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Image Compression Using Improved Method

Abstract: - Effective use of digital images requires certain techniques to lower the number of bits needed to represent them. The goal of compression is to reduce the size of an image while maintaining its information and originality. This research aims to achieve this target by developing a fuzzy logic and histogram-based image compression type detection approach. The main goal is to provide an approach that employs fuzzy logic and graphs for detecting the type of image compression. In order to decide the compression technique depending on the number of color levels in the image which was recovered with the use of histogram, the suggested technique combines a new combination of fuzzy logic as well as image histogram analysis. The experimental findings demonstrated the suggested technique's robustness and efficiency in detecting the best approach for each type of image compression. After 75 images with varying color densities were evaluated, the system's compression rate was approximately 95%. In addition to being a significant contribution to image processing, the study finds practical applications in the following areas: remote sensing through satellite; facsimile transmission of medical images in computer tomography magnetic resonance imaging; teleconferencing systems; military communication systems via radars; geological surveys; and communications systems built by computers.

Keywords: image compression, histogram, fuzzy

1. Introduction

Because image compression helps with the efficiency of transmitting, storing and retrieving images, it is an important area of study in the field of image processing science. [1]. There have been many kinds of image compression methods made during these years, like JPEG, PNG and GIF. Each method has its own good points as well as some problems that come with it. A difficulty within image compression is the capacity to identify what kind of compression an image has gone through, something very important in digital forensics and assessment of image quality [2].

In the presented research, we use lossless compression and propose a different way to measure the size of image compression using histogram and fuzzy logic. The method that is suggested combines the strengths from both techniques which results in more precise classification results with increased strength against noise. The analysis of histogram can help in extracting features from compressed image such as color distribution and frequency information. After this, fuzzy logic is used for representing the uncertainty and imprecision in classification due to aspects like noise, differences between compression methods and image quality.

The technique that is suggested could be utilized for many practical uses in the real world. For instance, it can help with checking image quality or finding images based on their content. This technique also has the possibility to enhance how accurately we detect image compression using methods currently available to us. The findings from this study might lead to better methods of handling images and enhance people's ability - both practitioners and researchers - in assessing and understanding compressed images more effectively.

2. Image compression

The procedure of making an image smaller in size but still maintaining its quality is called image compression. In this section, we discuss different types of image forms and methods for compression. The manner by which a lot of data is sent and kept regarding digital images is known as image compression [3].

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Compressed images load faster than uncompressed images. This matters because the speed at which webpages and applications load has a huge impact on SEO, conversion rates, the user's digital experience, and other crucial metrics. Improving web performance is one of the major ways that developers optimize websites.[4]

There are two main types of image compression: lossy and lossless. Those change depending on how the image file is resized. The latter makes sure that the quality of the image is maintained, whereas the former reduces the size by removing specific elements.[5] Our approach to this study is lossless.

3. Histogram

A histogram can be defined as a type of bar chart which displays the frequency or quantity of data inside various bins, or numerical ranges. Typically, the bins are given as non-overlapping, consecutive intervals of a variable. It represents the frequencies regarding observations occurring in specific ranges of values, and is utilized to evaluate the probability distribution of a particular variable in rough terms.[6] One technique for image compression which could increase redundancy is histogram equalization. Large-scale image transmission and huge image storage in databases both benefit from image compression. A performance analysis of the various image compression techniques is suggested using the histogram equalization-based approach. [7]

In this research it used histogram to detect the range of color in every image then use the fuzzy to determine type of compression method that will be using to compress image.

4. Fuzzy logic

Any real number between 0 and 1 can be the truth value of a variable in fuzzy logic, a type of many-valued logic. It is used to deal with the idea of partial truth, in which there is a possibility that the truth value could be anywhere from completely true to completely false. The idea behind fuzzy logic is that individuals tend to base their conclusions on non-numerical and imprecise information. The term "fuzzy" refers to mathematical representations of imprecise and vagueness information, such as fuzzy sets or models. Those models possess the ability to recognize, manipulate, represent, use and interpret ambiguous and imprecise information and data [8]. The foundation of fuzzy logic is sets. A few linguistic factors that define the potential state of the output are represented by each set. It is an approach to decision-making that involves more than just simple yes or no values. Instead, it utilizes a fuzzy set and a computer process that can understand natural language. The system operates on the principle of assigning individual output based on the probability of an input state.[9]

There are different types of fuzzifiers in fuzzy logic such as singleton fuzzifier, Gaussian fuzzifier, and trapezoidal or triangular fuzzifier.[10]

Fuzzy logic can be used in image compression to enhance image quality and increase the PSNR value of compressed images. It can also reduce errors.[11].

If we apply "if-then" rules, it is possible for the Mamdani approach to handle complex problems with fewer uncertainties (Jang, 1993). A Mamdani FIS has four main stages: fuzzification, rule evaluation, aggregation and defuzzification. The base of fuzzy set theory gives a method to use fuzzy inference systems (FIS), which aids in producing a clear result when provided with crisp inputs. At first, when Mamdani fuzzy inference was introduced there, it served as a method to create control systems. The process involved merging a group of linguistic control rules that had been gathered from skilled human operators. In every rule within the Mamdani system, it creates a fuzzy set.

In this research use fuzzy to choose a prepare compression blocks.

5. Related work:

1- R. D. Dharaskar and P. R. Deshmukh, 2012. In this paper, a method is suggested to identify the types of JPEG and JPEG2000 compressions by using fuzzy C-means clustering coupled with histogram analysis. Fuzzy C-means clustering is utilized for splitting the compressed image according to color similarity into various regions whereas histogram analysis helps in gathering characteristics from every area [12].

2- M. M. Islam and M. A. Islam, 2009 - This article suggests a mix of fuzzy logic with statistical moments as a way to find out about image compression types (Islam & Islam, 2009). The authors apply fuzzy logic for handling uncertainty and imprecision during classification, then they use statistical moments for feature extraction from the compressed image [13].

3- R. Priyadharshini and S. K. Srivatsa, this research indicates that wavelet transform and fuzzy logic can be used jointly for identifying what type of image compression is being utilized. The writers clarify they utilize fuzzy logic for modeling the imprecision and uncertainty in classifying process, then wavelet transform assists in getting details from compressed image. [14].

Those researches have highlighted the importance of uncertainty and imprecision resolution in the process of classification, in addition to demonstrating histogram analysis and fuzzy logic potential for the identification of various image compression forms.

4- F. I. Abbas, et al., 2020. This paper gives an idea for finding out illnesses that affect wheat. This is crucial because food protection, one of the main concerns for human existence, depends greatly on maintaining healthy crops such as wheat. In handling large farming regions, farmers rely heavily on the systems and methods they have at present. The study suggests utilizing fuzzy-logic based histogram equalization (FHE) for improving image contrast. The subject method was tested with subjective metrics. It has been verified to give better results by enhancing contrast and preserving image details. The method's assessment was done using MSE and PSNR as measuring tools. For Mildew Powdery disease, the best outcomes were MSE=0.071 and PSNR=39.58 [15].

5- M. Veluchamy and B. Subramani,2020. This research suggests using techniques based on histograms for intensity transformation. But, doing this might result in excessive improvement of the dominating parts in histogram and a decrease in visual quality. To solve this issue, it is advised to apply Fuzzy Dissimilarity Adaptive Histogram Equalization with Gamma Correction (FDAHE-GC) technique. This method uses a fuzzy dissimilarity histogram (FDH) to help enhance the contrast of an image while preserving its natural features and extract intensity mapping functions. To highlight dark areas, we apply gamma correction. The suggested method displays superior performance in comparison with prior methods as verified by various tools for image quality assessment [16].

6- N. Tu Trung,X. Hien Le and T. Manh Tuan,2023. For enhancing images obtained from satellites, this work introduces a new technique called remote sensing image enhancement based on cluster enhancement (RSIECE). Clustering of the input image is done using fuzzy semi-supervised clustering and the cluster is used for estimating lower and upper bounds. Then, via an enhancement operator, a sub-algorithm for cluster enhancement is implemented which converts the gray levels for every channel (R, G and B) to produce fresh equivalent gray levels. Together with the matching cluster membership value, the output gray level value comes from combining improved gray levels. As found in tests, RSIECE algorithm performs better compared to some newly created methods [17].

7- C. Stud Angalakurthi, R. Nallagarla, 2021. A creative medical method to observe the inside structure and tasks of human brain, heart, knee, liver etc. is called magnetic resonance imaging (MRI). Traditional magnetic resonance scans are now needed for better diagnosis but their resolution is often not enough. This causes problems in getting precise and complete information from these kinds of tests. Thus, the study suggests using concepts of compressive sensing (CS) and fuzzy logical rules to enhance data quality for super resolution (SR) of MR brain images. It is a difficult work but the suggested technique uses compressive sensing to study a relatively small number of images and applies fuzzy logical rules for a certain membership function to improve image resolution. Various criteria are examined in order to evaluate how effectively this proposal can produce better outcomes [18].

6. Proposed system and results

The method that is put forward pays attention to finding the right compression type, depending on an image's contrast. A set of images are sorted into groups based on their details, size and type. After this classification was done, we extracted histogram from image. To determine the contrast value of an image, fuzzy logic equations were used. At last, the right filter for compression is identified. In this study, three filters are chosen according to the size of binary matrix used: 2*2, 3*3 and 4*4 blocks. An algorithm is given below that explains the method suggested:

Algorithm: POCS //proposed compression system
Input: color image.
Output: compressed image by apply one of these block size 2x2, 3x3, 4x4.

Step1: Convert the image to a grayscale format.

Step2: extract histogram from images.

Step3: Determine the contrast value of the image using fuzzy logic equations, which take from histogram as input.

Step4: Classify the image into one of three compression types based on its contrast value: low, medium, or high.

Step5: Choice compression type on image by selects an appropriate compression block size: 2x2, 3x3, or 4x4.

Step6: Apply selected compression block on image to compress it.

Step7: Save the compressed image then apply uncompressing to return to original image.

Step8: End.

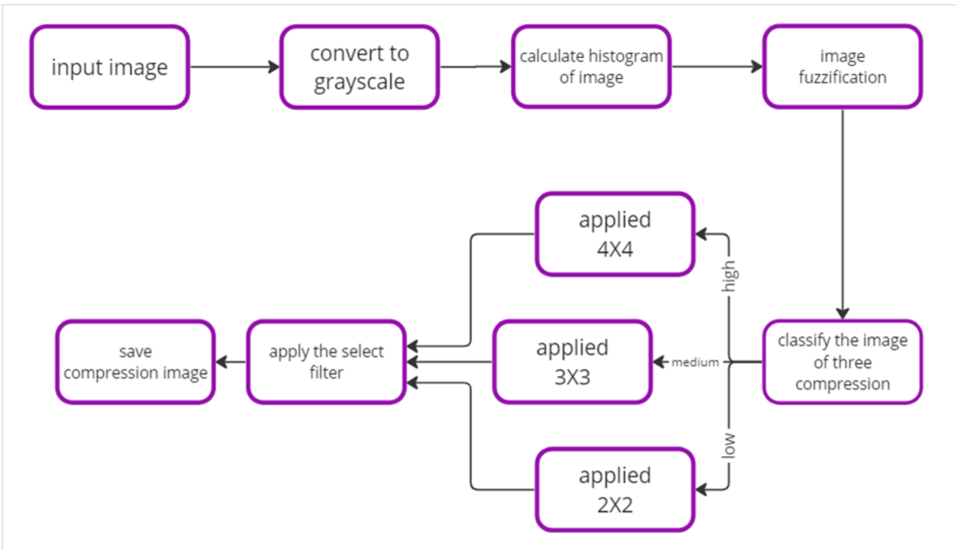


Figure (1): describe algorithm of proposed system.

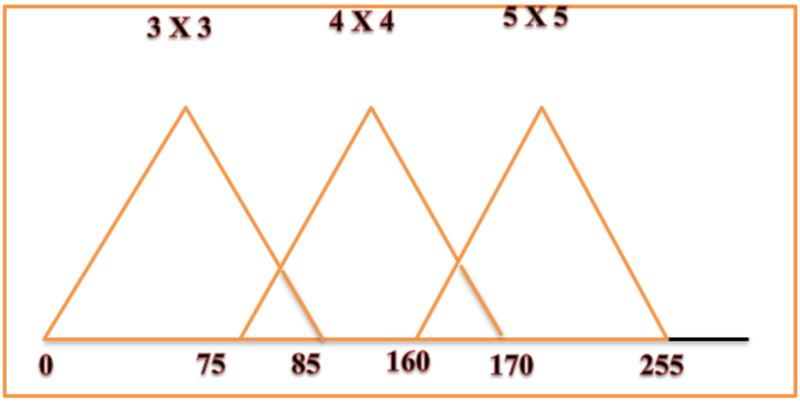


Figure (2): describe fuzzy algorithm for proposed system

7. Image Compression ratio

Since image compression eliminates redundant data, it lowers the amount of data needed for representing a digital image. It entails shrinking image data files while keeping all relevant information. In mathematical terms, this entails converting a 2D pixel array—that is, an image—into a data set that is statistically uncorrelated. The alteration is done before the image is transmitted or stored. In order to reconstruct the original (uncompressed) image or an approximation of it, the compressed image is later decompressed.

The Compression Ratio (CR) can be defined as the ratio of original (uncompressed) image to the compressed image:

$$C_R = \frac{Uncompressed\ Image\ Size}{Compressed\ Image\ Size} = \frac{Usize}{Csize}$$

Where:

$$Usize = M \times N \times k$$

$$Csize = size\ of\ compressed\ image\ file\ stored\ in\ a\ disk$$

M, N are the original image's dimensions, and K is the number of bits per pixel. An 8-bit image with 256x256 pixels is an example of this. The image size after compression is 6,554 bytes. Next, calculate the compression ratio by:

Usize = (256 × 256 × 8) / 8 = 65,536 bytes

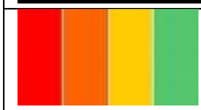
Compression Ratio = 65536 / 6554 = 9.999 ≈ 10 (also written 10:1) This means that the original image has 10 bytes for every 1 byte in the compressed image.

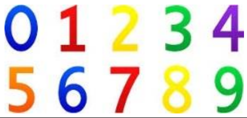
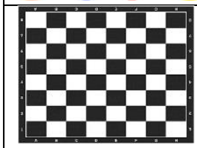
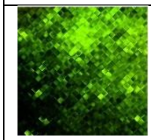
8. Experimental result

In this experimental of the proposal system, we use **23** different color images varying in size, number of color level, and details, table 1 show sample of the images and its property.

Table 1: sample of images that used in experimental result

Image	Image No.	size KB	resolution	No. of color
	"001"	1066.25	1280x853	180
	"002"	1066.25	1280x853	168
	"003"	963.75	960x1028	210
	"004"	878.75	1280x703	163
	"005"	1066.25	1280x853	213

	"006"	2373.04	1800x1350	256
	"007"	1066.25	1280x853	171
	"008"	1066.25	1280x853	182
	"009"	1066.25	1280x853	170
	"010"	1066.25	853x1280	129
	"011"	1063.75	1280x851	153
	"012"	1054.68	1200x900	189
	"013"	8.230	98x86	1
	"014"	791.016	900x900	103
	"015"	4800	2560x1920	80
	"016"	413.965	900x471	23
	"017"	429.258	814x540	168
	"018"	4036.524	1660x2490	254

	"019"	49.252	334x151	204
	"020"	126.563	360x360	139
	"021"	600	960x640	196
	"022"	400	640x640	214
	"023"	750.234	1164x660	195

After implement proposed system, table 2, shows each image and its compressed ratio according to block compression methods:

Table 2: compressed method that used in experimental result

image No.	size KB	2x2 block compression method	3x3 block compression method	4x4 block compression method
"001"	1066.25	55.5	49.4	48.6
"002"	1066.25	56.1	52	51.4
"003"	963.75	61.6	55.7	54.9
"004"	878.75	42.7	38.2	37.1
"005"	1066.25	55.6	49.4	48.6
"006"	2373.04	120	112	106
"007"	1066.25	55	48.7	48
"008"	1066.25	55.8	49.2	48.5
"009"	1066.25	54.7	49.1	48.4
"010"	1066.25	45.4	40.8	39.6
"011"	1063.75	55.9	50.7	50.2
"012"	1054.68	55.1	50.7	48
"013"	8.23	16.4	7.03	3.9
"014"	791.02	40.2	40.3	38.1
"015"	4800.00	106	82.1	70
"016"	413.96	15	14.5	12.4
"017"	429.26	95.5	88.4	84.9
"018"	4036.52	206	192	184

"019"	49.25	196	184	173
"020"	126.56	300	271	244
"021"	600.00	209	194	190
"022"	400.00	318	289	282
"023"	750.23	239	222	212

When applying the proposal fuzzy method to select the proper method of compression. The following table 3 show the best compressed method that selected by system:

image No.	size KB	2X2 ratio	3X3 ratio	4X4 ratio	proposed system selection
"001"	1066.25	19	22	22	2x2
"002"	1066.25	19	21	21	3x3
"003"	963.75	16	17	18	2x2
"004"	878.75	21	23	24	3x3
"005"	1066.25	19	22	22	2x2
"006"	2373.04	20	21	22	2x2
"007"	1066.25	19	22	22	2x2
"008"	1066.25	19	22	22	2x2
"009"	1066.25	19	22	22	3x3
"010"	1066.25	23	26	27	3x3
"011"	1063.75	19	21	21	3x3
"012"	1054.68	19	21	22	2x2
"013"	24.9	2	4	6	4x4
"014"	791.02	20	20	21	3x3
"015"	4800.00	45	58	69	3x3
"016"	413.96	28	29	33	4x4
"017"	429.26	4	5	5	3x3
"018"	4036.52	20	21	22	2x2
"019"	148	1	1	1	2x2
"020"	379	1	1	2	3x3
"021"	600.00	3	3	3	2x2
"022"	400.00	1	1	1	2x2
"023"	750.23	3	3	4	2x2

9. **Conclusion**

In this work, we provide a novel technique for image compression. first it analyzes the histogram of image to determine number of color levels within the image, then according of that number it be use fuzzy logic to analyze and select one of three proposed methods for compression: 2x2, 3x3, or 4x4 to get the best method.

After practical application of the suggested system, the results indicate the quality of work of the proposed algorithm.

It is noted from the table 2 above that some images were subjected to significant compression, unlike the rest, where the compression was less. It is noted that the number of colors within the image has an effective effect in choosing the proposed compression method.

The compression ratio ranges from a maximum of 69:1 to a minimum of 1:1. There are many reasons that we are about to discuss here. It is noted that the larger number of color levels in the image, the lower compression ratio and vice versa.

The size and quality of the image also effect on the ratio and amount of compression of the image, as it was observed that some images reached a compression ratio of 69:1, while others are much less than that reaching a ratio of 1:1, which means there is no compression, or by such a small amount that it is neglected.

Some images appear to be less than their original size after compression, and the reason is due to two important things: the first is the large number of color gradients in the image, and the other is the fact that the image was originally compressed, or is a space image, or is an abstract image.

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