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A Survey on Efficient Analysis of Soft Tissues Tumors using Machine Learning

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Abstract

Soft tissue tumors (STT) represent a significant medical challenge, requiring accurate and efficient analysis for timely diagnosis and treatment. This survey explores the application of machine learning techniques in the analysis of soft tissue tumors, focusing on enhancing efficiency in detection and classification. The review encompasses various approaches, including traditional image processing methods and the more recent advancements in machine learning. One of the key contributions of this survey is the proposal of a method employing Convolutional Neural Networks (CNN) for the analysis of soft tissue tumors. CNNs have demonstrated remarkable success in image-related tasks, making them particularly suitable for medical image analysis. The research particularly aims in distinguishing Melanoma from normal skin tissue. To enhance the efficiency of research on the analysis of soft tissue tumors, the proposed study provides a comprehensive review of relevant literature, focusing on the application of machine learning in the identification of soft tissue tumors. This review includes an evaluation of the merits and demerits of each system. Furthermore, the study introduces a suggested model capable of providing accurate classification for soft tissue tumors.

Keywords: Machine learning, STT, CNN, Classification, Deep learning.

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1. Introduction

Soft tissue tumors can develop anywhere in the body. They develop in the soft tissues of the body, including the muscles, tendons, ligaments, and blood vessels. These tumors can form in anybody and at any point in a person's life. The advent of machine learning has ushered in a new era in healthcare, revolutionizing the way we diagnose and treat various medical conditions. One area where this technology holds immense promise is in the automated assessment of soft tissue tumors. Soft tissue tumors, encompassing a wide array of benign and malignant neoplasms, have traditionally posed significant challenges to accurate and timely diagnosis. However, the integration of machine learning algorithms into the diagnostic process offers the potential for more precise, efficient, and consistent assessments. In this context, this study explores the remarkable strides made within the domain of automated soft tissue tumor diagnosis through machine learning, highlighting the benefits it brings in terms of early detection, personalized treatment planning, and improved patient outcomes.

Machine learning use in the diagnosis of soft tissue tumors is particularly significant due to the intricate and varied nature of these tumors. Soft tissue tumors can manifest in numerous locations, exhibit diverse morphologies, and possess a range of histological characteristics. Traditional diagnostic methods often rely on human interpretation of images used in medical field, such as MRI, CT scans, or histopathology slides, which can be time-consuming and subject to inter-observer variability. Strong datasets and cutting-edge imaging methods enable machine learning algorithms to not only speed up diagnosis times but also improve consistency and accuracy. This study will delve into the key techniques and challenges associated with automated soft tissue tumor diagnosis, shedding light on the transformative potential of machine learning in that critical domain of healthcare.

1.1 Soft Tissue Tumors

Soft tissue tumors represent heterogeneous groups of neoplastic growths arising in various anatomical locations within the body's non-skeletal structures. These tumors encompass a broad range of both benign and harmful substances, each with unique clinical presentations, histological features, and treatment implications. Soft tissue tumors can emerge from muscles, tendons, ligaments, fat, nerves, blood vessels, and other connective tissues, making their diagnosis and classification a complex and multifaceted challenge for healthcare professionals. Understanding and accurately characterizing soft tissue tumors is of paramount importance, as it directly influences treatment decisions, prognosis, and patient outcomes.

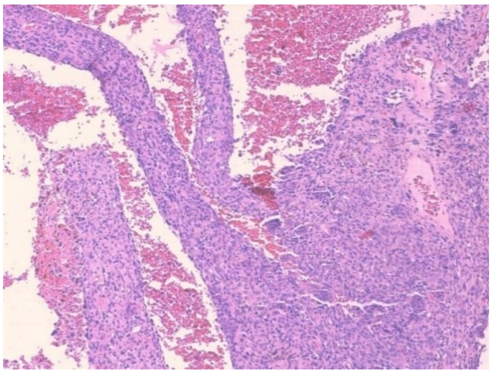

Figure 1. Soft Tissue Tumor cells

1.2 Diagnosis and Classification

Diagnosis and classification are fundamental aspects of medical practice, critical for understanding and managing a vast array of diseases and conditions. In the context of healthcare, diagnosis refers to the procedure for determining a specific ailment or condition in a patient, while classification involves categorizing and organizing diseases based on their characteristics and etiology. These processes serve as the cornerstone of modern medicine, guiding treatment decisions, predicting patient outcomes, and facilitating medical research. Accurate diagnosis and precise classification are essential for delivering effective and personalized healthcare, particularly in complex and diverse medical domains such as oncology and infectious diseases. This study introduces the pivotal role of diagnosis and classification within the domain of medicine, highlighting their importance in the quest for improved patient care and medical advancements.

1.3 Soft Tissue Tumor Management

Soft tissue tumors present a complex and diverse challenge in the realm of healthcare, requiring a comprehensive and multidisciplinary approach to ensure optimal patient care. The management of soft tissue tumors encompasses a wide range of therapeutic strategies, including surgery, radiation therapy, and systemic treatments. These tumors, which can arise in various anatomical locations, exhibit diverse biological behaviours, and carry distinct prognostic implications, necessitate a personalized and nuanced approach to treatment. This study provides an introduction to the intricacies of soft tissue tumor management, highlighting the importance of a well-coordinated, evidence-based, and patient- centered approach to achieving the best possible outcomes.

1.4 Neoplastic Growths

Neoplastic growths, a term often used interchangeably with tumors, represent diverse groups of abnormal cell proliferations. Neoplasia signifies uncontrolled cellular growth, which can lead to the formation of masses or lumps, and it can manifest in a multitude of tissues and organs throughout the human body. These abnormal cell growths can be benign, with limited impact on health, or malignant, posing a significant threat to life. Understanding the nature and mechanisms of neoplastic growth is paramount within the domain of medicine, as it forms the basis for cancer diagnosis, treatment, and ongoing research into its causes and potential cures. The study of neoplastic growths is a cornerstone of modern oncology and pathology, as these growths can have a profound impact on a patient's health and standard of living. Benign neoplasms, while generally not life-threatening, can lead to various health issues depending on their location and size. Malignant tumors can metastasis (spread) to the brain. The most frequent malignancies that can spread to the brain are those of the breast, skin (melanoma), lung, colon, and kidney. As skin cancer is one of the common malignancies that can metastasize to the brain, the proposed study focuses on developing an accurate method using machine learning to detect soft tissue tumors.

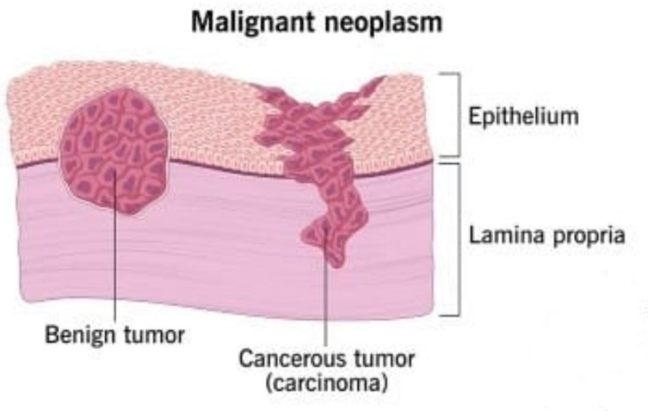

Figure 2. Malignant Neoplasm

1.5 Objectives

- To present a comprehensive study on the relevant literature that details the diagnosis of the soft tissue tumors.
- To Suggest a machine learning-based approach using Convolutional Neural Networks (CNNs) to accurately classify and diagnose skin tumors, with a particular focus on Melanoma.

2. Literature Review

J. Wang et.al. [1] proposed a method for examining sarcomas, classified as delicate soft tissue tumors (STT), which are found in tissues surrounding, supporting, and in contact with bodily structures. Magnetic Resonance Imaging (MRI) images of these tumors appear heterogeneous due to their unique variety and shallow frequency in the body. While numerous AI models have been introduced by researchers for tumor classification, none have adequately addressed the issue of misdiagnosis. Similarly, comparative studies suggesting frameworks for evaluating these types of tumors often overlook heterogeneity and data size. Consequently, an AI-based method that combines pre-processing techniques to adjust features, resampling techniques to eliminate variability and bias, and classifier tests based on a Deep Learning Algorithm as part of an Artificial Brain Organization is proposed. Given their sensitivity to various contaminants, including cancers that can develop anywhere in the human body, these delicate tissues require specialized attention.

Shubhangi Solanki et.al., [2] explores tumors characterized by rapid and uncontrolled cell growth in the brain, which may prove lethal if left untreated during the early stages. Despite considerable efforts and positive outcomes, accurate segmentation and classification remain challenging. The difficulties stem from variations in tumor site, form, and proportions, making brain tumor detection extremely intricate. The primary objective of this study is to provide researchers with an extensive literature review on the use of magnetic resonance imaging (MRI) for detecting brain malignancies. The study suggests multiple methods for detecting tumors and brain cancer using statistical image processing and artificial intelligence. It also presents an assessment matrix for a specific system employing particular methodologies and datasets. The study covers the morphology of brain tumors, available datasets, augmentation techniques, component extraction, and classification using machine learning (ML), transfer learning (TL), and deep learning (DL) models. Finally, our research consolidates pertinent information for identifying and comprehending cancers, including their advantages, disadvantages, developments, and future trends."

In this paper, Parmar et.al., [3] has proposed an accurate and real-time model that uses a BP neural network enhanced by a genetic algorithm. The model classifies the soft tissue epidermis into meshes, and when tension is applied, it calculates the displacements resulting from these meshes. The coordination between the displacement and tension of the mesh is established by the new cylindrical spiral spring model. The ideal BP neural network is trained utilizing sample data to the mesh point and vertical tension, enabling the determination of the force and displacement of every mesh point on the soft tissue's epidermis. The experiment results indicate that the proposed model, with its realistic force feedback and good visual interface, can meet the requirement of deformation simulation for soft tissues grasping in virtual surgery.

A Soft tissue tumor is tumor in the musculoskeletal system that involves soft tissue (tissue other than bone tissue). It consists of connective tissue, muscle, blood vessels, nerves, and fat. There are two types of soft tissue tumors: benign and malignant. The study utilizes the data from patients with soft tissue tumors at Nur Hidayah Hospital in Yogyakarta, Indonesia, and applies the stochastic support vector machine for performing the classification. The Stochastic Support Vector Machine outperforms the original Support Vector Machine and offers improved accuracy. [4]

In this work, J. Patel et al., [5] suggest that MR should be considered the gold standard for diagnosing and evaluating soft tissue cancers. Soft tissues include fat, muscle, blood vessels, deep skin tissues, nerves, and the tissues surrounding joints (synovial tissues). Soft tissues include any tissues that support, link, or surround other body structures and organs and tumors can develop in almost any part of the body. Radiologists often rely on specific features of the magnetic resonance image to discriminate between benign and malignant STT tumors. However, the challenge of accurately perceiving texture in some malignant tumors contributes to a notable discrepancy between the study's sensitivity and specificity.

In this study, R. F. Umbara et al., [6] hypothesized that multi-parametric MRI offers non-invasive techniques for evaluating the response of soft-tissue sarcoma (STS) to non-surgical therapy. However, evaluating MRI characteristics over the entire tumor volume may not fully disclose the extent of post-treatment modifications, as STS tumors are frequently highly heterogeneous, containing compartments of cystic tissue, fat, necrosis, and cellular tumor. In this pilot study, the author explores the automatic tissue compartment delineation in STS using machine-learning techniques, and applies this technique to track changes that occur after radiation therapy. Multi-parametric MRI was used to assess 18 patients with retroperitoneal sarcoma, and the patients underwent a follow-up imaging examination 2-4 weeks following pre-operative irradiation. There was no discernible difference in the five machine-learning approaches' high median cross-validation accuracies (82.2%, range 80.5–82.5%). Using a 3.5 GHz personal computer, the Naïve-Bayes technique was chosen because of its comparatively quick training and class-prediction periods (median 0.73 and 0.69 ms, respectively.

In this research, T. B. Trafalis et al., [7] claim that machine learning is a popular tool for tumor characterization in recent times. The purpose of this study is to investigate the viability of using ADC features-based least absolute shrinkage and selection operator (LASSO)-logistic prediction models and whole tumor fat-suppressed (FS) T2WI in the differentiating of soft tissue neoplasms (STN). Retrospective assessment of 160 instances with 161 histologically verified STN was conducted using diffusion-weighted imaging (DWI) with b values of 50, 400, and 800 s/mm2 in 75 of the cases. These instances were divided into training (70%) and validation (30%) cohorts after categorization into benign and malignant groups. Machine learning, at the intersection of computer science and statistics, has recently been increasingly integrated into the medical industry. LASSO known for its robustness, is widely utilized. In high dimensional data, it overcomes the drawbacks of multiple regression and proved useful in the feature selection process. The normal distribution was tested using the Kolmogorov-Smirnov test. To examine the variations in texture features, an independent student's test was used. The cut-off values were discovered by generating ROC curves.

In this study, B. Gui et al., [8] that dental implants are commonly used in both partially and fully edentulous individuals to support fixed and removable prostheses. Current systematic reviews encompassing a multitude of clinical investigations anticipate high survival rates at both the implant and restorative levels. Adequate bone volume is a prerequisite for implant placement, leading to the implementation of various ridge preservation and augmentation techniques. It is recommended to maintain marginal bone levels around the implant over time by ensuring a facial bone thickness of at least 2 mm. The physiological and cosmetic significance of soft tissues at dental implant sites has been assessed in a number of studies resulting in the proposal of various indications and therapeutic approaches. This narrative review focuses on the management, timing, targeted interventions, and prevention of soft tissue issues in implant dentistry. This article provides a timeline and a risk rating for various actions to avoid and manage soft tissue problems, along with supporting evidence. Studies indicate that between 46% and 74% of all implanted implants lack an adequate band of connected and keratinized tissue.

S. Foersch et.al., [9] In this study, soft tissue sarcomas (STSs), malignant tumors of mesenchymal origin, were investigated due to their increasing incidence and significant impact on morbidity and mortality, especially among young individuals. Accurate classification is crucial given the substantial variations in biological function, clinical prognosis, and therapy responsiveness among different STS subgroups. The study employed recent deep learning techniques to accurately diagnose prevalent STS subtypes, compared the model's performance with pathology specialists, and used AI to predict prognoses based on histomorphology, particularly focusing on leiomyosarcomas (LMSs). Visualization strategies were explored to identify microscopic characteristics linked to diverse prognoses, addressing the challenges in STS diagnosis and classification.

Amin Abbasi shankoo et.al., [10] has proposed a minimally invasive surgery (MIS) that has gained popularity in recent years, primarily due to its benefits for patient recovery. This surgical procedure, which involves only minor incisions on the patient’s body, not only reduces body damage but also allows the patient to recover faster. The primary objective of robotic surgery is to enhance the surgeon’s capabilities. Additionally, this method adds value, with many MISs incorporating standard subtasks such as suturing, knotting, cutting, and more.

Table 1. Comparative Table

Ref. No	Methodology	Merits	Demerits	Quantitative Analysis
[1]	RNN (Recurrent Neural Network)	Train large dataset	Data imbalance	Accuracy of 85%
[2]	Deep learning	Cost effective	Model generalizability is not considered	Accuracy of 46.3%
[3]	BP Neural Network	Fast and easy to program	Performance is not sufficiently high	Accuracy of 80%
[4]	SVM (Support Vector Machine)	It handles high-dimension of data	Do not handle Hyper parameter Tuning	Accuracy of 57.82%
[5]	Bayes classifier, Linear classifier	It is simple and easy to implement	Data Quality and Quantity. Does not handle large dataset	Accuracy of 60%
[6]	SVM, NN and KNN (K-Nearest Neighbour)	Effective handle of both numerical and category features	Computational resources required for training and implementing are not addressed	Accuracy of 64.80%
[7]	LASSO-logistic predictive model	Select some automatic features	Feature selection process is not explained	Accuracy of 83%

[8]	Buccal soft tissue recession	Better long-term stability	Complex in implement strategies in a clinical setting	Accuracy of 69.7%
[9]	Densely connected convolutional network	Makes the network easier to train	Validation methodology is not described	Accuracy of 79%
[10]	DNN (Deep Neural Network)	Ultimate platform flexibility	Does not have ability to deep reinforcement learning	Accuracy of 79.9%

The graphical representation below in Figure.3 presents the accuracy of different methods in the detection of soft tissue tumors based on the study.

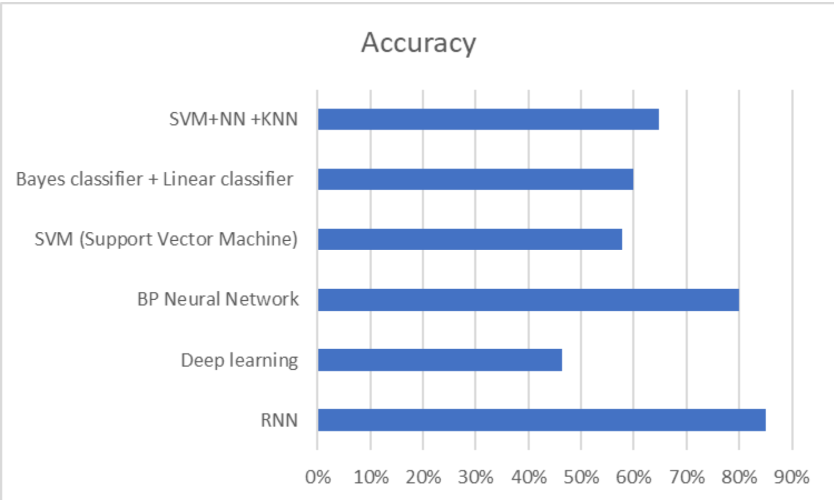

Figure 3. Comparison Graph

3. Proposed System

The proposed system presents a machine learning-based approach to classify and diagnose Soft Tissue Tumors (STTs), specifically focusing on skin tumors. It incorporates innovative techniques for data pre-processing and to extract relevant features as well as classify them using a Convolutional Neural Network (CNN) model. This integration aims to improve the accuracy of automated diagnosis and reduce the occurrence of misdiagnosis. The system will utilize multiparametric magnetic resonance imaging (MRI) data obtained from patients with skin tumors as its input. The MRI data will undergo pre-processing typically involves various steps such as resizing and rescaling, normalization, noise reduction etc. to prepare the dataset for analysis. The the informative features such as tumor size, shape, intensity, and texture are extracted using CNN. These extracted features will then be utilized as input for the CNN model to perform classification. To train the CNN model, a dataset of labeled MRI images of STTs will be used. Throughout the training process, the model will learn to identify patterns within the MRI images that correspond to different types of STTs.

Table 2. Details of Layers Used in CNN

Layer	Type	Number of Images	Size	Convolution Kernel Size/pooling Size	Number of Filters /Neurons	Dropout	Activation
0	Input Layer	1	46*46				
1	Convolution Layer	6	40*40	7*7			
2	Pooling Layer	6	20*20	2*2			
3	Convolution Layer	16	14*14	7*7			
4	Pooling Layer	16	7*7	2*2			
5	Convolution Layer	50	1*1	7*7			
6	Fully Connected Layer				100	0.5	ReLU
7	Fully Connected Layer				11		SoftMax

3.1 Dataset Description

In this section, data related to Soft Tissue Tumors (STTs), particularly skin tumors, is acquired and imported into the research environment. This typically includes medical imaging data, patient records, and other relevant information used for the classification and diagnosis of STTs.

Table 3. Soft Tissues Tumor Dataset Details

No.	Attribute	Description	Type
1.	ID	Patient ID	Numerical
2.	Age	Patient Age in years	Numerical
3.	Gender	Man or Woman	Numerical
4.	Blood Type	Patient Blood Type	Numerical
5.	Blood glucose	Blood Glucose Level	Numerical
6.	WBC	Number of white blood cells in thousands per microliter of blood	Numerical
7.	RBC	Number of red blood cells in millions per microliter of blood	Numerical
8.	Size	Size of the Soft Tissue Tumor cell	Numerical
9.	Shape	Shape of the Soft Tissue Tumor cell	Numerical
10.	Clump Thickness	Clump Thickness of Soft Tissue Tumor cell	Numerical

3.2 Data Preprocessing

Data reprocessing is a crucial step where the acquired data is cleaned, organized, and prepared for further analysis. It involves tasks such as data cleaning, noise reduction, image enhancement, and normalization to ensure that the data is in a suitable format for machine learning algorithms.

3.3 Feature Transformation

At this preprocessing step, the raw data from the various tests and information sources are collected and transformed into a numerical format so that the CNN classifiers can be applied. For this, all categorical attributes (blood type, AGS-AS, gender, and disease) were first classified in nominal type (blood type), binomial (AGS-AS, gender, and disease), and missing values, then converted to numerical format in the following way depending on the type.

3.4 Epoch Value Generation

An epoch in machine learning is one complete pass through the entire training dataset. One pass means a complete forward and backward pass through the entire training dataset. The training dataset can be a single batch or divided into more than one smaller batch. One epoch is complete when the model has processed all the batches and updated its parameter based on calculated loss. The processing of a batch of data through the model, calculating the loss, and updating the model's parameters is called an iteration.

3.5 Classification

The CNN is trained with the appropriate dataset and the classification results are observed.

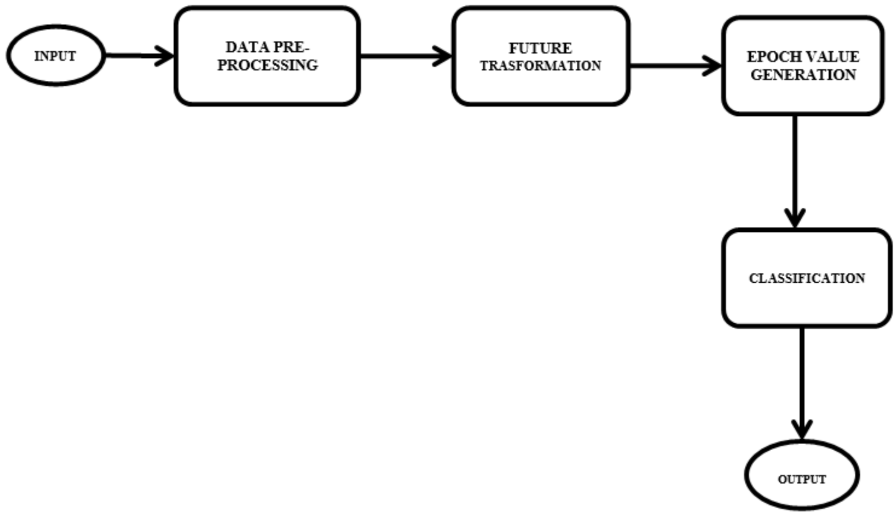

Figure 4. System Flow Diagram

3.6 Advantages of Proposed System

- CNNs have shown very high accuracy image classification tasks CNN is used in the proposed work.
- This can learn to extract features from images without the need for human intervention.
- This is important for soft tissue tumor classification, as it can be difficult for humans to identify all of the relevant features in a tumor image.

- It can be used to classify tumors in a variety of different imaging modalities, such as MRI, CT, and ultrasound. This makes them a versatile tool for soft tissue tumor classification.

4. Discussion

The research presented in this study introduces a machine learning-based approach that utilizes Convolutional Neural Networks (CNNs) for the classification and diagnosis of Soft Tissue Tumors (STTs), with a specific focus on skin tumors. The proposed study offers a comprehensive review of the different machine learning approaches used in the soft tissue tumors classification and suggests a method to have an accurate classification employing the CNN. As Convolutional Neural Networks (CNNs) have demonstrated remarkable accuracy in image classification tasks, making them a widely adopted architecture in various fields. In the proposed work, CNNs are utilized to harness their ability to autonomously extract features from images, eliminating the need for manual feature engineering. This capability is particularly crucial in soft tissue tumor classification, where discerning all relevant features in a tumor image can be challenging for human observers. CNNs excel in capturing intricate patterns and subtle details within images, thereby enhancing the accuracy of tumor classification. Furthermore, the versatility of CNNs allows them to be employed across diverse imaging modalities, including Magnetic Resonance Imaging (MRI), Computed Tomography (CT), and ultrasound. This adaptability underscores the significance of CNNs as a powerful and flexible tool for the comprehensive and effective classification of soft tissue tumors in medical imaging.

5. Future Work

The proposed skin tumor classification and diagnosis system is a promising approach for improving the accuracy and efficiency of skin tumor diagnosis. However, there are still some areas where future work can be done to further improve the system. The future work of the review will concentrate on dataset collection and the analysis of the proposed model. It involves, training the model on the collected dataset, and evaluating its performance.

6. Conclusion

In conclusion, there is a chance that the suggested system for classifying and diagnosing skin tumors will greatly increase the precision and effectiveness of skin tumor detection. In order to achieve high classification accuracy, the system combines unique data pre-processing approaches for feature extraction and classification with a Convolutional Neural Network (CNN) model. This is especially useful in differentiating between normal skin tissue and melanoma. In future the work would concentrate on the collection of sizable dataset of MRI scans of skin tumors to train the system, and evaluate using metrics like robustness to noise and fluctuations in image quality, accuracy in tumor segmentation, and classification accuracy. The technology may be implemented in a clinical setting to assist medical professionals in making better judgments on the identification and management of skin cancers.

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