

## A Review on Image Processing

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**Abstract:** Image processing, a crucial aspect of both human perception and machine interpretation, involves the manipulation of fundamental characteristics within an image to enhance its visual content. In the electronic domain, the field of digital image processing delves into the conversion of images into sets of numerical pixels, representing physical attributes like scene radiance. Stored in digital memory, these pixels undergo computerized processing, playing a pivotal role in various applications. This review paper explores key facets of digital image processing techniques, emphasizing their role in augmenting visual information for human comprehension and facilitating the storage, transmission, and representation of image data for autonomous machine perception. Of particular significance is the challenge posed by edge identification, a complex problem crucial for defining boundaries. This paper delves into the intricacies of this fundamental issue, shedding light on its significance in the realm of image processing.

**Keywords:** Image Enhancement, storage, MATLAB, Feature Extraction, electronic, technology, AI, 5G.

### 1. Introduction

The advent of electronic media and the pervasive integration of computers into our daily lives have propelled society into an era dominated by technology. Computers serve as the vanguards of modern innovation, ushering in transformative revolutions across the globe. In this technological age, computer vision emerges as a pivotal domain, playing a crucial role in information processing, archiving, and transmission. The quest for endowing machines with human-like visual identification capabilities stands out as a primary objective in computer vision research [1, 2, 3]. Over the last two decades, face recognition has emerged as a focal point, capturing the keen interest of researchers due to its versatile applications in secure trading terminals, user authentication, surveillance, closed-circuit television (CCTV) control, intelligent robots, and human-computer interfaces (HCI). Notably, numerous face recognition algorithms have been meticulously developed, giving rise to sophisticated systems designed for real-world implementation [4, 5].

The pervasive influence of computer vision extends across diverse fields, reflecting its wide-ranging significance. At the core of these applications lies the ambitious pursuit of bestowing computers with visual recognition skills akin to those possessed by humans [1, 2, 3]. This pursuit aligns with the broader goal of advancing the capabilities of computer vision to match or even exceed human visual perception. The development

of human-like visual recognition skills in computer vision stands as a pivotal and challenging task, demanding continuous innovation and exploration. As technology continues to evolve, the convergence of computer vision and human cognition opens new frontiers, promising transformative impacts on various sectors. This review paper delves into the intricate landscape of image processing, exploring the nuances of computer vision and its applications, with a particular focus on the evolution and advancements in face recognition algorithms and systems.

### 2. Different Approach

The term "digital image processing" refers to how a digital computer processes images that have a digital basis. Three primary applications power it. The first goal is to enhance visual information for human perceptions, which implies that we should strive to make every image we receive appear better. Autonomous systems play a significant role in various industries, especially in tasks like quality control and assembly automation, constituting the second application. The third application revolves around efficient transmission and storage. For instance, when storing a picture on a computer, the image processing involved consumes disk space, prompting the utilization of techniques to minimize such requirements. Digital image processing explores how computers represent and manipulate visual input. Many devices, such as satellite sensors, digital cameras, medical imaging equipment, and more, are supported by the Image Processing Toolbox. These images can be processed, displayed, and analysed. They are available in several data types, such as signed or unsigned 8-, 16-, and 32-bit integers, as well as single- and double-precision floating-point numbers. Importing and

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exporting images into and out of the MATLAB environment for processing involves various methods. Additionally, the Image Acquisition Toolbox, released separately, facilitates the recording of live images from Webcams, frame grabbers, DCAM-compatible cameras, and other compatible devices. It can access photos saved in databases that are ODBC and JDBC compliant with the help of Database Toolbox (also provided separately). MATLAB supports the following common picture and data formats: ASCII, binary files, HDF, FITS, TIFF, HDF-EOS, PNG, JPEG, and Microsoft Excel. Furthermore, supported are multiband picture formats such as LANDSAT. It is possible to write custom procedures for interfacing with any kind of data format thanks to low-level I/O functions. picture Processing Toolbox supports several specialized picture file types.

**Image as input:** The image processing system under consideration requires input images in various formats. These images, typically photographs, undergo processing through computer algorithms tailored to match the characteristics of the input image. The computer methods employed generate two distinct kinds of images: magnitude images and noisy images.

**Image size:** In our study, three different image sizes are utilized: (1024 X 1024), (256 X 256), and (512 X 512). The choice of image size is a critical aspect of image processing, impacting computational efficiency and output quality.

The mostly used formats include TIFF and JPEG which are discussed below:

- **TIFF:** TIFF stands for “Tagged Image File Format”. Its extensions ".tif" and ".tiff" are acknowledged. These file types are used to hold visual content, like photos and line art. supports both grayscale and color images and have become popular for high-color-depth photos.
- **JPEG:** JPEG stands for “Joint Photographic Experts Group's acronym”. Only the ".jpg" and ".jpeg" extensions may be used. It is the most widely used image compression method, especially used in the case of storing and transmitting photographic images on the Internet.



“Fig.1. .JPG Image Format”

**There are four types of images are present, namely, Intensity images, Binary images, Indexed and RGB images and are discussed below:**

**1. Intensity images** – These images represent data matrices indicating intensities within a specified range. The values can be integers or floating-point numbers.

In MATLAB, an intensity image is saved as a matrix where each element relates to a pixel in the image. The integer values of the intensity image can be in class uint8 (ranging from 0 to 255) or class uint16 (ranging from 0 to 65535).

Intensity pictures which have values in [0,1] range often have scaled with double data type.



“Fig.2. GRAY Image Format”

**2. Binary images** - The logical array of the binary picture is made up of 1s and 0s. Binary images have a straightforward visual interpretation – a pixel with a value of 0 appears black, while a pixel with a value of 1 appears white. It is worth noting that, in MATLAB, a binary image is distinct from intensity images and needs to be of class logical [6].



“Fig.3. BW Image Format”

“This gives an image in Black and White.”

**3. Indexed images-** Comprising a color map matrix and a data matrix, indexed images use a color map to map pixel values to specific colors. The color map is essentially a double-class array containing red, green, and blue components. This format allows for efficient representation of images with a limited color palette. Pixel values in these images and corresponding color map values are mapped directly [7].

**4. RGB images-** Often referred to as true color images, RGB images are defined by a MATLAB data array with dimensions of m by n by three, representing red, green,

and blue colors for each pixel. This format is widely used in graphics, and the representation of color varies based on the combination of intensities in the red, green, and blue channels.

RGB array class can be created using uint8, double or uint16. In a double-class RGB array, each colour element ranges between 0 and 1. Pixels with colour components (0,0,0) display as black, while those with (1,1,1) shows as white.



“Fig. 5: RGB Image Format”

**Resolution-** Resolution, a critical aspect of image processing, refers to the quantization and sampling of brightness values in the spatial domain.

In the digital realm, it signifies the ratio of pixels displayed to the number of rows and columns. A pixel is the unit of measurement that separates a row from a column.

For example, a resolution of 640x480 indicates that each of the 480 rows contains 640 pixels. This concept is prevalent in the characterization of images captured with digital cameras or optical devices. Additionally, in the context of printing equipment or display systems, resolution is often expressed in dots per inch (dpi), further underscoring its importance in ensuring optimal image quality for diverse applications.

**Pre- and Post-Processing Images:** Post-processing refines output through operations such as filtering and segmentation, contributing to improved visual aesthetics and the extraction of meaningful information. Understanding and optimizing both pre- and post-processing stages are crucial for advancing image processing techniques, and this section aims to provide insights into their collective significance in shaping the field.

Three broad categories can be used to categorize image processing operations:

1. Image Restoration
2. Image Segmentation
3. Remove “noise” from an image.
4. Image Compression
5. Image Enhancement
6. Image transformation
7. Feature extraction

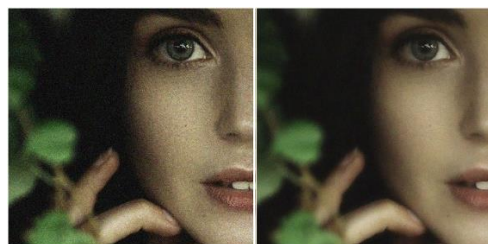
8. Remove motion blur from an image.

➤ **Image Restoration:** Making a clean image out of a distorted one is the aim of restoration. Old photo and video archives may display significant degradation, and the consequence is distorted images that don't adequately reflect the real environment due to the noise that many sensors are prone to.

Therefore, there are two primary uses for picture restoration:

- a) Eliminating noise from the sensor, and
- b) restoring ancient, archival film and photos.

Figures 6 and 7 provide an explanation that is easy to understand.



“Fig. 6: Original image” “Fig. 7: Image after restoration”

➤ **Image Enhancement:** Using image enhancement techniques found in the Picture Processing Toolbox, one can increase the signal-to-noise ratio and accentuate visual qualities. These techniques alter the colors or intensities of a picture. It has the ability to:

- a) Equalize histograms
- b) Perform linear, median, or adaptive filtering
- c) Reorganize the dynamic range
- d) Alter the gamma value
- e) Execute de correlation stretching

Along with particular filtering approaches, the toolbox also includes a generic multidimensional filtering function that can handle integer picture types, different border padding options, convolution, and correlation. Predefined filters and tools for building and utilizing custom linear filters are also supplied.

a) Histogram equalization- The toolkit also includes particular filtering algorithms, convolution, correlation, and a generic multidimensional filtering function that can handle integer image formats. Functions for generating and utilizing one's own linear filters are also available, along with standard filters. It's a stage in the image-processing workflow when the consistency of the image's [8] contrast is checked. After equalizing the histogram, the picture.

Next stage of the image-processing procedure makes sure that the contrast [8] of the picture is constant.



**Fig 8:** “Histogram Equalization”

De-correlation Stretch: The method used to "stretch" or intensify the color disparities in a color image is known as "de-correlation stretch." This is achieved by removing the inter-channel correlation from the input pixels using a process known as "decorrelation stretch."

This text's objective is to:

- Explain the typical situations with multispectral data.
- Explain how a de-correlation stretch satisfies those requirements.
- Explain the computing steps involved in a de-correlation stretch
- Explain the drawbacks of this methodology.

**Remap the dynamic range:** “High-dynamic-range imaging” known as HDR, is a group of techniques used in computer graphics, image processing, and photography to enable a wider dynamic range of luminance between an image's lightest and darkest areas than can currently be achieved with traditional digital imaging techniques or photographic methods. A wider range of intensity levels observed in natural situations, from bright sunshine to soft moonlight, can be more properly captured in HDR photographs because of their wide dynamic range. [9]

Computer renderings and the blending of multiple images—also referred to as “low dynamic range (LDR)” [10] or “standard dynamic range (SDR)”[11] images—are the two primary sources of HDR photography.

Tone-mapping techniques can be used to produce photographs that maintain or emphasize local contrast for visual impact. HDR images may be displayed on displays with a lower dynamic range thanks to tone-mapping techniques that reduce overall contrast. First merged to HDR and then decreased to LDR.



**“Fig.9. Local tone mapping”**



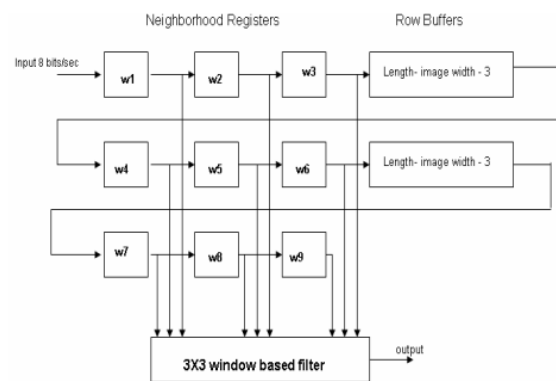
**“Fig.10. Simple contrast reduction”**

Adjusting the gamma setting involves manipulating the correlation between a pixel's luminosity on the display and its numerical representation. Given the established range of red, green, and blue values spanning from 0 to 255, one would logically expect a value of 127 to signify half the maximum potential brightness in an image, 64 to represent a quarter, and so forth.

Have you noticed how the hue and saturation of the color vary with the gamma?

This implies that if the gamma setting on your display is off, you won't be able to see colors and tones the way you want them to look on other people's monitors, and they won't view your photos the way you intended.

**Median Filter:** Median filtering is a non-linear lowpass filtering technique that removes "speckle" noise from photographs. A median filter can be more effective in this type of noisy image than linear low-pass filters since it may be able to remove all the noise without affecting the “clean pixels”. Whether they are dark or bright, individual pixels are eliminated by median filters.



**“Fig.12. Implementation of a 3 × 3 median filter window”**

➤ **Remove “noise” from an image:** In the realm of image processing, the elimination of unwanted artifacts, known as noise, is a critical task. Noise, in this context, refers to any measurement that does not contribute to the meaningful information within the image. MATLAB offers various noise types, including "localvar," "Salt & pepper (Median)," and "Gaussian," along with others such as "Poisson" and "Speckle." Through image processing techniques, the introduced noise is meticulously addressed and removed, allowing for a

cleaner and more accurate representation of the underlying phenomenon.

➤ **Deblurring Images:** Addressing image blurring is an essential aspect of image processing. A range of basic deblurring methods, such as blind, Wiener, Lucy-Richardson, and regularised filter deconvolution, are available in the Image Processing Toolbox. These techniques are designed to rectify blurring caused by factors such as out-of-focus lenses, motion during image capture, atmospheric conditions, and more. Additionally, the toolbox facilitates the conversion between optical transfer functions and point spread functions, contributing to the enhancement of overall image quality. The versatility of these deblurring techniques extends to images in multiple dimensions, ensuring a comprehensive approach to image restoration.

➤ **Image Compression:** Efficient image compression techniques are imperative for the storage and transmission of digital images, particularly in the era of widespread network accessibility. The challenge lies in minimizing the data required to represent a digital image without compromising its integrity. Consider the example where an uncompressed image with 512 x 512 pixels occupies 0.75 MB of storage. Image compression becomes pivotal when dealing with larger files, such as an 18 MB digital slide or a 27 MB/second digital PAL video. Various compression methods, both lossless and lossy, including run-length encoding,

Huffman encoding, transform coding (FT/DCT/Wavelets), and predictive coding, play a crucial role in optimizing storage and transmission efficiency [14].

➤ **Image Segmentation:** “Image segmentation is a fundamental objective in image processing, aiming to partition an image into segments that closely correspond to real-life objects or regions”. This process involves separating pixels in the image that contribute to the overall analysis from those that do not. After an image is segmented, either a set of contours taken straight from the image or a collection of segments that together represent the full image are produced. By achieving this segmentation, image processing techniques enable a more focused and contextually relevant understanding of the depicted objects or scenes.

#### Techniques for segmenting data include:

- a) Edge detection segmentation.
- b) Threshold segmentation.

➤ **Edge detection:** There are numerous practical edge detection methods. The method for determining the borders of a picture is the same everywhere; the use of masks is the only difference. A range of masks, such as the Sobel, Prewitt, Kirsch, and Canny types, can be used.

Motivation behind Edge Detection: To detect noteworthy changes and modifications in the characteristics of the world, it is essential to identify sudden changes in the brightness of images. The presence of breaks in image brightness is expected to be correlated with:

- a) Discontinuities in the orientation of surfaces
- b) Fluctuations in the illumination of the scene
- c) Discontinuities in depth
- d) Alterations in material properties



“i) Roberts cross method” ii) “Canny mask method”

**Fig 14.** “Edge-detection”

**Thresholding:** Determining the presence or absence of edges at a specific location in an image involves applying a threshold after calculating an edge strength measure, typically the gradient magnitude. As the threshold decreases and more edges are detected, the result becomes more vulnerable to noise and may identify edges that represent insignificant image features. Conversely, a high threshold may result in fragmented detection or overlooking minor edges.

➤ **Feature Extraction:** In the realm of facial feature extraction, two distinct methods are explored. The initial step involves the creation of a binary image, a precursor to determining the facial image's centroid (X, Y) using equations 1 and 2. This method serves as a foundational approach for subsequent feature extraction processes [12].

**Gabor filter:** An alternative approach to extracting features from images involves employing a Gabor filter, which captures visual attributes across five frequencies and from eight perspectives. To derive the impulse response of the Gabor filter, a Gaussian function is multiplied by a harmonic function. By convoluting the Fourier transforms of these functions, the Fourier transform of the Gabor filter's impulse response is obtained, as dictated by the multiplication-convolution condition (Convolution theorem) [13].

Gabor filters are adept at extracting information from images oriented in specific ways, with the filter's direction and frequency being critical attributes. It is theorized that Gabor filters mimic sample cells present in the visual cortex [8].

In this context, facial photos are employed to construct a Gabor filter bank, utilizing eight orientations and five

frequencies to transform the image into a wavelet through convolution with 40 Gabor filters. Formally, the Gabor filter is described as a Gaussian filter with variances  $S_x$  and  $s_y$ .

“Equation: Gabor filter =  $G(x,y,\theta,f)$   $G = \exp -\frac{1}{2} \frac{x'^2}{s_x} - \frac{y'^2}{s_y} + \cos 2 \times \pi \times x' (3) x' = x \cos \theta + y \sin \theta y' = y \cos \theta - x \sin \theta$  f: frequency  $\theta$ : The orientation G: Output filter Gabout: Output filtered image.”

➤ **Image Transforms:** The pivotal role of image transforms in various image processing tasks is underscored by methods such as FFT and DCT. These techniques are indispensable for tasks such as compression, restoration, analysis, and picture enhancement. “Within the Image Processing Toolbox, there exists a repertoire of image transforms, including DCT, Radon, and fan-beam projection. Particularly applicable in tomography applications, these transforms leverage parallel-beam and fan-beam projection data for image reconstruction”. The versatile capabilities of MATLAB and the complementary Wavelet Toolbox further augment the range of available picture transformation techniques.

### 3. Result and Discussion

The integration of image processing not only facilitates the storage, transmission, and representation of images for autonomous machine perception but also enhances pictorial information. “The incorporation of a high-speed non-linear adaptive median filter” streamlines the various stages involved in digital picture processing, effectively eliminating impulsive noise and minimizing image distortion. The Image Processing Toolbox emerges as a valuable resource for enhancing the capabilities of the MATLAB numerical computing environment.

### 4. Conclusion

This work presents a computational model for facial recognition that is quick, easy to use, and accurate. Based on our goal, you may conclude that these methods are superior to previous face recognition schemes in terms of speed, ease of use, capacity for learning, and relative insensitivity to small or gradual changes in the face image. For instance, numerous edge detection techniques are offered here, each with special qualities. Similar to that, two procedures were used here for feature extraction: the gabor filter approach and the centriod (X, Y). Everything that is considered is dependent upon our goal.

### 5. Future Scope

To achieve optimal outcomes for images afflicted with noise, blur, and other imperfections, the choice of the most suitable algorithm becomes paramount. Emphasis is placed on the importance of photograph compression,

highlighting its necessity in reducing data size. Given that image compression involves various transformations to minimize the data required for image description, it plays a crucial role in ensuring efficient storage and transmission of images.

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