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Technology and applications of digital image processing

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Abstract—

Digital image processing is modification and enhancement of images by applying various filtering and enhancement techniques for perceiving better visual information and perform various analysis on the images. Application areas of computer digital image technology include measurement, computer aided design, physics, three-dimensional simulation.

Image processing accepts images as inputs and generates a modified image as output for human perception or the modified image may provide useful information. The applications of digital image processing are wide and the scope is large.

In addition to improving and encoding images, digital image processing allows users to extract useful information and save them in various format. Digital image processing is the use of a digital computer to process digital images through an algorithm.

As a subcategory or field of digital signal processing, digital image processing has many advantages over analogue image processing. The image processing system usually treats all images as 2D signals when applying certain predetermined signal processing methods.

Keywords – Image processing, acquisition, DNA, UVA, UVB, Remote sensing

Introduction-

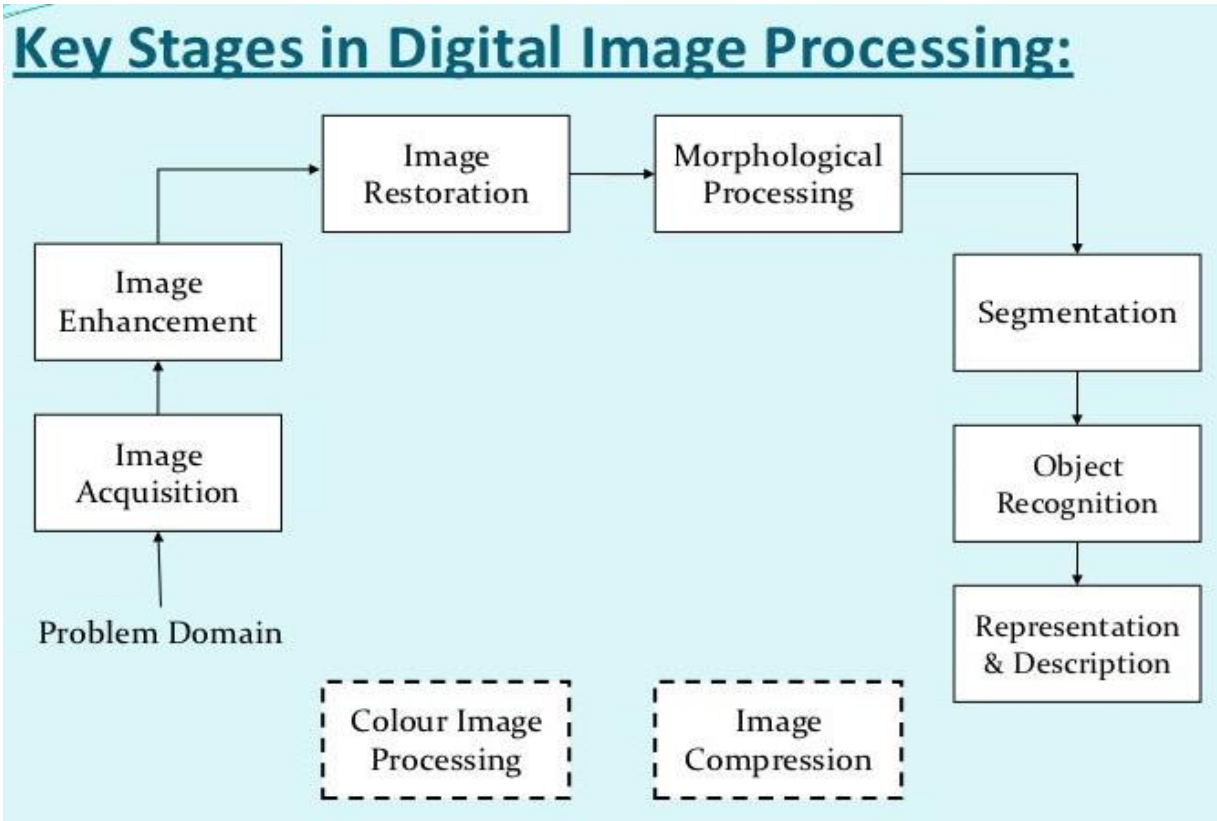
An image is an object or visual which one sees. It is a 2-dimensional function of a 3-dimensional world that surrounds us. Basically, images are 2-D light intensity function
f(x, y) where x and y are spatial or plane co-ordinates and the amplitude at any co-ordinates pair (x, y) is defined as the intensity or gray level of the image at that point.

If x, y and the intensity values are all finite and discrete, then the image is known as a digital image. The digital image is composed of a finite number of elements which has a particular location and value. These elements are called picture elements or pixels or pels.

The most common term for the components of a digital image is "pixel." Images play the single most significant function in human perception, which is not surprising given that vision is the most developed of our senses. Contrary to humans, who are constrained to the visual spectrum of the Imaging devices almost completely cover the full electromagnetic spectrum, from gamma to radio waves. They are able to work with visuals produced by sources that people aren't used to connecting with images. These consist of computer-generated pictures, electron microscopy, and ultrasound.

Image processing involves following three steps.

1. **Image acquisition:** Acquisition can be made via image capturing tools like an optical scanner or with digital photos.
2. **Image enhancement:** Once the image is acquired, it must be processed. Image enhancement includes cropping, enhancing, restoring, and removing glare or other elements. For example, image enhancement reduces signal distortion and clarifies fuzzy or poor-quality images.
3. **Image extraction:** Extraction involves extracting individual image components, thus, producing a result where the output can be an altered image. The process is necessary when an image has a specific shape and requires a description or representation. The image is partitioned into separate areas and labelled with relevant information. It can also create a report based on the image analysis.



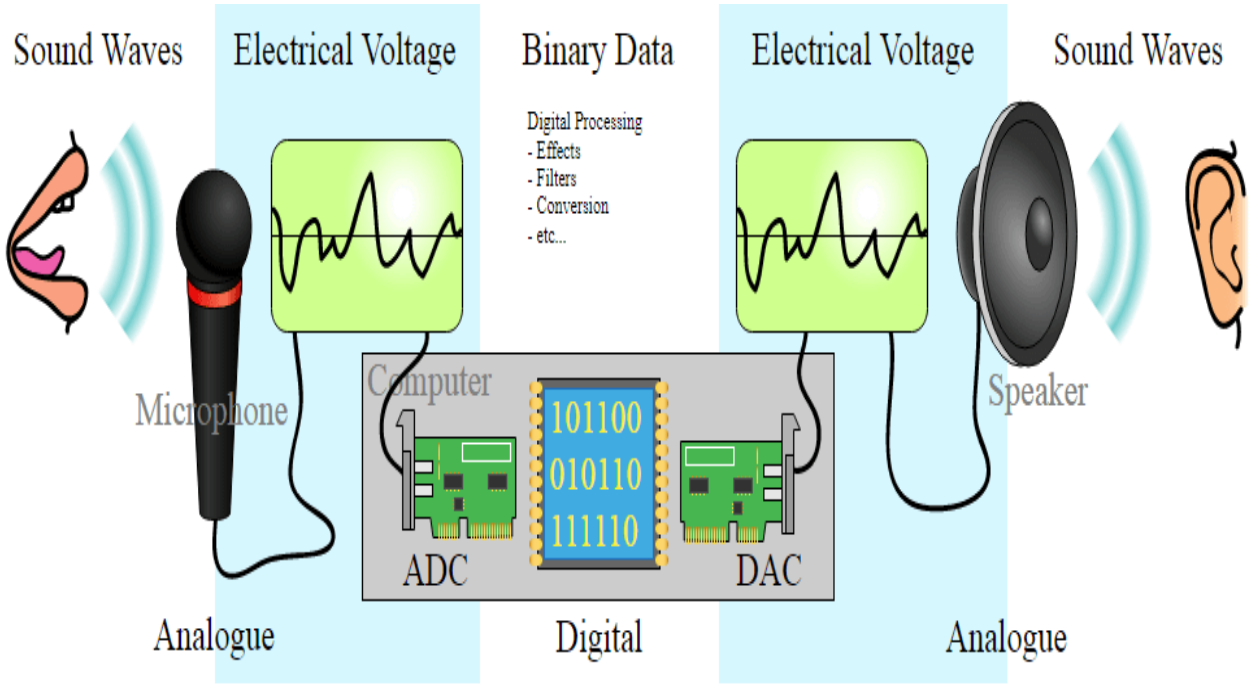
Basic principles of image processing begin with the observation that electromagnetic waves are oriented in a horizontal plane. A single light pixel can be converted into a single image by combining those pixels. These pixels represent different regions of the image. This information helps the computer detect objects and determine the appropriate resolution. Some of the applications of image processing include video processing. Because videos are composed of a sequence of separate images, motion detection is a vital video processing component.

Image processing is essential in many fields, from photography to satellite photographs. This technology improves subjective image quality and aims to make subsequent image recognition and analysis easier. Depending on the application, image processing can change image resolutions and aspect ratios and remove artifacts from a picture. Over the years, image processing has become one of the most rapidly growing technologies within engineering and even the computer science sector.

Two types of image processing –

1. Analogue Image Processing: Generally, analogue image processing is used for hard copies like photographs and printouts. Image analysts use various facets of interpretation while using these visual techniques.

2. Digital image processing: Digital image processing methods help in manipulating and analysing digital images. In addition to improving and encoding images, digital image processing allows users to extract useful information and save them in various formats. This article primarily discusses digital image processing techniques and various phases.



Advantages of Digital Image Processing System -

1. Enhanced Image Quality – One of the primary advantages of digital image processing is the ability to enhance the quality of images. With the use of algorithms, digital images can be sharpened, brightened, or colour corrected to produce a clearer and more visually appealing picture.
2. Improved Medical Diagnosis – Digital image processing is also used in the field of medicine to improve the accuracy of diagnosis. For example, medical images like X-rays and MRIs can be processed to highlight areas of interest or to differentiate between healthy and diseased tissues.
3. **Increased Efficiency** – Digital image processing systems can process images much faster than manual methods. This can help save time and resources in industries like manufacturing, where inspection and quality control processes are crucial.
4. Enhanced Security – Digital image processing systems are also used for security and surveillance purposes. For example, facial recognition algorithms can be used to identify people or to detect unusual activity in public spaces.
5. Creative Applications – Lastly, digital image processing can be used in creative applications like graphic design, video editing, and virtual reality. By manipulating digital images, artists and designers can create new and unique visual experiences.

Disadvantages of Digital Image Processing System -

1. **Complexity** – Digital image processing requires a lot of mathematical knowledge and expertise, making it complex and difficult for those who are not well-versed in the field.
2. **Cost** – The equipment and software required for digital image processing can be expensive, making it difficult for small businesses or individuals to afford.
3. **Quality** – While digital image processing can enhance image quality, it can also degrade it if not done properly. This is because the algorithms used to manipulate images can introduce artifacts or noise that detract from the quality.
4. **Time-consuming** – Digital image processing can be a time-consuming process, especially if a large number of images need to be processed. This can be a disadvantage for those who require quick results.
5. **Ethics** – Digital image processing can also raise ethical concerns. For example, it can be used to manipulate images for propaganda purposes or to deceive people. This raises questions about the authenticity and trustworthiness of digital images.

Applications of Digital Image Processing –

To develop a basic understanding of the breadth and length of the applications, the image processing applications are categorized according to their sources. The principal source of energy for images is the electromagnetic energy spectrum. It also includes acoustic, ultrasonic, electronic etc. Synthetic images used for modelling and visualization are generated in computer.

The most common applications of digital image processing are

1. **Gamma-ray Imaging –**

Imaging based on gamma rays are mostly for nuclear medicine, astronomical observations.

Gamma Rays Used in Medicine -

Any living thing can be killed by gamma rays. It is employed as a benefit in the medical area, particularly oncology. To combat cancer, Cancer patients are treated with these beams. In a procedure known as radiation, high doses of gamma rays are administered to eliminate the malignant cells. A concentrated gamma ray beam is utilized in this procedure to destroy the DNA of malignant cells. These intense rays ionize the water within the malignant cell, resulting in the production of H and OH free radicals. The extremely reactive free radicals interact with one another and damage the cell's DNA. The radiation oncologist's main goal is to direct the radiation beam as closely as possible to the malignancy in order to minimize adverse effects. They are used to treat cancers by sending a high-energy photon directly to the intended tumour, sparing the surrounding tissues from damage. Patients with cancer and tumours receive intensive care. Sanitizing medicinal apparatus. Gamma rays can easily penetrate the packaging of medical equipment and destroy biological tissues, including bacteria and viruses.

Sterilization of objects by gamma radiation -

Radiation of surgical and food supplies: Radiation is privileged method for eliminating microorganisms (fungi, bacteria, virus, etc.). As a result, several applications radiation exists for sterilization of items. For instance, today's disposable syringe and other medical-surgical equipment are radio-sterilized by specialized Industrialists. Similar to this, irradiating food items improves food safety by sterilizing spices and getting rid of salmonella in shrimp and frog legs. Food ionization is another name for this technique. Using gamma to treat artefacts helps to get rid of any germs, or larvae living inside of them, preventing deterioration. This method is applied to the conservation and restoration of artistic artefacts as well as to ethnology and archaeology. It may be used with a variety of materials, including leather, stone, and wood.

2. **X-ray Imaging –**

X-ray imaging is used mainly for medical dignostics and industrial imaging. It is also used for astronomical applications.

X-rays are created when extremely energetic electrons contact an anode and release energy in the form of photons, as we described previously. When these photons travel through materials, they are partially absorbed. The level of absorption varies depending on the kind of substance or material. Behind the region of interest is a cassette that contains a light-resistant material and an intensifying fluorescent screen.

The cassette is left behind when X-rays flow through the body through soft tissues like organs and muscles because these tissues cannot absorb the radiation. Big doses of radiation are administered to the patient, making the film appear black where they are present. In the body, rigid structures like bones allow X-rays to enter.

3. **Ultraviolet Imaging –**

It is used for lithography, industrial inspection, microscopy, lasers, biological imaging and astronomical observations.

A type of electromagnetic radiation called ultraviolet (UV) radiation is emitted by the sun and artificial sources like welding torches and tanning beds. The emission (sending out) of energy from any source is referred to as radiation. Radiation comes in a variety of forms, from very high-energy (high-frequency) radiation like x and gamma rays to very low-energy (low-frequency) radiation like radio waves. The middle of this spectrum is where UV rays fall. They have more energy than light that can be seen, but less than x-rays.

The quantity and nature of UV radiation that a person is exposed to from a tanning bed (or booth) varies on the particular lamps used in the bed, the length of time a person spends in the bed, and the number of times a person

uses the bed. The majority of current UV tanning beds release UVA radiation, with the remainder being UVB rays.

UV light therapy, or phototherapy, is used to treat some skin conditions like psoriasis. A medication called psoralen is first administered as part of the PUVA therapy. The medication accumulates in the skin, increasing its UV sensitivity. After that, UVA radiation is used to treat the patient. Utilizing UVB alone is a different therapy approach.

4. **Wide applications include**

a. Remote Sensing
b. Light microscopy
c. Astronomy
d. Weather observation and prediction
e. Visual inspection of manufactured goods
f. Traffic monitoring and surveillance
g. License plate character recognition
h. Currency recognition
i. Finger-print and face recognition
j. Radar imaging to explore inaccessible regions of the Earth's surface.
k. Mineral and oil exploration
l. Ultrasound imaging of foetus

The application fields of digital image processing are shown in table 1.

Table 1 Application analysis table of digital image processing

Field	Application
Physics and Chemistry	Spectrum Analysis
Biology and Medicine	Cell analysis; CT; X-ray analysis
Environment Protection	Research of atmosphere
Agriculture	Estimation of plants
Irrigation works	Lake, river and dam
Weather	Cloud and weather report
Communication	Fax; TV; phone
Traffic	Robot; products
Economics	IC-card
Military	Missile guidance; training

Analytics and recommendations –

Digital image processing requires computers to convert images into digital form using the digital conversion method and then process it. It is about subjecting various numerical depictions of images to a series of operations to obtain the desired result. This may include image compression, digital enhancement, or automated classification of targets. Digital images are comprised of pixels, which have discrete numeric representations of intensity. They are fed into the image processing system using spatial coordinates. They must be stored in a format compatible with digital computers to use digital images.

Unlike traditional analogue cameras, digital cameras do not have pixels in the same colour. The computer can recognize the differences between the colours by looking at their hue, saturation, and brightness. It then processes that data using a process called gray scaling. In a nutshell, gray scaling turn RGB pixels into one value. As a result, the amount of data in a pixel decreases, and the image becomes more compressed and easier to view. Cost targets often limit the technology that is used to process digital images. Thus, engineers must develop excellent and efficient algorithms while minimizing the number of resources consumed. While all digital image processing applications begin with illumination, it is crucial to understand that if the lighting is poor, the software will not be able to recover the lost information. That's why it is best to use a professional for these applications. A good assembly language programmer should be able to handle high-performance digital image processing applications.

Images are captured in a two-dimensional space, so a digital image processing system will be able to analyze that data. The system will then analyze it using different algorithms to generate output images.

Conclusion –

This research paper first analyses the research status and major application fields of digital image processing technology, and then studies the development trend of digital image technology. At present, digital image processing technology has made great progress in all walks of life. For example, applications in networks, mobile phones, etc., the development of digital image processing technology is closely related to people's lives.

It offers both - a) more sophisticated performance at simple tasks, b) the implementation of methods which would be impossible by analogue means.

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