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Role Of Digital Image Processing In Education And Medical Field

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Abstract
Digital image processing is a technique that uses computer algorithms to analyze images and transform images into better ones.It is an important branch of Telecommunication engineering that deals with the improvisation of reliability and accuracy of the digital communication by employing multiple techniques. Image processing involves many processes such as taking images, preprocessing, image enhancement, transformation and analysis. Variations in pixel values are one of the major challenges faced by image processing. Digital Signal Processing is at the core of virtually all of today's information technology, and its impact is felt everywhere in telecommunications, medical technology, radar and sonar, and in seismic data analysis.Digital Image Processing plays an important role in medical field and education. Various researches has been done and currently popularly used. In education, pictures can be used to enhance student learning and to develop students' self-esteem, or their utilization can be of little or no value and, if used carelessly, can, in fact, undermine students' self-confidence. Digital health technologies include both hardware and software solutions and services, including telemedicine, wearable devices, augmented reality, and virtual reality. Generally, digital health interconnects health systems to improve the use of computational technologies, smart devices, computational analysis techniques, and communication media to aid healthcare professionals and their patients manage illnesses and health risks, as well as promote health and wellbeing. Digital imaging gives healthcare providers better and more accurate images, which leads to establishing diagnoses sooner, making treatment of the patient more successful.

Keyterms: *Image processing, Digital health, Education*

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I. Introduction

Digital image processing is an area of computer science that is developing rapidly and a lot of research is going on. Digital Signal Processors (DSP) take real-world signals like voice, audio, video, temperature, pressure, or position that have been digitized and then mathematically manipulate them. A DSP is designed for performing mathematical functions like "add", "subtract", "multiply" and "divide" very quickly. Digital signal processing dramatically improves the sensitivity of a receiving unit. The effect is most noticeable when noise competes with a desired signal. Digital image processing is a technique that uses computer algorithms to analyze images and transform images into better ones. Digital image processing can improve the quality of digital images, extract features, enable automatic decision-making processes, etc. The basic principles of digital images are as follows.

Digital images are made up of grids of picture elements called pixels
Each pixel has a numerical value that represents the color information of the images.
Image resolution refers to the number of pixels, detail and clarity in images.
Grayscale images use a single channel to represent the intensity levels of images.
Color images utilize multiple channels to represent color information. (Example:RGB)
RGB models are color images created using blue, green, and red channels. CMYK models are images created using cyan, magenta, yellow, and black channels.

Various devices such as cameras, scanners and sensors are used to capture images.

Image processing involves many processes such as taking images, preprocessing, image enhancement, transformation and analysis. Variations in pixel values are one of the major challenges faced by image processing. Another challenge is lack of clarity due to various reasons while taking images.

II. Image Enhancement

Image enhancement process is used to improve visual quality and extract useful information.
Following are the main principles involved in image enhancement.

(i) Representing the distribution of pixels in images using graphical methods is called graphical equalization. This method helps to improve images with uneven pixel variation.
(ii) Point processing operations are used to map input pixel values to output values.
(iii) A filtering method is used to process each pixel based on its neighboring pixels.
(iv) Linear filters are used to modify pixel values. Lowpass filters are used to smooth images.
(v) Highpass filters are used to enhance image edges.
(vi) Adaptive histogram equalization is a method used to improve the local contrast of images.

It can be said that the process of image enhancement greatly helps in improving the images used for diagnosis in the medical field.

III. Image Conversion Methods

Image transformation process is used for image analysis, image enhancement and image transformation from one domain to another. Image transformation helps to detect image features, reduce image size and improve image contrast.
There are usually 2 types of image conversion methods.
(i) Fourier transform (ii) Wavelet transform

Fourier Transform:

The Fourier transform method converts the image from the spatial domain to the frequency domain. The Fourier transform method represents images as collections of sine waves and cosine waves. Image filtering and image detection can be easily done using the Fourier transform method. There are mainly 2 types of Fourier transform methods used.

Discrete Fourier Transform (DFT): This method is used to transform discrete image samples. Various algorithms like Fast Fourier Transform are used for this purpose.
Inverse Fourier Transform: To convert the image from frequency domain to spatial domain.

Wavelet Transformation:

Wavelet transformation is used to represent features of images at multiple scales and resolutions. Wavelet function is used to analyze various frequency components. Wavelet transform is mainly of 2 types.

Continuous Wavelet Transformation (CWT):

CWT works by using the wavelet function at different scales and positions, which helps to obtain detailed information about the frequency content.

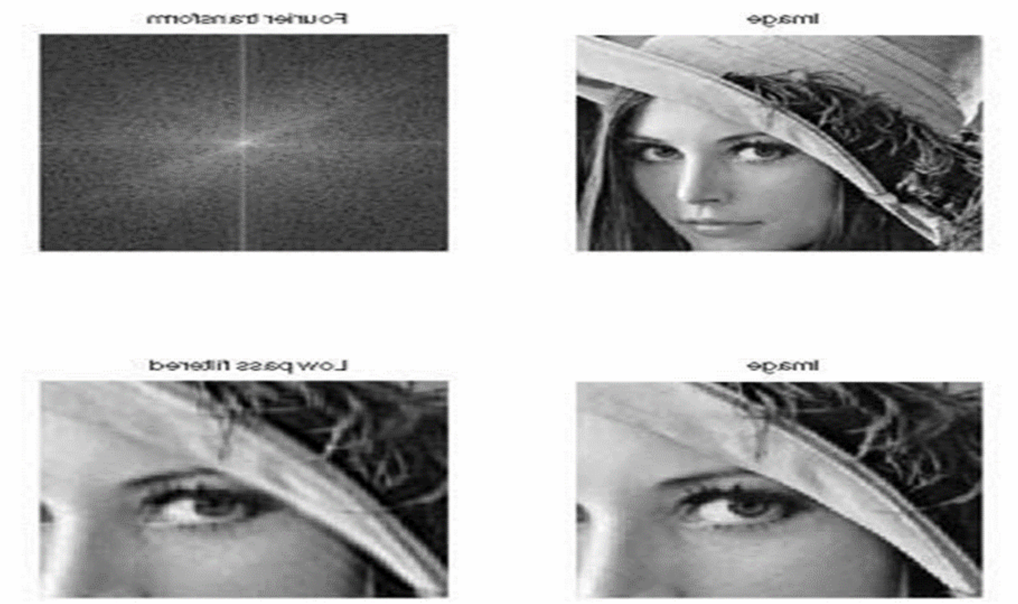
Discrete Wavelet TransformStion (DWT):

Discrete Wavelet Transform works by using discrete samples of images. It separates the images into different frequency bands.
Wavelet denoising process is used to separate noise from images.

IV. Frequency Domain Filtering:

Frequency domain filtering is an important filtering process used in the image transformation process. This method is used to modify the images by changing the frequency components of the images. Lowpass filters are used to remove the noises in the images.
Highpass filters are used to enhance images, edges and details.
The filtering process in the frequency domain is done in the following steps.
(i) Convert the image to frequency domain using Fourier transform.
(ii) Perform frequency domain filter process.
(iii) Convert the image to spatial domain using inverse Fourier transformation

Fig 1: Image processing



V. Image Filtering Methods

Image filtering process is done by changing pixel values by using filter kernel or mask. Image filtering process helps in improving the features of images and extracting information. Various types of filtering processes used in image processing are mentioned below.

Spatial filtering:

Spatial filters operate on pixels and near-pixels. This process combines the kernel with the corresponding pixel values.

Linear filtering:

The process of linear filtering is done through a process called convolution. In the convolution method, the output pixels are recorded as the sum of the weight values of the neighboring input pixels.

Nonlinear filtering:

The process of nonlinear filtering involves changing the pixel values using local information. This process helps to reduce the noise in the images.

Adaptive filtering:

Adaptive filtering is the process of adjusting the filter parameters based on the information in the image.

Image restoration

Image restoration is the process of restoring damaged images to their original state.

The process of image filtering helps to enhance the image information and prepare the images for analysis. Image restoration process helps to improve the quality of images.

VI. Image Compression

The original image is converted into a compressed file using the encoder software. The compressed file is then converted into a new image using the decoder software.Various steps involved in the image compression process.

VII. Functions That Shape The Image Elements:

Morphological image processing is the process used to analyze the shape and structure of images. This process is accomplished through comparisons and arrangements of pixel values.

VIII. Ways Of Representing Images:

Image representation process involves extracting meaningful features from images for image analysis. Pixel level features.

It includes both intensity and color of images.

Histograms are used to represent intensity distributions.

Texture analysis: Texture is the spatial arrangement of intensities.

Edge Detection: Edges are used to mark object boundaries.

Region Descriptions: Region descriptors are used to represent regions such as area and perimeter.

Color Descriptions: Color descriptors are used to represent color distributions and relationships between color channels.

IX. Recognition Of Images, And Image Registration.

For recognizing objects or patterns in images

Application of image recognition in image processing. Feature extraction process is used to extract features in objects. A template matching process is used to compare image regions to templates.

The image recognition process works in the following steps.

(i) Image recognition process uses a dataset consisting of images and associated labels. For example, if an image of a pigeon is used, the label 'pigeon' is used to identify it.

(ii) The next step is to feed such images to a neural network and train it. Convolutional neural networks are commonly used in image processing to perform this type of processing.

(iii) The third step is to include images that are not included in the training set.

Image registration:

It is the process of aligning multiple images of the same scenes or objects. Image registration process helps to correct differences in scales, rotations and translations.

Different types of image registration processes.

Intensity Based Registration: Intensity based registration is used to match images by optimizing the similarity between images.

Feature Based Registration: Feature based registration helps to find features in images and match between images.

Image to Image Registration: Used to align 2 images of the same scene taken at different times. These are useful for purposes such as comparing images in the medical field.

X. Importance Of Digital Image Processing In Medical Field

Medical imaging, tumor localization, skin reference marks, treatment planning, virtual simulation are key parts of radiation treatment. Medical diagnosis for detection, staging, grading, treatment planning before radiation therapy, treatment guidance and verification, evaluation of response to therapy, and treatment follow-up is involved with imaging of tumors and surrounding normal tissues .

Tumor localization

In oncology, benign, pre-malignant, and malignant tumors are the most prevalent forms. Early imaging techniques aid in the reduction of cancer-related morbidity. Pre-processing, segmentation, and morphological operation are the three stages of tumor image processing . The goal of this image processing is always to determine tumor location . The main concern of segmentation, detection, and extraction of tumor area from imaging modalities images that helps to perform radiologists or clinical experts for treatment planning .

Treatment planning

Treatment planning is a computerized procedure that employs a variety of technologies to update treatment outcomes . Image datasets are required by treatment planning systems in order to construct a detailed plan for each beamline route for delivering radiation. The complex programming for multi-leaf collimator (MLC) leaf is sequencing to shape the beam around critical structures during dose delivery . From the initial characterization of tumor volumes through the development of digitally reconstructed radiographs for patient treatment setup and treatment verification, medical images such as CT images are used in the treatment planning process. CT enables tumor imaging as well as the reconstruction of three-dimensional (3D) anatomical information, which is then utilized to create patient models with all of the relevant anatomic, geometric, and electron density data. CT has become the method of choice for 3D treatment planning due to these characteristics, as well as its widespread availability and inexpensive cost.

Virtual simulation

The virtual simulator is a software program that helps with the geometric component of 3D radiation treatment planning.After completion of treatment planning, the patient is directly placed at the LINAC. The actual position is registered by the LINAC-based imaging units .It is obvious that without a high-quality image, all radiation treatments will proceed incorrectly, potentially increasing cancer mortality. As a result, image processing is becoming increasingly important in radiation oncology.

Imaging modalities for cancer diagnosis

Different types of imaging modalities are utilized in diagnosis. How to get an image from modalities is a popular inquiry for the audience. Some imaging modalities are given below:

Mammography

One of the most frequent diagnostics for detecting breast tissue abnormalities is mammography, which uses X-rays to create images of the breast that is known as a mammogram . The two-dimensional image that relies on the identification of morphologic findings for breast cancer these findings include masses, grouped calcifications, asymmetries, and areas of architectural distortion. Spot compression, magnification, rolling, extended views, and genuine lateral views are some of the diagnostic mammographic views that can be used to describe and locate abnormalities. When a high-energy X-ray photon with a low dose interacts with tissue, the photon is attenuated. The reconstruction method captures and images changes in attenuation. In terms of identifying cancer, it has a high specificity sensitivity and temporal response of a portable gadget (about 1 minute). When employing mammography, good resolution means higher accuracy in thick breasts. The number of false-positive predictions is considerable. When compared to CT and MRI, the contrast is poor.

Worldwide breast cancer screening programs, digital mammography (DM) use as a standard imaging technique. The primary benefit of DBT is that it provides depth information about the breast, allowing for improved imaging of possible concealed lesions and demonstrating a difficult reconstruction procedure to build a pseudo-3D representation of the breast from a small number of projection images [48]. The image quality of digital breast tomosynthesis (DBT) volumes depends greatly on the reconstruction algorithm . DBT images have the acquisition of several low-dose planar X-ray projections of the compressed breast over a limited angular range, which is then reconstructed into a pseudo-3D volume. The inherent challenges of this acquisition approach degrade image quality. The limited angle acquisition gives rise to out-of-plane artifacts and low vertical resolution, the low dose per projection increases the impact of noise, and X-ray scatter decreases contrast. The reconstruction algorithm is one of the main aspects of image creation that could ameliorate these technical drawbacks and therefore can greatly affect the final quality of DBT images. DBT has been demonstrated to help with two-dimensional (2D) mammography breast tissue overlapping concerns. However, contemporary DBT technologies are still limited in comparison to mammography. Statistical image reconstruction (SIR) approaches have the ability to reduce DBT through-plane artifacts, and hence could be utilized to reduce anatomical clutter even more .

Galactography can detect a variety of breast abnormalities, including pathological nipple discharge, which is described as bloody, serous, or clear single-orifice nipple discharge . The GL technique is essential for diagnosing and finding intraductal lesions. GL has been shown in several trials to be ineffective in distinguishing benign from malignant tumors.

Scintimammography using 99mtc-sestamibi is a non-invasive and painless diagnostic imaging method where a variety of radiopharmaceuticals create planar and tomographic pictures as well as provide information on tumor cell viability and cellularity that is used to detect breast cancer when mammography is inconclusive . In the presence of cancer tissue, the radiopharmaceutical accumulates in the breast, which may be seen clearly in the photographs . It is the most widely used agent for this purpose because of the advantages of 99mTcsestamibi tagging and its great efficiency in detecting carcinomas.

Image processing techniques

Contrast stretching, histogram processing, spatial filtering (mean filter and median filter) Adaptive histogram equalization (AHE), brightness preserving bi-histogram equalization (BPBHE), recursive mean separate histogram decomposition (RMSHD), multi-decomposition histogram equalization (MDHE), minimum mean brightness error bi-histogram equalization (MMBEBHE), and adaptive smoothing

- Low pass filtering: Butterworth low pass filter and Gaussian low pass filter. High pass filtering: ideal high pass filter and Butterworth high pass filter .
- Enhancement based upon wavelet transform and morphology, morphological operations (enhancement of image using multi-scale morphology)
- Direct contrast enhancement techniques
- Adaptive neighborhood contrast enhancement

Removal of noise using wiener function [62]

An intuitionistic fuzzification scheme based on the optimization of intuitionistic fuzzy entropy and contrast limited adaptive histogram equalization (CLAHE)

Mammogram enhancement, non-subsampled pyramid (NSP), low pass filter (LPF), high pass filter (HPF), directional filter bank (DFB), 2D-directional edge filter (HTDE), combining directional and scale features, adaptive histogram equalization (AHE), one-dimensional spatial profile of difference of Gaussian and HTDE filter, detection of microcalcification (MC)

Ultrasound

A hand-held transducer transmits and receives pulsed acoustic waves, which are used in medical ultrasound imaging. This is a well-established technique that is widely used throughout the world. Its benefits include cost-effectiveness, flexibility, and the absence of ionizing radiation. Generally, the morphology, orientation, internal structure, and margins of lesions from multiple planes with a high resolution both in predominantly fatty breasts and dense, glandular structures find out from ultrasound. Ultrasound electrography, contrast-enhanced ultrasound, three-dimensional ultrasound, automated breast sonography, computer-aided detection for breast ultrasound use for better outcome of image quality.

The biggest disadvantage of ultrasound is its restricted penetration, which is due to the fact that sound waves cannot pass through bone or air, limiting its usage in the brain, lungs, and abdominal region [69].

Image processing techniques

Modern beamforming techniques, dynamically focused transmission and reception, apodization, limited diffraction beams, pulse compression, compounding, spatial compounding, frequency compounding, strain compounding, harmonic imaging, pulse inversion, filtering, adaptive filters, anisotropic diffusion, wavelets, and deconvolution.

Gray-level normalization, image fuzzification, and fuzzy histogram computation, histogram partitioning and equalization, and image defuzzification

Contrast limited adaptive histogram equalization (CLAHE) block size, histogram bins, max slope, 3D discrete wavelet transform (3D DWT), wavelet thresholding, and bilateral filter

CT

The CT scanner displays several slices of bodily tissues in various directions. Due to more informative CT images so it is more effective than X-ray . The resolution, noise, and contrast are the three key elements that influence image quality. Contrast materials are frequently injected into the body during CT scans to improve visibility of certain organs, blood arteries, or tissues by increasing contrast between these locations and surrounding structures in CT images. Contrast enhanced CT (CECT) is a technique that provides useful anatomical information that is not acquired by standard non-enhanced CT (NECT) imaging . Modern micro-CT- and X-ray-based scanners allow the acquisition of three-dimensional (3-D) images of core samples with a resolution as fine as 0.1 μm per voxel these images can be used to construct 3-D digital models of core samples in extremely fine detail.

Image processing techniques

Noise filter, watershed segmentation, thresholding, image acquisition, and image pre-processing (smoothing, enhancement, image segmentation, feature extraction, and classification) Data analyze and interpretations: histogram, particles analyze, and profile plot

MRI

Magnetic resonance imaging (MRI) is a noninvasive imaging tool for examining anatomic features, physiological functions, and tissue molecular composition. MRI is known as a non-invasive, radiation-free imaging technology for detecting and diagnosing small lesions, with significant implications for various kinds of cancer diagnosis, prognosis, and treatment.

Image processing techniques

Histogram equalization techniques, typical histogram equalization (HE), brightness preserving bi-histogram equalization (BBHE), recursive mean separated histogram equalization (RMSHE), and dynamic histogram equalization (DHE), Dynamic block coding ,Median filter, Wiener filter,Local area histogram equalization (LAHE) .

Positron emission tomography (PET)

PET and combined PET/computed tomography (CT) is increasingly used for oncologic imaging . Fluorodeoxyglucose (FDG) PET demonstrates abnormal metabolic features associated with malignancy that often precedes morphologic findings demonstrated with anatomic imaging . Combined PET/CT systems are increasingly available and currently account for almost all of the new whole-body PET installations. In these systems, the CT and PET images are fused and provide combined anatomic and physiologic imaging . Typically, the CT portion is used to provide attenuation correction as well as an anatomic correlation for the PET imaging component . This modality allows more precise anatomic localization of PET abnormalities and in general has been shown to improve diagnostic accuracy compared with FDG PET alone .

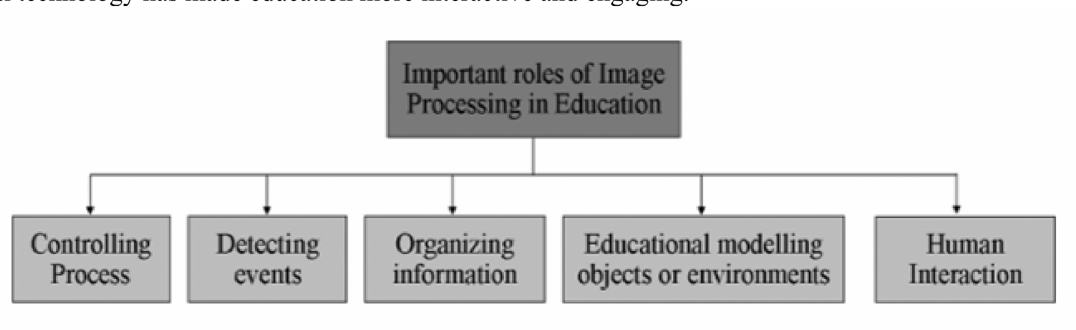
XI. Role Of Digital Image Processing In Education.

The Image Processing for Teaching (IPT) project provides a powerful medium to excite students about science and mathematics, especially children from minority groups and others whose needs have not been met by traditional “coded” ways of teaching these subjects.

Pictures can be used to enhance student learning and to develop students self-esteem, or their utilization can be of little or no value and, if used carelessly, can, in fact, undermine students' self-confidence.

Students can access a vast range of information and resources that were unavailable in traditional classrooms. Increased student engagement

Digital technology has made education more interactive and engaging.



• Controlling Process: The control procedure includes cautiously gathering the data about a student and instructor individual or gathering of individuals so as to settle on important choices about each, for example, ordering databases of images and image sequencing.
• Detecting event: Event recognition is the way toward distinguishing that an occasion was produced in the use of image processing. Regularly, connectors
Organizing information: Organizing data is a major piece of perusing and composing achievement. So as to plainly understand what a student is perusing, you should have the option to assemble and compose the data being introduced. For example, ordering of databases of image and image groupings.
• Educational displaying items or situations: A model of educating is a portrayal of a learning domain, including our conduct as instructors when that model is utilized. Eggen (1979) characterized that models are prescriptive showing systems that help to acknowledge explicit instructional objectives, for example, modern review, clinical picture investigation, or land demonstrating.
• Human Interaction: Human interaction manages discussions and conversations among students and teachers. A facilitator conveying a talk to a gathering of understudies in a study hall where feelings, contact, and charge are present. We regularly accept that innovation is taking a front seat in instruction, for example, as the contribution to a device for computers human collaboration.

XII.

Conclusion

The application of digital signal processing technology in communication is most visible in almost all fields. Although its benefits are evident and it is a future development trend, there are certain drawbacks, such as signal quality and signal transmission rate. In the healthcare and education field digital signal processing had made a remarkable part. As a result, future research on digital signal processing technology in communication will be required to assure more convenient and dependable communication and also in other fields. High-speed digital processing technology and multi-core digital processing technology, for example, are being researched.

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