-cursive nature and discontinuities create more problems for the OCR framework. Generalized Hough Transformation can be used to improve accuracy in charactersegmentation and different fonts, the result obtained was 86% accurate. Whereas, for cursive, a successrate of up to 97% could be obtained.

4. Bengali script- [26] Bengali is the fifth most communicated in language on the planet. It has no upper or lower case like the ones in English but Bengali characters have a part called “Matra” that remains connected making the process of recognition slower. Self-Organizing Map (SOM) otherwise referred to as Kohonen Neural Network

(KNN) is used to group different characters. This results in saving of 33% recognition time as compared to standard methods.

5. Rashi font- [27] An algorithm supported by the utilization of fuzzy logic-based rules, depending upon the factual information of the investigated text style is utilized. This new methodology consolidates letter measurements and relationship coefficients in a lot of fuzzy-based principles, empowering the extraction of contorted letters that might not be recognized by some other method. It centers around Rashi text styles related to critiques of the book of the bible that is transcribed calligraphy.

6. Multilingual Indian document- [28] A thorough examination of the various databases includingwritten and computer-generated records is done. The best result was found to be around 99% accurate. Also, algorithms that bolster multilingual Indian report pictures containing mixed writings of Devanagari and Latin contents are proposed. The primary two components are generated using thepixel of the character center, while the third element is calculated using the neighbor's pixel information.

VII. CONCLUSION

Optical Character Recognition has a variety of applications. It is being used to extract the text from ancientbooks and scripts, images, etc. There is ongoing research in this area to improve the precision of the extracted text and increasing the range on which a single OCR system can work. Since it came up there have been challenges that researchers have faced in this field, some of them that have been solved like the slow speed of early OCR systems but some are yet to solved like achieving a 100% accuracy and limited range for a single OCR. Thus, albeit there's an enormous amount of analysis occurring in this field, there's still a lot of scope for a lot more. In the future, new techniques or algorithms can be found to improve the accuracy and help create an OCR system that can work on any kind of dataset regardless of language, font, etc. Also, with the help of other fields like Artificial Intelligence and Augmented Reality, it can be used for a lot more applications and its possibilities become endless.

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