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AN AUTOMATED SKIN DISEASE DIAGNOSTIC SYSTEM BASED ON DEEP LEARNING MODEL

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Abstract: The use of computer technology has greatly enhanced the medical field, many computer applications, such as patient information system, monitoring and control systems, and diagnostic systems have been used to enhance healthcare. Technological developments in healthcare has helped in saving countless patients and are continuously improving our quality of life. Also technology in the medical field has had a massive impact on nearly all processes and practices of healthcare professionals. This study developed a robust system to enhance the decision making of dermatologist in Nigeria in terms of diagnosis of selected skin diseases, so as to foster quick diagnosis and treatment of various skin diseases through the use of a deep learning model. The developed system achieved the network accuracy of 98.44% and the validation accuracy of the test set is 99.44 % as specified by the training results, further testing reveal that the developed system yielded rejection rate of 2.2% and recognition accuracy of 97.8%.
Keywords: Dermatology, Artificial Intelligence, Deep Learning, AlexNet

1. INTRODUCTION

Artificial intelligence (AI) has recently experienced an era of explosive growth across many industries, and healthcare is no exception [1]. AI has particular utility in healthcare and will dramatically change the diagnostic and treatment pathways for many, if not most, diseases [2]. Regardless of the specific technique, the general aim of these technologies in medicine is to use computer algorithms to uncover relevant information from data and to assist clinical decision making [3]. In many developed countries, the application of AI technology in healthcare has developed quickly, at least in part because it enhances human resources and abilities and improves the accuracy of medical treatment [2]. As many countries that support the development of advanced technologies welcome the incoming era of AI, they will begin to develop the necessary specifications of governance by law, regulation, technology, and standards to fully optimize this developing field of technology [2]. Thus, this study seeks to see the relevance of AI in the field of dermatology.
Dermatology is the medical specialty that deals with diseases and conditions that affect the skin, hair, scalp, and nails. A larger part of dermatology, however, is focused on the problems and treatments of skin. This is because the skin, being the most extensive organ of the body, is more prone to a wider range of conditions and diseases [4]. People of all ages, from newborns to the elderly, are all susceptible to skin problems, which come in many different types, from rare to common problems, and from chronic to brief ones [5]
There are various of skin diseases with four types of skin conditions as Chronic diseases, Acute skin problems, Skin infections, Skin discolorations. Acute skin problems refer to skin conditions that occur briefly and suddenly but cause severe symptoms [4]. The most common acute skin problems are: Cold sores, Warts, Hair loss, Blisters, Corns and calluses, Sunburn, Ingrown hair, Dermatitis, Itching, Hives, Lice, Bruises and Sebaceous cysts.
Skin infections are reactions to bacteria, fungi, and viral irritants. Common bacterial infections that affect the skin are carbuncles, boils, cysts, abscesses, leprosy, Staph infection, and cellulitis. Fungal skin infections include ringworm, Athlete's Foot, yeast infection, fungal nail infections, and Sporotrichosis (Chambers, 2014). Common viral infections, on the other hand, include shingles, chicken pox, and Molluscum Contagiosum [4].
Dermatologists also deal with skin discolorations such as birthmarks, moles, freckles, and skin tags. These are patches or spots on the skin that differ in color. In many cases, discolorations are inborn. However, they may also develop later in life. Most of the time, birthmarks, moles, and freckles do not require medical attention [5]. However, in some cases, either due to their size, positioning, or other symptoms felt by the patient, a dermatologist may intervene. Common causes of skin discolorations are genetics and exposure to the sun. Commonly used treatments include cryosurgery or freezing and removing, electrosurgery or burning and removing, and laser treatments.

2. STATEMENT OF THE PROBLEM

Nowadays, skin disease among humans has been a common disease [6]. Usually, these diseases have hidden dangers which lead to human not only lack of self-confidence and psychological depression but also a risk of skin cancer [7]. Skin diseases are one of the most infectious diseases to see among people. Because of the physical structure affected by the direct exposure to ultraviolet radiation i.e. use of different types of high-frequency wireless equipment for a long time and it can develop skin cancer [7]. The diagnosis of skin diseases is very challenging due to the symptom of skin disease is an extended and continuously transforming process with occurring in certain areas of the skin [8]. In order to diagnose skin disease, a lot of clues such as specific lesion anatomy, physical assortment, scaling, shade, and arrangement can be used. The recognition process may be quite complicated by individually analyzing specific components [6]. Diagnosis of these kinds of diseases usually required medical experts with high-level instruments due to a lack of visual resolution in skin disease images [8]. Moreover, manual diagnosis of skin disease is often subjective, time-consuming, and required more human effort [9]. Thus, there is a need to develop a computer-aided system that can automatically diagnoses skin diseases.

Nigeria is a developing tropical country located in the western part of sub-Saharan Africa, with about hundred specialist dermatologists servicing a country population of 177 million people, the ratio of a dermatologist to patients is 1:1,770,000 [10]. Furthermore, [10] highlighted atopic dermatitis, tinea, acne, contact dermatitis, urticaria, seborrheic dermatitis, pityriasis versicolor, vitiligo and human papilloma virus infections as the nine most common skin disorders in Nigeria. In this regards, there is a need to develop a robust system that is aimed at not replacing the dermatologists in Nigeria but to aid their decision making in terms of diagnosis of selected skin disease, so as to foster quick diagnosis and treatment of various skin diseases. Thus, this study seeks to develop a deep learning model in diagnosis of the nine most common skin disorders in Nigeria as specified by [10].

3. EMPERICAL REVIEW OF LITERATURE

In order to carry out this study, it is highly important to critically review all available and relevant literatures in medical image processing so as to establish and validate the pragmatic status of this research work. Thus, this study looks into the related research works, which is the relevant contribution that has been proposed and implemented in medical image processing in relation to dermatology.

Modern medicine is faced with the challenge of acquiring, analysing and applying the large amount of knowledge necessary to solve complex clinical problems. The development of medical artificial intelligence has been related to the development of AI programs intended to help the clinician in the formulation of a diagnosis, the making of therapeutic decisions and the prediction of outcome. They are designed to support healthcare workers in their everyday duties, assisting with tasks that rely on the manipulation of data and knowledge. Such systems include Artificial neural networks (ANNs), fuzzy expert systems, evolutionary computation and hybrid intelligent systems (Ramesh, Kambhampati, Monson and Drew, 2004). Neural networks have advanced at a remarkable rate, and they have found practical applications in various fields of study [12]. Deep learning can solve problems which are hardly solvable with traditional artificial intelligence, as it can utilize unlabeled information during training; it is thus well-suited to addressing heterogeneous information and data, in order to learn and acquire knowledge [13].

A large number of newer studies have highlighted the capabilities of advanced deep learning technologies, including learning from complex data, image recognition, text categorization among host of others [13]. One of the main applications of deep learning is for medical diagnosis [14]. This includes but is not limited to health informatics, biomedicine, and magnetic resonance image MRI analysis. More specific uses of deep learning in the medical field are segmentation, diagnosis, classification, prediction, and detection of various anatomical regions of interest. Compared to traditional machine learning, deep learning is far superior as it can learn from raw data, and has multiple hidden layers which allow it to learn abstractions based on inputs [15]. The key to deep learning capabilities lies in the capability of the neural networks to learn from data through general purpose learning procedure [15].

The process for creating and assessing the classification model for dermatological classification was designed [16] with deep learning technique. They employ CNN architecture of AlexNet with transfer learning scenario. This study uses the dermatological images from a public data source. These data are the dermatoscopic images of seven skin lesions related to the disease. In order to broadly investigating the transfer-learning concept, they created three types of models (Alexnet-TL, FESVM, and FESVM+PD, respectively). The experimental results performed on a public dataset show that the CNN model can classify skin diseases with 79.29% accuracy.

[17] studied the effectiveness and capability of convolutional neural networks in the classification of 8 skin diseases. Different pre-trained state-of-the-art architectures (DenseNet 201, ResNet 152, Inception v3, InceptionResNet v2) were used and applied on 10135 dermoscopy skin images in total (*HAM10000*: 10015, *PH2*:

120). The utilized dataset includes 8 diagnostic categories - melanoma, melanocytic nevi, basal cell carcinoma, benign keratosis, actinic keratosis and intraepithelial carcinoma, dermatofibroma, vascular lesions, and atypical nevi. The aim is to compare the ability of deep learning with the performance of highly trained dermatologists. Overall, the mean results show that all deep learning models outperformed dermatologists (at least 11%). The best ROC AUC values for melanoma and basal cell carcinoma are 94.40% (ResNet 152) and 99.30% (DenseNet 201) versus 82.26% and 88.82% of dermatologists, respectively. Also, DenseNet 201 had the highest macro and micro averaged AUC values for overall classification (98.16%, 98.79%, respectively).

A high-precision deep learning neural network for automated diagnosis of skin tumors was created [18]. During the works, a training sample was formed, comprising real photographs of skin lesions and the images obtained from the source through various distortions. The unique augmentation algorithms, coupled with the loss functions, are the main authoring, allowing to achieve a high quality classification of skin diseases with a limited training set. The developed model allows quality diagnosis of melanoma with an accuracy of not less than 91%, which is comparable with the diagnostic capabilities of highly qualified dermatologists. The use of intelligent systems of this type to identify skin diseases will provide substantial support in the diagnosis of both dermatologists and general practitioners.

[17] determined the accuracy of deep learning algorithms to diagnose three common dermatopathology diagnoses. The developed system accurately classified 123/124 (99.45%) BCCs (nodular), 113/114 (99.4%) dermal nevi, and 123/123 (100%) seborrheic keratoses. The authors Concluded that Artificial intelligence using deep learning algorithms is a potential adjunct to diagnosis and may result in improved workflow efficiencies for dermatopathologists and laboratories.

[19] employed pre-trained ResNet-34, ResNet-50, ResNet-101, and ResNet-152 were chosen as the candidate architectures since they exhibit feature re-use and propagation, which were essential to our fine tuning. They normalized data with the recommended mean and standard deviation. The data was split in 5:1 ratio into training and validation sets. We performed dynamic in-memory augmentation such as crop, random zoom, horizontal & vertical flips in the dataloader. This demonstrated that several skin diseases can be identified from user submitted images with deep learning based classifiers. We showed that given sufficient training, the accuracy levels become architecture agnostic. There exists a significant gap between error-free detection and the peak performance achieved by contemporary methods. This gap may not be bridged easily since it manifests from the nature of skin disease presentation. We also showed that the performance dipped by at least 10% in non-ideal conditions such as noise, blur and distribution shift, which are reasonable scenarios in any field trial. We emphasize the role of trained practitioners in conjunction with these methods to improve the quality of dermatological services.

A system to classify skin diseases of 10 different classes containing 5500 images obtained from the Dermnet dataset was proposed [20]. The proposed system consists of 2 parts- image processing and transfer learning for training of dermatological images. The image processing part deals with image augmentation and removal of unwanted elements, which is found to be necessary before further processing, else it will affect the output efficiency. And transfer learning part deals with features extractions and fine tuning of pre-trained VGG16 model. The validation accuracy is found of be 74.1% and by further fine tuning is found to be 76.3% when tested on those datasets.

[21] projected a method that uses techniques related to computer vision to distinguish different kinds of dermatological skin abnormalities. We have employed various types of Deep learning algorithms (Inception_v3, MobileNet, Resnet, xception) for feature extraction and learning algorithm (preferably Random forest or Logistic Regression) for training and testing purpose. Using the state-of-the-art architecture considerably increases the efficiency up to 88 percentage. And further more by using ensemble features mapping, combing the models trained using Inception V3, MobileNet, Resnet, Xception a voting-based model will be ensemble and thereby increasing the efficiency13. For enhanced performance and selecting the optimum architecture for the application, we have used logistic regression technique. In this method, the divide mode is set to 90% for the training of the data, 10% for the validating/testing of the data. To characterize the efficiency of a classification model (or "classifier") on a set of test data for which the true values, a table of confusion matrix is used.

It is evident that majority of all the aforementioned authors in this empirical study focused on skin cancer classification. The empirical review of this study established that skin cancer is a common concept that interest researchers in diverse field of study which make it not restricted to dermatology alone but also exposed it to computer science and engineering. Thus, this empirical study revealed that numerous researchers in this regard ventured into skin cancer, moreover, various studies have established that larger percentage of skin diseases can lead or cause skin cancer if not well managed.

Hence, this study is tailored to research in to some obvious skin diseases (those that are common to Nigerians), truly, they may not be life threatening but these specified skin diseases have higher tendency of

afflicting higher degree of distress to the carriers of such skin diseases. As a result, this study aims to employ pretrained deep learning algorithm in to the classification of these selected diseases, so as to aid effective diagnosis which will foster appropriate treatment of these diseases.

4. METHODOLOGY

In order to accomplish the purpose of this study, the development process follows the designed framework as specified in figure 1. The datasets for the skin diseases classification were built, the images were acquired over the internet by keywords searches. A total of one thousand eight hundred images were obtained for the nine classes which were basically used for training and another two hundred and seventy images were obtained for the nine classes with were used for further testing and evaluation of the model. For the purpose of Image Pre-processing, the acquired images were subjected to basic image preprocessing tasks which include cropping and resizing. In this regards, images in this study were resized to 227 by 277 by 3, which is accepted image size for the AlexNet model.

This study uses the AlexNet pretrained model, where the training dataset (one thousand eight hundred images) were split into 80% by 20%, where the 80% is used for training and the remaining 20% is used for validation upon which the validation accuracy of the developed system is based. Before the training of the model, the pretrained AlexNet was fine-tuned so as to accommodate the specified nine classes. After the training of the model, the new trained model was saved and renamed as **DERMNET**. The testing datasets (two hundred and seventy images) were used to further test and evaluate the developed system, the result of which was regarded as the overall recognition accuracy of the system.

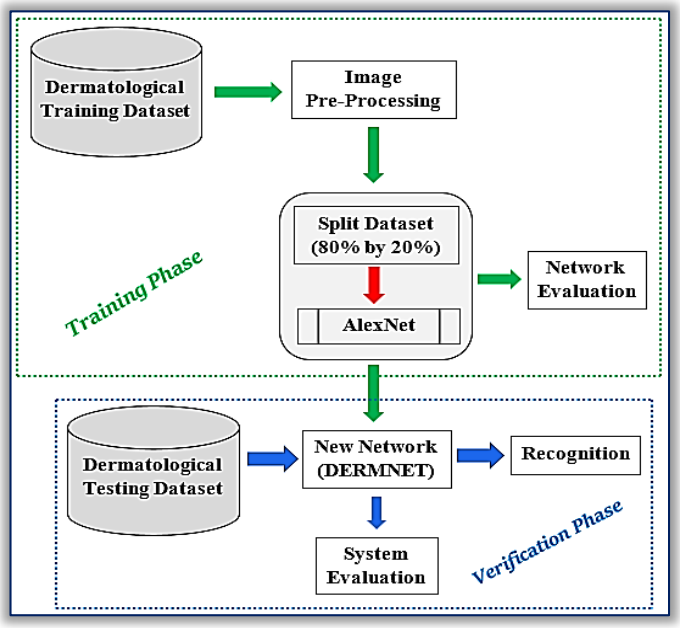

Figure 1: System Architecture for diagnosing of the nine most common skin disorders in Nigeria

5. RESULTS

This study presents the application of deep learning model in diagnosis of the nine most common skin disorders in Nigeria, the development is based on the system architecture adopted for this study (see figure 1) and the basic system requirements (Machine name: DESKTOP-Q2NPMI9, Machine Id: {5C1CDF56-5C07-4E2F-BB5B-6EA9441721FF}, Operating System: Windows 10 Pro 64-bit (10.0, Build 18363) (18362.19h1_release.190318-1202), System Manufacturer: TOSHIBA, System Model: Satellite L650, BIOS: InsydeH2O Version 1.90 (type: BIOS), Processor: Intel(R) Core(TM) i5 CPU M 430 @ 2.27GHz (4 CPUs), ~2.3GHz, Memory: 4096MB RAM).

The developed system achieved the network accuracy of 98.44% as show in table 1 and the validation accuracy of the test set is 99.44 % as show see figure 2. Furthermore, the model was subjected to further testing using testing dataset (270 images) which yielded rejection rate of 2.2% and recognition accuracy of 97.8% as show see table 2. Also, the findings of this study with respect to table 2 indicate that total testing sample for this study is 270 images where each class have 30 images. All the classes yielded 100% recognition accuracy except for Pityraisis Versicolour, Seborrheic Dermatitis and Tinea with 93.3%, 90% and 96.7% respectively. Statistical evaluation of the result using descriptive statistics indicates that all classes yielded the standard deviation of 0.00000 except for Pityraisis Versicolour, Seborrheic Dermatitis and Tinea with 0.25371%, 0.30513 and 0.18257 respectively.

Table 1: Training Progress

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:09	18.75%	2.7835%	1.0000e-05
3	50	00:07:16	71.88%	0.9400%	1.0000e-05
5	100	00:14:31	92.19%	0.4635%	1.0000e-05
7	150	00:21:46	93.75%	0.2022%	1.0000e-05
10	200	00:28:53	100.00%	0.0540%	1.0000e-05
10	220	00:38:15	98.44%	0.1030%	1.0000e-05

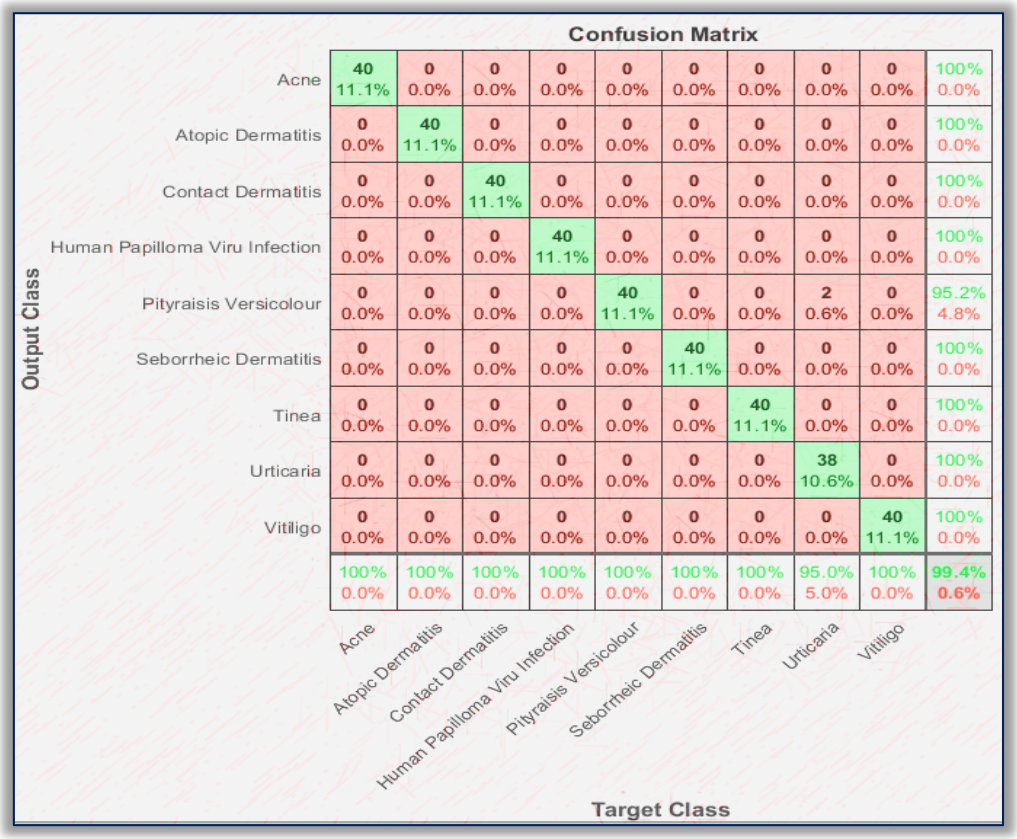

Figure 2: Confusion Matrix

Table 2: System Verification

Skin Diseases	N	Minimum	Maximum	Mean	Std. Deviation
Acne	30	1.00	1.00	1.0000	.00000
Atopic Dermatitis	30	1.00	1.00	1.0000	.00000
Contact Dermatitis	30	1.00	1.00	1.0000	.00000
Human Papilloma Virus Infection	30	1.00	1.00	1.0000	.00000
Pityraisis Versicolour	30	1.00	2.00	1.0667	.25371
Seborrheic Dermatitis	30	1.00	2.00	1.1000	.30513
Tinea	30	1.00	2.00	1.0333	.18257
Urticaria	30	1.00	1.00	1.0000	.00000
Vitiligo	30	1.00	1.00	1.0000	.00000

Table 3: Descriptive Statistics

Skin diseases	Testing samples	Correctly recognised	Incorrectly recognised	Not recognised	Recognition rate
Acne	30	30	0	0	100%
Atopic Dermatitis	30	30	0	0	100%
Contact Dermatitis	30	30	0	0	100%
Human Papilloma Virus Infection	30	30	0	0	100%
Pityraisis Versicolour	30	28	02	0	93.3%
Seborrheic Dermatitis	30	27	03	0	90%
Tinea	30	29	01	0	96.7%
Urticaria	30	30	0	0	100%
Vitiligo	30	30	0	0	100%
TOTAL	270	264	06	0	97.8%

6. CONCLUSION

This study investigates the application of deep learning in diagnosis of the nine most common skin disorders in Nigeria, with the aim of using AlexNet pretrained deep learning model. The findings of this study indicates that the overall recognition accuracy of the developed system is 97.8% thus, accomplishing its purpose. Moreover, comparing the results of this study with its contemporaries indicate that this model will aid the diagnosis skills of the Nigerian dermatologists.

Nevertheless, the recognition accuracy of Pityraisis Versicolour, Seborrheic Dermatitis and Tinea cannot be overlooked, thus, this study recommends that quality and more datasets should be used in future trainings so as to yield better skin diagnosis.

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