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Survey Article

Application of Object Detection in Medical Image Diagnosis using Deep Learning

Abhishek Thoke[1*], Sakshi Rai[2]

[1,2]Dept. of Computer Science, LNCT University, Bhopal, India

[*]*Corresponding Author: thoke.abhishek@gmail.com, Tel.: +91 9893225432*

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Abstract: In today's digital medicine era, many medical photographs are generated daily. As a result, there is a growing need for sophisticated tools to assist medical professionals across various specialties in their diagnostic efforts. Thanks to the evolution of artificial intelligence, convolutional neural network (CNN) techniques have made significant strides in this field. These algorithms are crucial in medical image categorization, object detection, and semantic segmentation. However, while medical imaging classification has garnered widespread attention, object recognition and semantic imaging segmentation have received less focus. In this review, we will explore the development of object detection and semantic segmentation in medical imaging studies, along with a discussion on how to accurately identify the location and boundaries of diseases.

Keywords: Object detection, Image classification, Convolution neural network, Deep Learning, Machine Learning

1. Introduction

Computer vision, especially object detection, has greatly benefited from the advances in artificial intelligence (AI). This study examines how artificial intelligence (AI) has changed object detection, highlighting metadata's critical role in boosting AI's power. Accurate object recognition is essential in the digital age because of the deluge of visual data from surveillance, medical imaging, and self-driving cars. Artificial Intelligence (AI), particularly with deep learning algorithms like convolutional neural networks (CNNs), has emerged as a reliable solution that can increasingly accurately overcome problems like occlusion and scale fluctuations.

The following essential components are frequently included in object detection: determining the size and location of items in a picture. This is commonly shown by bounding boxes to outline objects and provide their dimensions (width and height) and spatial coordinates (x, y). They put a type-specific name or category on every object that is found. For example, object detection may identify and classify objects in a scene that contains a variety of objects, such as cars, pedestrians, animals, and other entities.

Deep learning models like convolutional neural networks (CNNs) are widely used for object detection. These models are made to work on simultaneous localization and classification tasks. After training on large datasets containing tagged photos, they can identify items and precisely pinpoint their locations.

Several practical medical diagnostic applications, including early tumor detection, vascular plaque segmentation, and the detection of exudates in diabetic patients' retinas [1, 2], have made extensive use of object detection techniques possible through the ongoing advancement of deep learning technologies. When making a traditional medical diagnosis, a doctor would often manually identify any lesions in an image. This is a labor- and time-intensive task. However, because there are a lot of photos that doctors must view each day, it is easy to get visual fatigue from doing this work frequently, which can result in missing or incorrect diagnoses.

This is a complex error. Therefore, a key component of medical detection is applying deep learning techniques to allow machines to automatically recognize features in images and identify abnormal areas [3, 4]. Making the computer filter out most of the background data and correctly identify the little lesions in the photos remains a significant difficulty in the field of object identification, nevertheless, because the objects to be recognized in medical images are small.

In summary, the goals of this survey are to:
- Demonstrate the widespread use of deep learning techniques in medical image analysis.
- pinpoint the obstacles to the successful integration of deep learning into medical imaging tasks and
- highlight advancements that address or get around these obstacles.

The remainder of the survey is organized as follows. The primary deep learning methods used in medical image analysis and discussed throughout the survey are introduced in Section 2. Deep learning's contributions to the standard tasks of medical image analysis—classification, detection, segmentation, registration, retrieval, picture production, and enhancement—are discussed in Section 3.

2.An Overview of Techniques for Deep Learning

This section formally introduces and defines the profound learning ideas, methods, and architectures we discovered in the medical image analysis articles this work surveyed. Machine learning comprises mainly two tasks.

First, unsupervised learning tries to find the unknown patterns with unlabelled data, enabling extensive representation of the information. On the other hand, in supervised learning [5,6], target variables known as labels y_i are given. This data related to labels is required to identify patterns [7,8]. A classification method is better suited for discrete label classes (yes/no), but regression techniques are used for continuous label values. Supervised learning is divided into two major phases: The testing phase and the training phase. In the training phase, a model (F)[9] learns by using any effective machine learning-based algorithm from the training data, whereas in the second phase, i.e., the testing phase, the model is given some unknown inputs for which the best labels y is predicted for the sample X by

$$y_i=F(x_i) \quad (1)$$

The collected data is divided into two parts: training and testing. Generally, the training requires more data for efficient and accurate results.

In machine learning, neural network-based techniques like CNN [10], NN, BPNN, etc., work on the principle of supervised learning. Various baseline architectures of CNN have been developed for image diagnosis, such as AlexNet, AlexNetOWTBn, GoogLeNet, VGG, etc. ACNN consists of three main steps: Convolution, Pooling, and fully connected layers. The convolution and pooling layers extract the model's features, and the fully connected layers classify the features based on functions.

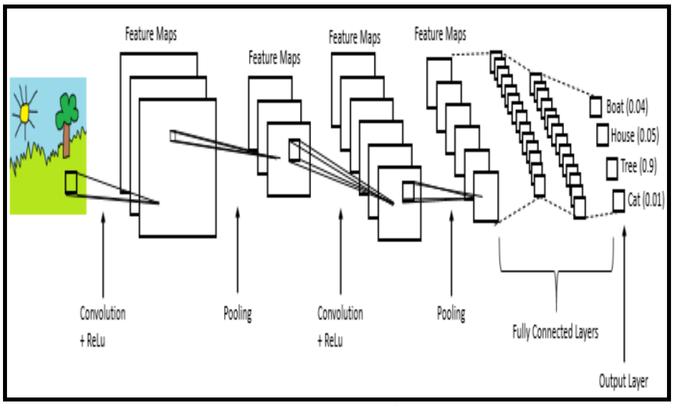

Figure 1: A graphical depiction of the CNN model

- A CNN architecture called AlexNet [11] was developed in 2012. Two fully connected hidden layers, five convolutional layers, and one fully connected output thousand-way soft max classifier layer comprise the eight layers. AlexNet emerged as the initial Artificial Neural Network to take home the ImageNet Huge-scale Visual Recognizing Challenge, thanks to its astounding architecture for object-detection tasks generally. AlexNet uses ReLU activation functions along with local response normalization layers.
- The convolutional neural network architecture VGGNet [12] was developed in 2014 and employs a complex design with many convolutional layers that are completely coupled. Three fully connected layers and five convolutional layers make up the model. The VGGNet architecture uses a deep net with 16–19 layers and tiny convolutional filtering methods with a (3 × 3) dimension. ReLU activation functions are applied, and the process is concluded using a softmax classifier. The main objective of this technique is to allow the network to learn more complex properties by using small filters (3 ×3) to capture minute details in the images and stacking layers to increase the network's depth.
- Based on Google's 2014 Inception architecture, GoogLeNet [13], also called Inception v1, is a convolution neural network framework. The network can use Inception modules to select the optimal filters for a particular input. GoogleNet is composed of nine "inception modules," or inception blocks. These are separated by max pooling and comprise three portions. Twenty-two deep layers and 27 pooling layers are present. These modules gather features at various length scales, concatenate them, and then move on to the following layer and final global average pooling.

3. Deep Learning & Machine Learning for Medical Image Diagnosis

Thanks to improvements in medical image analysis techniques, DL models allow machines to reach the necessary precision. When a cardiologist evaluated and relabelled all the data in [14], they discarded the data that did not include heart failure and standard images and used the labeled chest X-rays to diagnose heart illness. Data augmentation and TL were utilized with 83% accuracy, 75% specificity, and 96% sensitivity for heart failure to extract the precise information from the images.

With the least manual labor, an automatic feature selection system was established [15] utilizing histopathology images labeled as positive and negative cancer images. While a single-layer network of K-means centroids was utilized for unsupervised feature learning, two networks, dubbed Deep Neural Network (DNN) 2-F and DNN1-F, were applied with PCA to minimize features in DNN. Afterward, a comparison was made between supervised (94.52%) and uncontrolled (93.56%) learning outcomes. To handle data efficiently, the DL model automates the feature extraction process [15, 16].

The method by which DL algorithms anticipate and diagnose different diseases is shown in Figure 2.

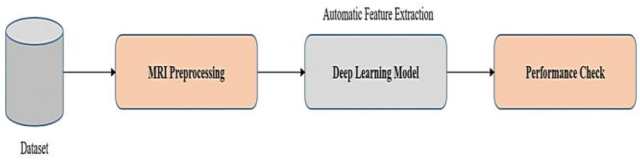

Figure 2. Deep Learning Steps for Image Diagnosis

A subset of artificial intelligence, machine learning (ML), uses data to find patterns and automate decision-making with the most minor human input possible [17, 18, 19]. The ability of a machine learning model to adapt on its own, learn from past computations, and generate accurate results when repeatedly applied to fresh datasets is its most crucial feature. The two primary components are (i) machine learning techniques that assist doctors in quickly interpreting medical pictures using computer-aided design (CAD) and (ii) algorithms utilized for complex tasks such as brain tumor segmentation with MRI, breast cancer, and mammography, and CT scan segmentation [20].

Conventional machine learning models operate on organized datasets with preset approaches for each step; the applied technique fails if a step is missing. Assessing the data quality that ML and DL algorithms employ is a crucial task [21, 22, 23]. However, the exclusion of data in modern algorithms is adjusted according to the algorithm's need for resilience. The method by which ML algorithms anticipate and diagnose diseases is shown in Figure 3.

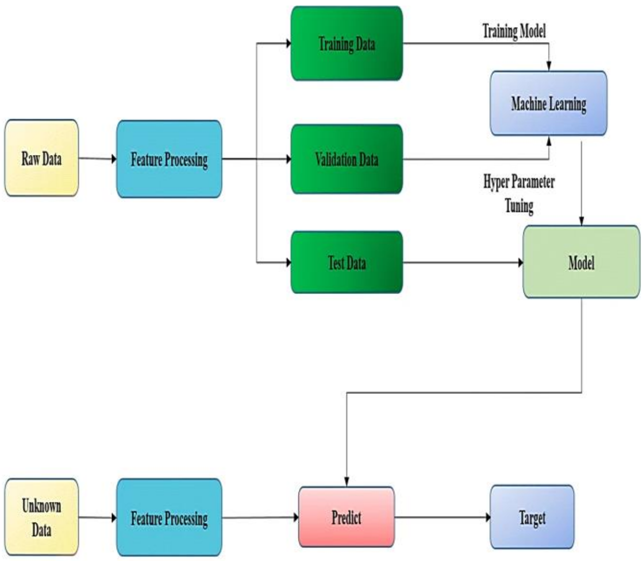

Figure 3. Machine Learning Steps for Image Diagnosis

Machine learning and deep learning methods were used in medical images to improve prediction and accuracy. Medical images from different modalities are used as input, and these images are subjected to algorithms. The input image is then divided into segments according to several criteria; these segments were then utilized to apply feature extraction techniques to extract the most essential features.

Machine learning (ML) is the process by which computers utilize algorithms and data to learn how to do tasks without explicit programming. With fresh datasets, it makes predictions via pattern recognition. As an alternative, deep learning is modeled after the organization of the human brain, which includes a sophisticated set of algorithms that allow computers to process documents, text, and images. It uses algorithms with layered structures, like CNN, ANN, etc.

4. Review Techniques

This literature review adhered to the systematic review procedures that were developed.

A. Research Questions

The following review questions must be discussed for any research project:

1. How are machine learning and deep learning methods now applied to medical imaging?
1.1 What factors are considered when choosing classifiers?
1.2 What assessment metrics are applied to classification models?
2. What are the several medical picture modalities used to categorize diseases?
3. How are medical imaging instruments and methods used?
4. Which datasets are employed by several researchers in the field of healthcare?
5. What are the findings from the comparison study between deep learning models and machine learning classifiers based on MRI dataset experiments?

B. Source content

The procedures for searching the body of knowledge in ML and DL in medical imaging are adhered to. The electronic database sources utilized for searching are as follows:

- Springer (https://www.springer.com/in).
- PubMed (https://pubmed.ncbi.nlm.nih.gov/16495534/).
- Wiley Interscience (https://onlinelibrary.wiley.com/).
- Google Scholar (https://scholar.google.co.in/).
- IOP (https://www.iop.org/#gref).
- Oxford Publications (https://india.oup.com/).
- Elsevier (Elsevier Books and Journals - Elsevier).
- Hindawi (https://www.hindawi.com).
- Bentham Science (Bentham Science - International Publisher of Journals and Books).

C. Criteria for Search and Quality Assessment

The first search yielded 1900 articles using the article selection approach; these were narrowed down to 200 using targeted keywords. After that, 90 papers were found using their titles as a guide, and another 60 articles were found using their abstracts and introductions. Thirty papers met the inclusion and exclusion criteria and were chosen as primary studies.

The quality of the review was guaranteed after discussing the inclusion and exclusion criteria. These primary studies came from various publications (manuscripts, web records, and society publications), conferences, workshops, and journals. To ensure impartiality and external and internal validation of the findings by the CRD criteria, every article was analyzed to identify the high-quality ones.

The top 20 most influential and mentioned publications on disease classification, tool and technique identification, disease cause explanation, and disease diagnosis and treatment.

5. Conclusion and Future Work

This paper presents an overview of different machine learning (ML) and deep learning (DL) approaches for illness diagnosis, including classification, imaging modalities, tools, algorithms, datasets, and medical domain issues. The most often utilized modalities for diagnosing diseases are MRI and X-ray scans. According to this study, denoising techniques with DL models should be used in the healthcare industry. It also concludes that a variety of traditional ML and DL methods are widely used to address data uncertainty. DL techniques have gained a lot of traction among researchers recently because of their improved performance. This evaluation will help the medical community, doctors, clinicians, and practitioners select the best machine learning (ML) and deep learning (DL) techniques for fast and accurate disease detection.

In the future, all diseases will be diagnosed using DL techniques that take noise reduction from any given dataset into account. It is possible to investigate the extra features and characteristics of DL models for medical pictures. Large amounts of data are needed to increase accuracy, hence the model's capacity to handle big datasets needs to be enhanced. To improve accuracy, various data augmentation methods can be investigated in addition to the dataset's necessary attributes.

Declarations:

Competing interests

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Author’s Contribution:

Abhishek Thoke has prepared the manuscript under the guidance of Dr. Sakshi Rai. Dr. Sakshi Rai has done Proofreading of the work and also reviewed the complete work.

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AUTHORS PROFILE

Mr. Abhishek Thoke completed his Bachelor of Engineering in 2008 and his M.Tech in Computer Science and Engineering in 2012 from RGPV University, Bhopal. He is pursuing a Ph.D. from LNCT University, Bhopal, and has 14 academic years. His primary research focuses on Data Mining, IoT, and Computational Intelligence education.

Dr. Sakshi Rai is the Director of Dept. of Computer Science and Technology, Lakshmi Narain College of Technology, Jabalpur – 482053, Madhya Pradesh, India. She has completed her Ph.D. in Computer Science and Engineering Department from LNCT University; her research area focuses on “An Enhancement Of Medical Cyber-Physical System A Security Prospects." She has published several papers in reputed international journals, including SCI & Web of Science, and conferences, including IEEE, and it's also available online.