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ROLE OF IMAGE PROCESSING IN MODERN HEALTHCARE: A REVIEW OF TECHNIQUES AND APPLICATIONS

Dr.R.RAMAN[1], Associate Professor, Department of ECE, Aditya College of Engineering, Surampalem, East Godavari district, Andhra Pradesh, ramanphdr@gmail.com

Dr.W.Deva Priya[2], Professor, Department of Computer Science and Engineering, Saveetha School of Engineering, SIMATs University, w.devapriyya@gmail.com

Ms Indhumathi G[3], Assistant, Rajalakshmi Engineering College, Chennai, Indhumathi.g@rajalakshmi.edu.in

A Hariom prakash rao[4], Associate professor, PNR Collge of pharmacy, Shamshabad, hp0696513@gmail.com

Anju Asokan[5], Assistant professor, Computer and communication Engineering , Sri Eshwar college of engineering, Kinathukadavu, anjuasokan@sece.ac.in

Dr K T Vigneswara Rao[6], Assistant Professor NICMAR Business School, NICMAR University, Pune - 411045, ktvraofpm@gmail.com

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ABSTRACT:

Image processing has emerged as a critical technology in modern healthcare, revolutionizing various aspects of medical diagnosis, treatment, and research. This paper presents a comprehensive review of the role of image processing techniques and their applications in healthcare. The paper begins by highlighting the fundamental importance of medical imaging in diagnosing diseases and guiding treatment decisions. It then delves into the various image processing techniques that are employed to enhance and analyze medical images. These techniques include image enhancement, segmentation, registration, and classification. Image enhancement techniques aim to improve the visual quality of medical images by reducing noise, enhancing contrast, and improving spatial resolution. Various filtering algorithms, such as median filtering and wavelet transforms, are commonly employed for noise reduction. Contrast enhancement techniques, such as histogram equalization and adaptive filtering, are used to enhance the visibility of structures within the images. Segmentation plays a crucial role in extracting relevant information from medical images. It involves partitioning an image into meaningful regions, such as organs or lesions. Numerous segmentation algorithms, including thresholding, region-growing, and active contours, have been developed to accurately delineate anatomical structures or identify abnormalities within images. Image registration techniques enable the alignment of multiple images acquired at different times or from different modalities. By aligning images, clinicians can compare changes in a patient's condition over time or fuse complementary information from different modalities, such as magnetic resonance imaging (MRI) and computed tomography (CT). Registration algorithms utilize features such as landmarks, intensity-based methods, or deformable models to achieve accurate alignment. Classification techniques utilize machine learning algorithms to classify medical images into different categories, such as identifying cancerous tumors or classifying diseases based on their severity. Deep learning approaches, particularly convolutional neural networks (CNNs), have demonstrated remarkable success in automating the diagnosis process by learning complex patterns and features from large datasets. The paper then explores a wide range of applications of image processing in healthcare. These applications include computer-aided diagnosis, image-guided surgery, image-based treatment planning, virtual reality visualization, and medical research. Image processing techniques enable accurate detection, characterization, and quantification of diseases, facilitating early diagnosis and personalized treatment strategies. Overall, image processing techniques have revolutionized modern healthcare by enabling more accurate and efficient analysis of medical images. They play a pivotal role in various medical domains, including radiology, pathology, cardiology, and oncology. As technology continues to advance, image processing is expected to further enhance its contributions to healthcare, paving the way for more precise diagnostics, targeted therapies, and improved patient outcomes.

Keywords: Image Processing, Medical Imaging, Computer aided Diagnosis, etc.,

1.INTRODUCTION:

Image processing has emerged as a vital technology in modern healthcare, revolutionizing various aspects of medical diagnosis, treatment, and research. The ability to acquire, analyze, and interpret medical images plays a fundamental role in clinical decision-making, allowing healthcare professionals to visualize and understand the underlying structures and abnormalities within the human body. With the advent of advanced imaging modalities and sophisticated image processing techniques, the field of medical imaging has witnessed remarkable progress in recent years. Medical imaging techniques provide a non-invasive means of capturing detailed anatomical and functional information about the human body. These techniques include X-ray imaging, computed tomography (CT), magnetic resonance imaging (MRI), ultrasound, nuclear medicine imaging, and positron emission tomography (PET), among others. These modalities generate vast amounts of data in the form of digital images, which need to be processed and analyzed to extract meaningful information for clinical diagnosis and decision-making.

Image processing refers to a set of techniques and algorithms that are applied to digital images to improve their quality, extract relevant features, and enable automated analysis. These techniques utilize principles from various disciplines, including mathematics, physics, signal processing, and computer science, to manipulate and interpret the acquired images. By applying image processing techniques, medical images can be enhanced, segmented, registered, and classified, enabling clinicians to obtain valuable insights and make informed decisions. The primary objective of image processing in healthcare is to improve the accuracy, efficiency, and reliability of medical diagnosis. The enhanced visual quality of medical images obtained through image processing techniques allows clinicians to identify and interpret anatomical structures more accurately. Moreover, image processing facilitates the detection and characterization of abnormalities, enabling early diagnosis and treatment planning. It also plays a crucial role in image-guided interventions and surgical procedures, providing real-time guidance and feedback to the operating team.

One of the key areas where image processing has made significant contributions is in computer-aided diagnosis (CAD). CAD systems utilize image processing algorithms, combined with machine learning and artificial intelligence techniques, to assist radiologists

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and clinicians in the interpretation and analysis of medical images. These systems can automatically detect and highlight potential abnormalities, helping to reduce human error and improve diagnostic accuracy. CAD systems have been particularly successful in areas such as mammography for breast cancer detection and lung nodule detection in chest X-rays. Image processing techniques are also instrumental in image segmentation, which involves partitioning an image into meaningful regions or objects. Accurate segmentation is critical for identifying and delineating anatomical structures, lesions, tumors, and other abnormalities within medical images. Segmentation algorithms utilize various approaches, including thresholding, region-growing, level sets, and machine learning-based methods, to extract and separate relevant structures from the background or neighbouring tissues. Segmentation plays a crucial role in treatment planning, surgical guidance, and the quantitative analysis of disease progression.

Image registration is another important aspect of image processing in healthcare. It involves aligning multiple images acquired from different modalities or at different time points, enabling clinicians to compare and analyze changes in a patient's condition. By registering images, healthcare professionals can fuse complementary information from different imaging modalities, such as combining MRI and CT images, to obtain a more comprehensive view of a patient's anatomy and pathology. Image registration algorithms utilize various techniques, including feature-based methods, intensity-based methods, and deformable models, to achieve accurate alignment and fusion of images.

Classification of medical images is a critical task that involves categorizing images into different classes or groups based on specific features or characteristics. Image classification techniques utilize machine learning and pattern recognition algorithms to automatically identify and classify diseases, tumors, or abnormalities. Deep learning techniques, particularly convolutional neural networks (CNNs), have shown remarkable success in image classification tasks, achieving performance levels comparable to or even surpassing human experts. CNNs can learn complex patterns and features directly from medical images, enabling automated and accurate diagnosis.The applications of image processing in healthcare are vast and diverse. In addition to CAD systems, image processing techniques are widely used in image-based treatment planning, where medical images are utilized to optimize radiation therapy or surgical procedures. By analyzing and segmenting images, treatment plans can be tailored to individual patients, optimizing treatment outcomes and minimizing side effects. Image processing also plays a crucial role in image-guided surgery, providing real-time visualization and feedback to surgeons during complex procedures such as tumor resections or navigated interventions.

Furthermore, image processing techniques are invaluable in medical research, enabling quantitative analysis, longitudinal studies, and large-scale data mining. By extracting quantitative features and biomarkers from medical images, researchers can investigate disease progression, treatment response, and the impact of interventions. These findings can contribute to the development of new diagnostic tools, treatment strategies, and personalized medicine approaches.

2.RELATED STUDY:

With the widespread use of EHRs, it is now feasible to apply automated approaches to rapidly extract actionable insights from medical records. Important pieces of health data, such

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as oncology medical events, are made up of characteristics that characterize cancerous tumors. The extraction of events in cancer medicine has become a popular topic of study in recent years. It is published as an evaluation assignment at a number of academic conferences, and a wealth of high-quality annotation data is made available. This piece presents a medical occurrence with tumor-related features, focusing on their distinct qualities. The main tumor site, primary tumor size features, and tumor metastasis sites may all be extracted simultaneously using the conventional extraction approach. In addition, a key-based strategy is presented to address the issue of a lack of annotation texts for medical events associated with tumors. The transfer learning capacity of the default extraction approach is enhanced for various tumor-related medical event extractions by employing a pseudo-data-generation algorithm that randomly substitutes information in the complete domain. In the CCKS2020 electronic health record's clinical medical event extraction and evaluation task, the suggested solution placed third. The efficiency of the suggested strategy is confirmed by several trials on the CCKS2020 dataset [1].

For women everywhere, breast cancer is the leading cause of cancer death. Since its cause remains unknown, there are currently no successful methods for preventing or treating breast cancer. A higher chance of a full recovery from breast cancer is associated with an early diagnosis, which is a very effective method of detection and management. When it comes to the early detection of breast cancer, mammography is unrivaled. As an added bonus, this gadget can help doctors figure out if a malignancy is benign, malignant, or completely normal. This article explores a machine learning and image processing-based evolutionary strategy for breast cancer classification and detection. With the use of this model, skin illnesses may be more easily classified and identified through the application of image preprocessing, feature extraction, feature selection, and machine learning. A geometric mean filter is applied to improve the image. To accomplish feature extraction, AlexNet is employed. The relief algorithm is utilized for feature selection. The model employs machine learning techniques including least squares support vector machines, KNN, random forests, and naive Bayes to classify and diagnose diseases. MIAS data gathering is used in the experimental inquiry. The suggested method is useful for analyzing breast cancer images and making a precise diagnosis [2].

This thesis proposes a platform for combining Augmented Reality (AR) hardware with machine learning in a user-oriented pipeline, providing medical staff with an intuitive 3D visualization of volumetric Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) medical image segmentations inside the AR headset without the need for human intervention in the loading, processing, or segmentation of medical images. The frontend-backend design of the Microsoft HoloLens-based augmented reality visualization is modular, making it scalable to support real-time visualizations on a wide variety of augmented reality headsets. The pipeline also contains a completely automated CNN algorithm for segmenting the liver from CT images, since Convolutional Neural Networks (CNNs) have recently showed improved performance for the machine learning job of image semantic segmentation. The model is based on the Deep Retinal Image Understanding (DRIU) model, which is a Fully Convolutional Network that produces side outputs from feature maps of varying resolutions. The input to this 2.5D method is a sequence of scan slices taken in successive order. Good results and adaptability were shown in trials conducted on the Liver Tumor Segmentation Challenge (LiTS) dataset for liver segmentation. While many have dabbled in this area, very few have made significant progress in bringing this technology into clinical

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settings such as operating rooms. Following this, we intend to get real-world feedback from medical professionals and radiologists [3].

When it comes to female mortality, breast cancer (BC) is by far the worst. Typically, it strikes women over the age of 40. Since it allows for the diagnosis and decision-making of several illnesses, like BC, medical image analysis is one of the most promising research topics. This work employs a structured literature review (SLR) to investigate the application of ML and IP methods to BC imaging. From 2000–2019–August, 530 papers were chosen and analyzed based on the following ten criteria: year and publication channel; empirical type; research type; medical task; machine learning techniques; datasets used; validation methods; performance measures; and image processing techniques such as image pre-processing, segmentation, feature extraction, and feature selection. Diagnostics were found to be the most common medical activity, with deep learning (DL) approaches being employed for categorization. Furthermore, we discovered that classification, followed by prediction, and then clustering, was the most researched ML aim. Studies were chosen because they employed public or private datasets, with MIAS being the most commonly analyzed public dataset and mammography as the imaging modality rather than ultrasound or magnetic resonance imaging. The bulk of the included studies use noise reduction and color normalization as part of their input picture processing, while some employ segmentation to extract the region of interest through the thresholding approach. To extract features, researchers either used traditional methods (texture features, shape features, etc.) or deep learning methods (e.g., VGG16, VGG19, ResNet, etc.); finally, feature selection techniques, in particular filter methods, were used by only a small fraction of papers [4].

3. GENERALIZED METHODOLOGY OF FLOW CHART:

Figure 3.1 displays the procedures undergoing for the Medical Image diagnosing to identify diseases, it shows the step-by-step approach of the implementation. Here it includes the comparative processors, Feature extraction method and classifiers of the existing approaches.

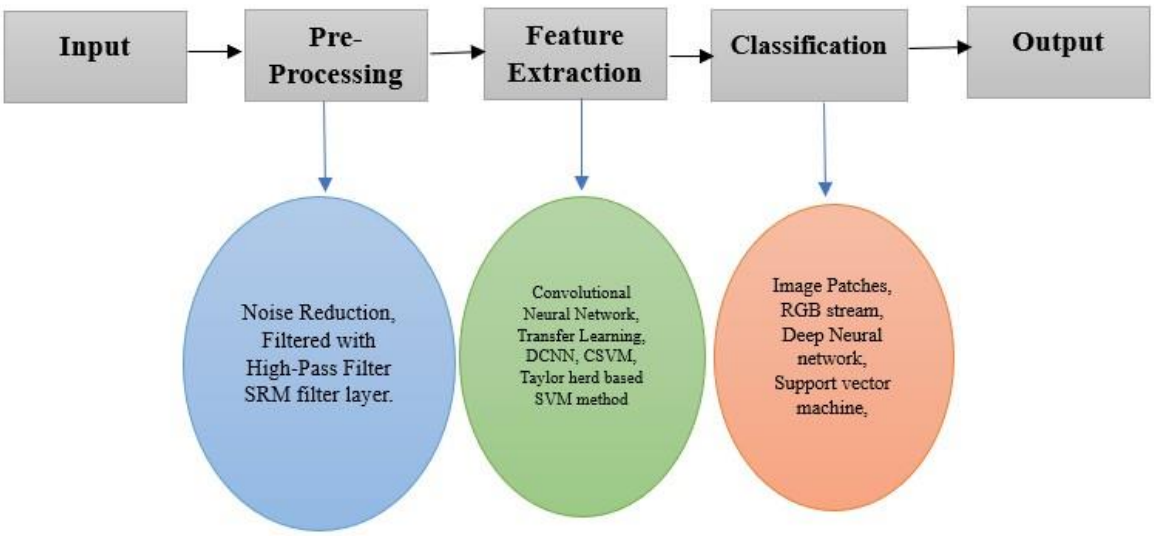

Figure 3.1: Process of Medical Image Processing

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Pre-Processing: Pre-processing is an essential step in image processing that involves several techniques aimed at enhancing the quality and usability of medical images before further analysis and interpretation. In the medical field, pre-processing techniques play a crucial role in reducing noise, improving contrast, and standardizing images to ensure consistency and reliability in subsequent image processing tasks.

One of the primary pre-processing techniques is noise reduction, which aims to remove or reduce unwanted variations or artifacts present in medical images. Noise can be caused by various factors, such as sensor imperfections, transmission errors, or environmental interference. Common noise reduction techniques include filtering algorithms such as median filtering, Gaussian filtering, or wavelet denoising. These techniques help to enhance the clarity and visual quality of medical images by removing or reducing noise while preserving important diagnostic information.

Feature Extraction: Feature extraction is a crucial step in image processing and analysis, particularly in the medical field, where it plays a pivotal role in capturing relevant information and characteristics from medical images. Feature extraction involves transforming raw pixel data into a set of meaningful and representative features that can be used for subsequent tasks such as classification, segmentation, or pattern recognition.

In medical image analysis, features can encompass various aspects, including intensity, texture, shape, and spatial relationships. Intensity-based features capture statistical properties of pixel intensity values, such as mean, variance, or histogram-based measures. These features provide information about the overall brightness, contrast, or distribution of pixel intensities within an image.

Feature Classification: Feature classification is a vital step in medical image analysis, where extracted features are utilized to categorize and classify medical images into different classes or categories based on specific characteristics or patterns. Classification techniques aim to automate the process of assigning labels or diagnoses to medical images, enabling efficient and accurate decision-making.

Various machine learning algorithms, such as support vector machines (SVM), random forests, or convolutional neural networks (CNN), are commonly employed for feature classification in medical image analysis. These algorithms leverage the extracted features to learn discriminative patterns and create models that can accurately differentiate between different classes of medical images.

Medical image processing has a wide range of important applications in healthcare. Some of the key applications include:

Diagnosis and Detection: Medical image processing plays a critical role in the diagnosis and detection of various diseases and conditions. It enables the analysis and interpretation of medical images to identify abnormalities, lesions, tumors, or other indicators of diseases. For example, in radiology, image processing techniques are used to detect and diagnose conditions such as cancer, cardiovascular diseases, neurological disorders, and musculoskeletal abnormalities.

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Image Enhancement: Image processing techniques are employed to enhance the quality and clarity of medical images, improving visibility and aiding in accurate diagnosis. Image enhancement techniques such as noise reduction, contrast adjustment, and sharpening algorithms help to improve the visibility of structures and abnormalities, ensuring that important details are not obscured or distorted.

Segmentation: Image segmentation involves dividing an image into meaningful and distinct regions or objects. Medical image segmentation is crucial for identifying and delineating specific structures or regions of interest, such as organs, tumors, blood vessels, or lesions. Accurate segmentation allows for precise measurements, quantitative analysis, and targeted interventions.

4.RESULTS COMPARISSION:

Table 1: Analysing the existing techniques based on image processing based diagonising

S.NO	AUTHORS	FEATURES EXTRACTED	CLASSIFIER USED	ACCURACY	DATASET
1.	AgostinaJ Larrazabal,C'esar Mart'inez,Ben Glocker and Enzo Ferrante [5]	erroneous and noisy segmentation masks can be improved using Post-DAE.	Random Forest and DAE	Not Available	Not Available
2.	Fangfang Ye , Sen Xu , Ting Wang , Zhangquan Wang , and Tiaojuan Ren [6]	Improve the structure of traditional neural network and improve the efficiency and accuracy	Hybrid algorithm of CNN in chaotic recursive diagonal model	Not Available	Not Available
3.	Gaurav Dhiman, Sapna Juneja, Wattana Viriyasitavat, Hamidreza Mohafez, Maryam Hadizadeh, Mohammad Aminul Islam, Ibrahim El Bayoumy and Kamal Gulati [7]	The problem of the small number and types of annotation texts for tumour-related medical events, an key based approach.	Pseudo data generation	89.52%	CCKS2020 Dataset
4.	Siyuan Zhang, Yifan Wang , Jiayao Jiang, Jingxian Dong, Weiwei Yi , and Wenguang Hou [8]	The medical ultrasound Image Quality Analysis in basis of Convolutional Neural	Deep Convolutional Neural Network with transfer learning	Not Available	LIVE IQA has 982 images in total

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		Network			
5.	Mandong Hu,Yi Zhong,Shuxuan Xie,Haibin Lv and Zhihan Lv [9]	Higher accuracy, a more apparent denoising effect and the best segmentation and recognition effect	Improved fuzzy clustering and HPU-Net	0.845 and 0.798	Sample Dataset
6.	Peihua Liu,Nan Yue and Jiandong Chen [10]	A telemedicine image acquision system can be built, so that medical experts can identify atheletes' injuries in time and provide the basis	C-Support Vector Machine and Chan-Vese and SVM	90%	McConnell Brain Imaging center online image library 800 groups os image
7.	Y.N Fu'adah, I Wijayanto,N K C Pratiwi, F F Taliningsih,S Rizal and M A Pramudito [11]	Develop automated classification system of Alzheimer's Disease	CNN using AlexNet Architecture	95%	Alzheimer's MRI dataset has 664 images.
8.	C.Narasimha and A. Nagaraja Rao [12]	Tunes the hyperplane parameters of SVM optimally so that the optimal identification of the noisy pixels in the image is ensured and replaced.	Taylor herd based SVM method	30.36dB	BRATS
9.	Joao Victor S. das Chagas, Douglas de A. Rodrigues, Robertro F.Lvo, Mohammad Mehedi Hassan,Victor Hugo C.de	Real time Internet of Things system to detect pneumonia in chest X-ray images	VGG19 architecture with the SVM classifier using RBF kernel used	96.46%	6000 chest X-ray images of children

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	Albuqurque,Pedro P.Reboucas Filho [13]				
10.	Naiqin Feng,Xiuqin Geng and Lijuan Qin [14]	A uniform learning framework is established with the use conditional rando field	DCNN and Conditional Random Forest	Not Available	Not Available

5. CONCLUSION:

In conclusion, image processing and its integration with machine learning algorithms have become indispensable in the field of healthcare. The review of techniques and applications has highlighted the significant role of image processing in modern healthcare, ranging from medical imaging and diagnostics to treatment planning and research.

Image processing techniques, such as pre-processing, feature extraction, and classification, are crucial for improving the quality and interpretability of medical images. Pre-processing techniques enable noise reduction, contrast enhancement, and standardization, resulting in clearer and more reliable images for further analysis. Feature extraction techniques capture meaningful and relevant information from medical images, including intensity, texture, shape, and spatial relationships. These extracted features provide valuable insights and act as inputs for machine learning algorithms. Machine learning algorithms, including convolutional neural networks (CNNs), support vector machines (SVM), random forests, and deep belief networks (DBNs), have been successfully applied in medical image analysis. These algorithms automate the interpretation, classification, and decision-making processes, enabling accurate diagnostics, disease classification, and treatment planning. They leverage the extracted features to learn patterns and relationships, making predictions and classifications based on the learned knowledge.

The integration of image processing and machine learning in healthcare has revolutionized the field by improving efficiency, accuracy, and personalized care. It has paved the way for automated diagnosis, precise treatment planning, and individualized medicine. The advancements in image processing techniques and machine learning algorithms have enabled healthcare professionals to harness the power of large-scale medical image datasets and make informed decisions for patient care. Moreover, image processing and machine learning have facilitated medical research by enabling quantitative analysis, longitudinal studies, and data mining. These techniques have contributed to the development of new diagnostic tools, treatment strategies, and personalized medicine approaches. They have also accelerated the discovery of biomarkers, disease progression models, and therapeutic targets.

However, challenges still exist in the field of image processing and machine learning in healthcare. These include the need for robust and interpretable algorithms, addressing issues of data privacy and security, ensuring ethical use of AI in healthcare, and integrating these technologies seamlessly into clinical workflows.In summary, image processing, in conjunction with machine learning algorithms, has become an integral part of modern healthcare. It has transformed the way medical images are acquired, analyzed, and utilized,

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leading to improved diagnostics, personalized treatments, and enhanced patient outcomes. The continued advancements in image processing and machine learning hold great promise for further innovations in healthcare, ultimately benefiting patients worldwide.

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