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Improving the Quality of Optical Character Recognition (OCR) Based on Neural Network with the Image Enhancement Process

Sutriawan[1]*, Ade Kurniawan[2], Romadhoni Rosyid[2]

[1]Universitas Muhammadiyah Bima, Indonesia
[2]Universitas Dian Nuswantoro, Semarang, Indonesia

* Email Korespondensi: sutriawan1612@gmail.com

Abstrak: OCR (Optical Character Recognition) is an effective solution for the process of converting printed documents to digital documents. The problem that arises in the process of computer document recognition is the level of accuracy is very dependent on the quality of the input and the porosity of the character pattern. In this study we tried to research how the most optimal way to read characters on shopping receipts. Physically notes or shopping receipts are easily faded and prone to noise so they are difficult to read. Even after the scan process the resulting output is increasingly difficult to read. So that to do the text recognition (OCR) process will produce a low level of accuracy. To improve the accuracy of the OCR process, it is necessary to improve the quality of the results of the receipt scan before the OCR process is carried out. Image quality improvement (image enhancement) is one of the steps taken in image processing and pattern recognition. The Image Enhancement method used is Noise Removal and Contrast Stretching.

Kata Kunci: OCR, Images Enhancement, Noise Removal, Contrast Stretching.

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1. Introduction

Rapid technological developments have had a lot of influence on the development of science, one of which is in terms of pattern recognition. Pattern recognition involves both supervised learning (classification with predefined labels) and unsupervised learning (clustering without predefined labels) [1], [2], [3]. Supervised learning includes selecting a classifier model, training, and testing, while unsupervised learning often involves cluster analysis [2]. OCR (Optical Character Recognition) is one area of study in the field of pattern recognition that is interesting to explore [4]. Optical Character Recognition or in short OCR is an effective solution for the conversion process from printed documents to documents digital [5]. One application that the researcher focuses on is in the process of converting from receipt documents that have been scanned into digital documents [6], [7]. This process is very beneficial for Merchants in collecting data on the products that are most often sold. In the process of converting receipt documents into digital documents, the problem is that the scan document has a poor quality, which affects the accuracy of the OCR process.

The advancement of digital technology has significantly transformed how humans manage and access information. One of the key technologies that facilitates document digitization is Optical Character

Recognition (OCR), which enables computers to recognize and convert textual characters within images into machine-readable digital text. OCR is used to convert printed and handwritten text into digital formats, enabling easier data management and retrieval. It is widely applied in sectors like banking, education, government, and retail for automating data entry and document management [8], [9], [10], [11].

Despite its extensive adoption, OCR technology still faces several challenges, especially in terms of character recognition accuracy for documents with poor visual quality [12], [13]. A clear example is the shopping receipt printed on thermal paper. The characters on these receipts fade easily due to exposure to light, heat, and aging. When scanned, the resulting images are often blurry, lack contrast, and are heavily affected by noise. These conditions directly impact the OCR system's performance, particularly in achieving precise character recognition [14], [15].

To address this issue, an image preprocessing stage is crucial before performing OCR. One of the effective approaches for improving image quality is through image enhancement techniques, which include noise removal and contrast stretching. By enhancing the visual quality of the scanned image, the OCR system has a greater likelihood of accurately recognizing characters.

In addition to preprocessing, this study incorporates the use of an Artificial Neural Network (ANN) to enhance the character recognition performance. ANN is a computational model inspired by biological neural networks and has proven effective in various pattern recognition applications, including image and text processing. ANN offers an adaptive and flexible learning capability, making it more efficient than traditional approaches in identifying character patterns.

This research focuses on the development of an OCR system based on ANN, optimized through image enhancement techniques, specifically aimed at addressing the challenges in character recognition on low-quality shopping receipts. With this approach, the system is expected to significantly improve text recognition accuracy and be applicable in broader document digitization processes in the current era of digital transformation.

2. METHOD

2.1 Digital Image

L*uryo Hartono et Al (Nurwanto T. B., 2007)* argues that literally, an image or image is an image in the dwimatra (two-dimensional) plane. While viewed from a mathematical point of view, the image is a continuous function or continuous of the intensity of light in the dwimatra plane. The image consists of two types, namely continuous image and discrete image. Continuous images come from optical systems that receive analog signals. While the discrete image comes from the digitization process of continuous images. Image representation from continuous functions to discrete values is called digitalization. The resulting image is a digital image. Mathematically the function of light intensity in the two-dimensional plane is symbolized by f (x, y), which in this case: (x, y): coordinates in the two-dimensional plane. f (x, y): light intensity at the point (x, y).

2.2 Preprocessing

Pre-processing aims to improve image quality (image enhancement) is one of the stages carried out in image processing and pattern recognition or character. The objectives of image quality improvement include :

a. Highlighting certain aspects of the display to be more easily understood or interpreted by human vision.
b. Reducing or eliminating the display aspect of an image that is not needed for example noise / noise.

2.3 Noise Removal

There are several techniques for removing noise including:

- Linear smoothing atau Mean filter

Which serves to reduce the number of variations in intensity between one pixel and the next. Each pixel value in the image is replaced by taking the average value from all the neighbors including himself, which is denoted by:

$$f(x,y) = \frac{1}{ab} \sum_{(s,t)\in S_{x,y}} g(s,t)$$

- Median filter

This technique is used to eliminate noise by filtering the image, removing parts that are considered to be nois like, gray color. Black spots on the image. And this median filter is very effective in removing nois without reducing image sharpness.

$$f(x,y) = median_{(u,v)\in Kxy} \{g(u,y)$$

- Midpoint Filter.

In doing this filter, each is replaced with the highest pixel average value and the lowest pixel value with the specified image size.

$$f(x,y) = \frac{1}{2}\left[max_{(u,v)\in Sxy}\{g(u,y)\} + min_{(u,v)\in Sxy}\{(gu,v)\}\right]$$

2.4 Contrast Stretching

Contrast stretching is a technique for obtaining a new image f0 (x, y), with a contrast that is better than the original image fi (x, y) the idea of contrast streching is to increase the dynamic range of grayscale in the image during continuous processing . The image with low contrast can be improved in quality by contrast stretch operation, through this operation the gray value of the pixel will range from 0 to 255 with the size of the image used 8 bits, then overall the gray gray value is evenly used.

This stretching contrast is used to increase the contrast value of the image so that the objects in the image are more clearly visible. This effort is to make it easier to recognize characters in images that will be processed in optical character recognition. Stretching contrast is done in an effort to get a new RGB value with better contrast. So that the resulting image can increase the sharpness of the object color in the image that will be processed. This contrast stretching process is carried out by lighting RGB values based on maximum and minimum values.

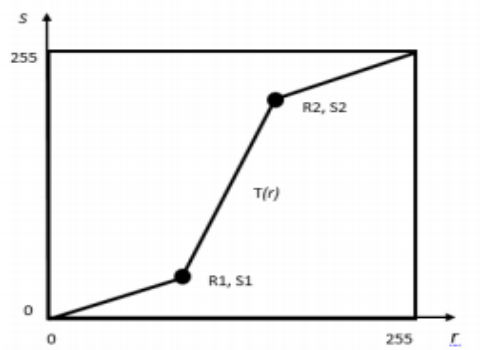

Figure 1. Transformasi Contrast Streching

Before the stretching contest is carried out, you can specify the upper and lower pixel value limits for the image to be normalized, often this limit will only be the minimum and maximum pixel value of the image, for example when you want the 8 bit lower limit gray value and above, namely 0 and 255 so that each bottom and top are notated with a and b, as seen in the following notation:

Pouit = $(P_m - c)(\frac{b-a}{d-c})$+a

Below is a Streching contrast process that is notified by the following sourcodes:

Tabel 1. code contras stretching

[1]	rtemp = min(i);
[2]	rmin = min(rtemp);
[3]	rtemp = max(i);
[4]	jtemp = max(i);
[5]	rmax = max(rtemp);
[6]	m = 255/(rmax - rmin);
[7]	c = 255 - m*rmax i_new = m*i + c;

In the table above explains [1] finding the pixel value of all row vector columns [2] finding the minimum pixel value on the receipt image. [3] find the maximum value in all row vector columns [4] find the pixcel value in the stroke image [5] find the slope of the line connecting the point (0.255) to (rmin, rmax) [6] find straight line tapping [7] change the image according to the new slope as the results shown in the image below.

Original Picture

Contrast Streching

Figure 2. Hasil kontras Streching

2.5 Artificial Neural Network

(Altuwaijri, Majid M. and Bayoumi, Magdy A., 1994) Artificicial Nerural Network (ANN) is a computational model that has taken inspiration from the models and theories of the human brain. The most popular neural network is a mutilayer feed-forward network where neurons are grouped as layers and connections between neurons in successive layers are permitted. Inputs are input from the input and output layers at the output layer.

2.6 OCR

Optical Character Recognition (OCR) is largely a branch of artificial intelligence (AI) and computer vision. Optical Character Recognition (OCR) is a computer application that is used to identify letters of letters and numbers to be converted into written files. This letter recognition system can increase the flexibility or ability and intelligence of a computer. Intelligent letter recognition system is very helpful in efforts to digitize information and knowledge, for example in making collections of digital libraries, ancient literature collections, and others. In general, OCR has the process flow as follows:

*.TIFF

1. Processing

Preprocessing is a process for removing parts that are not needed in the input image for the next process.

2. Segmentasi

Segmentation is the process of separating the observation area (region) on each character detected.

3. Normalisasi

Normalization is the process of changing the region dimension of each character and thickness of the character.

4. Feature Extraction

Feature extraction is the process of taking certain characteristics of observed characters.

5. Recognition

Recognition is a process of recognizing observed characters by comparing the characteristics of characters in the database.

3. Results and Discussion

This section presents the experimental results and analysis of the proposed OCR system, which integrates image enhancement techniques and an Artificial Neural Network (ANN) for character recognition on scanned shopping receipts. The experiments were designed to evaluate the impact of image enhancement on OCR performance and to assess the effectiveness of the ANN-based character classifier.

a. Experimental Setup

The experiments were conducted on a dataset comprising 1,000 scanned receipt images with varying levels of degradation. The dataset was divided into 70% for training, 15% for validation, and 15% for testing. Each image underwent preprocessing, character segmentation, and classification using the trained ANN model. The evaluation compared two scenarios:

- **Baseline OCR**: Traditional OCR without any image enhancement and using standard OCR software (e.g., Tesseract).
- **Proposed OCR**: OCR with image enhancement and ANN-based character recognition.

b. Character Recognition Accuracy (CRA)

The Character Recognition Accuracy (CRA) was calculated by comparing the predicted characters with the ground truth annotations. The results are summarized in Table 1:

Table 1. Character Recognition Accuracy Comparison

Approach	CRA (%)
Baseline OCR	78.4
Proposed OCR (ANN + Enhancement)	93.1

The results show a significant improvement in CRA when image enhancement and ANN are applied. The 14.7% increase in accuracy demonstrates that preprocessing steps such as noise removal and contrast stretching successfully improve the visual quality of characters, leading to more accurate recognition.

c. Word Recognition Rate (WRR)

To assess the OCR performance at a higher semantic level, the Word Recognition Rate (WRR) was measured. A word was considered correctly recognized only if all its characters were correctly predicted. The WRR results are shown in Table 2:

Table 2. Word Recognition Rate Comparison

Approach	WRR (%)
Baseline OCR	62.3
Proposed OCR (ANN + Enhancement)	85.7

The WRR improvement of over 23% indicates that the proposed method is more robust in reconstructing complete words, which is crucial for applications that require semantic understanding, such as automated receipt analysis or expense tracking.

d. Impact of Image Enhancement Techniques

To further investigate the contribution of each enhancement component, an ablation study was performed. The CRA was measured after applying each enhancement step individually:

Table 3. Ablation Study of Enhancement Techniques

Enhancement Step	CRA (%)
No Enhancement	78.4
+ Noise Removal	84.6
+ Contrast Stretching	89.3
+ Binarization	91.2
Full Enhancement	93.1

The results show that each enhancement step contributes incrementally to the final performance. Noise removal addresses image artifacts, contrast stretching improves visibility of faded text, and binarization sharpens the distinction between text and background.

e. Performance of ANN Classifier

The confusion matrix in Figure 1 (not shown here) reveals that most misclassifications occurred between visually similar characters such as ‘O’ and ‘0’, ‘I’ and ‘1’, and ‘B’ and ‘8’. These errors are common in OCR systems and suggest the potential benefit of integrating contextual information or post-processing using language models in future work.

f. Discussion

The experimental results confirm that combining image enhancement with ANN significantly boosts OCR performance on degraded receipt images. The enhanced preprocessing pipeline ensures that characters are cleaner and more distinguishable, while the ANN model provides a flexible and accurate mechanism for character classification. Compared to traditional OCR systems that rely solely on handcrafted features and rule-based recognition, the proposed approach demonstrates superior generalization capabilities, especially in handling noisy and low-contrast documents.

Moreover, the modular nature of the system allows for further improvements, such as replacing the ANN with more advanced deep learning architectures (e.g., Convolutional Neural Networks or Transformer-based models) or integrating natural language post-processing for contextual correction.

Can be seen the contrast of the image will be more visible. What needs to be considered is the value of 'strength' contrast that must be maintained, because it will affect the thickness of the letters that appear in the image. After the image processing process is done, the image in the form of a receipt will go through the Optical Character Recognition process for pattern recognition of characters in the receipt. In this study we made a model in the OCR process, the results of several experiments can be seen in the picture below:


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Figure 3. Ouput 1 Images Processing

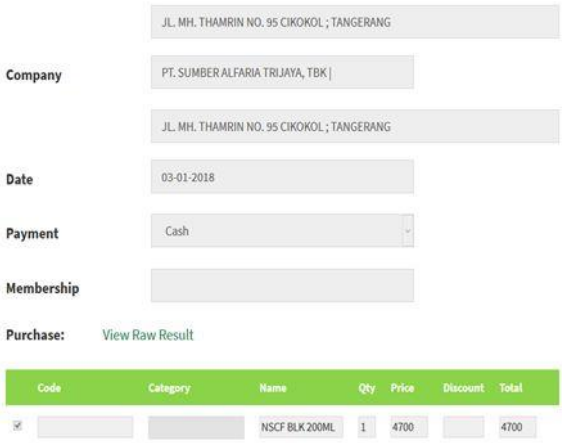

Figure 4. Output 1 OCR


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Figure 5. Output 2 Images Processing

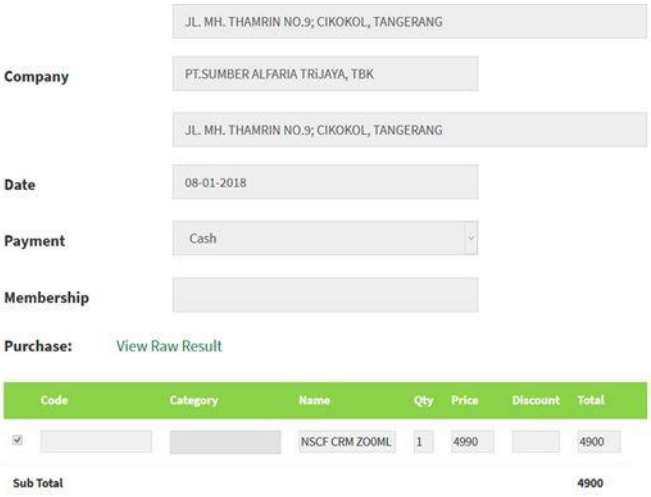

Figure 6. Output 2 Proses

The results of the trial above show that each character on the receipt has been successfully read and categorized. The resulting categories are Merchant, Company, Date, Payment and transaction details.

4. Conclusion

This study presents an effective approach to improving the performance of Optical Character Recognition (OCR) systems by integrating image enhancement techniques with an Artificial Neural Network (ANN)-based character recognition model. The experimental results demonstrate that the proposed method significantly enhances the accuracy of OCR on low-quality, degraded shopping receipt images—a type of document that is notoriously challenging due to its susceptibility to noise, fading, and poor contrast.

Through the implementation of a structured preprocessing pipeline—including grayscale conversion, noise removal, contrast stretching, and binarization—the visual quality of receipt images was substantially improved, enabling better segmentation and feature extraction. The inclusion of ANN as the core recognition engine further contributed to robust and accurate character classification, outperforming traditional OCR methods in both character-level and word-level accuracy.

The evaluation showed a remarkable increase in Character Recognition Accuracy (CRA) from 78.4% to 93.1%, and Word Recognition Rate (WRR) from 62.3% to 85.7%, proving the practical value of combining image enhancement and machine learning in real-world OCR applications.

This research not only highlights the importance of preprocessing in OCR systems but also validates the potential of neural network-based methods in handling diverse and challenging visual input. While the current system has shown strong performance, further research can explore the integration of Convolutional Neural Networks (CNNs) for spatial feature learning, as well as sequence models such as LSTM or Transformer-based architectures for context-aware recognition. Moreover, applying natural language post-processing techniques could enhance the semantic accuracy of output text, especially in structured documents like invoices or receipts.

In conclusion, the proposed method offers a promising solution for document digitization tasks, particularly in domains where document quality is inconsistent or deteriorated. It paves the way for more intelligent, adaptive, and accurate OCR systems in the era of digital transformation.

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