

Improving the Quality of Digital Images on Identity Cards Using Contrast Stretching and Retinex Methods

Nur Salsabilla^{1*}, Achmad Fauzi², I Gusti Prahmana³

^{1,2,3}STMIK Kaputama

nrsalsa1401@gmail.com^{1*}, fauzyrivai88@gmail.com^{2*}, igustiprahmana4@gmail.com^{3*}

Abstract

Enhancing the image quality of the Indonesian Identity Card is crucial to ensure the clarity and accuracy of information in various applications, such as identity verification, administration, and security. This study aims to improve the digital image quality of Identity Card using the *Contrast Stretching* and *Retinex* methods. *Contrast Stretching* is employed to enhance image contrast, while the *Retinex* method is used to maintain and improve the clarity of colors and image details. The implementation of these methods is carried out using Python. The test results show that these methods are effective in improving the quality of Identity Card images, making the information on the images clearer and easier to read. This research contributes to the development of more advanced image processing technology, which can be applied to various verification and administrative needs that require high reliability.

Keywords: Identity Card, Contrast Stretching, Retinex, Image Processing, Image Quality Enhancement

1. Introduction

Image enhancement is one of the initial processes in image preprocessing. Image enhancement is one of the first processes in image preprocessing, as it is often the case that the image being tested is of poor quality. Quality improvement is needed because often the tested image has poor quality, for example, the image is too bright or dark, the image is less sharp, blurred, and so on. image is too bright or dark, the image is less sharp, blurred, and so on [1].

The author takes the title of the improvement of the Contrast Stretching and Retinex method to increase the brightness of digital images. Where, the Contrast Stretching method is a method that is done by adding or reduce Contrast (lighting) so that the image is sharper than the image (Muhammad Shaleh, Indah Novita Sari 2011), while the Retinex method is a method used to obtain a new image. method is a method used to obtain a new image with a better contrast than the contrast of the original image. better than the contrast of the original image. Retinex method is a method method used for image improvement that is point processing, which means that this process only depends on the intensity value [2]. this process only depends on the intensity value (grey level) of one pixel, not depending on other pixels around it. depending on the other pixels around it. Here it is assumed that the image has a grey level range from 0 to 255. There are four main steps that will be carried out to obtain a new image up to the process of displaying image statistics. display image statistics, namely the process of displaying the initial image in the window, image contrast improvement, displaying image histograms and displaying image statistics image [3].

2. Literature Review

2.1. Definition of Digital Image

A digital image is a two-dimensional image that is generated from a continuous two-dimensional analog image through a sampling process. The analog image is divided into N rows and M columns so that it becomes a discrete image. Digital images are images that can be processed by computers. What is stored in the computer are only numbers that show the intensity of each pixel. Because it is in the form of numerical data, digital images can be processed by computer [4].

2.2. Definition of Image Quality Improvement

Image enhancement is one of the initial processes in image preprocessing. Quality improvement is needed because often the image being tested has poor quality, for example, the image is too bright or dark, the image is less sharp, blurred, and so on [1].

2.3. Definition of Contrast Stretching

Contrast Stretching algorithm is a method that is done by increasing or decreasing the contrast (lighting) so that the image is sharper than the original image. Contrast Stretching process includes an image improvement process that is point processing, which means that this process only depends on the intensity value (gray level) of one pixel, not depending on other pixels around it. Contrast Stretching is a technique used to obtain a new image with better contrast than the contrast of the original image. So in this study, image quality improvement will be developed using the Contrast Stretching method with input images in the form of grayscale images and RGB images (color images) in .JPG and .bmp formats [5]. The Contrast Stretching method is related to the distribution of pixel intensity, which is the process of expanding the intensity range. Contrast stretching is one way to improve image quality through point operations. improve image quality through point operations. The new intensity value at (x,y) coordinate, namely new(x,y), is obtained as a result of contrast stretching. Here the intensity range is 0 to 255. Where old(x,y) is intensity of the processed pixel, rmin is the lowest intensity value, and rmax is the highest intensity value the image has. An image with low contrast is an image that has a narrow intensity distribution [6].

2.4. Definition of Retinex

Retinex method is a method used to obtain a new image with better contrast than the original image. The Retinex method is a method used for point processing image improvement, which means that this process only depends on the intensity value (gray level) of one pixel, not depending on the other pixels around it. Here it is assumed that the image has a gray level range from 0 to 255. There are four main stages that will be carried out to obtain a new image until the process of displaying image statistics, namely the process of displaying the initial image in the window, image contrast enhancement, displaying the image histogram, and displaying image statistics and displaying image statistics [3]. The Retinex method is a method that is used to obtain a new image with a better contrast than the one that is used to get a new image with a better contrast than the contrast used for point processing. used for point processing image enhancement, which is carried out to obtain a new image up to the process of displaying statistical image, image contrast enhancement, displaying the histogram of the statistical image and can be applied in image brightening to become an image with a clearer clearer pixels [7].

2.5. Identity Card

Identity Card is an official identity document issued by the Indonesian government to every Indonesian citizen who is 17 years old and above. As one of the most important identity documents in Indonesia, Identity Card play a vital role in various aspects of citizens' lives, from everyday transactions to more complex administrative processes.

2.6. Python

Python is one of the programming languages widely used by large companies and developers to develop various types of desktop, web, and mobile applications. Python was created by Guido van Rossum in the Netherlands in 1990, and its name is derived from Guido's favorite television show, Monty Python's Flying Circus. Van Rossum developed Python as a hobby, and then Python became a programming language widely used in industry and education due to its simplicity, conciseness, intuitive syntax, and extensive libraries. The popularity of Python has made it a programming language that many students, especially those in IT-based campuses, are starting to learn in order to complete coursework, final projects, and research tasks. To tackle various programming assignments, one needs to understand algorithms, as fundamentally, computer programs are implementations of algorithms [8].

3. Research Methods

This research uses Contrast Stretching and Retinex methods to improve the quality of digital images on Identity Cards. This research focuses on comparing the two methods to improve image contrast and sharpness.

This research uses data in the form of digital images of Identity Cards obtained through shooting using a digital camera or smartphone. This Identity Card image was chosen because KTP is one of the important identity documents that often experience image quality problems, such as low contrast and lack of sharpness.



Fig. 1: Identity Card

3.1. Contrast Stretching

Table 1: 4x4 Red Pixel Slice

(x,y)	0	1	2	3
0	202	204	201	197
1	201	201	199	197
2	203	202	199	197
3	201	199	191	207

Table 2: 4x4 Green Pixel Slice

(x,y)	0	1	2	3
0	178	179	180	176

1	191	192	191	197
2	199	201	201	196
3	199	199	200	202

Table 3: 4x4 Blue Pixel Slice

(x,y)	0	1	2	3
0	218	219	217	219
1	220	223	223	213
2	224	224	222	211
3	227	224	218	214

1. Calculating RGB to find the grayscale value is as follows:

$$\text{Gray}(x,y) = \frac{\text{Red}(x,y) + \text{Green}(x,y) + \text{Blue}(x,y)}{3}$$

$$\text{Gray}(0,0) = \frac{\text{Red}(0,0) + \text{Green}(0,0) + \text{Blue}(0,0)}{3} = \frac{202 + 178 + 218}{3} = 199$$

$$\text{Gray}(0,1) = \frac{\text{Red}(0,1) + \text{Green}(0,1) + \text{Blue}(0,1)}{3} = \frac{204 + 179 + 219}{3} = 201$$

$$\text{Gray}(0,2) = \frac{\text{Red}(0,2) + \text{Green}(0,2) + \text{Blue}(0,2)}{3} = \frac{201 + 180 + 217}{3} = 199$$

Thus, Grayscale pixels are obtained:

Table 4: Grayscale pixels

(x,y)	0	1	2	3
0	199	201	199	197
1	204	205	204	202
2	209	209	207	201
3	209	207	203	208

From the table above, the values C1 = 209, C2 = 199, D1 = 208, D2 = 118 are obtained. Next is the value transformation process with the contrast conditions above, the pixel value improvement process is as follows: Proses Pixel Red (0,0) to (3,3):

Process Pixel Red (0,0) to (3,3):

- C(0,0) = 202

$$D(0,0) = D2 + \frac{(C(0,0) - C2) * (255 - D2)}{(255 - C2)} = 197 + \frac{(202 - 199) * (255 - 197)}{(255 - 199)} = 200$$
- C(0,1) = 204

$$D(0,1) = D2 + \frac{(C(0,1) - C2) * (255 - D2)}{(255 - C2)} = 197 + \frac{(204 - 199) * (255 - 197)}{(255 - 199)} = 202$$
- C(0,2) = 201

$$D(0,2) = D2 + \frac{(C(0,2) - C2) * (255 - D2)}{(255 - C2)} = 197 + \frac{(201 - 199) * (255 - 197)}{(255 - 199)} = 199$$

Thus, we get the repaired pixels:

Table 5: Repaired pixels

(x,y)	0	1	2	3
0	200	202	199	195
1	199	199	197	195
2	201	200	197	195
3	199	197	191	207

Continue with the same process for the green and blue pixels to perform the result improvement.

Retinex

Table 6: Pixel Value Matrix as Test Against Retinex Method

(x,y)	2	3	4	5
2	214	218	221	218
3	216	218	220	218
4	217	217	215	213
5	216	215	211	209

Gaussian process:

The process of determining the weights of the 3x3 matrix kernel on the gaussian with the equation $G(x,y) = \frac{1}{2 \cdot \sigma^2 \cdot \pi} \cdot e^{-\frac{(x^2) + (y^2)}{2 \cdot \sigma^2}}$, sing the sigma value (σ) = 1,1.

Here's the process :

Wher :

$\sigma = 1,1$

$\pi = \frac{22}{7}$

$e = 2,711828182846$

$$\begin{pmatrix} \frac{1}{2n(1,1)^2 \cdot \pi} \cdot e^{-\frac{(0^2)+(0^2)}{2 \cdot (1,1^2)}} & \frac{1}{2n(1,1)^2 \cdot \pi} \cdot e^{-\frac{(0^2)+(1^2)}{2 \cdot (1,1^2)}} & \frac{1}{2n(1,1)^2 \cdot \pi} \cdot e^{-\frac{(0^2)+(2^2)}{2 \cdot (1,1^2)}} \\ \frac{1}{2n(1,1)^2 \cdot \pi} \cdot e^{-\frac{(1^2)+(0^2)}{2 \cdot (1,1^2)}} & \frac{1}{2n(1,1)^2 \cdot \pi} \cdot e^{-\frac{(1^2)+(1^2)}{2 \cdot (1,1^2)}} & \frac{1}{2n(1,1)^2 \cdot \pi} \cdot e^{-\frac{(1^2)+(2^2)}{2 \cdot (1,1^2)}} \\ \frac{1}{2n(1,1)^2 \cdot \pi} \cdot e^{-\frac{(2^2)+(0^2)}{2 \cdot (1,1^2)}} & \frac{1}{2n(1,1)^2 \cdot \pi} \cdot e^{-\frac{(2^2)+(1^2)}{2 \cdot (1,1^2)}} & \frac{1}{2n(1,1)^2 \cdot \pi} \cdot e^{-\frac{(2^2)+(2^2)}{2 \cdot (1,1^2)}} \end{pmatrix}$$

Table 7: Initial Kernel Weight Positions

(X,Y)	0	1	2
0	(0,0)	(0,1)	(0,2)
1	(1,0)	(1,1)	(1,2)
2	(2,0)	(2,1)	(2,2)

Kernel Boot Process:

$\sigma = 1,1$

$G(x,y) = \frac{1}{2 \cdot \sigma^2 \cdot \pi} \cdot e^{-\frac{(x^2)+(y^2)}{2 \cdot \sigma^2}}$

$G(0,0) = \frac{1}{2n(1,1)^2} \cdot e^{-\frac{(0^2)+(0^2)}{2 \cdot (1,1^2)}}$
 $= \frac{1}{7,60} \cdot e^{-0}$
 $= 0,13$

$\sigma = 1,1$

$G(0,1) = \frac{1}{2n(1,1)^2} \cdot e^{-\frac{(0^2)+(1^2)}{2 \cdot (1,1^2)}}$
 $= \frac{1}{7,60} \cdot e^{-0,41}$
 $= 0,19$

$\sigma = 1,1$

$G(x,y) = \frac{1}{2 \cdot \sigma^2 \cdot \pi} \cdot e^{-\frac{(x^2)+(y^2)}{2 \cdot \sigma^2}}$

Thus, the pixels obtained as a result of the weighting process:

Table 8: Weighting Process Result

(X,Y)	0	1	2
0	0,13	0,19	0,67
1	0,19	0,29	1,01
2	0,67	1,01	3,52

With the number of kernel weights (K) = 7.68 So the final weight of the Gaussian divided by the number of kernel weights is:

Table 9: Division Process with Number of Kernel Weights

(X,Y)	0	1	2
0	0,13/7,68	0,19/7,68	0,67/7,68
1	0,19/7,68	0,29/7,68	1,01/7,68
2	0,67/7,68	1,01/7,68	3,52/7,68

The final Gaussian weight is:

Table 10: Gaussian Final Weight

(X,Y)	0	1	2
0	0,016	0,024	0,087
1	0,024	0,037	0,131
2	0,087	0,131	0,458

Retinex Method Process:

After obtaining the final Gaussian value, then the value of the RGB pixels will be done with the final Gaussian result. Here's the process:

Table 11: F(x,y)

(x,y)	2	3	4	5
2	214	218	221	218
3	216	218	220	218
4	217	217	215	213
5	216	215	211	209

Table 12: G(x,y)

(X,Y)	0	1	2
0	0,016	0,024	0,087
1	0,024	0,037	0,131
2	0,087	0,131	0,458

The next step is the convolution operation performed by shifting the convolution kernel pixel-by-pixel the convolution result is stored in a new matrix.

214	218	221	218
216	218	220	218
217	217	215	213
216	215	211	209

0	0	0	0
0	190		0
0			0
0	0	0	0

The convolution result is obtained with the following calculation:

$$(214 \times 0,016) + (218 \times 0,025) + (221 \times 0,087) + (216 \times 0,024) + (218 \times 0,037) + (220 \times 0,131) + (217 \times 0,087) + (217 \times 0,131) + (215 \times 0,458) = 190.009$$

214	218	221	218
216	218	220	218
217	217	215	213
216	215	211	209

0	0	0	0
0	190	214	0
0			0
0	0	0	0

The convolution result is obtained with the following calculation:

$$(218 \times 0,016) + (221 \times 0,024) + (218 \times 0,087) + (218 \times 0,024) + (220 \times 0,037) + (218 \times 0,131) + (217 \times 0,087) + (215 \times 0,131) + (213 \times 0,458) = 214.286$$

Tabel 13: SSR1(Red) Results

190	214
212	200

Tabel 14: Comparative Analysis of Contrast Stretching and Retinex

No.	Methods	Initial Image				Result Image					
		Red				Red					
1.	Contrast Stretching	(X,Y)	0	1	2	3	(X,Y)	0	1	2	3
		0	202	204	201	197	0	200	202	199	195
		1	201	201	199	197	1	199	199	197	195
		2	203	202	199	197	2	201	200	197	195
		3	201	199	191	207	3	199	197	191	207
		Green				Green					
		(X,Y)	0	1	2	3	(X,Y)	0	1	2	3
		0	178	179	180	176	0	175	176	177	173
		1	191	192	191	197	1	189	190	189	195
2	199	201	201	196	2	197	201	201	196		
3	199	199	200	202	3	199	199	200	202		
Blue				Blue							
(X,Y)	0	1	2	3	(X,Y)	0	1	2	3		
0	218	219	217	219	0	217	218	216	218		
1	220	223	223	213	1	219	211	211	211		
2	224	224	222	211	2	223	223	221	209		
3	227	224	218	214	3	226	223	217	212		
2.	Retinex	Red				Red					
		(X,Y)	0	1	2	3					
		0	214	218	221	218	190		214		
		1	216	218	220	218	212		200		
		2	217	217	215	213					
		3	216	215	211	209					
		Green				Green					
		(X,Y)	0	1	2	3	217		214		
		0	215	219	219	216	218		218		
1	215	218	217	212							
2	216	219	219	214							
3	214	219	221	221							
Blue				Blue							
(X,Y)	0	1	2	3	230		230				
0	222	227	227	222	229		230				
1	217	221	224	224							
2	214	217	223	225							
3	212	217	223	224							

3.2. Flowchart

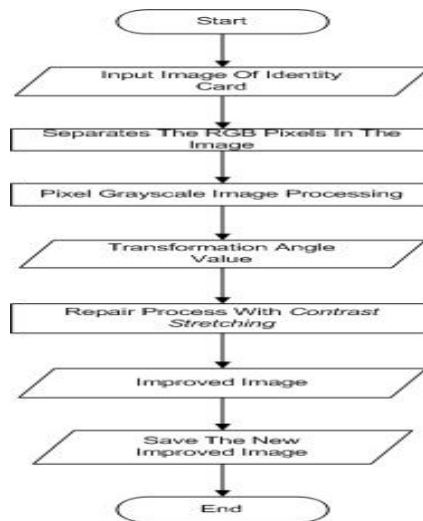


Fig.2: Flowchart of Identity Card Repair System with Contrast Stretching Method

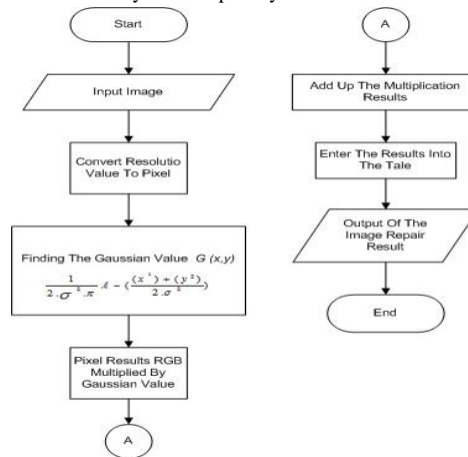


Fig.3: Flowchart of Identity Card Repair System with Retinex Method

4. Discussion and Implementation

4.1. Discussion

This research discusses the implementation of two image processing methods, namely Contrast Stretching and Retinex, to improve the quality of the National Identity Card image. This system serves to increase the contrast and brightness of digital images, so that the image becomes clearer and more detailed. In this research, the Contrast Stretching method is used to improve the distribution of pixel intensity in the image, while Retinex aims to maintain color clarity and image detail.

The implementation of these two methods is done using Python application with OpenCV library. Tests were conducted on several ID card images that experienced quality degradation, such as low contrast and loss of color detail. The test results show that the Contrast Stretching method successfully improves image contrast, while the Retinex method is more effective in improving brightness and maintaining color details. Thus, these two methods can be used synergistically to improve the quality of ID card images with more optimal results.

Interface Contrast Stretching



Fig. 4: Original Image Display Contrast Stretching



Fig. 5: Display of Contrast Stretching Result Image

Interface Retinex



Fig 6: Retinex Original Image Display



Fig. 7: Display of Contrast Stretching Result Image

4.2. Implementasi

This chapter will explain the results of the test program regarding the comparison between the Contrast Stretching method and the Retinex method. These methods were chosen because both techniques are effective in improving the visual quality of images. Contrast Stretching is used to expand the range of pixel intensity so that image contrast increases, while the Retinex method is able to improve lighting and contrast more adaptively by reducing the effects of uneven lighting and clarifying image details. This comparison aims to determine which method provides the best image quality improvement results, especially in the context of image processing.

5. Conclusion

From the results of research, analysis, design and implementation stages on the comparison of the work results of the Contrast Stretching method and the Retinex method on RGB digital images. Based on the implementation and testing results of the application program, the conclusions that can be obtained in this research are as follows:

1. Contrast Stretching method and Retinex method, both can work well on RGB color image.
2. Contrast Stretching expands the range of pixel intensities, so that previously blurry details become more visible. This method is particularly useful in situations where a quick adjustment of too low or high contrast is required.
3. Retinex provides more consistent enhancement under complex lighting conditions by mimicking human visual perception of lighting, and the results are better at reducing noise and making the image more natural and identifiable.

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