Parallel Histogram Equalization

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Introduction

- Histogram equalization is a widely used technique in image processing that improves the contrast and brightness of an image.
- While histogram equalization is a powerful technique, it can be computationally intensive, especially for large images. This has led to the development of parallel implementations of the algorithm, which can distribute the workload across multiple processors or computing units.
- The aim of this project was to develop and test a parallel implementation of histogram equalization and compare its performance to a sequential implementation.

Problem Statement

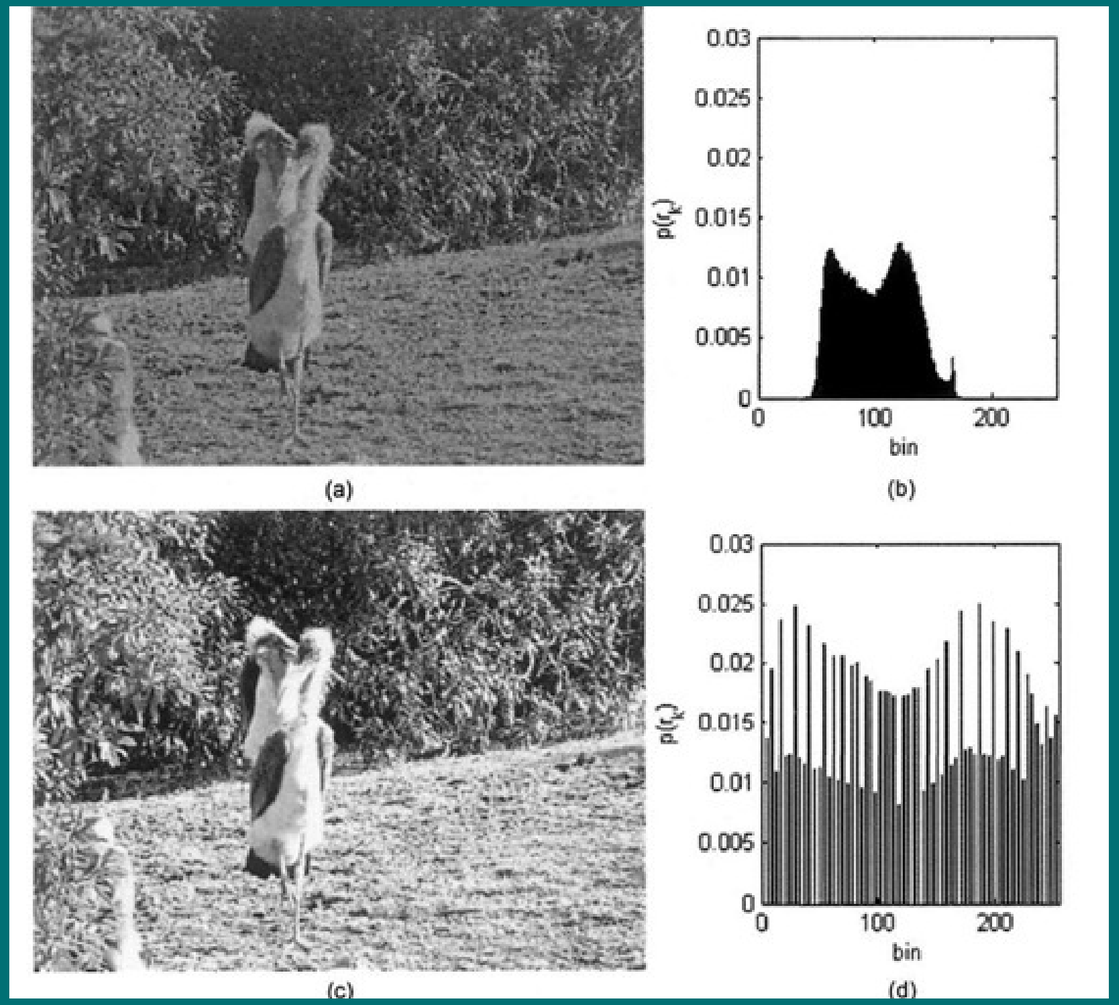
- Enhance the contrast and visual quality of an input image using histogram equalization.
- Sequential implementation of histogram equalization can be computationally expensive and time-consuming for larger images.
- Develop a parallel algorithm to accelerate the histogram equalization process and improve its efficiency for larger images.
- Ensure that the quality of the equalized image remains intact while achieving better performance and faster execution times.

Histogram Equalization

- Histogram equalization is a technique used to improve the contrast and brightness of an image.
- In histogram equalization, the contrast of the image is stretched so that image contrast is maximized by applying a gray level transform.
- Histogram equalization can be done using two methods, Linear stretching and using cumulative distribution function.

Histogram equalization is a simple and effective technique that can improve the appearance of images in a wide range of applications, including medical imaging, remote sensing, and computer vision.

HISTOGRAM EQUALIZATION



- (A) ORIGINAL IMAGE OF BIRD.
- (B) UNPROCESSED HISTOGRAM,
- (C) HISTOGRAM EQUALIZED BIRD IMAGE,
- (D) EQUALIZED HISTOGRAM, EXHIBITING AN APPROXIMATION TO A UNIFORM DISTRIBUTION ACROSS THE RANGE [0-255],

Sequential implementation

THE IMAGE PIXELS ARE PROCESSED ONE AT A TIME, AND THE OPERATIONS ARE PERFORMED IN A SEQUENTIAL ORDER. THIS MEANS THAT EACH PIXEL VALUE IS PROCESSED BEFORE MOVING ON TO THE NEXT ONE. THIS APPROACH IS SUITABLE FOR PROCESSING SMALL IMAGES. HOWEVER, IT CAN BE TIME-CONSUMING FOR LARGER IMAGES.

Parallel implementation

THE IMAGE PIXELS ARE DIVIDED INTO SMALLER REGIONS, AND EACH REGION IS PROCESSED SIMULTANEOUSLY BY MULTIPLE PROCESSORS OR THREADS. THIS ALLOWS FOR MORE EFFICIENT USE OF COMPUTING RESOURCES AND REDUCE THE PROCESSING TIME FOR LARGE IMAGES.

PARALLEL IMPLEMENTATION CAN BE ACHIEVED USING DIFFERENT TECHNIQUES, SUCH AS:

- Task parallelism (This can be done using parallel programming frameworks such as OpenMP or MPI)
- Data parallelism (This can be done using parallel programming frameworks such as CUDA or OpenCL.)
- Pipeline parallelism (This can be done using specialized hardware architectures such as FPGA or ASIC.)

Stages of Implementation

1- LOAD THE IMAGE DATA INTO MEMORY.

2- DIVIDE THE IMAGE INTO SMALLER SUB-IMAGES THAT CAN BE PROCESSED INDEPENDENTLY IN PARALLEL.

3- COMPUTE ITS HISTOGRAM IN PARALLEL FOR EACH SUB IMAGE

4- COMBINE THE HISTOGRAMS FROM ALL SUB-IMAGES TO OBTAIN THE GLOBAL HISTOGRAM OF THE IMAGE.

5- COMPUTE THE TRANSFORMATION FUNCTION BY MAPPING THE GLOBAL HISTOGRAM TO A DESIRED OUTPUT HISTOGRAM (E.G. A UNIFORM DISTRIBUTION).

6- FOR EACH SUB-IMAGE, APPLY THE TRANSFORMATION FUNCTION TO ITS PIXEL VALUES IN PARALLEL.

7- COMBINE THE TRANSFORMED SUB-IMAGES TO OBTAIN THE FINAL PROCESSED IMAGE.

8- SAVE THE PROCESSED IMAGE TO DISK OR DISPLAY IT.

Conclusion

The parallel histogram equalization project is a promising technique for enhancing the contrast and visual quality of large images. By leveraging parallel processing, the algorithm significantly improves the efficiency of histogram equalization, resulting in faster execution times and higher quality images.

The advantages of this approach include its potential for real-time image processing, ability to process multiple images simultaneously, and the opportunity for further optimization and development. With the increasing demand for high-quality images in various applications such as medical imaging, computer vision, and gaming, the parallel histogram equalization technique can make a significant contribution to the field of image processing.

Thank you!