Design and analysis of Contrast Enhancement of an image using DCTCS in Parallel computing environment using MATLAB

Kunal Gupta[1*], M. Madiajagan[2], Nipunn Miglani[3], Shrivats Agrawal[4]

[1,2,3,4]SCOPE VIT University, Vellore, 632014, Tamil Nadu, India

[*]*Corresponding Author: kggupta842@gmail.com, Tel.: +91-9467770006*

Abstract: For a wide variety of applications, image contrast enhancement is very essential. Thus, it is imperative to have a low-cost, highly efficient and quick image contrast enhancement tools. In the past image contrast enhancement has always been performed sequentially on one core. With the advent of multi-core architecture in computers, it is now possible to perform tasks concurrently which do not have task dependencies. Parallel MATLAB Toolbox is an additional functionality provided by MATLAB which utilizes the parallel capabilities of modern day computers by allowing us to resolve computationally and data-intensive problems using multicore processors, GPUs, and computer clusters. Image processing and contrast enhancement are fields which could greatly benefit from parallelization to improve performance and achieve speedup. These applications have the potential of high degree of parallelism and thus are a exceptional source for multi-core platform. Parallelization aims at taking less time and making better use of available resources for time intensive and real time jobs. This paper aims to use Parallel MATLAB Toolbox to parallelize the process of Discrete Cosine Transform and coefficient Scaling.

I. INTRODUCTION

Image Processing and Applications: Information perceived by the eye is pivotal kind of information, processes plus used by the human brain. A huge portion of the human brain is devoted to the processing of visual information.

In Computer Science, the use of digital image processing in computer algorithms is in performing image processing on digital images. Digital image processing has a wide array of advantage over conventional analog image processing. Due to being processed on a digital device, digital signals can take advantages of a huge variety of algorithms which can transform the image radically depending on the application. Furthermore, build-up of noise and distortion of signals is also significantly reduced as compared to analog processing.

Representation of images in different domains:
Images can be effectively represented in various domains such as Spatial, Fourier, Wavelet, Radon, Hough etc. Transformations are required to convert the image from one domain to another. Generally, the images are represented in a spatial domain but some types of processing in this domain prove to be very computationally expensive, which can be done with a lot less computational power in other domain. Thus, to make these processes

easier and less computationally expensive images are transformed from one domain to another using various transformations.

Domain transformations in many cases also give extra information about an image and can offer compression and reduced overall size of the image [1].

In this paper, we deal with the conversion of image from spatial domain to the frequency domain for performing coefficient scaling and vice versa.

II. RELATED WORKS

A. Spatial Domain
The most well-known portrayal of the value of a pixel and it's location is spatial, it shows up in three measurements (x, y, z). The value of pixel and it's location in this space is generally alluded to by the x coordinate to represent the column, y coordinate to represent the row and the z coordinate to represent the value and is known as the spatial area. In any case, a pixel's value and location can be written in the form of other domains too.

Grid of pixels makes up a digital image. Pixel is the smallest element of an image. Every pixel of the image matches to any one particular value called pixel intensity. Different the location of a pixel, different would be the intensity that varies with location of pixel [2].

The word '**Spatial**' is used to denote space. With respect to an image, the space is a 2-Dimensional plane (x-y plane). Therefore, **spatial domain** denotes the plane of the image. The processes performed in the spatial domain are directly built on adjusting the pixel values. Spatial domain methods are constituted as:

$I1(x,y)=T[I(x,y)]$

B. Frequency Domain

In digital image processing, frequency domain represents, every point in the spatial domain of an image contains a particular frequency. Rationalize; it is actually the study of the change in values of pixel in an image. These changes in frequency domain thus, are cause of change in shape of an image (spatial distribution). Edges reflects high frequency component; smooth regions have low frequency components.

In the frequency or Fourier domain, the sinusoidal relationships and curves depict the value and location of the pixel. These relationships and curves are contingent on the pixel's frequency present within an image at a particular point. In this domain, x- and y-frequencies represents the pixel location and its amplitude represents it value. Transforming images to the Fourier domain can help us recognize which pixel contains more important and relevant information and which are not visible in the spatial or other domains and also find repeating patterns [3].

C. Discrete Cosine Transform

DCT is used to differentiate the image into two categories of varying significance (in correlation to the quality of the image). The DCT works in a parallel fashion to the discrete Fourier transform as an image from the spatial domain is converted to the frequency domain. [7] A sum of sinusoids of varying frequencies and magnitude of an image combined forms the discrete cosine transform (DCT) of that image. The dct2 function is used in MATLAB to find the 2D discrete cosine transform (DCT) of an image. For a specific image, DCT finds application in image compression as it can represent a large percent of the graphically significant information in a small number of DCT coefficients. DCT for these reasons finds recognition as the lossy compression algorithm for images by the international standards [4, 5].

In this project we use the DCT to convert the image from spatial to frequency domain to perform the contrast enhancement using coefficient scaling techniques.

D. Image Contrast Enhancement

Improvement techniques of images have seen wide use in many areas in different fields. Image processing is used as the graphical quality of images is significant for human understanding. Contrast plays a key role in the subjective evaluation and determines the quality of the image along with other parameters. The dissimilarity between the luminance reflected from two adjacent surfaces is contrast. In simpler terms, contrast is the distinction in visual features that makes a particular object pop out from the background or in relation with other objects. Human eye has the capability to fathom perceive contrast which is nothing but the difference in the luminance and color of the object with other things. We can perceive the world similarly regardless of the considerable changes in illumination conditions as our eyes are more responsive to contrast than luminance. Many algorithms have been developed for the purpose of contrast enhancement and have been successfully applied to varied range of problems in image processing [4, 5].

E. MATLAB Parallel Toolbox

Parallel Computing Toolbox in MATLAB is an extension in MATLAB which helps in solving computational problems and problems which require a large amount of data using multicore processors, computer clusters, and GPUs. Parallelization in MATLAB applications is done with high-level constructs such as parallel for-loops, parallelized numerical algorithms, and special arrays. Without the help of CUDA or MPI programming this toolbox can also be used with the software Simulink to execute multiple simulations of a model together.

The toolbox can make use of the complete processing power of multicore desktops by performing applications on different workers (i.e. computational engines) that run on the local machine. The same applications can be executed on a computer cluster without changing the code. Also, this toolbox has the capability to run applications in parallel or in batch. In the field of image processing where millions of computations are performed sequentially with low levels of dependence parallelization using the MATLAB Parallel Toolbox can significantly help us to speed up the process of image manipulation, enhancement, restoration etc [6].

We use the MATLAB Parallel Toolbox to parallelize the process of coefficient scaling in terms of contrast enhancement of the image in the frequency domain. Subsequently it can also be used for image compression and many other applications.

III. LITERATURE REVIEW

Around 20 different research papers regarding Discrete Cosine Transform, Parallel MATLAB Toolbox, Contrast Enhancement algorithms, Parallel Image Processing, etc. were referred for the research. These papers provided the major guidance for the research and have greatly influenced our work. There are a lot of methods and algorithms available for the contrast enhancement of images, but none of them have made use of MATLAB which is a very powerful tool for the same. With the use of papers referring to the use of Parallel MATLAB Toolbox, which is an integrated part of the software, we have been able to further improve the time efficiency of our algorithm.

[1] *Discrete Cosine Transform* Paper have evidently shown the effective use of this simple conversion. But each and every algorithm shown has a sequential approach and no

concern for execution time. Also the different Image contrast enhancement techniques combined in this article have strong and effective results but with no regard to complete resource utilization [5].

[2] *An Edge Detection Method in DCT Domain*, it focuses on using edge detection to avoid Inverse DCT calculations which takes a lot of time and is an improvement in the conventional approach as these calculations are faster. But on the other hand, IDCT gives the entire image back, and the given method gives only the edges [8].

[3] *The Brain Dynamics Toolbox for MATLAB,* the authors discussed The Brain Dynamics Toolbox. This furnishes platform which is interactive and which can be used for exploring such applications in MATLAB. It has support for the most prominent classes of differential equations that come handy in computational neuroscience. But the applications are limited and implementation in fields other than neuroscience is not common [9].

[4] *Dragonfly: A multi-platform parallel toolbox for MATLAB/Octave*, there was an alternative for Parallel MATLAB Toolbox which provides a robust system, which is flexible, interoperable and pellucid. But this requires intensive initializations and data collections before executing and hence, keeping the efficiency of the code in mind, Parallel MATLAB Toolbox was used [10].

[5] *Splicing Detection for Combined DCT, DWT and Spatial Markov Features Using Ensemble Classifier*, feature extraction using three domains, namely, Spatial, DCT and DWT was focused upon. Using these techniques combined, best results was found for contrast enhancements as compared to other picture splicing detection techniques. But, computation time also increases as three different techniques are combined. As the objective of the research is to decrease the computation time while at the same time increasing the efficiency, this was not feasible for parallelization [11].

The papers concerning the Parallelization segment have pointed out the different ways to achieve maximum performance timing from any algorithm. The Parallel MATLAB section has given us an insight into the different toolboxes or frameworks to do the same parallelization in the MATLAB environment. Combining these studies, one can find an efficient, fast (in terms of execution time) and highly parallelized algorithm for image enhancement using MATLAB.

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IV. NEED FOR PARALLELISM

Parallel figuring is a sort of computation within which numerous computations or the running of procedures are completed at the same time. Large problems can be broken down into small problems, which can then be solved in the meantime. Parallel processing can be undertaken in various forms: bit-level, instruction level, data, and task parallelism. Parallelism for some time has been used in high performance computing, yet it's increasing and overwhelming enthusiasm in day to day use can be seen due to constraints placed on frequency scaling. As the cost of power (and subsequently heat generation) by Personal Computers has turned into an issue in the recent time, parallel computation offered a solution and thus has been adopted as the most widely accepted worldview in PC design, principally centred on multi-core processors [12].
In image processing, millions of instructions are performed to manipulate the images whether it be for contrast enhancement, compression or other uses. On a system with sequential architecture the power of the multi-cores is not utilized. By implementing parallelization in the field of image contrast enhancement we can radically improve the computational speed leading to faster rendering and much lesser computation and processing time.

V. DESIGN METHODOLOGY

When there is an image having low contrast, the energy amount is reduced in an image in high frequency regions. For increasing the contrast, we must increase the energy in those regions and thereby giving the image more features and better luminance. These features are clearly visible through edge extraction of the RGB image applied before and after the algorithm. And this can be achieved by scaling up the DCT coefficients. Now this coefficient scaling is applied in the parallel environment using MATLAB for better time complexity thereby decreasing the time taken for enhancing the contrast. After increasing the luminance of the image, Inverse DCT is applied to convert it back to spatial domain. Now the edge extraction of the image is also done to get the idea of how the features of the image have changed with the increase in contrast of the image
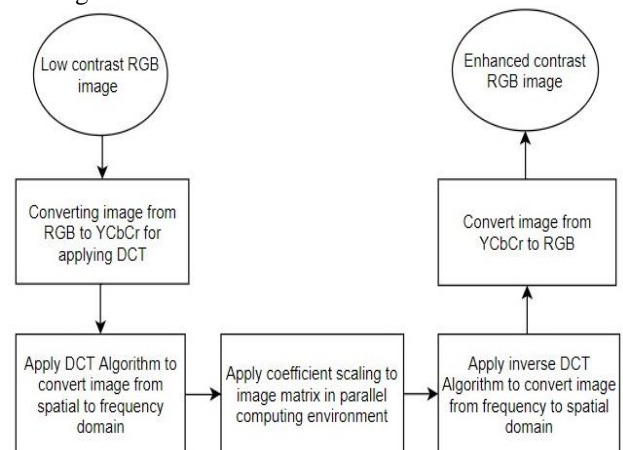

Figure 1: Design flowchart of our algorithm

VI. ALGORITHM

Contrast Enhancement using DCTCS in parallel: This algorithm is divided into two parts, one where the Contrast Enhancement is done using DCTCS and the other part where the instances where this process can be parallelized are recognized and implemented.

Input:
It will be an RGB image of any format (.jpeg, .jpg, .png)

Figure 2: Input Image

Algorithm:
1. Read the input image
2. Perform pre-processing by converting RGB image format to YCbCr image format
3. Apply DCT to image to transform it from spatial domain to frequency domain
4. Coefficient Scaling process has to be applied using parallel MATLAB toolbox
5. Apply Inverse DCT to convert it back to spatial domain
6. Convert back from YCbCr format to RGB format for better contrasting image
7. Contrast Enhanced output image along with edge extraction of the images

Areas of parallelism: The image is first converted to its YCBCR format. The output image is transferred to frequency domain using the Discrete Cosine Transform. Next we apply of Coefficient Scaling to the image in the frequency domain which is an intensive task. This Coefficient scaling has been parallelized in our algorithm.
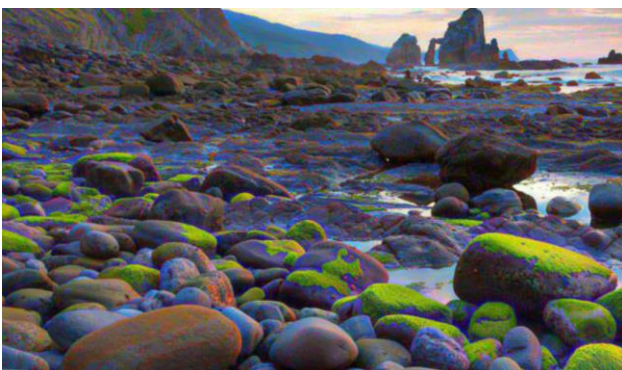
Output:

Figure 3: Contrast Enhanced image

VII. IMPLEMENTATION

The paper we have considered for this project defines a novel method to increase the contrast of an image using Coefficient Scaling in the Frequency domain. The complete process involves steps such as colour code conversion, DCT of the image matrix, application of the coefficient scaling, Inverse DCT and back to RGB. Most of the above steps are high taxing with reference to processor usage and the algorithm execution time can be significantly decreased by adopting parallel schemes. Here we have used MATLAB platform for implementing the proposed algorithm and hence we have parallelized the MATLAB code using the MATLAB parallel platform.

The given model suggests the presence for computation intensive algorithm for Discrete Cosine transform, its inverse, YCBCR transformation, Coefficient Scaling, etc. are long and serialized loops which can potentially be serialized. MATLAB has a parallel toolbox for computing which helps solving computational and problems related to data using multicore processors, GPUs and computer clusters. This concept is applicable for single images and its manipulation. The same model can be applied for videos by taking each frame as a single image. But that would require extremely high quantity of parallelization. The algorithms that we are going to use are DCT transform and IDCT transform. Also we are going to parallelize it using the SIMD concept where the process will speed up by the application of the same instruction on different DataStream at the same time.

VIII. RESULTS AND DISCUSSION

After improving the contrast of input image, performance of the process is subjective to human eye. Our novel method has greatly improved the quality of image brightness and color, it performed better than all other contrast enhancement algorithms. For the purpose of security, image plays a very important role and the ability to process the image is greatly enhanced by our algorithm. Often, many other algorithms produce noise in the image. Although, these disturbances are not easily decipherable by the naked eye, the integrity and the information contained in the image are compromised.

With our algorithm, all the above mentioned factors are taken into consideration and output images are noise and disturbances free. The research paper successfully deals with the parallelization and increase in speed of contrast enhancement of color images using DCT. The results for some sample images are as follows:
1) Before Parallelization:
Elapsed time for contrast enhancement is 2.671159 seconds.

2) After Parallelization using DCT and Parallel MATLAB:
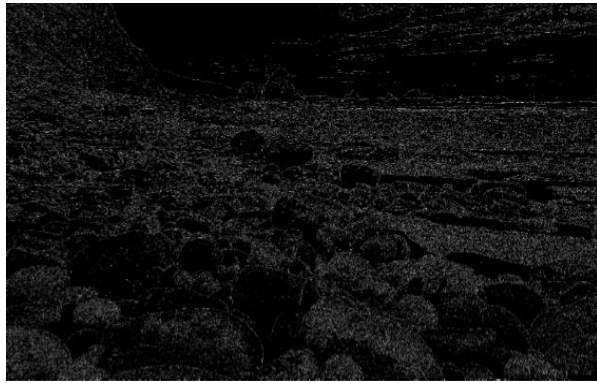Elapsed time for contrast enhancement is 1.767792 seconds.
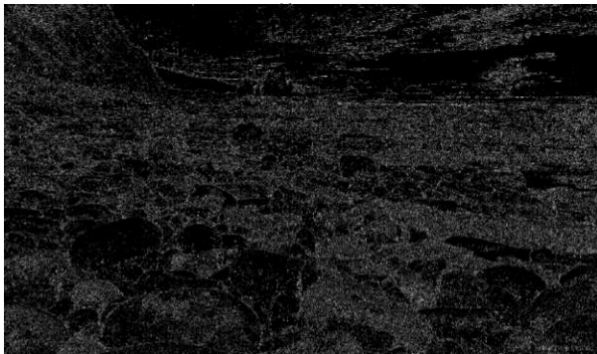
Figure 4: Edge Extraction of Input Image

Figure 5: Edge Extraction of Contrast Enhanced   Image

IX.   CONCLUSION AND FUTURE WORK

Most of the security footage used in the present time is enhanced and processed to make the information more easily visible and extractable. The methods for contrast enhancements existing presently only work upon the brightness of the image and not on the colors of the image. Furthermore, many of these contrast enhancement methods through the process damage the quality of the image. In this research paper a novel method to enhance the contrast for color images using the Discrete Cosine Transform and Coefficient Scaling is proposed. Furthermore, the algorithm is made more efficient by using the Parallel MATLAB Toolbox. The method proposed in the research paper outperforms most of the existing methods in terms of efficiency of resources used by the processors, GPU and computer clusters. Image processing as proven by the contents of the paper will benefit a great deal by the introduction of the concept of high degree of parallelism. Most of the security footage used in the present time is enhanced and processed to make the information more easily visible and extractable. The methods for contrast enhancements existing presently only work upon the brightness of the image and no on the colors of the image. Furthermore, many of these contrast enhancement methods through the process damage the quality of the image [13].

As future work the concept presented in this paper can be extended to enhance the contrast of videos as well in an efficient and a quick way.

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AUTHORS PROFILE

Kunal Gupta, completed his B. Tech degree in Computer Science Engineering from Vellore Institute of Technology, Vellore. He is currently interning at PwC India as an Associate. His major interests include towards Emerging Technologies like Parallel Computing, Image Processing, Artificial Intelligence and Augmented and Virtual Reality.

Prof. M. Madiajagan, completed his B.E. Computer Science and Engineering from University of Madras, M.S. from BITS Pilani, Rajasthan, India. He completed his Ph.D. from BITS Pilani, Rajasthan, India in the year 2009. Presently he is working as an Associate Professor in School of Computer Science and Engineering, VIT, Vellore, Tamil Nadu. He is having more than 25 years of Teaching experience. He published more than 25 papers in many International and National Journals and Conferences and book chapters indexed by Scopus, Elsevier, IOS and many more. His current research areas are Human Brain Computing Interface (BCI), Artificial Intelligence, Deep Learning, Cyber Physical Security(CPS) and ICT. Healthcare

Nipunn Miglani, completed his B. Tech degree in Computer Science Engineering from Vellore Institute of Technology, Vellore. He is currently interning at TCS as a System Engineer. His major interests include Emerging Technologies like Parallel Computing, Image Processing, Machine Learning and Data Sciences.

Shrivats Agrawal, completed B. Tech in Computer Science Engineering from Vellore Institute of Technology, Vellore. He is currently a data science intern at CL Educate Ltd. His interests lie in pattern recognition, NLP and Data Sciences.