An artificial intelligence approach for the recognition of early stages of eczema

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Abstract: The rural population of India suffers from various medical ailments and due to the lack of medical facilities and practitioners, enough support is not available. Medical help might come late and the problem might have been aggravated. With the increasing awareness about artificial intelligence (AI), it is possible to solve these problems using technology. The research aims at detecting an early stage of the skin disease 'eczema', when the affected part of the human body is captured through a smart phone and approximate symptoms are provided by the medical practitioner. It uses artificial intelligence algorithms like convolutional neural networks and support vector machines algorithm for classifying the images, and back propagation algorithm for training a model based on the symptoms. Around 50 clinical photographs of eczema acquired from KEM Hospital, Mumbai to train the classifier and then different images of eczema were tested with an accuracy of greater than 85%.

Keywords: artificial intelligence; back propagation network; BPN; convolutional neural network; support vector machine.

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1 Introduction

In the rural areas of India, due to the large population and comparatively lesser number of doctors, there are various unresolved medical problems, of which a major problem is skin disease. One in 20 people in India suffer from skin disease (Kumar and Kumar, 1996). Many dermatologists are practicing in the cities and large towns; hence the rural population which is around 80% of the total has no easy access to a dermatologist (Patil and Patil, 2012). Medical help is not quickly available and patients have to wait for long durations for treatment of their ailments. Further, the technological help available for the doctors in these areas is also not up to the mark. Existing applications require a chip-on device, which increases the cost of the said application (IIT Kharagpur Develops Mobile App that detects skin cancer, http://www.kgpkonnect.in/iit-kharagpur-developsmobile-app-that-detects-skin-cancer.html). This wait, lack of quality, and high cost of the necessary technology, not only causes more problems for the patient himself, but also might lead to aggravating the said medical condition. This problem can very much be toned down, if not solved completely, due to the development in the field of mobile computing and with the advent of machine learning, neural networks. This application takes a skin image as an input, tests if the image belongs to eczema and gives the probability that the concerned image belongs to eczema. As a result, the dermatologist can immediately identify the type of skin disease with related symptoms. The algorithm is designed to effectively scan and preprocess the various skin disease related image parameters captured by the in-built camera of the mobile handset with proper learning

and training of the symptoms, to produce the output. The research aims at designing an application for existing Android-enabled smart phone devices which will mainly focus on early diagnosis of eczema. The research work is based on health sector having its utility to semi-rural part of India (Rao et al., 2003). Some researchers have suggested that the condition of skin diseases can be improved by having a better standard of living, sanitation, education and nutritious food. In spite of this solution, there is still a need for having an early detection system for diseases which is affordable and easy to use. This is necessary to make sure that even if there is a case of eczema somewhere in the village; it would not go unnoticed just because good medical help is not available.

The proposed method is non-invasive in nature and does not required injection and extraction of blood from the human body. It uses the external scanning method, i.e., inbuilt camera on the smart phone to scan the infected skin image for further processing. There is no additional hardware required in this project. It is completely software based system. Hence this will make the application cost efficient. In this context, the proposed research aims to develop an efficient and inexpensive smart-phone enabled health solution and diagnosis system of skin diseases for semi-rural population.

2 Literature review

Surveys about the dermatological concerns of the rural population have been made. Also, studies and research about how technology field could be useful to the dermatology field have been conducted. This section thus gives a brief review about how there is a growing need of medical help in this field in the rural areas. Also, the various algorithms and techniques used till now for recognising and predicting the skin patterns through images have been discussed.

Verma (2007) tells that only 5,000 dermatologists are present in India that treat 1.1 billion of Indian population. This indicates a 1:200,000 dermatologist to patient ratio in India. Even though exact numbers are not available, it can be assumed safely that over 90% of dermatologists practice in urban areas. And due to this, there are insignificant numbers of dermatologists for the 750 million population of the villages.

In Rao et al. (2003), a study of the medical camp at Kumble in Kerela has been provided which suggests that 3,673 patients attended the same. According to this analysis, 410 patients, i.e., 11.16% of the total people had dermatological problems. Among these patients, 234, i.e., 57.07% of the total people suffering from dermatological problems had non-infectious diseases. Also, eczemas took an upper hand in non-infectious group, i.e., 32.19%. Improvement in the standard of living, education of the general public, improvement in the environmental sanitation and good nutritious food may help us to bring down the skin disease in this area.

According to Saa'd (2009), authors have thought of automating the interpreting of skin disease images using its colour and texture for detection of skin diseases. The methodology proposed uses the combination of wavelets and neural networks to represent the type of texture. This system detects many types of distributed diseases in distributed regions which are close together. But this method is unable to detect the diseases which are separated by a significant distance.

In their research paper Jaleel et al. (2012), the use of back propagation network (BPN) Algorithm to classify cancerous and noncancerous skin has been discussed. It indicates that Bayesian classification presumes an underlying probabilistic model which

permits capturing of uncertainty about the model in a principled way by determining probabilities of the outcomes. Hence, it can solve diagnostic and predictive problems and give efficient results even when inputs have high dimensionality. It requires small amount of training data for estimation. Also, it has been observed that this model can be further optimised with the use of machine learning technique.

Bourouis et al. (2013) has presented the artificial neural network based skin disease analysis system using smartphone's camera. This is used to analyse the skin images to identify skin cancer. The dataset of skin images which was available on the internet (DermAtlas: Dermatology Image Atlas with 10917 Dermatology Images, http://www.xmarks.com/s/site/dermatlas.med.jhmi.edu/derm/) have been used. Also, rooted method of Android O.S. is used to optimise the battery life (Safely Root Your Android Device, https://www.oneclickroot.com).

As many dermatologists are practicing in the cities and large towns, the rural population which is around 80% of the total Indian population, has no easy access to a dermatologist (Patil and Patil, 2012). Hence, research work is necessary based on the health sector of India. The research will be helpful to people in rural part of India who cannot afford hospital fees. No application exists for early diagnosis of skin diseases using mobile technology for rural population. Hence, the designing of a smartphone application is necessary for the early stage detection of any skin disease.

3 Existing method

IIT Kharagpur Develops Mobile App that detects skin cancer (http://www.kgpkonnect.in/Iitkharagpur-develops-mobile-app-that-detects-skin-cancer.html) shows the creation of a mobile phone application by IIT Kharagpur students for helping doctors to diagnose skin cancers quickly and accurately. The application 'ClipOCam-Derma', which can be used on any smartphone, has been developed in the School of Medical Science and Technology at IIT Kharagpur, led by research scholar Debdoot sheet. The researchers say the app can be used by semi-skilled paramedics working in rural and primary healthcare centres. It will assist in fast and high-precision screening of skin lesions and abnormalities like cancers, psoriasis, scaling, keratinisation, melanoma, inflammation, ulcers, lipoma, healing and non-healing wounds, and heavy-metal induced dysplasia, all of which may or may not be evidently visible on the surface.

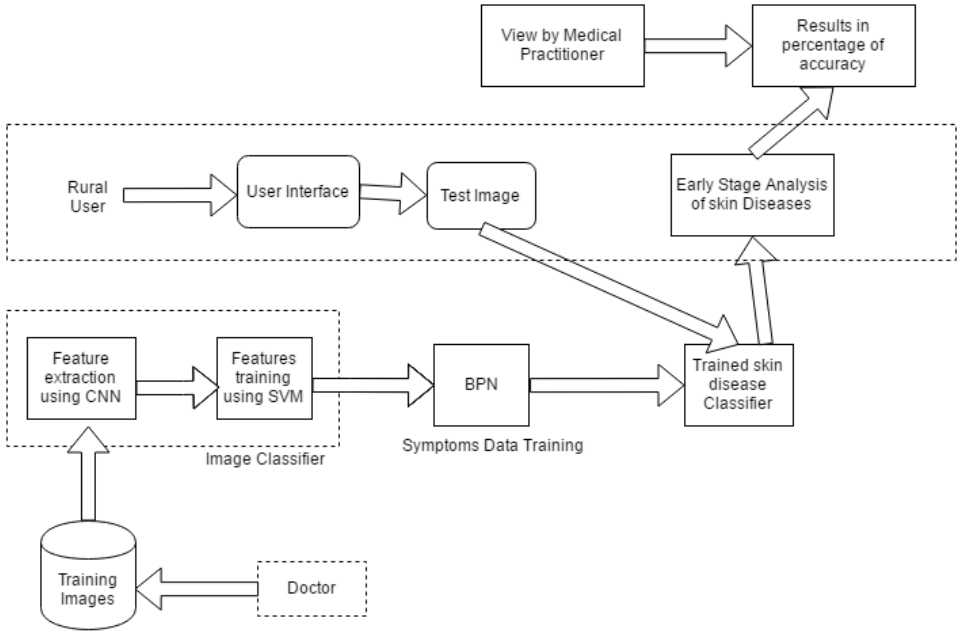
Filimon and Albu (2014) this is a MATLAB simulation, which involves identification of psoriasis, seborrheic dermatitis, lichen planus, pityriasis rosea, chronic dermatitis, pityriasis rubra pilaris, using a pre-defined set of symptoms which can be rated according to their intensity for each of the disease. This set of symptoms is trained using BPN and then tested for values obtained from other patients, which can be different from those for which it was trained. Here, the output is one only for one disease, indicating the decision of the classifier.

4 Proposed method

This section describes the proposed methodology of the system to detect early stages of Eczema. Figure 1 describes the overall model for our proposed system. The training

images are first obtained from the doctor. These images are then fed to the dermatological skin image training module. Following this, symptom training is performed. After that, an image is provided to the classifier for testing, and results are displayed as probability of presence of eczema in terms of percentage.

Figure 1 Flow diagram of the modules of the system



4.1 Dermatological data training module using BPN

The objective of the module is to find the symptoms from the database in correlation with disease database. The inputs will be trained by using supervised learning algorithms to calculate the optimum result. An artificial neuron has many inputs and one output. The neuron has two modes of operation; the training mode and the using mode. In the training mode, the neuron can be trained to fire (or not), for particular input patterns. In the using mode, when a taught input pattern is detected at the input, its associated output becomes the current output. Among several neural networks where backpropagation works far faster than earlier approaches to learning, making it possible to use neural nets to solve problems which had previously been insoluble [23]. In this module, we have prepared the dataset for ten various symptoms of Eczema. The symptoms are being trained on a scale of 0–10. The ideal values of the symptoms have been obtained from Dr. Uday Khopkar, Skin Department of KEM Hospital. These symptoms are trained for the eczema. This trained classifier is then used with the symptoms of the patient and a result is being obtained in terms of probability. This probability denotes the possibility of Eczema; a patient is suffering from. This model on its own give an efficient result for recognition of the disease.

4.2 Dermatological skin image training module using artificial intelligence algorithms

The objective of this module is to perform skin image analysis and extract meaningful information from images; mainly from digital images by means of digital image processing techniques. Similar to data classification, this module also has a training and using mode. For the training mode, some 50 skin images of patients suffering from Eczema were provided by the Skin Department of The KEM Hospital. The images are then given to the feature extraction technique to extract significant properties present in the image. Our system uses the convolutional neural network to train the images and generate 256 features from these images. These set of features have to be trained for classifying them for the disease Eczema. The Support Vector Machines Algorithm is thus used to classify the features as Eczema or no. This trained classifier is then used in the using mode. In the using mode, the input to the system will be an image of the affected area of skin of the patient and the output will be the percentage of eczema the patient has.

4.3 Android Application design and development module

This module deals with implementing the proposed algorithms based on artificial intelligence for the android platform. The main focus is to develop an application that is efficient, user friendly and adaptable to the various android versions and devices. It thinks about designing usable, simple and compatible user interface module for the application. The implementation follows a modularised design pattern to enable easy maintainability and allowing for new features to be added in the future. Open source libraries and built in Android features are utilised to enable the application to perform image capturing, processing and other computations. The application asks the user to either capture an image instantly or take it from gallery. Also, there is a cropping option provided which lets the user for selecting only the relevant affected part of the skin. After that the image is stored in the device and also uploaded on our server. Later the doctor is asked to fill in the symptoms of the patient on a scale of 0–10 as taken in the first module. Also, the details of the user should be filled for preparing a complete report of the disease. After filling the entire form, the results are calculated and the report of the patient gets displayed along with the probability of Eczema generated from the above two modules. This module thus gives an easy user experience with the appropriate results.

5 Results and analysis

5.1 Server-side results

The symptoms classifier uses dataset of 250 entries of all the ten symptom values for the disease eczema. Later a training algorithm of back propagation is applied on the dataset and the probability of the symptoms indicating Eczema is given. When tested on different symptoms, it gives a good result. Later, a database of two classes, i.e., a class of 50 images of eczema and another class of 50 non-eczema images which is a mixture of various diseases, is prepared. 256 features are extracted from these images using CNN and these images are then trained using SVM classifier. The accuracy of this classifier when tested comes out to be around 85%.

5.2 Application-side results

The application was then validated at the KEM Hospital on the live patients. The following results were obtained:

5.2.1 Eczema present

A live eczema patient was brought in for testing. When we clicked the image of the affected part, supplied the symptom values and ran it through our algorithm, we got a probability of 94.17% indicating that the results were correct.

Figure 2 Probability of eczema in an eczema patient (see online version for colours)

5.2.2 Eczema not present

A live furuncle patient was brought in for testing. When we clicked the image of the affected part, supplied the symptom values and ran it through our algorithm, we got a probability of 4.059% indicating that it is not eczema.

Figure 3 Probability of eczema in a non-eczema patient (see online version for colours)

6 Ethical conduct

We have taken utmost care while designing and implementing this application to do everything ethically. The ethical conduct followed by us is as follows:

- While capturing image or providing symptoms as input to the application, no kind of physical contact to the affected part of the patient is being required.

- Our application as well as our database would not be accessible to anyone without the knowledge of KEM Hospital.
- References to the pre-existing algorithms for symptoms training and image classification has been given.
- Training data mapping of the symptoms to diseases have been done.

7 Conclusions

The current status of lack of medical help in the rural areas in the field of dermatology, demanded for the development of a user-friendly and efficient way of recognising the early stages of skin diseases, so that necessary action can be taken. Hence, we have given a methodology for detecting eczema using artificial intelligence. The capability of neural networks to make sense of data and the use of machine learning to classify the data has made it possible to build a complex application which gives wonderful results. The aim of the project was to develop a computational model for the recognition of skin diseases. We have built a model for detecting eczema, but very small amount of changes will be required for detecting various other diseases in the future. This system gives an accuracy of around 85%, i.e., 85 out of 100 images and their corresponding symptoms are correctly classified as either belonging to the class eczema or not. This is very close to that predicted by any dermatologist. Also, the response time of the application is less so the results are obtained within no time. Hence, this is a very effective use of technology for helping the society.

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