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A Discussion on the Variety of Techniques used in the Processing of Digital Images

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Abstract*: Digital image processing, or DIP, is the process of using various computer techniques to process digital photos. Digital image processing has been employed in many industries, such as pattern identification, remote sensing, picture sharpening, color and video processing, and medicine. This research provides an overview and review of the literature on digital image processing techniques, such as edge recognition, segmentation, compression, and picture pre-processing.*

Keywords: Digital Image Processing, Image Compression, Image Filtering, Edge Detection.

I. INTRODUCTION

A digitally processed image is inspected and modified, especially to improve the quality of the processing. Traffic control systems, medical imaging, agricultural imaging, diagnostic image analysis, surgical planning, object detection and matching, background subtraction in video, tumor localization, measuring tissue volumes, and object recognition in satellite images (roads, forests, etc.) are just a few of the many applications for which the DIP technique is useful.DIP fixes issues and impediments including picture quality degradation to enhance damaged photographs. The literature on DIP is reviewed and discussed in this research. The primary DIP techniques discussed are pre-processing, image compression, edge detection, and segmentation.

II. PRE-PROCESSING

Prior to computer processing, pre-processing of images entails a range of methods, including boosting or removing data pictures, modifying the intensity of each individual particle image, and lowering low-frequency background noise. Prior to beginning the segmentation procedure, Eapen et al. [1] have presented a technique to improve the edges and lower the noise level in the input pictures. Image scaling, histogram equalization, ROI selection, and median filtering were all included in the pre-processing module. This technique, which makes use of a global histogram equalization, works wonders for enhancing the contrast and texture of medical images.

The idea for medical picture edge detection was proposed by Sivappriya et al. in [2]. Pre-processing is an essential step in both medical picture segmentation and 3D reconstruction. The amount of salt and pepper noise in medical pictures was higher, and traditional techniques to lower it proved to be ineffective. The most effective filter for eliminating noise from salt and pepper is morphological deterioration. The experiment's outcomes showed that medical picture de-noising skills have improved.

A pre-processing method for converting pixels into "super pixels" was introduced by Puri et al. Working with "super pixels" that are local, coherent, and retain a significant amount of the structure required for segmentation at the size of interest is what they would want. To create the super pixel map, they used the normalized cut technique. The procedure took into account both texture and shape signals [3].

III. IMAGE COMPRESSION

Picture compression is a kind of data compression where the original picture is encoded using a very small amount of bits. Improving data storage or transmission efficiency and lowering visual redundancy are the two main goals of image compression. The primary objective is to minimize the amount of data saved, and the decoded picture that shows on the screen would look to be as close to the original as is realistically achievable. Afifi et al.'s [4] system uses the Wavelet

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Algorithm to preserve picture quality after image compression. They employed PNG and JPEG images in their work. Using the Haar wavelet approach, it was discovered that a JPEG image's size was almost half that of the original because, despite lossy compression, the image's quality and information were preserved. An improved method for picture quality was presented by Raju et al. [5]. After that, a modified watershed technique that took use of mean-shift clustering was used to segment the improved picture. With the use of wavelets, more anisotropic diffusion, and LAHE, the improvement technique produced a hybrid version that enhanced the initial satellite picture. The data was segmented using three different methods. These included the modified watershed approach, the k-means methodology based on clustering, and the traditional mean-shift method. Numerous tests revealed that compared to the other two algorithms, the modified watershed approach yielded superior segmentation results. The excess segmentation process was well managed by the suggested watershed strategy, however the under segmentation process was disregarded.

Praveenkumar et al. [25] have demonstrated the effective compression and encoding performance of a medical application based on integer multiwavelet transform. In telemedicine applications, this transform is used to compress medical pictures. Images produced by the suggested algorithm were of higher quality. Using lossless picture data was the project's main objective. For this objective, they suggested multiwavelet-based compression, which has been shown to have a significantly higher coding efficiency and a lot lower computing cost than previous methods. The higher compression ratio allowed for the achievement of the high PSNR.

Sukanya et al. [6] covered a number of compression methods based on processing time, error comparison, mean square error, peak signal to noise ratio, and compression ratio. These methods included JPEG 2000, Embedded ZeroTree (EZW), Set Partition in Hierarchical Trees (SPIHT), and Highly Scalable SPIHT (HS-SPIHT). However, they were scaling the picture further using the line-based Wavelet transform, which uses less memory without compromising the Wavelet transform's outcome, in order to accomplish even more compression. Set Partitioning in Hierarchical Trees (SPIHT) is the foundation of the author's highly scalable image compression technique, HS_SPIHT. They created the HS-SPIHT technique, which increases scalability and compression ratio while reducing bit stream, or the size of the picture. At last, they were able to achieve higher scalability and a reduced bit stream.

IV. EDGE DETECTION

To locate sudden brightness changes, or more precisely, discontinuities, in digital pictures, a set of mathematical algorithms called "edge detection" is used.

Saif et al. presented on two segmentation algorithm methodologies in [7], namely Otsu thresholding and Canny edge detection. The effectiveness of the proposed algorithms was evaluated for both non-medical and medical image kinds. For non-medical imaging, two algorithms provided nicely segmented images. Canny segmentation outperforms Otsu when it comes to MRI greyscale images and endoscopic images where it is challenging to discern objects from backgrounds.

Watershed and edge detection methodologies provide the basis of Salman, et al.'s [8] recommended combination of K-means, watershed segmentation method, and Difference In Strength (DIS) map to undertake edge detection and picture segmentation tasks. They've used two strategies. In the first, new merging methods based on mean intensity value are used to segment the image sections and determine their boundaries using the watershed approach. Our second technique was the edge strength methodology, which allowed us to get accurate edge maps of our photographs without requiring the usage of the watershed approach. They discovered a way to address the problem of the watershed algorithm's undesirable oversegmentation results when used on raw data images. Furthermore, the edge maps they obtained include no broken lines at all, and the final edge detection result displays a single closed border for every actual region in the image.

Karantzalos et al. [9] integrated two complex nonlinear scale space representations, isotropic diffusion filtering and morphological levellings, to develop a processing method. The proposed method was used to edge recognition and watershed segmentation challenges.

Experimental results on autonomous olive tree extraction and watershed segmentation demonstrated its effectiveness as a pre-processing tool for edge recognition and segmentation from remote sensing photographs. While they have focused on processing panchromatic high spatial resolution satellite sensor data, the created approach may also be used to multidimensional and color image data by processing each channel individually.

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Alamri et al. [10] offered approaches for edge segmentation of satellite pictures and showed which of the seven techniques—Sobel operator technique, Prewitt technique, Kiresh technique, Laplacian technique, Canny technique, Roberts technique, and Edge Maximization Technique (EMT)—was the best. Experiments on the Kiresh, EMT, and Perwitt processes show that these are the most effective methodologies for edge identification.

To enhance the watershed technique, Shahzad et al. proposed a system in Enhanced Watershed Image Processing Segmentation. The image was first converted to grayscale, then the canny edge detector was applied. Finally, after some minor processing for enhancement, watershed was performed. The segmentation was assessed by comparing each item in the actual segmentation with the object in the marker-controlled watershed segmentation or the recommended method. The proposed method improves the marker-controlled watershed's result [11].

Ramadevi et al. [12] discussed the connection between object recognition and image segmentation (using several edge detection approaches). Edge detection methods such as Laplacian of Guassian (LoG), Sobel, Prewitt, Roberts, and Canny are used to segment the image. Three distinct approaches were used to demonstrate the relationship between the object identification and segmented images: expectation-maximization (EM), OTSU thresholding, and genetic. Anticipation: The optimization and OTSU methods both demonstrated the steady segmentation effect.

A range of image segmentation techniques that may be used with security architecture were discussed by Nagabhushana Rao, et al. in [13]. Edge detection is the most often used technique for locating notable discontinuities in gray level. A comparison of many picture edge detection techniques was shown using fingerprint photographs. An examination of the images reveals that Prewitt, Sobel, and Laplacian perform best, in that sequence.

Evaluating the Chromosome G-band Edge Detection Quality For the Segmentation technique, Wayalun et al. [14] recommended using edge detection of chromosomes in G-band type pictures. It is an essential preprocessing step for segmentation. A poor quality image of the G-band chromosome is one that is noisy. The identification of edges formed by chromosomes may easily trick the edge detection algorithm. This study presented on the analysis of evaluation chromosomal G-band image edge detection. It has been seen on chromosomal image type G-band using four different methods: Canny, Laplacain, Robert's, and Sobel. The results of their investigation show that Robert's method produces the greatest accuracy when compared to the other three algorithms.

V. WATERSHED SEGMENTATION

A novel technique for picture segmentation utilizing mathematical morphology was suggested in a watershed transformation algorithm by Belaid et al. [24]. The watershed transition served as the basis for the strategy. They suggested modifying the topological gradient approach to prevent oversegmentation. Good results are obtained by combining the watershed transformation with a quick technique based on the topological gradient approach.

Dey et al.'s [23] paper, Robust Watershed Segmentation of Noisy Image using Wavelet, discussed the use of wavelet thresholding, a highly powerful de-noising approach. Because the soft thresholding approach performs better than other de-noising methods, it was utilized to examine the de-noising system methods for various degrees of DWT decomposition. This research demonstrates that region-based Watershed Segmentation on noisy images may get extremely good results by using soft threshold wavelet.

A quick watershed transform that identifies prominent items in a picture was suggested by Thenmozhi et al. [22]. Because it was not dependent on mathematical morphology, this transformation was completely distinct from classical watershed. First, the picture pixels were sorted by intensity levels and then stored in the appropriate FIFO structure. The chain coding algorithm was used to achieve this technique. It also outperformed all previous watershed algorithms in terms of speed. rapid Water Snakes are a novel segmentation technique that arises from integrating this rapid watershed with energy-based segmentation. Without the use of markers, it reduced over- and under-segmentation caused by thick watershed lines.

By drawing inspiration from the friction ridges on a human finger, Acharjya et al. [19] developed a highly helpful image segmentation approach for finger print segmentation that also included an efficient storage capacity for the segmented pictures. The Watershed Algorithm relies on ridges for accurate segmentation; this need is often met in contour detection, where object boundaries are represented by ridges. For the aim of segmentation, the watershed algorithm idea was used. One of the main areas of worry was the volumes of the databases. In order to minimize the size of the databases, they had so saved the segmented fingerprint photos rather than the original photographs.

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An technique based on combining the results of morphological watershed analysis with improved edge detection analysis was presented by Siddiqui et al. [21]. The watershed technique's overall performance was improved by using the color histogram approach as a post-processing step to each of the segmented sections that were created. For photos with degradation, the suggested technique improved the outcome of marker-controlled watershed.

Acharjya and colleagues (2021) presented a novel watershed algorithm technique that applies distance transform to picture segmentation. They obtained an overly segmented picture after using the Watershed Algorithm. The picture's edges were found using the watershed approach with Laplacian of Gaussian (LoG) edge detector, which resulted in a less overly segmented image.

An technique for counting various blood cells during a blood smear test was described by Tulsani et al. [18]. The segmentation method based on morphological watershed transformation was the one that was presented. Masks were created using morphological processes, and cell segmentation was accomplished using marker-based watershed transform. The morphological operators and color conversion may be used to easily get the masks for each kind of cell. The over-segmentation issue related to the watershed transform was resolved via marker-based segmentation. In order to reduce the over segmentation issue, Acharjya et al. [15] proposed an efficient method of digital picture segmentation using the watershed algorithm. For smoothing, a gaussian 7x7 mask was used. Using the Watershed technique, the final segmented picture was produced. The end product, or segmented photos, demonstrate that the strategy of minimizing over-segmentation has been successfully implemented.

A hybrid strategy was developed by Vijayran et al. [16] to carry out the picture segmentation. The adaptive threshold technique, the watershed algorithm, and morphological operators were the methods discussed. In addition to defining the fundamental segmentation techniques, a novel hybrid was introduced that enables efficient segmentation. The crucial visual aspect known as thinning was the center of attention. The purpose of the thinning procedure is to pinpoint the lower-level feature extraction and internal picture processing. The pre-processing methods used in this study comprised the median filter; the region selection and distance measure for the feature point identification; the watershed and morphological operators for the edge detection and region identification; and the threshold for the area exclusion. The results demonstrated how well the split region worked throughout the picture.

Acharjya and colleagues [17] introduced a novel method for segmenting images and detecting edges. To lessen the excessive segmentation issue, the watershed method was used together with twelve brand-new, random structure components and morphological smoothing operations. Because the structural element acts as a seed or needle to gather picture information, this is the fundamental idea behind employing it in mathematical morphological operations. The statistical analysis was presented, and the segmented pictures using the suggested technique produced superior edge detection accuracy and also minimized the over segmentation issue, according to the visual perception study.

VI. CONCLUSION

Digital image processing is the process of modifying digital photos using a digital computer. The many DIP technique types that have been documented in the literature are examined and discussed in this research. By combining edge detection, segmentation, and compression, the DIP technique yields better compression ratios and image accuracy.

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