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Explainable deep inherent learning for multi-classes skin lesion classification

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Highlights

- A novel inherent learning technique with multiple convolution filters is proposed.
- The proposed algorithm overcomes image shortages and degradation.
- Different explanations prove the proposed model's capability to detect lesion areas in the skin accurately.
- The proposed deep inherent learning method is less error-prone than shallow networks.
- The proposed method's ability to classify skin lesions accurately is proven.

Abstract

There is often a lack of explanation when artificial intelligence (AI) is used to diagnose skin lesions, which makes the physician unable to interpret and validate the output; thus, diagnostic systems become significantly less safe. In this paper, we proposed a deep inherent learning method to classify seven types of skin lesions. The proposed deep inherent learning was validated using different explanation techniques. Explainable AI (X-AI) was used to explain decision-making processes at the local and global levels. In addition, we provide visual information to help physicians trust the proposed method. The challenging dataset, HAM10000, was used to evaluate the proposed method. Medical practitioners can better understand the mechanisms of black-box AI models using our simple, stage-based X-AI framework. They can trust the proposed method because the rationale for its decisions is explained.

Introduction

Skin cancer occurs when abnormal cells in the epidermis, the top layer of skin, grow rapidly without control [1]. Skin cancer is estimated to account for one-third of all cancers, according to the World Health Organization (WHO) [2], [3]. Climate changes, high temperatures, and prolonged direct exposure to sunlight are among the most important causes of skin cancer. Squamous cell carcinoma (SCC), melanoma, and Basal cell carcinoma (BCC) are the three main kinds of skin cancer, as shown in Fig. 1.

The two most common types of skin cancer in the US are BCC and SCC. Every year, approximately 4.3 million cases of BCC and 1 million cases of SCC are reported [4]. Among the deadliest types of skin cancer, melanoma causes about 9000 deaths annually in the US and 132,000 cases globally [5], [6], [7]. BCC and SCC are highly curable. The number of new cases of skin melanoma in 2020 exceeded 150,000. Skin cancers other than melanoma are often excluded from cancer statistics. Due to its prevalence, common underdiagnosis, and common treatment within primary care, it is not reported in global cancer statistics [8], [9].

Doctors employ various techniques to detect skin cancer [9]. Visual detection is the first step to examine the skin lesion [10], [11]. A reference for the potential shape of melanoma known as ABCD (asymmetry, border, color, diameter) [12] was created by the American Center for the Study of Dermatology and used by physicians for preliminary screening of the condition [13].

The physician conducts a biopsy of the potential skin lesion and examines it under a microscope to confirm if it is harmless or cancerous and what type of skin cancer it may be [14]. Differently, doctors utilize dermoscopy as a method to identify skin cancer. It entails capturing images of the skin lesion's shape resembling black dots. It can be difficult to accurately identify a lesion due to factors such as hair, blood vessels, lighting, and the shape of the areas, and several issues challenge this method, the most significant of which is the inability to identify the lesion's nature [15].

Clinical decision support is frequently used for skin cancer detection. Over the past few years, extensive research has been carried out in this field because of the increasing occurrence of skin cancer patients and the encouraging therapy outcomes for early identification. In this context, DNNs have been proven to be an effective technique for creating a model for classifying skin images. The outstanding level of interest has resulted in various alternative approaches with varied performance levels. All of them have in common the training of a model that may be utilized for diagnosis and, hence, clinical decision assistance. As a result, new approaches are frequently evaluated in terms of whether they permit models that lead to superior performance results in various dermatological diagnostic tasks. Simultaneously, the explainability of model predictions is becoming increasingly important in other fields of AI research [16].

Maintaining high prediction accuracy and learning performance while improving the explainability of models is responsible for enhancing the performance of proposed methods. Furthermore, it is essential to rely on artificial intelligence, effectively grasp the new generation of AI, and trust them appropriately. When it comes to medical diagnosis, explainable artificial (XAI) intelligence is essential. XAI is especially true regarding the classification of skin cancer, which can be challenging to detect. AI models that can explain their diagnosis are crucial because a clear understanding of the reasoning behind a diagnosis is essential for patient treatment. Responsible AI uses interpretable machine learning models as one technique for classifying skin cancers [17].

Several techniques are employed to provide insights into how these models make their predictions, for example, feature significance analysis and the visualization of decisions. Moreover, one of the methods of boosting the accuracy of a machine learning model is to apply techniques such as guided Backpropagation and saliency maps to highlight specific portions of an image that the model will use to reach the diagnosis. A further advantage of some responsible AI frameworks is the ability to allow domain experts to access their models through their interfaces, enabling them to comment on and explain the model to help it progress. The accuracy and reliability of AI-assisted diagnosis can be improved using explainable AI in skin cancer classification [18].

Due to artifacts and differences in image resolution, it is generally challenging to classify skin cancers. Lesions on the skin can be complicated and uncomfortable, and clinical procedures often fail to differentiate between different types of lesions because of the high similarity between different lesion types. Computer vision and machine learning are promising tools for overcoming the challenges associated with skin lesion classification. This paper presents a novel CNN model for classifying seven types of skin lesions. The inherent learning approach addresses degradation by improving information flow and overstepping layer input connections to enhance information flow. A variety of inherent blocks is proposed to construct a deep inherent network. Lesions can be easily found and screened using the proposed method. This work has the following primary contributions:

1. A novel inherent learning technique with multiple convolution filters is proposed to overcome image shortages and degradation.
2. Different explanations prove the proposed model's capability to accurately detect lesion areas in the skin.
3. The proposed deep inherent learning is less error-prone than shallow networks.
4. A challenging dataset was utilized to examine and evaluate the proposed method's ability to classify skin lesions accurately.

The remaining part of the paper is divided into A summary of the latest technology advancements discussed in the "Related Work" section. The suggested approach is defined as the "proposed method." "Experimental Findings and Discussion" presents the experiments that were carried out and the acquired results. The ability of the proposed method to detect the lesion area accurately is discussed in "Responsible AI." The final section, "Conclusion," contains the conclusion.

Section snippets

Related work

By 2030, cancer will likely account for 13.1 million deaths worldwide, according to the World Health Organization (WHO) [19]. As a result of abnormal cell growth on the skin, which can quickly invade and spread to other parts of the human body, skin cancer is a common disease in humans [20]. In recent years, various approaches have been presented and put into practice in the healthcare sector, focusing on classifying skin lesions. The HAM10000 dataset [21] was used by Chowdhury et al. [22] to …

Proposed deep inherent learning method

If no sufficient features are applied, the classification will not be correct. Discriminative features are thus essential to conduct a successful classification process. Deep learning techniques are proposed to enable an accurate method for skin lesion classification using a challenging dataset, including a large number of skin lesion Images, using inherent learning, inner quadrant correlation, and mismatching data. A new architecture for Deep Learning comprising 54 layers has been suggested. …

Experimental findings and discussion

A computer with an IBM Core i7 processor, 16 GB DDR RAM, and an NVIDIA GeForce MX150 graphics card was utilized for experiments and evaluations. The proposed method was coded and executed with MATLAB 2022b 64-bit. The International Skin Imaging Collaboration (ISIC) 2018 challenge dataset was used for testing and evaluation in this work [21], [34]. The ISIC 2018 dataset contains 10,015 images. The ISIC dataset is organized into seven categories. The number of images in each of these …

Explainable AI

As AI has grown, additional complex, indistinct models have been created and utilized to tackle challenging issues. The architecture design for these models makes them harder to understand and handle than previous models. It can be challenging for developers and end users to identify the root cause of such models' failures or failures that do not behave as anticipated or hoped for or to come up with solutions. By revealing the underlying workings of these opaque models, XAI satisfies the …

Conclusion

Dermatologists may use the skin image classifier of a clinical decision support system as a second opinion. So, an inherent deep learning method is proposed to classify seven skin lesions. The objective of this paper is to diagnose dermoscopy images through the use of an inherent deep learning network to overcome a shortage of skin lesion images as well as to provide visual information to assist in the diagnosis of the lesion. Our dermoscopy data set ISIC 2018 (HAM10000) results were …

CRediT authorship contribution statement

Wael Said: Validation, Resources, Funding acquisition. **Khalid M. Hosny:** Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization. **Mohamed A. Kassem:** Writing – original draft, Software, Methodology, Data curation, Conceptualization. **Mahmoud Elmezain:** Visualization, Project administration. …

Declaration of Competing Interest

No conflict of interest exists.

The second author received a fund, which is acknowledged in the manuscript.

The authors understand that the Corresponding Author is the sole contact for the Editorial process. He is responsible for communicating with the other authors about progress, submissions of revisions, and final approval of proofs. …

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exchange, categorized into case-based, textual, and auxiliary explanations. In addition to this, the authors in [149] introduce modified deep learning models, MobileNetV2 and DenseNet201, augmented with additional convolutional layers, to enhance skin cancer detection efficiency in detecting both benign and malignant cases. The Inception-ResNetV2 model enhanced with local binary patterns [150] is used for precise lung and colon cancer diagnosis, achieving 99.98\% accuracy.…

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