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IMPLEMENTATION OF BILATERAL FILTERING FOR AESTHETIC ENHANCEMENT OF FACIAL IMAGES

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Abstract

Digital image is a representation of an image in the form of pixels arranged in a matrix. The image processing process includes acquisition, analysis, and manipulation to produce the desired output. In photography and social media, digital images play an important role in attracting attention. However, photos often experience problems such as noise and uneven lighting, which can reduce image quality. Therefore, image enhancement is needed to overcome these problems. The Bilateral Filtering method is one of the techniques that is very effective in reducing noise by considering the special distance and intensity differences between pixels, so that it can maintain the clarity of important elements in the image. This study aims to implement this technique in improving the aesthetics of facial images and evaluate its effectiveness in producing more attractive and high-quality images. from 50 datasets taken. The results of the study showed that Bilateral Filtering was able to improve the clarity of facial images without eliminating important details. The evaluation was carried out using image quality parameters such as PSNR (Peak Signal-to-Noise Ratio) and SSIM (Structural Similarity Index), which showed an increase in quality after the application of this method. In terms of user satisfaction, the results of the questionnaire showed that the satisfaction level reached 86.38%, which based on Table 5 is included in the "very good" category. Thus, the Bilateral Filtering method not only successfully improves the image quality without losing important details on the face. Objectively, but also provides high satisfaction for users in terms of aesthetics and visual comfort.



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I. INTRODUCTION

A digital image is a two-dimensional representation of an image as a set of numeric values processed by a computer. Basically, a digital image consists of image elements called pixels, which are arranged in a two-dimensional matrix [1]. The image referred to here is a still image (photo) while digital here means that image/image processing is done digitally using a computer. The technique commonly used in image processing is importing an image, acquiring, analyzing and manipulating it to produce output [2]. Facial image aesthetics, this relates to how facial images can be modified to produce a more beautiful or attractive appearance, taking into account

the visual aspects that influence the perception of beauty. There are several aspects that can influence the aesthetics of facial images, including symmetry, color balance, skin smoothness, and proper contrast.

In photography and social media, digital images are very important to attract attention and build identity. However, facial images often experience problems such as noise, uneven lighting and lack of sharpness, which can reduce image quality. Especially for individuals with facial problems such as spots, acne, dark spots and wrinkles. Image enhancement aims to correct technical deficiencies and improve facial aesthetics, resulting in more attractive and high-quality images. This process aims

to change the image to be better than the original version, especially in cases of poor-quality images. The Bilateral Filtering method is a non-linear filter introduced by Tomasi. This filter is a development of the Gaussian smoothing concept by emphasizing the filter coefficient with its relationship to the relative intensity of the pixel [3]. Bilateral Filtering is used to reduce noise in images. The process considers both the spatial distance between pixels and the difference in intensity between them, making it very effective for solving problems in facial images or in shooting situations. With this method of working, this filter is able to provide smoother and more detailed results. While maintaining the clarity of important elements in the image.

II. LITERATURE

2.1. Digital Image Processing

Digital image processing is a branch of science that focuses on various techniques for processing and improving image quality. Some of the main aspects in this field include contrast enhancement, color changes, and image quality improvement to make it clearer. In addition, image processing also includes image transformations, such as rotation, resizing, and modifying geometric shapes. In addition to improving the appearance of images, image processing techniques are also used to extract important features or characteristics from an image for analysis purposes [2][4]–[7].

Digital images are visual representations consisting of pixel elements, where each pixel has a certain value that determines the characteristics of a point in the image. Digital images can be in the form of still images (photos) or moving images obtained from devices such as webcams and cameras. In the context of image processing, the term "digital" refers to the process of manipulating images carried out with the help of a computer. This process allows for various processing techniques, such as image quality enhancement, feature analysis [8], [9]. Bilateral filtering is an image processing technique used to reduce noise while maintaining sharp edges in an image [10].

2.2 Visual Quality Assessment

The results of the repaired image will be tested using Visual Quality Assessment. Visual quality assessment is carried out by comparing the original image and the processed image, based on several criteria such as sharpness, noise reduction, and clarity of facial details. to determine the extent to which the processed image maintains its visual quality[11].

2.3. MATLAB

MATLAB is a software used for numerical computation, data analysis, modeling, and programming, especially in engineering, science, and mathematics. MATLAB has strong capabilities in matrix-based operations, script-based programming,

and data visualization in the form of 2D and 3D graphics. In addition, MATLAB provides various toolboxes that support special needs such as image processing, artificial intelligence, and dynamic system simulation using Simulink [12]–[14].

III. RESEARCH METHOD

In the development of technology, digital images are one of the most important forms of data and are widely used in various fields such as medical, security, and entertainment. Applications that utilize digital images, such as facial recognition and disease diagnosis, require high image quality. However, digital images often experience degradation due to factors such as noise, blur, uneven lighting and especially for individuals with facial problems such as spots, acne, dark spots and wrinkles. Which makes it difficult for the facial recognition process. The analysis of the application of the system is carried out through two main stages, namely the training stage and the testing stage. In the training stage, the dataset used is a collection of previously taken human face images that have quality problems or problems with the face itself. A manually taken image dataset of 50 samples was used in this study. The main problem with images taken using a cellphone camera often experiences problems with quality such as uneven lighting, blurriness and noise, the quality of the camera is often low which makes the photos obtained less than optimal or broken and problems with the face itself such as acne, wrinkles and dark spots. Which makes it difficult for the image processing system to detect faces, therefore image improvement is needed.

Bilateral filtering is one of the effective methods in improving image quality by preserving edge details and reducing noise. This technique works by considering spatial differences and pixel intensities in a certain area, resulting in aesthetic enhancement without losing important details in the facial image. With proper implementation, bilateral filtering can be an effective solution to improve the aesthetics of facial images and repair images that are degraded due to various environmental and technical factors.

Program Design

The program design carried out in this study used the Experimental method. Experiment is a method used to determine the cause and effect of an image [15]. The stages in conducting the experimental method are as follows:

a. Data Collection

In this data collection, the researcher took a facial image dataset, which consisted of 50 images taken using a cellphone camera. The images taken had various quality problems, such as noise, blurriness and different facial variations (eg, spots, acne, or wrinkles

b. Matlab GUI Design

At this stage, the interface system was created, for the interface design consisting of creating a title using a label, then using two axes to display the original image, the resulting image that had been input and using 3 pushbuttons to input, filtering and save processes. In this experiment, the researcher will change the image of a face contaminated with noise and compare the results with the image that has been processed using Bilateral Filtering. At this stage, the experiment will include the Image Group processed using Bilateral Filtering with various parameter values.

c. Pre-processing

Pixel intensity normalization aims to flatten the distribution of intensity values in the image, so that all images have a uniform pixel value range and are at the appropriate standard for the next process.

d. Application of Bilateral Filtering

Bilateral filtering is an image processing technique used to reduce noise while maintaining sharp edges in an image.

IV. RESULTS

The results of the study show that Bilateral Filtering is able to improve the clarity of facial images without eliminating important details. The evaluation was carried out using image quality parameters such as PSNR (Peak Signal-to-Noise Ratio) and SSIM (Structural Similarity Index), which showed an increase in quality after the application of this method. In terms of user satisfaction, the questionnaire results showed that the satisfaction level reached 86.38%, which based on Table 5 is included in the "very good" category. Thus, the Bilateral Filtering method not only succeeded in improving image quality without eliminating important details on the face. Objectively, but also provides high satisfaction for users in terms of aesthetics and visual comfort.

The image above is the initial display of the matlab menu, where the author can create a matlab gui design by calling the guide function to display the interface design menu for the system to be created.

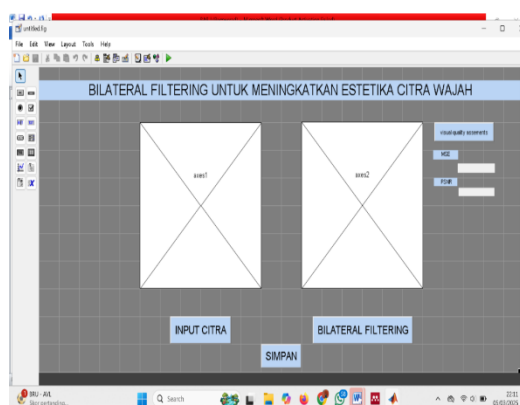


Figure 1. Menu Design

The image above is a menu design that has been created, where in the design there are two accesses to display photos and buttons to input images, process photos, perform testing and save the photo results after filtering.

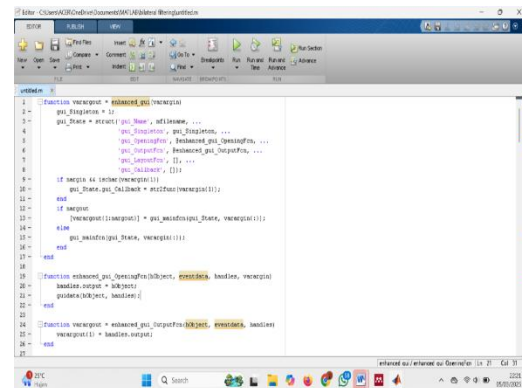


Figure 2. Encoding

After the interface design on the MATLAB GUI is created, then call the viewcallbacks button function, to display the place where the author enters the coding according to the existing buttons and runs the system that has been created.

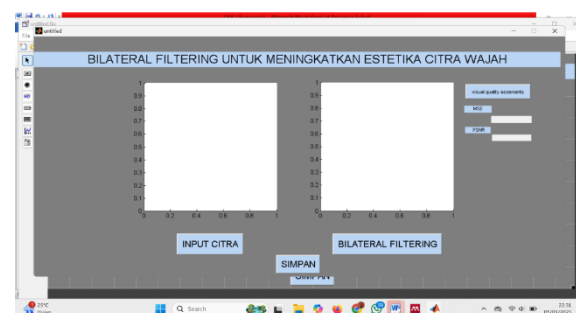


Figure 3 User interface

The image above is the process of testing the system on the matlab application that has been created. To find out whether bilateral filtering can repair damaged images and whether the buttons above can function or not, which will be explained in the image below.

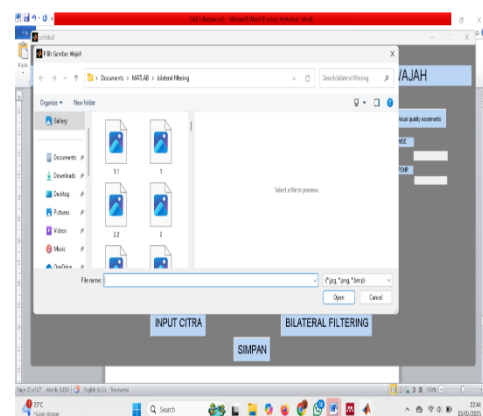


Figure 4. Image Input

at this stage the user can select the image to be repaired through the interface. By inputting the image in the form of a file with PNG, JPG or JPEG format and will display the image in accesses 1.

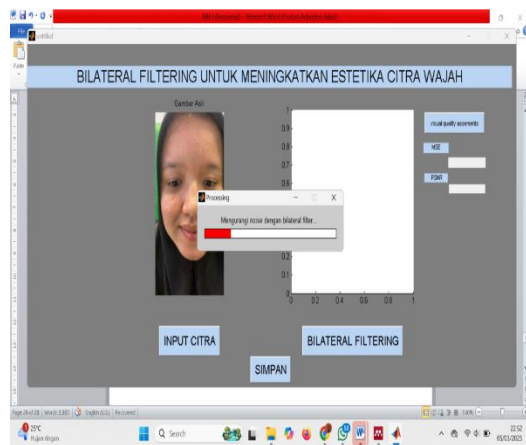


Figure 5. Filtering Process

After the image is input, the image will be processed using the bilateral filtering method to improve the visual quality and repair damaged images.



Figure 6. Testing

After the image is successfully applied to bilateral filtering, the next step is to test it using MSE and PSNR. To find out how far bilateral filtering can repair damaged images.

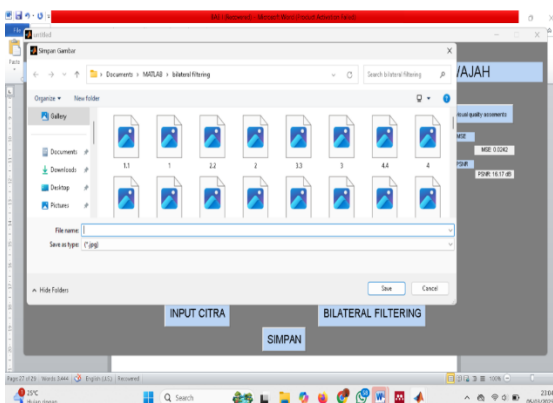


Figure 7. Saves the Filtering Results

After the testing process is complete, the image that has been processed using bilateral filtering can be saved using a format according to the input image.

V. CONCLUSION

Based on the research results, the Bilateral Filtering method has proven to be effective in improving the quality of facial images by maintaining important details, such as edges and facial structures. The results of subjective evaluation through a questionnaire showed that the majority of respondents (86.38%) gave a high satisfaction score with the category "very good", indicating that this method is well accepted in the context of improving the aesthetics of facial images. In terms of performance, Bilateral Filtering is able to improve the aesthetics of images with a PSNR accuracy of 76% and an MSE accuracy of 56%. This shows that this method can be relied on to produce clearer and more aesthetic facial images without sacrificing important details. However, despite providing better results, Bilateral Filtering has limitations in terms of slower processing speed compared to Gaussian Filtering. The main advantage of Bilateral Filtering is its ability to maintain better facial details than other methods, making it more ideal for use in applications that require visual quality enhancement without losing important information. Therefore, this method is recommended for application in facial image editing, especially in the fields of aesthetics and facial analysis.

Bilateral Filtering is highly recommended in facial image editing due to its ability to preserve important details such as edges and fine structures. This technique allows for image quality enhancement without destroying essential visual aspects, making it very useful in photo editing, especially in aesthetic applications and facial analysis. To improve the effectiveness of Bilateral Filtering, it is recommended to optimize parameters such as kernel size and sigma value. Adjusting these parameters can help the method perform better in various lighting conditions and different noise levels. With the right settings, the image processing results can be more optimal without reducing sharpness or eliminating important facial details. One of the main disadvantages of Bilateral Filtering is its slower processing speed compared to other methods such as Gaussian Filtering. For real-time applications or on devices with limited resources, algorithm optimization is needed to make it more efficient. Some approaches that can be used are the implementation of parallel processing or the use of computational optimization techniques so that this method can be used more widely in practical applications.

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