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Perspective Study of Color Quantization Techniques

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Abstract—

Image quantization is a process which helps in keeping image in computer with less space by depleting the count of colors in it so that it can be stored in computer using less space and Image is quantized such that perceived difference between original and quantized image is as small as possible. Basically Image Quantization is used in devices where storage requirement is small and it is used for displaying images in devices which support a few number of colors and also used to reduce the transmission bandwidth in multimedia applications. Image quantization has been implemented using different algorithms, mainly clustering and splitting algorithms has been used. In Splitting algorithms, by using some criteria the color area of original image is divided into two decouple cells. After that Unless the required number of cells not acquired, the splitting method is repeated. Then, the choice of cluster heads of the cells is made to be the illustrative colours in a color map and in Clustering algorithms we assign colors into group so that colors with similar properties are placed in one group and can be differentiated from the colors of other group. Two types of clustering algorithms are used which include pre-clustering and post clustering. Commonly pre-clustering approach is used because it do not require complex interrelationship between color clusters. Different techniques have been used to implement Image Quantization using these algorithms. In this paper these algorithms has been discussed and the performance of Image Quantization techniques have been compared on the basis of these algorithms.

Keywords-- ***Quantization, Splitting Algorithms, Clustering Algorithms, Median Cut, BBO, CL, BFO.***

I. INTRODUCTION

Digital Image Processing is basically processing of Digital Images by means of digital computer. Images are captured and stored in digital computer and their processing produces modified version of these images. Images can be of any type they can be monochrome images, Grey scale images, Color images and half toned images and these are manipulated by computer algorithms are written in computer to process these images. Various applications of digital image processing are Office Automation, Bio-medical fields, scientific applications, information technology, printing and graphics art etc.

Image quantization has very important applications in Image Processing. It is a process which helps in decreasing count of colors in an image so that less memory is needed for to store it and quantization is done such that the perceived visual difference between the actual and processed image may be as small as possible. This process can be implemented on documented color images as well.

Assume P be the actual image shown by

C= {C[p], p=I, II...M} and q be the quantized image represented by

D= {D[q], q=I, II…N} such that N<M and quantization is a mapping from C->D such that every color of picture P of CS is mapped into decreased color set q. Nearest neighbour principal is used for this mapping.

Color quantization can be implemented on colored text documents or any colored picture. According to this technique, we first look for the original count of colors exists in the picture. Then, a choice will be made for a color model such as RGB, LAB, and CMY etc. Then, the distance between the color and their closeness is judged by utilizing variety of distance formula methods. Colors are dropped which are far off and mapping is done on close colors. Decision can be made on count of colors present in an image and when to end its further depletion of colors based on specific requirement.

Image quantization has important applications in computer graphics and image processing and also used in devices where memory requirements are small like in mobile phones etc and it is loosy compression techniques. It is used for displaying images in devices which support a few number of colors and to access quantization techniques human perception, run time and memory requirements are considered.

The main objectives of this research are:

- To reduce the space requirement for storage
- To reduce full color image to image with small color palate and the perceived difference between the original and quantized image should be small.
- To improve the level of document image so that we can contrast between the image and text wrapped over it.
- To reduce transmission bandwidth in multimedia applications.

Commonly used algorithms for image quantization are splitting algorithms and clustering based algorithms.

II. SPLITTING ALRORITHMS

In Splitting algorithms, by using some criteria the color area of original image is divided into two decouple cells. After that Unless the required number of cells not acquired, the splitting method is repeated. Then, the choice of cluster heads of the cells is made to be the illustrative colours in a color map.
Algorithms include

A. Popularity algorithms

These algorithms split the color space into much compact regions, rather than splitting the color area into 256 regions The representative of the region is chosen by taking the average of color mapped into it. In this algorithm, popular color regions in the picture is finded to generate the color map. Then, the histogram is focused and the highest occurrences colors are picked to become the final members of color map.

B. Median –cut algorithm

This algorithm split the color area into two parts. The inclination of cutting area is normal to one of the coordinate axis with a sizeable range of image pixels. For divion, the Median of colors space is considered. When the required number of colors are completed then finally the operation is completed. The process of median cut is as following [1]:

1. Discover the tiniest box having the entire colors in the image.
2. Arraange the surrounded color along with the lengthiest axis of the box.
3. Break the Box into 2 regions at median of the arranged record.
4. Until the primary color area has been splitted into 256 region, the above process is iterated.

C. Octree algorithm

There is a octree of depth eight which represent a distinct color on every leaf at depth 8. Assume a k which indicated the limit of leaves on the tree i.e k=256. Putting color on the tree leads to two outcomes.

1. The Color is dripped down the tree until either leaf ree is not reached or It approaches the leaf node denoting distinct color.
2. Intigration of some group of leaves present in the tree is performed if the number of leaves are greater than k and a new color placed in their parents[1].

Octree algorithms are considered best compared with median cut and popularity algorithms.

Some of applications where these algorithms are implemented are discussed:

"Color quantization using modified median cut" by Dan S. Bloomberg. In this research he uses modified median cut algorithm and proved that its result are nearly as good as octree algorithm. In above technique, division of the R G B color area which is performed positively in such a manner that the colors having visual consequence, even a few in number, will be shown representatives into that color map[2].
The results were compared with two pass octree quantizer and was concluded that

1. MMCQ is not better than QQ for rendering small color clusters for example different red and pink in the picture.
2. MMCQ does a perfect job of avoiding posterization for rendering majority color regions.

The reason behind is that it is more rigorous at splitting the color area up in the most laboriously populated regions.

One approach "color quantization using octree" by Dan S.Bloomberg he described methods by using an octree data structure for implementing color quantization on full color RGB pictures.The upper hand of the octree is that it is easy to produce both a nice divisioning of the color area and also a quick inverse color table to look for color index for every pixel in that picture.In both first pass and second pass, octree color quantization were utilized and outcomes were collated with the best median cut algorithms. It will be a s good as it can be done with 256 colors[3].

One approach was "Color image quantization using distances between adjacent colors along the color axis with highest color variance" . This research shows hierarchically divisive color map design strategy using simple splitting algorithm for color picture quantization. [4].

III. CLUSTERING ALGORITHMS

Clustering is an task of assigning objects into group so that object with similar properties are placed in one group and can be differentiated from the elements of other group and in image quantization this approach can be applied to image colors that can
Clustering algorithms are divided into pre clustering and post clustering algorithms.

(1)Pre clustering algorithm: In pre clustering algorithm a color space is subdivided into set of clusters represented by set of boxes with faces parallel to color axis. Pre clustering algorithms go with color spaces of simple geometric properties. It scans the colors one by one and decides if the current color should be merged with the previously formed clusters or starts a new cluster.

(2)Post clustering algorithm: In case of post clustering method first representative colors are found. In this case initial approximation of color palate is assumed and colors of original image are mapped into it. Main advantage of post clustering over pre clustering is that these approaches can work with arbitrary shaped clusters. Examples include K-means algorithm which is also called local minimum and Kohonen self organized map. Research shows that post clustering algorithms require small amount of memory and produce small number of errors but are rather slow.

Some of the clustering algorithms are:

A. C Means Clustering algorithm

Assume a 3-D data set of points y=(yR,yG,yB) includes the red, blue and green component of a color pixel y and that area included the color Histogram of a picture and is known as the color space. Another color area can be achieved using linear transformation that can be more adaptive to the human visual system. By clustering the color area into a given count of clusters sK, color quantization is achieved. Each cluster is shown with single representative color rK=(rKR,rKG,rKB). The group of cluster representatives {rK}, K shows a color palette of the quantized picture.In mapping of pixel, every color pixel is having one of the cluster and take a place with the representative of that cluster. with minimizing the following objective function, Optimal quantization is achieved.

B. The competitive learning algorithm

In this technique, sequential order os followed to present colors. This presented order is choosen randomly from the color. If the color y belongs to the given set then the closest cluster center moves in direction of x while all remaining at their same positions. This initialy guarantees arrangement of the cluster centers globally and After that a fine alteration is required.
Both these algorithm depends upon initial position of cluster center.

C. Hierarchical competitive learning algorithm

This algorithm does not depend on initial conditions and proceed as follows:

1. Starting with a cluster from any random position and the complete Color space can be represented as single cluster with the help of CL.
2. Break this center into two separate ones and again CL is applied on both.
3. Until the required cluster centers not gained, step two is iterated. The splitting is the last step which is to be implemented on a few count of center but only if the required number of clusters is not matched with a power of two.

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Various approaches have been used to implement image quantization using these clustering algorithms. Some of them are discussed below:

It has been implemented using" Local K means algorithm for window system" by Oleg Verevka and it explains that for efficient quantization with window system, post clusterinh can be a one solution. In this paper he described that in window environment applications share common color map. Window reserves small number of K* colors for its own purpose such as window border, icons etc. image is quantized if its palate is > than (K-K*). In research it was assumed that window system displays 256 simultaneous colors and K*=104 entries. For each displayed image simulated application produces a small palate with 32 colors.
This algorithm solves quantization problem within window systems. This problem can also be reduced to general image quantization problem but we have to choose desired palate according to already allocated colors. [5]

It has also been performed as "Color quantization in document images using biogeography based optimization" in that species are assigned among adjacent island and quantization is performed with this approach in which faraway colors slide to more near color islands. using this technique first noise was removed from images using filters then edge was detected for text using the marr-hildreth edge detector and the canny edge detector. Then, at last color quantization was done using BBO approach in L*A*B color area. There approach is a Population based optimization algorithm mainly looked on the distribution of species among adjecent islands and goes along with similar steps as evolutionary algorithms to find near-optimal results which known as Biogeography based optimization. In this color quantization results were optimized based on theory of immigration of BBO approach.
This method has improved the quantization process in document images. Results of this are shown below. [6]

Original image Quantized image [6]

It has also been implemented with AI technique "Optimization color quantization in L*A*B color space using Particle Swarm Optimization". Particle Swarm Optimization is concept taken from collection of particles. Movement of each particle is determined through the search area by integrating a few aspect of the history of its own best and current locations with those of one or more members of the swarm. The next turn takes place after all particles have been passed. The swarm as a whole is likely to move close to an optimum of the fitness function. The main learning stratagem of PSO is that the solution will be the position of each single. Finally, the solution of each single particle is changed with the reason of its own finest experience and other individuals' foremost experiences.
This concept is implemented in L*A*B color space in which first the color image to be quantized corresponding to which color map is generated from which little set of colors are selected from all combination in L A B color space and algorithm is applied to get desired optimization.[7]
Experimental results of this approach are as following:


Original image Quantized image

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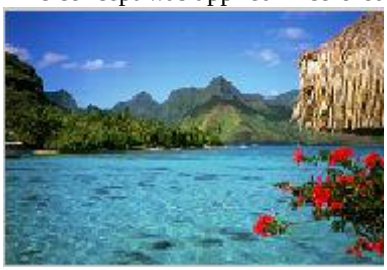
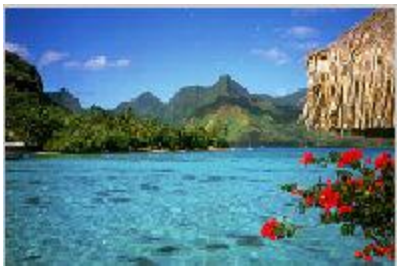
One more technique is "A Gamut preserving color image quantization"which focused on image based color gamut sampling of L*A*B color area that conserve the color gamut shape of a picture. This technique includes 6 steps, divide and merges technique. In very first step uniform-sampling of L* A* B* color area is implemented based on a sphere packing strategy. The 2nd pace includes on deleting all samples which do not relate to the gamut of the L*A*B* color space. The third includes on over-sampling the L*A*B* color space when the color distribution of the picture around a sample is not correctly shown by only a single sample. In fourth step sub-sampling the L*A*B* color space is done when the color distribution all over a sample is empty. In 5th step two most representative color samples are selected. At last refinement of the couple of color samples is performed in order to build it more representative of the color image gamut. [8]

In another approach "color image quantization using BFO" swarm intelligence technique Bacteria foraging optimization is used which is based on the concept that to boost energy gained per unit time, EColi Bacteria look for nutrients according to that. For communication purpose, each bacteria sends signals to other bacteria which includes fectors bacteria takes foraging decisions.Processes which are part in this algorithm are:
Chemotaxis in which bacteria take little steps while looking for nutrients and in this process EColi slides from two processes tumbling and swimming. Bacteria can float for an interval of time in identical way or it may tumble and alternate among 2 modes of operation for the whole life journey. Second method is breading in a way delicate bacteria pass away and healthy bacteria breaks it in two bacteria.
Final process is extinction and dispersal in that proces bacteria can be wiped out from region of high concentration of nutrients due to sudden changes that occurs which may be the rise in temperature.[13]
This concept was applied in colored images the results are show below:



Original Images



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Quantized Images

Conclusion

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In this paper different splitting and clustering algorithms for image quantization has been discussed using different techniques and approaches and it was concluded that effective results were provided by clustering algorithms as compared to splitting algorithms. Pre-clustering algorithms are preferred over others because they do not require complex interrelationship between color clusters and post clustering algorithms are used for quantization within window systems as they preserve image quality even when many images can be displayed simultaneously and these algorithms require small amount of memory and produce small amount of errors.Splitting algorithms, on other hand, leads to discontinuities and are time consuming.

Clustering algorithms have been applied to color images and has provided effective results. These can also be applied to color document images.

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