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Exploring Distributed and Parallel Image Processing Analytically

Muhammad D. Hassan

Collage of Health and Medical Techniques, Northern Technical University, Kirkuk, Iraq

Abstract: The documentation that is currently available disjointed and does not provide a unified framework that is suitable for beginners to use efficiently. For this reason, it is essential to have a comprehensive understanding of the area of parallel and distributed image processing. For those who are new to the subject of parallel or distributed image processing, this article offers a comprehensive analysis of both parallel and distributed image processing. It contains a wealth of material that is quite helpful to those who are just starting out in the field.These are the findings of our inquiry into parallel and distributed image processing, which are presented in the accompanying report. Not only do we concentrate on the application areas and ongoing research endeavors, but we also pay attention to the methodologies, tools, technology, and API that are used. An examination of the research problems associated with parallel and distributed image processing is carried out by us. We also provide an overview of possible research topics that may be pursued in the field of distributed image processing in the future. Individuals who are just starting out in the subject of parallel and distributed image processing might benefit from this study since it provides a concise understanding of the topic.

Keywords: Data Parallelism, Parallel Image Processing Tools, Distributed Image Processing Systems ,Task Parallelism

I. INTRODUCTION

The notion of "utilizing multiple computational resources to solve time-consuming problems" seems to be both intriguing and valid. Nevertheless, the system designer has significant hurdles in coordinating many compute resources and intelligently distributing work among them. The literature that is currently available on parallel and distributed image processing may be obtained in a variety of places; however, it does not have a coherent structure and is not designed to cater to those who are new to the subject matter. For this reason, it is essential to have a comprehensive understanding of the area of parallel and distributed image processing. The purpose of this study is to provide a complete overview of the area of parallel and distributed image processing in order to fulfill this demand[1][2].

In this study, the goals are outlined as follows. 1) Clearly and concisely, analyze the ideas of distributed and parallel image processing. Parallel and distributed image processing are the primary topics of this study. Application programming interfaces (APIs), methodologies, approaches, technologies, application areas, and ongoing research in this subject are the main topics of this article. (3) Inspire and direct readers to delve further into distributed and parallel image processing by providing them with resources and guidance.

We investigate the possibility of parallelism in the field of image processing. Our explanation of why simultaneous image processing is necessary is clear and to the point. Examining the difficulties of image processing operators and showing that they may be made parallel is the main purpose of this article. Distributed systems and parallel hardware are also briefly explained on this page.. In addition, we provide training on the hardware, software, and application programming interfaces (APIs) used in the research and development of parallel and distributed image processing. Furthermore, this analytical study examines many application industries and the corresponding research related to those fields. This article offers a summary of the many strategies that are used for data parallel picture processing. This research presents a number of fundamental methods and demonstrates how they may be implemented in a data parallel fashion. As a result of our all-encompassing and condensed approach, which goes beyond the boundaries of data parallel image processing, our research is distinct from the work that they have done in the area of data parallel image processing[3][4].

II. PARALLELISM IS ESSENTIAL FOR IMAGE PROCESSING

As a result of the proliferation of social networking sites over the course of the last ten years, there has been a substantial rise in the amount of various types of multimedia data. Consequently, the Internet is home to a number of huge picture archives that may be accessed by using the internet. The ability to search for pictures using keywords is offered by a number of search engines, including Google. On the other hand, the outcome of the search is entirely dependent on the captions that are attached to the photos. The creation of a search tool that is able to analyze and retrieve information based on the content of photos is something that we believe will take place in the not-too-distant future[5][6]. In spite of this, the process of image processing, which involves creating an index on images based on the information they contain, is definitely a challenging endeavor. This search tool would have a wide range of applications, including the ability to search for pictures in order to verify that they have not been copied without permission, which is a capacity that is now absent from search engines. When it comes to managing huge photo databases, the traditional way of centralized computing is not a viable solution.

There has been a significant surge in commerce facilitated by the Internet. In order to provide an online product viewing experience and handle complex product inquiries, it is necessary to dynamically generate images of the product according to various user requirements There is no text provided. For instance, when a customer demands a crimson vehicle with a panoramic view from inside the automobile, the system should have the capability to instantly produce such a picture. Parallel or distributed image processing may provide rapid solutions to intricate queries [7][8].

The task of conducting high-speed image processing on sequences of photographs, recorded images from scientific study, and photos and videos collected by surveillance systems is a very demanding and intricate endeavor. Real-time image processing is used in several sectors such as multimedia, industrial inspection, medicine, and textiles. Real-time image processing involves the rapid processing of individual pictures or a sequence of images at a much quicker pace compared to conventional approaches. An image processing system that employs parallel or distributed processing may effectively handle high-speed picture processing.

The software programs. It is widely used in scientific and technical fields, including biomedical research, manufacturing and industrial automation, space exploration, agricultural science, and geological science. The human brain is superior to computers in terms of its ability to process pictures owing to its ability to swiftly analyze images by generalizing and inferring information from image data, as well as the simultaneous functioning of a large number of neurons. This is obvious when comparing the processing capabilities of people and computers for images. In contrast, the capabilities of computers image processing are restricted when compared to those of the human brain. Currently, the majority of the applied image processing research focuses on improving, repairing, and dividing the picture. Human participation is still necessary for picture interpretation and knowledge inference. With the developments that have been made in Artificial Intelligence, parallel computing, and network-based computing, it is now possible to tackle the challenge that was discussed before by using intelligent photo processing in conjunction with a system architecture that supports parallel and distributed computing.

Upon examining the design of a standalone computer, it becomes apparent that it has inherent limitations in terms of speed and memory. These limitations cannot be surpassed within the current architecture. Furthermore, the need for computation is consistently anticipated before considering computational performance. The present state of computer hardware technology has achieved its maximum potential, since there has been no significant advancement in CPU speed in recent years. As customers expect more advanced apps, there is a need for applications to have shorter processing times and quicker response rates. The proliferation of electronic information has led to a significant rise in computing demand. One potential solution to this issue is the implementation of parallel and distributed processing[9][10].

III. EXAMINATION OF PARALLELISM IN PICTURE PROCESSING

This section demonstrates the feasibility of using parallelism in image processing. First, we provide a concise overview of image processing operators, followed by a quick explanation of parallel processing. Next, we demonstrate the implementation of parallelism in image processing programs.

IV. PROCEDURES FOR IMAGE PROCESSING

Following are the levels at which the image processing is carried out.

- Simple processing of images
- Processing of images at a level with intermediate complexity
- More sophisticated picture processing

1- A triad of image operators is responsible for combining the processing of three separate picture pixels. To create the output pixel, local neighborhood operators look at the input picture pixel that matches the output pixel and its neighbors. Sharpening, smudging, and improving the borders are just a few of the ways these tools may improve and alter the visual quality of images. Another way they help is by reducing pollutants. In order to find out which pixels are created by global operators, every pixel in the input picture is used. One example of a global operator is the histogram transform, while another is the discrete Fourier transform (DFT).Picture processing at an intermediate degree of complexity: Abstractions created from the picture's constituent pixels are manipulated by the intermediate-level image processing algorithms. with order to aid with subsequent image decisions, the processing steps extract abstract representations from the picture pixels, including area labeling and object tracking. Area labeling, object tracking, image measurement, and perceptual classification are a few examples. More sophisticated picture processing: The high-level image processing techniques are performed to create more abstract representations. They focus on abstract concepts that are generated from image processing operators at an intermediate level. They are used to analyze the visual content of the picture. (for example, the process of categorizing and identifying objects). These operations manipulate graphs, lists, and relations between regions/objects in order to reach a judgment.

V. USING PARALLELISM

Parallelism refers to the concurrent execution of tasks by many processing units. There are two basic approaches that may be used in order to achieve parallelism: (1) the utilization of parallel processing hardware, and (2) the utilization of a distributed computing and processing system. A computer system that is equipped with a large number of processors is used in the first method for the purpose of carrying out computational duties. On the other hand, in the second method, a network of machines that are linked to one another is utilized in order to carry out the same computational operations. Each strategy has its advantages and disadvantages. However, the choice of architecture is made based on the specific needs of the application and the financial resources available [11][12].

VI. PARALLEL PROCESSING FOR IMAGE PROCESSING TASKS

There are three primary methods in which image processing systems may make advantage of parallelism: i) for data parallel processing, ii) for task parallel processing, and iii) for pipeline parallel processing. Each of these methods is described here. This article provides a description of each of these application techniques. Within the confines of this section, we shall discuss them.

1- In the data parallel technique, the data is divided and allocated among the computer units. The primary research obstacle is in the efficient breakdown of data and composition of results. Efficient parallel execution requires consideration of two factors: data locality and load balance. The distribution of image data across processing units should be optimized to minimize unwanted communication between them. The distribution of image data across processing units should be designed to ensure that each processing unit receives a roughly equal workload. Currently, the allocation of picture blocks is restricted to parallel computers that include multiple processing units. Nevertheless, this implementation incorporates the traditional method of data parallelism, since it anticipates the possibility of the "network is a computer" concept being a reality in the future. The use of data parallelism to image data may be accomplished via three basic methods: i) Parallel to the pixel, ii) Parallel to the row or column, and iii) Parallel at the block level. At the moment, the vast majority of applications that are used for parallel image processing make use of row/column parallel or block parallel approaches rather than pixel parallel approach.Any one of the following distribution strategies may be used in the course of parallel image processing in order to spread the picture data across the many processing units that are available. A fair and equal distribution of the workload is the major goal of the data distribution approach, which aims to achieve this purpose simultaneously. The following are the data dissemination approaches: The

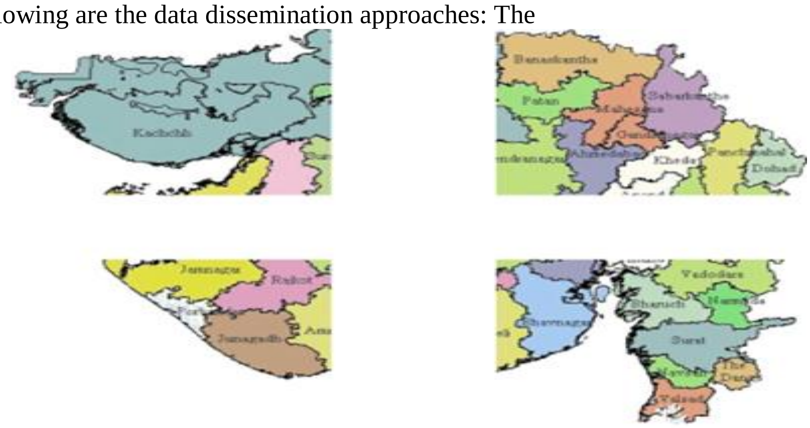

Figure I. In order to facilitate parallel processing utilizing the Block Parallel Approach, the map was divided into four blocks.

2- In the task parallel method, image processing instructions or low-level processes are organized into tasks, with each job being allocated to a separate computer unit. An image processing program comprises a multitude of distinct activities. Certain operations in this context are considered independent, meaning that the outcome of each operation is not influenced by the outcome of any other operation. The primary research obstacle in the task parallel method is the efficient breakdown of tasks and synthesis of results.

3- Pipeline parallelism is a technique used in some image processing methods where the computation is divided into sequential phases. Image processing applications may use pipeline processing to handle several pictures simultaneously. During pipeline processing, pictures will undergo many phases simultaneously (see to Figure II).

Time	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
t1	Image 5	Image 4	Image 3	Image 2	Image 1
t2	Image 6	Image 5	Image 4	Image 3	Image 2
t3	Image 7	Image 6	Image 5	Image 4	Image 3
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.					

Figure II. Concurrent image processing employing a sequential series of operations

VII. BUILD A BUILDING FOR PARALLELISM

Parallelism may be achieved via two main architectures: I) using parallel processing hardware, which is a tightly connected system, and ii) utilizing distributed computing systems, which are loosely coupled systems. The design of closely connected parallel processing involves a shared bus and common memory, although it is subject to several restrictions. As the network speed (measured in Gbps) increases, it becomes feasible to do parallel processing among interconnected computers. The exchange of data across processor units may be achieved via two fundamental mechanisms: (I) message transmission and (ii) shared memory use. In this discussion, we will provide a concise overview of the fundamental structure of parallel processing hardware and distributed systems.

VIII. HARDWARE FOR PARALLEL PROCESSING

Parallel processing hardware involves the simultaneous use of many computing resources to solve a calculation issue. It is possible to divide the design of parallel processing hardware into two categories: shared memory parallel computer architecture and distributed memory parallel computer architecture. The categorization of parallel processing hardware is based on the memory use of different central processing units (CPUs). Using a parallel solution that makes use of programming paradigms like shared memory, multi-threading, or message forwarding, it is possible to find a solution to a problem. According to Flynn's taxonomy of high-speed computers, there are four distinct forms of parallel processing hardware. These include: I) Single Instruction.

IX. SYSTEM THAT IS DISTRIBUTED

There are two basic forms of distributed system architecture that may be distinguished from one another: the master-slave system, and the peer-to-peer system. A discussion of the following points is presented below.

1- In order to do simultaneous image processing, the master-slave architectural method makes use of the "Distribute Compute and Gather" notion. Within the framework of this architectural style, the central processing unit is responsible for dividing and assigning the image data to the subordinate processing units. Each and every slave processing unit works in tandem with one another to complete the task that has been stated. Next, the central processing unit collects and reassembles the picture.

2- Peer-to-Peer: In a communication architecture known as peer-to-peer, all of the entities that are participating have equal capabilities and are able to initiate communication. Without the need for centralized coordination, such as that provided by a master or controller in a Master-Slave architecture, the entities that are participating in the network share a portion of their resources with different entities that are also participating in the network. The mechanisms that are suitable for efficient parallel processing are shown in Table I. These mechanisms are applicable to each approach of parallelism in image processing.

Table I. Mechanisms that are suitable for the many different parallelism methods used in image processing.

The use of parallelism in the processing of images	A perfect strategy for effective parallel processing
Data in Parallel	Making use of parallel computing devices
Execution of tasks in parallel	Distributed computing
Pipeline in parallel	Using low-latency groups for distributed computing

X. DISTRIBUTED IMAGE PROCESSING ASSESSMENT AND APPLICATION

The examination of parallel and distributed image processing algorithms is the primary emphasis of this research. The following is an examination of the resources available for distributed and parallel processing. Readers will have a grasp of the appropriate tool for different types of parallelism as a result of this examination. We also provide a detailed overview of the specific applications of distributed and parallel image processing. Furthermore, we lay out the current state of knowledge about distributed and parallel image processing.

XI. METHODS AND EQUIPMENT

A communication protocol designed for parallel applications running on a distributed memory system, the Message Passing Interface (MPI) is widely used. It is a protocol definition that is not dependant on any particular language. The three most important features according to the MPI are performance, scalability, and portability.

The OpenMP application programming interface (API) is widely used and well-known for building parallel applications in languages like C, C++, and Fortran that take use of shared memory. For instance, it is often used to declare the presence of parallelism in a program when the compiler fails to do so. When it comes to parallel computing on devices with numerous cores, OpenMP is a great option. Readers are urged to seek out further material on the topic of multi-core image processing using OpenMP.

The parallel computing architecture created by Nvidia is known as Compute Unified Device Architecture, or CUDA for short. Its primary function is to facilitate the programming of GPUs. Graphics processing units (GPUs) made by Nvidia include the computational powerhouse CUDA. The graphics processing unit's (GPU) capabilities may be used to enhance computing performance. It is compatible with several popular programming languages, so developers from all around the world may use it. Image and video processing, fluid dynamics modeling, computational biology, seismic analysis, medical analytic simulation, and many more applications are just a few of the many ways CUDA is employed by academics and scientists.

Intel TBB is one name for the Threading Building Blocks (TBB) template library; it's a C++ library that was made for parallel programming on multi-core CPU architectures. This complicates matters since thread packages and libraries often provide instructions on how to manually set up, sync, and terminate threads. The TBB framework provides a representation of a program by breaking it down into smaller, more specialized tasks that may eventually become interdependent on one another. A library performs the tasks according to their requirements, dynamically assigning them to certain processor cores. Before you integrate Intel TBB into your program, make sure you read the instructions carefully. The MATLAB Distributed Computing Server (MDCS) and the Parallel Computing Toolbox (PCT) in MATLAB are two components that are essential to the process. MATLAB offers very effective support for array processing as well as metric processing. MATLAB is able to resolve image processing challenges by using the power of multi-core processors, graphics processing units (GPUs), and computer clusters. This is made possible by the use of PCT. For the purpose of making this capability more accessible.

XII. DOMAINS OF APPLICATION

Table II is a concise summary of significant application areas that we provide. Parallel and/or distributed image processing may be used in any of these application fields.

Table II. MAJOR APPLICATION DOMAINS LISTED HERE

Domain of Application	Crucial Steps in Image Processing	Practical Application
Recognition by Optics	- Noise cancellation - picture orientation - differentiating between persons	converting images to text
Mining of Images	- Matching templates - linkage analysis	look for residential areas close to water bodies
Image retrieval based on	- Matching templates	Find pictures that include people

content		
Analysis of Biomedical Images	- Matching templates - extraction of features	Forecasting the likelihood of a decline in future
System for Monitoring	- Object Recognition	Protection, surveillance

XIII. A STUDY OF PARALLEL IMAGE PROCESSING

At the moment, we are in the process of developing and implementing a distributed image processing system that makes use of the concept of utility-based distributed computing. A graphical user interface (GUI) that is pleasant to users would be provided by the system for the purpose of developing, submitting, and monitoring their tasks. The graphical user interface (GUI) has drag-and-drop capabilities, which enables users to develop image processing applications in the form of a task graph. This system also allows users to design these apps. In order to accomplish the task of work assignment, the system would make use of the contract net protocol in an open and forthcoming way.Research on this system will also look at algorithms that can make good use of the system's resources while still satisfying the user's specified scheduling needs. Our research would center on looking at these algorithms: (1) An algorithm that may be used by management to assess whether contractors are qualified for certain jobs. Two, a method by which upper-level management may ascertain how long and how much money each application subtask will cost. (3) An algorithm that contractors may use to improve the price of subtasks and boost their competitiveness when bidding on future contracts. Tasks from different applications need to be effectively scheduled using a scheduling method that considers execution time, data transfer cost, and execution cost.

XIV. CONCLUSION

Our work on parallel and distributed image processing was comprehensive. In addition to outlining the many layers of image processing systems, this book investigates several methods for achieving parallelism in the field. On top of that, we laid out the technologies that are used in distributed and simultaneous image processing in a way that is easy to understand and follow. For your perusal, we have also highlighted several important areas of study within distributed and parallel image processing, and we have included brief descriptions and recommendations for further reading in these areas.

An overview of distributed and parallel image processing is what this analytical research is aiming to provide. Numerous facets of the subject will be covered in this investigation. Additionally, additional research into the several hardware devices and processors used for concurrent image processing is well within the realm of possibilities. Distributed image processing's content-based image retrieval and image mining may provide light on methods, algorithms, and system topologies that cover a lot of ground in the field of image processing. There could be a lot of applications for these findings.

REFERENCES

Journal Papers:

[1] M Ozaki, Y. Adachi, Y. Iwahori, and N. Ishii, Application of fuzzy theory to writer recognition of Chinese characters, *International Journal of Modelling and Simulation, 18(2),* 1998, 112-116. (8)

[2] van Heel, M., Harauz, G., Orlova, E. V., Schmidt, R., & Schatz, M. (1996). A new generation of the IMAGIC image processing system. Journal of structural biology, 116(1), 17-24.

[3] Kovásznay, L. S., & Joseph, H. M. (1955). Image processing. *Proceedings of the IRE*, *43*(5), 560-570.

[4] Van der Walt, S., Schönberger, J. L., Nunez-Iglesias, J., Boulogne, F., Warner, J. D., Yager, N., & Yu, T. (2014). scikit-image: image processing in Python. *Peer J*, *2*, e453.

[5] Acharya, T., & Ray, A. K. (2005). *Image processing: principles and applications*. John Wiley & Sons.

[6] Demant, C., Garnica, C., & Streicher-Abel, B. (2013). *Industrial image processing* (pp. 113-146). Heidelberg: Springer.

[7] Awcock, G. J., & Thomas, R. (1995). *Applied image processing* (pp. 111-118). Basingstoke, UK: Macmillan.

[8] Bovik, A. C. (Ed.). (2009). *The essential guide to image processing*. Academic Press.

[9] Huang, T. S., Schreiber, W. F., & Tretiak, O. J. (1971). Image processing. *Proceedings of the IEEE*, *59*(11), 1586-1609.

[10] Egmont-Petersen, M., de Ridder, D., & Handels, H. (2002). Image processing with neural networks—a review. *Pattern recognition*, *35*(10), 2279-2301.

[11] Parker, J. R. (2010). *Algorithms for image processing and computer vision*. John Wiley & Sons.

[12] Burger, W., & Burge, M. J. (2022). *Digital image processing: An algorithmic introduction*. Springer Nature.