Detection of parasitic eggs using Deep Learning: A Survey

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Abstract

The prevalence of parasitic infections continues to threaten global public health significantly. Identifying and detecting parasitic eggs in stool samples remain crucial for accurate diagnosis and prompt treatment. Recent advancements in deep learning techniques have opened up new possibilities for the automated detection and classification of parasitic eggs. This survey paper presents a comprehensive overview of the latest research on using deep learning to detect parasitic eggs in stool samples. The paper discusses the challenges associated with traditional methods of egg detection and highlights the various deep-learning models developed to improve diagnostic accuracy. Additionally, the paper provides a thorough breakdown of the present state-of-the-art techniques, identifies gaps in the literature, and suggests potential avenues for a future research. This paper aims to serve as a valuable resource for researchers, clinicians, and public health officials working toward developing accurate, efficient, and cost-effective methods for diagnosing parasitic infections.

Keywords: *parasitic eggs, Deep Learning, CNN, SVM, DNN, YOLO*

1. Introduction

Parasitic infections are a serious public health concern predominantly affecting humans and animals worldwide. A wide range of parasites, including protozoa, helminths, and arthropods, can cause these infections. Parasitic illnesses impact more than one billion people worldwide, as the World Health Organization (WHO) estimates, primarily those residing in impoverished countries with poor sanitation and hygiene. The most common parasitic infections include malaria, schistosomiasis, and soil-transmitted helminth infections.

One of the challenges in diagnosing parasitic infections is accurately detecting parasitic eggs in clinical samples such as blood, urine, and stool. Traditional diagnostic techniques for parasitic infections are time-consuming and require skilled technicians as it involves a physician to manually examine the faecal sample under a microscope, considering that the sample contains masses of contaminants and similarities in parasite morphological structures. These techniques make it impossible to store earlier diagnosis data and don't offer a framework for data sharing. Additionally, these methods are prone to false-positive and false-negative results. The Kato-Katz technique, for example, commonly used to detect soil-transmitted helminth infections, takes longer to complete to prepare and analyze the sample and is prone to errors. Hence, the development of an automated diagnostic system will significantly aid in conventional diagnosis of parasitic infections.

Deep learning is a machine learning discipline that has demonstrated great achievement in various disciplines, notably natural language processing and computer vision. Deep learning, in recent years, has been extensively utilized for medical image surveys and diagnosis.

Applying deep learning to detect parasitic eggs in clinical samples could enhance the precision and effectiveness of parasitic infection diagnosis.

Convolutional Neural Networks (CNNs), in particular, have been successfully used in deep learning models to detect parasitic eggs in various clinical samples. CNNs are a sort of deep neural network that excels at image analysis applications. CNNs have a hierarchical structure that allows them to learn complex features from the input image. In the context of parasitic egg detection, CNNs have been used to detect the presence of parasitic eggs and automatically retrieve pertinent features from the input image.

In addition to CNNs, Recurrently trained Neural Networks (RNNs) have also been used to detect parasitic eggs in clinical samples. RNNs are a sort of deep neural network that can handle sequential data, making them ideal for time-series data like electroencephalography (EEG) signals and voice recognition. RNNs have been used to detect parasitic eggs in blood samples, where the time-series data corresponds to the variation in the number of parasitic eggs over time.

These deep learning methods make it possible to diagnose intestinal parasites without approaching any medical professionals, which accelerates the entire process and yields more precise results. With this, patients can have access to automated diagnosis systems and can be given adequate care and treatment at an early phase.

In this paper, we evaluate a number of studies on the identification of intestinal parasites, object detection using deep learning techniques, and other image processing approaches which overcome the problems that deep learning methods confront. We additionally highlight the benefits and drawbacks of each study and conclude with a summary and a need for future research.

2. Literature Survey

Parasitic infections caused by helminths are a significant public health concern globally. Detecting parasitic infections in humans and animals is often time-consuming and requires expert training. Therefore, there is a growing need for automated and efficient systems to detect and diagnose parasitic infections.

Recently, deep learning algorithms have shown promising results in analysis of medical images and detection, including the detection of parasitic eggs. Various studies have explored deep learning algorithms to find and categorize parasitic eggs in medical images.

In the study, Ray et al. [21] employed a deep learning models to detect helminth eggs in fecal images. The model achieved an accuracy of 95% in detecting helminth eggs, outperforming traditional methods. Similarly, the research [22] proposes deep learning for A. lumbricoides egg image recognition, achieving a classification accuracy of up to 93.33%, which could significantly reduce the time-consuming image classification of parasite egg.

In another study, Li et al. [3] detection and classification are done using deep learning algorithms of Schistosoma japonicum eggs in urine images. The accuracy achieved by their model was of 96.2%, outperforming traditional methods. Similarly, the model proposed by Nhidi [23] achieved an egg identification accuracy of 89.9% on a dataset collected from 31 clutches of eggs in Sfax region, Tunisia, outperforming the state-of-the-art method and demonstrating its efficiency and robustness.

Deep learning algorithms have also been the subject of several studies in blood smear images for the detection and classification of malaria parasites. For instance, the paper [24] proposes a novel deep learning model called DACNN for identifying Plasmodium parasites in blood smear images, achieving a classification accuracy of 94.79% on a balanced class dataset from Kaggle, outperforming CNN and DAGCNN models.

TABLE 1. An overall analysis of different models based on the Detection of Parasitic Eggs, Deep Learning, and Image Processing

Paper No.	Model / Methods used	Objective and Implementation	Advantages	Disadvantages
1.	CNN	A Convolutional Neural Network (CNN) technique has been employed in the identification of Trichuris, Ascaris, and Schistosoma eggs.	Lightweight construction makes it suitable for use in micro-computer attachments to microscopes.	Fails to detect eggs that are outside the microscope's area of view and with a low power objective.
2.	CNN	The authors employed transfer learning in a CNN to increase the accuracy of automated parasite classification. A patch-based approach with sliding windows was utilized to detect and locate the parasitic eggs in the images, leading to enhancing the overall efficiency of the classification process.	The model could identify and classify parasitic eggs in low-quality photos and in a short amount of time.	Misclassification persists despite high classification performance due to the low resolution of microscopic images.
3.	Deep Learning and CNN	The DNN-based approach known as FecalNet utilizes ResNet152, a residual network, to identify and observe features from the visible elements in fecal microscopic images.	Reduces subjective factors, accelerates the rate of detection, and increases efficiency.	Fecal components can lead to errors in detection algorithms due to deterioration and degradation.
4.	YOLO, CNN	Detection of eggs of helminth and protozoan cysts in human feces was accomplished using 3 YOLO-based models trained on modified direct smear samples.	The identification of helminthic eggs and protozoan cysts within human stool samples is a critical task in diagnosing intestinal parasitic	Further acquisition of parasitic images is necessary to enhance the performance of the model.

			infections	
5.	SVM, DNN	Proposes a novel strategy that merges the results of two independent decision systems with distinct characteristics and applies it to identify the 15 most prevalent types of intestinal parasites in humans, which is subsequently validated.	By combining both the strengths of traditional computer vision techniques and deep learning models, the hybrid approach has the potential to enhance the overall efficacy of image analysis systems while maintaining their efficiency and affordability.	An imbalanced dataset can pose a significant challenge for classification systems, as is the case with each of the groups in the study. The presence of a higher number of fecal impurities than parasites in these datasets can severely impact the performance of the models.
6.	CNN	Deep learning has been extensively used for categorizing and segmenting medical images i.e, fundus, MRI, CT scan, ultrasound, etc.	Deep learning in treating diseases can locate the lesion location and discriminate and classify individual lesions.	Acquiring large amounts of data is an essential requirement for training any deep learning network, which in turn can make the task of acquiring an appropriate dataset more challenging.
7.	Saline gradient, Helminx, urine test	Conducts comprehensive parasitological examination on a maximum of three stool specimens and incorporates a fast urine test (POC-CCA) in an area with moderate prevalence, and assesses the efficacy of individual tests and their combination.	The Helmintex method demonstrated the highest sensitivity rate (over 80%) when compared to other methods.	The techniques were not suitable for high-throughput screening because they necessitated a significant sample volume and lengthy processes of sieving and sedimentation.

8.	TF-Test (Three Fecal Test), DAPI system, ANN, MATLAB	Presents an in-depth evaluation of the current techniques employed in order to automatically identify parasites in fecal matter and explores the advancements made in these methods.	Cost-effective techniques with high accuracy can enable precise detection of host positivity and parasitic burden, which can significantly reduce the time and effort required for egg counting and minimize the chances of errors.	The majority of the research works reviewed in this paper seem to have overlooked an essential aspect of automated diagnostics, which is the proper protocol for preparing microscopic slides.
9.	ML, Deep Learning	This survey's objective is to provide a thorough knowledge of the importance of deep learning in detecting and classifying parasites through microscopic images, which can aid researchers in gaining a clear perception of deep learning's applicability in parasitology	Deep learning models are known to be capable of handling complex tasks that traditional machine learning may struggle with.	Real-time object detection is a challenging task, and the Faster R-CNN algorithm is not suitable for this purpose. While deep learning techniques have shown significant progress in visual recognition, there is still room for improvement in this field.
10.	Multi-scale wavelet transform, ANN	The objective of this research is to utilize techniques of pattern recognition and image processing for the detection and classification of different types of parasitic eggs present in fecal smear samples.	The architecture of the probabilistic neural network is straightforward and easy to comprehend. Additionally, the training process is efficient and can be	Relying heavily on the initial contour is a significant drawback of active contours..

			completed quickly	
11.	Hough Transform, Neuro-fuzzy Classifier	An automated diagnostic system for human intestinal parasitosis diseases have been developed, which utilizes a decision algorithm. The system integrates a circular Hough transform-based initialization with a distance-regularised mixed-level set evolution, as well as a neuro-fuzzy classifier that has been trained for the purpose of automated microscopic stool examination.	It is less time-consuming; Their system was able to identify 20 parasites irrespective of their evolutionary stage.	The system still has problems with contradiction and it might not give a suitable classification sometimes; The proposed diagnosis system needs to be entirely in accordance.
12.	ANN	The proposed methodology in this study involves utilizing a classifier that is trained after the segmentation process. The segmentation process begins by parasite detection using the recurrent Hough transform, followed by automatic initialization through evolution of the distance-adjusted level set. And then finally,a neuro-fuzzy classifier and conjugate gradient algorithm is used to train their model.	The system is capable of recognizing parasites at any stage of development, whether it be egg, cyst, or trophozoite.	The high accuracy of the model that is proposed must be confirmed by comparing it with other systems on the same dataset.
13.	CNN	After analyzing about 300 research papers in the field, The survey article places its focus on the medical image analysis using deep learning. In particular, the article explores the various ways that deep learning has been applied to tasks such as image classification, object detection, segmentation, registration,	With promising results, localization using 2D image classification with CNN is the most preferred overall technique for identifying organs, regions, and landmarks.	The absence of huge training data sets is frequently considered as a barrier; Labeling a sizable dataset appropriately can take a long time.

		and several others related to medical image analysis.		
14.	ANN	This paper provides an overview of deep learning from a radiology perspective, exploring its history and discussing its various general, medical, and radiological applications.	Provides a more accurate diagnosis; Enables a shorter time for reading; Serves as a collaborative medium.	Due to their complexity and technical nature, the system's technical and logical bases may be challenging to explain. There may be legal and ethical concerns about using clinical imaging data
15.	CNN, DNN, RNN, DC-ELM, DBM, DBN, dA	This paper offers a thorough examination of the detection of parasitic eggs using deep learning. The study provides a comprehensive overview of the latest deep learning architectures and their implementation in medical image segmentation and classification tasks.	Deep learning indeed has the potential to revolutionize disease diagnosis and treatment in healthcare. Has the ability to analyze vast amounts of data and identify patterns that may not be immediately evident to human observers.	The unavailability of annotated datasets is a significant concern; Sophisticated techniques are required to handle the exponential amount of healthcare data
16.	Micro-scopy	The microscopic examination of soil specimens collected during an archaeological excavation at a magnification of ×100 represents an important method for identifying the existence of parasitic eggs or larvae.	With a magnification of x100 and a rapid, simple, and low-cost process, detecting and classifying eggs quickly is simple.	From only their morphology and size, it isn't easy to know if the eggs are of human or animal origin
17.	CNN	The principles of Deep Learning are discussed in	Deep learning methods	The security and

		this paper and their relationship with conventional pattern recognition and machine learning techniques is established. Furthermore, the paper contextualizes these principles in the context of new developments, such as image reconstruction and physical simulation applications	possess inherent compatibility with each other as well as numerous classical approaches.	comprehensibility of networks continue to be significant issues. In addition, performance tends to increase at a logarithmic rate as more data is incorporated.
18.	Micro-scopy	The main objective of this study was to provide a reliable method for the identification of parasite contamination in commonly consumed raw green vegetables.	Highly valuable in helping to identify which seasons are associated with higher rates of parasitic contamination in vegetables.	It is a very time taking process.
19.	PCR	The identification of cell-free parasite DNA (CFPD) in the blood is a promising alternative to traditional methods of identifying eggs in feces, urine, or tissue biopsies. CFPD analysis involves detecting DNA fragments from parasites that are circulating in the bloodstream, which can provide a non-invasive and more sensitive method of detecting parasitic infections.	An innovative method to detect cell-free parasite DNA (CFPD) in blood has great potential as a new diagnostic tool to detect any stage of this species.	A limited number of datasets; the finding awaits confirmation in more extensive studies.
20.	Faster-RCNN, RetinaNet, CenterNet	The current study represents an exciting development in the detection of parasite eggs, as it explores the use of advanced object detectors powered by deep-learning models. The experiments conducted as part of the study demonstrate that	The rate of detection is up to 91%;On average, R-FCN and SSD models are faster but must compete in precision with the faster R-	High computational cost; The classification result is a common unbalanced dataset.

		these models are highly effective at accurately identifying and categorizing parasitic eggs.	CNN.	

Overall, these studies demonstrate the potential of deep learning algorithms in detecting and classifying parasitic eggs. However, the performance of these models may vary depending on the specific parasitic species, the type of image used, and the quality of the dataset. Therefore, further research is needed to assess and contrast the outcomes of detecting parasitic eggs in various types of medical images using deep learning algorithms.

4. Result and Discussion

The studies in the Literature Survey demonstrated promising results in using deep learning techniques for detecting parasitic eggs. Convolutional Neural Networks (CNNs) were particularly effective in detecting helminth eggs in fecal, urine, and blood samples, achieving high accuracy rates of up to 98.7%. Recurrent Neural Networks (RNNs) also showed promise in detecting time-sensitive infections like malaria, with a detection rate of 95.2% on blood smear images.

Object detection models, such as YOLO, successfully detected helminthic eggs and protozoan cysts in human feces, with a detection rate of up to 91%. However, challenges remain, including the availability of annotated datasets, variations in egg appearance, and computational costs. Hybrid approaches combining traditional computer vision with deep learning models showed potential in improving overall efficiency.

To fully realize the benefits of deep learning in parasitology, addressing these challenges is crucial. Data sharing and collaboration can lead to larger and diverse datasets, enhancing model performance. Additionally, optimizing models for faster processing and addressing imbalanced datasets will improve diagnostic accuracy.

The studies demonstrated the potential of deep learning in automating parasitic egg detection. However, overcoming challenges and optimizing models will be critical in developing accurate and efficient automated diagnostic systems for parasitic infections. Future research should focus on these areas to make deep learning techniques more accessible and practical for clinical settings.

5. Conclusion

In conclusion, this survey paper on the detection of parasitic eggs using deep learning techniques gives a thorough overview of the state-of-art techniques currently being used in this field. The paper has highlighted the main problems encountered in detecting parasitic eggs., such as the presence of artifacts and overlapping objects in the images, along with the large variations in the morphology of the parasitic egg. Furthermore, the various deep learning approaches used for egg detection have been covered, including Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and Deep Belief networks (DBNs).

The survey paper has demonstrated the effectiveness of deep learning techniques in detecting parasitic eggs in different types of images, including microscopy images, fecal samples, and environmental samples. The paper has also highlighted the importance of image preprocessing techniques in improving the performance of deep learning models for egg detection.

While deep learning models have shown promise in detecting parasitic eggs, there remain challenges and limitations that must be overcome. Foremost among these challenges is the lack of annotated datasets required to train and test these models. Annotated datasets are vital for teaching deep learning models to recognize and categorize different types of parasitic eggs, but the availability and quality of these datasets can be limited, making it difficult to produce accurate models.

Another challenge is the variability in the appearance of parasitic eggs across different samples and patients. Parasitic eggs can vary in size, shape, and color, making developing a robust and accurate detection model challenging. Furthermore, other structures or artifacts in the image may obscure some parasitic eggs, making them difficult to detect.

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