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Digital Image and Video Processing: Algorithms and Applications

Abstract: - Many of the techniques that are used in digital image and video processing were developed in the 1960s at Bell Laboratories. These techniques have applications in a variety of fields, including medical imaging, videophone, character recognition, satellite imagery, and wire-photo standards conversion. Additional applications include enhancement of photographs or vidoes. The early stages of image and video processing were developed with the intention of enhancing the overall quality of the image or video. For the purpose of enhancing the visual effect of humans, it is intended for human beings. When it comes to image and video processing, the input is an image of poor quality, and the output is an image and video of higher quality. Research on algorithms and applications of digital image and video processing is the primary purpose of this study, which aims to investigate these topics extensively. The methodology employed in this study is qualitative research technique. In accordance with the findings of this research, "Image Processing" refers to the process of analyzing images with the objective of determining the significance of objects and identifying them. Image analysts analyze data that has been remotely sensed and attempt to detect, identify, classify, measure, and evaluate the significance of physical and cultural objects, as well as their patterns and spatial relationships. One subcategory of signal processing is known as video processing, and it is distinguished by the fact that the signals that are input and output are video files or video streams. Technology such as television sets, videocassette recorders (VCRs), DVD players, and other devices all make use of video processing algorithms. The processing of images and videos is extremely useful in a variety of contexts.

Keywords: Digital Image; Image processing; Video Processing; Applications; Algorithms.

I. INTRODUCTION

The term "image processing" is most commonly used to refer to digital image processing; however, optical and analog image processing are also viable options. Imaging is a term that refers to the process of acquiring images because it involves the production of the input image in the first place[1]. There is a sort of video recording technology known as digital video, which functions by employing a digital video signal rather than an analog video signal [2].

One of the earliest applications of digital video and image processing was to enhance the quality of the images that were taken. However, as the power of computers increased, the number of applications in which video and image

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processing might make a difference also increased [3]. Today, video and image processing are utilized in a wide variety of applications, including but not limited to the following: astronomy, medicine, sports, rehabilitation, motion pictures, surveillance, robot control, and television productions [4,6].

It is common practice to classify the various techniques for processing images and videos into these categories, which includes image processing. computer vision, machine vision, and video processing [5]. Figure below is an illustration of the block diagram of image and video processing, which provides an overview of the diagram.

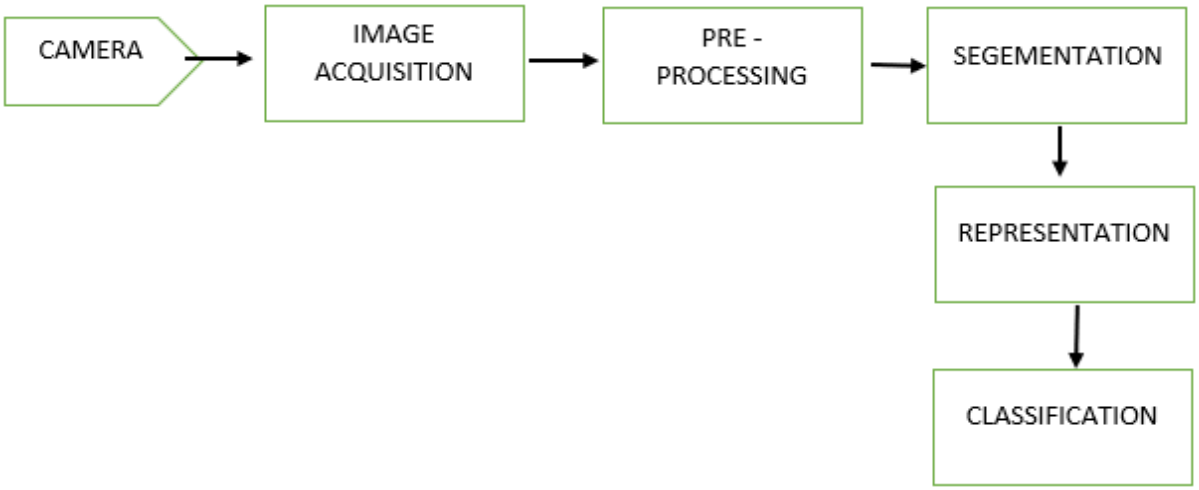

Figure 1: Basic Block diagram of Image and video processing[2]

Algorithms and Applications of Digital Image and Video Processing is the topic of the next part, which provides an in-depth analysis of the previous literatures relevant to this topic.

II. RELATED WORKS

Table 1: Literature review

AUTHORS & YEAR	METHODOLOGY	FINDINGS
Bouwmans et al., (2018) [7]	This article's objective is to provide a comprehensive overview of the various uses of Robust Principal Component Analysis (RPCA) in the field of computer vision.	The findings of this study provided unique insights into potential future research directions as well as algorithmic frameworks that are appropriate for the applications being discussed.
Aeffner et al., (2019) [8]	This study covered tissue image analysis basics and informs pathologists about these new tools' characteristics, uses, and workflow.	The review covered basic software solutions, analytical methodologies, technological considerations, and algorithm readouts. Tissue image analysis pros and cons are examined, along with AI and ML.
Pimpalkhute et al., (2021) [9]	This study presented a hybrid Discrete Wavelet Transform (DWT) and edge information removal approach to assess digital picture Gaussian noise strength. A Sobel edge detector excludes spatial domain edge wavelet coefficients from noise estimation calculation.	The suggested technique is tested on a standard LIVE image dataset. Benchmarking shows that the suggested approach beats all state-of-the-art algorithms throughout a wide noise range.
Alazzam et al., (2022) [10]	This study examined how cold plasma affects osteoporosis-infected rabbit bone	The search found that plasma affects Ca and vitamin D levels. Bone calcium and

[2] http://what-when-how.com/introduction-to-video-and-image-processing/introduction-to-video-and-image-processing/

	tissue. The search is separated into control, infected, and treated.	alkali phosphates (ALP) respond to cold plasma. As additional proof, second-order gray level matrix image processing with textural features is used. The biology and image processing results match, indicating excellent treatment.
Vishnu et al., (2022) [11]	This study compared video processing Edge Detection methods with a focus on dramatically lowering image/video processing dimensionality.	The evaluation of edge detection methods uses Peak Signal to Noise Ratio (PSNR), Signal to Noise Ratio (SNR), Mean Squared Error (MSE), Entropy, and Execution time. Many video and image processing applications require fast processing.

Research Gap

Previous research defines image and video processing as changing images to enhance human interpretation and machine detection. Digital image and video processing involves converting images and videos into pixels, which represent physical attributes and data in digital memory before being processed by a computer. Two main applications of digital image and video processing techniques are improving images for human interpretation and processing data for storage, transmission, and autonomous machine perception. One of the most challenging jobs in image processing is recognizing edges, which establish boundaries [12]. This is a fundamental issue in image and video processing. The number of studies that are associated with this field is rather low.

Therefore, the main focus of this study is to carry out research on the digital image and video processing algorithms and applications.

III. METHODOLOGY

Qualitative research methodology was used for this study. When conducting qualitative research, the objective is to get an understanding of concepts, opinions, or experiences by the collection and analysis of non-numerical data (such as text, video, or audio). Obtaining in-depth insights into a topic or coming up with new ideas for study are both possible use of this tool [13]. The information required for this study was gathered through the usage of online databases. The primary emphasis of the research between the years 2018 and 2023.

IV. RESULTS AND DISCUSSIONS

In the following sections, the algorithms and applications of image and video processing will be introduced and discussed in greater detail.

DIGITAL IMAGE PROCESSING

Image processing is the process of processing images in order to improve them and extract information that is valuable from them. In this technique, images are handled as if they were two-dimensional signals, and the inputs that are used are either a photograph or a video segment. It is of the utmost importance to be aware of the fact that the algorithms used for image processing play the most critical role in digital image processing. Multiple image processing methods have been utilized and implemented by developers in order to handle a variety of jobs [14]. When it comes to the capturing of a whole image, image processing techniques are typically divided into the following categories [15]:

- Low-level techniques, the elimination of noise, and the improvement of color
- Binarization and compression are examples of approaches working at a medium level.
- The extraction of semantic information from the data that has been recorded is the focus of higher-level approaches, which include detection, segmentation, and recognition algorithms.

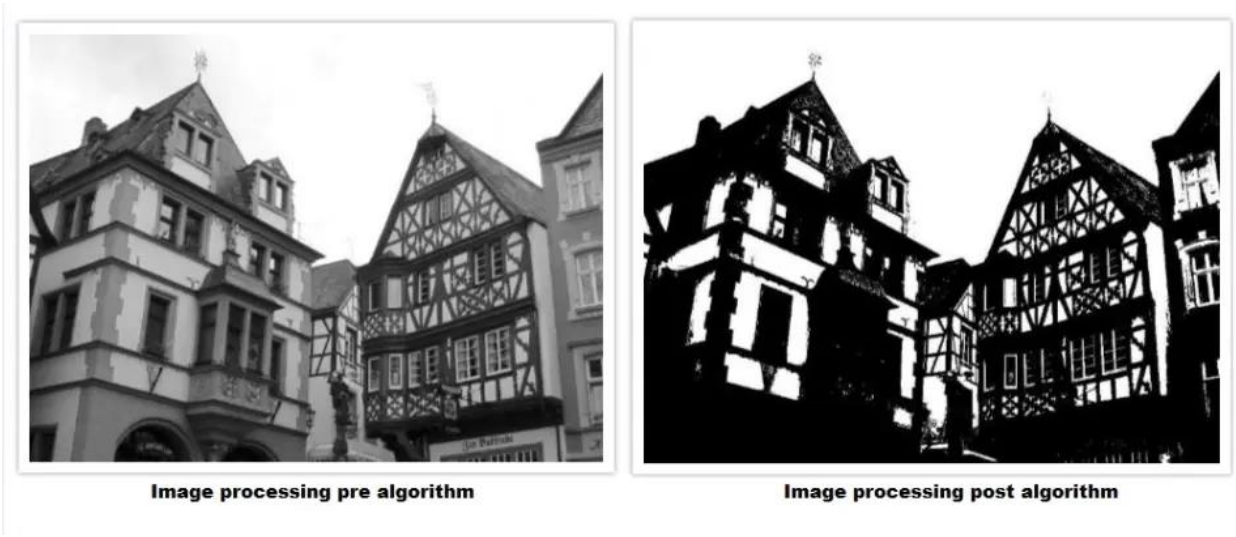

Figure 2: An example of execution of image processing algorithm[3]

There are numerous categories of algorithms that are used for image processing. Image production and image analysis are the two methods that are included in the process of processing images [15]. In the realm of image processing, some of the most common algorithms include the following table 2.

Table 2: Digital Image Processing Algorithms and Applications.

ALGORITHMS	METHODS	DESCRIPTION
Contrast Enhancement algorithm	Histogram equalization algorithm	Image contrast improvement with histogram
	Adaptive histogram equalization algorithm	Histogram equalization adjusts to local contrast.
	Connected-component labeling algorithm	Locating and tagging disconnected sections
Dithering and half-toning algorithm	Error diffusion algorithm	When a picture transitions from light to dark, the error-diffusion method generates a black pixel.
	Floyd–Steinberg dithering algorithm	The Floyd-Steinberg dithering algorithm reduces an image's colors while minimizing perceived changes.
	Ordered dithering algorithm	The ordered dithering algorithm renders the image normally, but for each pixel, it offsets its color value with a threshold map value based on its location, quantizing in a different color if it exceeds the threshold.
	Riemersma dithering algorithm	A unique dithering algorithm, Riemersma dither, may reduce a grey scale or color image to any color map (palette) and limits the influence of a dithered pixel to a tiny area.
Elser difference-map algorithm	Search Algorithm	A search algorithm that is utilized for solving generic constraint satisfaction problems is what this is. X-ray diffraction microscopy was the initial application for this instrument.
Feature detection algorithm	Marr–Hildreth algorithm	Early edge detection algorithm
	Canny edge detector algorithm	Canny edge detector detects many picture edges.

[3] https://www.pre-scient.com/knowledge-center/image-processing/image-processing-algorithms/

	Generalized Hough transform algorithm	The generalized Hough transform turns identifying the model's position into finding the transformation parameter that translates it into the image.
	Hough transform algorithm	Hough Transform detects lines and circles in images using computer vision. It turns these forms into mathematical representations in a parameter space, making them easier to identify even if damaged or obstructed.
	SIFT (Scale-invariant feature transform) algorithm	Image local feature identification and definition algorithm SIFT
	SURF (Speeded Up Robust Features) algorithm	Strong local feature detector SURF
	Richardson–Lucy deconvolution algorithm	This algorithm deblurs images.
Blind deconvolution algorithm	deconvolution algorithm	It deblurs images like Richardson–Lucy deconvolution algorithm when the point spread function is unknown.
Seam carving algorithm	carving algorithm	The content-aware seam carving algorithm resizes images.
Segmentation algorithm	GrowCut algorithm	GrowCut uses cellular automata to segment digital images.
	Random walker algorithm	Segmenting images with the random walker method. A user interactively names a few pixels with known labels (seeds) like "object" and "background" in the first method description.
	Region growing algorithm	Region growing begins with a seed position and merges surrounding pixels until no more can be added.
	Watershed transformation algorithm	Watershed algorithms are mostly employed in image processing to segment objects. This lets you count or analyze separated things.

DIGITAL VIDEO PROCESSING

A video signal refers to a series of temporally changing images. A still image can be defined as a representation of spatial intensities that remain unchanged over time, while a time-varying image is characterized by a spatial intensity distribution that undergoes changes over time. The video signal is processed and represented as a sequence of discrete visual entities known as frames. The perception of a seamless video experience is achieved through the rapid alteration of frames, commonly referred to as frame rate [11].

During the process of creating a digital video, the visual information is digitized in both a spatial and temporal sense, and the pixel intensities that are produced thereafter are quantized [10]. Figure 3 presents a block diagram that illustrates the method of producing digital video from a natural scene that is continuous.

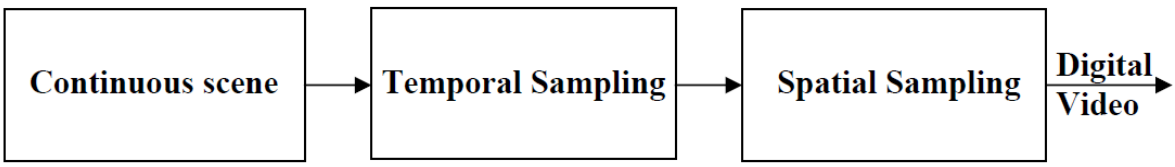

Figure 3: Step by step processing of Digital Video[4]

[4] https://dl.icdst.org/pdfs/files/da090a75f2b3c3179de82d428b33ef4d.pdf

The following table provides a detailed explanation of the algorithms that are utilized in the processing of video.

Table 3: Video Processing Algorithms

ALGORITHMS	EXPLANATIONS
Full-search algorithm	The most straightforward brute-force block matching technique, full-search, matches all candidates in the search window for the best result. However, computation is costly.
Three Step Search Algorithm	In the first step of the three-step search technique, nine candidate macroblocks are picked, one at the center pixel and eight at eight coarsely separated pixels around it. The matching function is calculated. The second phase tests eight more shifts around the minimum distortion obtained in the previous stage, except this time, the pixel spacing is tighter. The following technique is repeated until the step size is less than one and the motion vector is found.
Foreground and Background Segmentation	The foreground and background segmentation methods presume moving items in the forefront and immobile objects in the background. Object segmentation involves moving region detection.
Graph Cut Algorithm	The Graph Cut Algorithm quickly solves low-level computer vision issues, including image smoothing, stereo correspondence, and others that involve energy minimization.
Thresholding	One of the easiest but less successful ways for still photos. It assumes automobiles are compact objects with various backdrop intensities. Thus, thresholding intensities in small locations separates the vehicle from the background. This method relies on a threshold that matches the vehicle and its background.
Edge-based detection (spatial differentiation)	Methods in this class focus on object edge features. These methods can recognize the edge structure of stationary cars in single photos. Morphological edge-detection techniques are widely used because to their outstanding performance.
Feature aggregation and object tracking	These algorithms can detect or track characteristic points of an item in the feature space. They are commonly employed in object detection to enhance reliability and reduce false detection rates. In the aggregation process, previously recognized traits are used to locate automobiles or vehicle lines in case of congestion. Features are aggregated based on the vehicle's geometry.

V. CONCLUSION

This paper provides a detailed examination of several digital image and video processing techniques and applications. In summary, image processing is the process of looking at pictures in order to recognize objects and determine their importance. Image analysts analyze remotely sensed data and make logical attempts to detect, recognize, classify, measure, and assess the importance of physical and cultural objects, as well as their patterns and spatial relationships. When video files or streams are used as the input and output signals, video processing is a specific type of signal processing. Video players, DVD players, VCRs, television sets, and other devices all use video processing techniques. Processing images and videos is incredibly beneficial in a variety of ways.

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