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The Identification and Classification of Rash Conditions Compared to Skin Cancer

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Abstract: *When left untreated, skin cancer can quickly spread throughout the human body. To a Dermatologist, skin cancer and rashes may look the same. Therefore, distinguishing between rashes and skin cancer might be challenging. People and medical professionals alike use the term "rash" to refer to any visible alteration in the skin, including but not limited to an infection, an allergic reaction, or a disease. A dermatologist will suspect skin cancer from a rash if it does not improve after several weeks of treatment and if it quickly spreads to other areas of the body. Meanwhile, being aware of the distinctions between rashes and skin cancer might assist a person decide whether to seek medical attention or relax about a rash that is not dangerous. The purpose of this study is to aid in the early detection of skin cancer by clarifying the differences between skin cancer and rashes. Image classification has been used well in previous research to distinguish between different forms of skin cancer. This model uses a Convolutional Neural Network (CNN) to recognise and distinguish between skin cancer and rash photos. With an average accuracy of 80.2%, the model determined whether the image depicted skin cancer or a rash.*

Keywords: *Image Classification, Image processing, Convolutional Neural Network, Deep learning*

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Introduction

The term "Image Processing" refers to the process of digitising an image and then manipulating the digital file in order to improve the image or extract relevant data. It's a form of signal distribution where a picture or video frame is used as the source material [1]. The result could be an actual picture or just some information about it. Typical ways of pre-processing signals in an Image Processing system involve seeing images as two-dimensional signals and applying those standards to the data. It's one of the most promising new technologies, having potential uses in many areas of business [2]. The study of images is also fundamental to the fields of engineering and computer science [3-9]. Digital image processing now permeates virtually every industry [10]. Since its inception, the study of medical image processing has grown rapidly and has become a multidisciplinary field of study, requiring the application of concepts from fields as diverse as medicine, physics, biology, statistics, and computer science [11]. An integral part of clinical routine has been improved by computer-aided diagnostic processing; however, with the rapid advancement of new high technology and the use of different imaging modalities comes new challenges, such as how to process and analyse a sizable portion of the image to generate high-quality information for disease diagnosis and treatment [12-15].

Medical imaging is the practise of producing images of the human body's internal structures and functions for the purposes of clinical assessment and medical intervention [16]. When it comes to diagnosing and treating illness, medical imaging aims to unearth structures often buried by skin and bone [17-24]. The typical anatomy and physiology of a patient are catalogued through medical imaging so that anomalies can be more easily recognised. While it is true that medical imaging can be performed on organs and tissues that have been surgically removed, this is typically classified as part of pathology rather than medical imaging [25]. It is a subfield of biological imaging and can be thought of as a whole. X-ray radiography, MRI, thermography, ultrasound, endoscopy, elastography, tactile imaging, thermography, medical photography, and nuclear medicine functional image techniques like Positron Emission Tomography (PET) and Single-Photon Emission Computed Tomography are all part of radiology (SPECT) [26-31]. Other methods that generate data amenable to display as a parameter graph vs. time or maps which contain data about the measurement locations include electroencephalography (EEG), magnetoencephalography (MEG), and electrocardiography (ECG), among others. These methods are, to a certain extent, analogous to other types of medical imaging [32-35].

Both analogue and digital approaches are employed in the field of Image Processing. Images on paper, such as prints and photographs, can be processed visually or through an analogue method [36]. While employing these visual methods, image analysts draw on a wide range of interpretation theory. When analysing images, it's not just the subject matter at hand that matters, but rather the analyst's breadth of understanding [37-41]. An additional useful strategy for processing images visually is association [42-46]. As a result, analysts utilise both first-hand experience and other sources of information while conducting picture analysis. The ability to manipulate digital images on a computer is made possible by digital processing techniques. Imperfections exist in the raw data collected by image sensors onboard satellite systems [47-55]. In order to remove such errors and ensure the data is unique, it must go through several stages of processing [56].

To put it simply, sun exposure increases the risk of developing skin cancer. However, this prevalent kind of cancer can also develop in shadier parts of the body [57-62]. Basal cell carcinoma, squamous cell carcinoma, and melanoma are the three most common forms of skin cancer. Sun-exposed parts of the body are most vulnerable to the onset of skin cancer, and they include the scalp, face, lips, ears, neck, chest, arms, hands, and, in women, the legs. However, it can also develop on regions of the body that are rarely exposed to sunlight, such as the palms, the spaces between the fingers and toes, and the vaginal area [63-69]. Those with darker skin tones are not immune to developing skin cancer. Melanoma is more common on parts of the body that are rarely exposed to sunlight, such as the palms and soles. Squamous cell carcinoma is most common in parts of the body that are frequently exposed to sunlight. This includes the face, ears, and hands [70]. Squamous cell carcinoma occurs more frequently on parts of the body that are rarely exposed to sunlight, and is therefore more dangerous for people with darker skin tones. Melanoma can appear on any part of the body, either as a new mole or as a malignant change in an existing mole. Males are more likely to develop melanoma on their face or trunk [71-75]. Women are more likely to acquire this form of cancer in the lower legs. Melanoma can develop in men and women even if their skin has never been exposed to the sun. Melanoma is not selective in who it affects [76-81]. Melanoma is more common in the palms and soles, as well as under the fingernails and toenails, of those with darker skin tones [82].

The goal of this initiative is to put into action a novel image-processing system capable of distinguishing between skin cancer and harmless rashes [83-89]. A combination of deep neural networks and convolutional neural networks (CNNs) are used in the proposed image processing method's two main steps, (1) pre-processing and (2) picture fusion. Methods for detecting skin cancer have been the primary focus of this system [90]. The medical field greatly benefits from advances in skin cancer detection. Aiming to bridge the gap between bottom-up affinity-based segmentation methods and top-down generative model-based approaches, this study presents a review of many well-known methodologies for the automatic segmentation of heterogeneous picture data [91-92]. The primary goal of this investigation is to investigate methods for more effectively detecting skin cancer. It has been discovered that the majority of current approaches do not take into account photos with low quality, such as those with noise or low brightness [93-96].

Dermatologists rely on medical X-ray images for diagnosis, making research into image enhancement critically crucial [97-101]. However, the X-ray image is distorted by the influence of the imaging system as imaging progresses. It contains a high percentage of grey tones, making it difficult to make out any of the finer features. The homomorphic filter's primary function is to improve image quality by compensating for lighting differences [102]. It is a part of frequency-domain processing that uses a frequency transfer function; nevertheless, the transfer function's low-frequency attenuation and loss of grey information in the X-ray image's dark space pose a challenge [103-109]. The TV model was used to suggest a novel homomorphic fIlter by Wang rei and Wang Guoyu, which achieves a nice compromise between adjusting the brightness and boosting the details. Findings demonstrate the efficiency of the homomorphic filter in improving medical images. Background information is collectively computed using theroutines approach [110-116]. The entropy value demonstrates that the quality of the globe image is higher than our way, and it is clear that the

CLAHE method performs well on contrast adjustment. While doing so, our strategy improves upon the details in a number of ways [117-121].

In order to train decision forest classifiers and regressors that are more representative and patient-specific, a new learning target is presented [122]. This enhancement improves landmark localization precision by allowing trained models to account for differences in organ pose and size between images. The proposed method also serves as a more precise roadmap for later image analysis methods [123-129]. Any method of describing and recognising images that allows for the division of the image into sections requires image segmentation as a prerequisite. Tissue classification and abnormality detection by picture segmentation [130]. It identifies each and every pixel in the picture. In this way, it is possible to quickly and easily assess the medical image because all of the pixels with the same label will share the same properties [131-135]. The experimental results demonstrate that the suggested method, when employed as an initialization technique for state-of-the-art multi-atlas segmentation, yields improved accuracy and resilient performance [136-141]. The suggested patient-centered method is flexible enough to be implemented in a variety of decision tree architectures to improve classification and regression. This encompasses the use of a variety of modalities and an assortment of organs as targets [142].

There are several uses for X-ray imaging technology, including the detection of fractures, metals, and other materials. There has been a lot of good research done in this area, and there is still plenty of room for more [143]. This article explores a wide range of imaging methods, including CAD, image segmentation, edge detection, and many others. The scope of use for these methods in image processing is determined by these factors [144]. The primary purpose of this research is to provide a method for identifying bone fractures that is more precise, reliable, and efficient. For MHSI data classification jobs, a suggested network uses a pair of E-to-E fusion channels. An E-to-E-Net is developed with principle components as the output mechanism [145-149]. Both the unsupervised feature extraction technique and the fusion of MHSI and main component feature information into a single dataset with reduced noise levels have been shown to be advantageous [150]. Additionally, a standard CNN was used to make up for the shortcomings of the E to E-detailed Net's information in order to make full use of the patch-based global information and the detailed local information. Experimental verification on two real-world MHSI data sets shows that the proposed E-to-E-Fusion method outperforms several state-of-the-art strategies despite using less training samples [151].

Skin cancer and birthmark moles can be identified, and skin cancer can be classified as benign or malignant, based on the mole's border, form, texture, and colour [152-153]. Warnings will be displayed if cancer is detected. A larger number of features are required by older approaches to determine whether a lesion is benign or malignant. It is not possible to focus border features more, as was the case in older approaches, to achieve better categorization outcomes. Lesions on the skin can be either malignant or benign, and this approach describes how to do so using less factors such as shape, colour, border, and texture to make that determination for both full and partial lesions. Probability of having a birthmark is taken into account [154]. In some cases, a birthmark may raise concerns that it is skin cancer. When the constituent features of a system are small, the categorization model is more stable. It has been found that while attempting to classify data into two categories, Support Vector Machine performs more effectively as a classifier. The procedure identified melanoma as either benign or malignant and also discovered skin cancer and moles associated with birthmarks [155]. To accomplish this, the system employs a method known as hybrid classification

(Artificial Neural Network and Support Vector Machine). A 91.2 percent accuracy rate was found using the technique [156].

Like ANNs, poorly taught DNNs have a number of drawbacks. Overfitting and excessive calculation time are two typical problems [157]. The additional abstraction layers that DNNs utilise to model uncommon dependencies in the training data make them susceptible to overfitting [158]. To avoid overfitting, trainers might use regularisation strategies like Ivakhnenko's unit pruning, weight decay (regularisation), and scarcity (regularisation). In contrast, dropout regularisation arbitrarily eliminates hidden layer units. This aids in the elimination of infrequent requirements. Finally, data can be enhanced by techniques like cropping and rotating to increase the size of smaller training sets and decrease the likelihood of overfitting.

Many factors must be taken into account when training a DNN, including the network's size (in terms of layers and units per layer), the learning rate, and the initial weights. Searching the entire parameter space for the best values could take too much time and computing power to be practical. Computing can be sped up using techniques like batching. Since the necessary matrix and vector computations are well-suited for GPUs, their adoption has resulted in significant training speedups. It's also possible that engineers will look into different varieties of neural networks that have simpler and more convergent training techniques. Cerebellar Model Articulation Controller (CMAC) is a neural network. To use it, you need neither training weights nor a learning rate. The computing complexity of the training algorithm is linear in the number of neurons, and it is guaranteed to converge in a single step whenever a new set of data is introduced during the training process.

The software product requirements specification is a technical document outlining the product specifications. It is the initial phase of analysing customer needs. Specific functional, performance, and security requirements for a piece of software are outlined. The criteria also detail possible user, operational, and administrative use cases. Information about the project, its parameters, and its intended outcomes can all be found in the software requirements specification. Those interested in the project's intended outcome, proposed user interface, and necessary hardware and software can learn more here. It describes how the project and its features are understood by the customer, the team, and the audience.

Overexposure to the sun's UV rays can cause skin cancer, which can develop in almost any size, shape, etc., on virtually any portion of the body. Two layers, a CNN layer and a Pooling layer, make up the suggested approach. One of the most time-consuming parts of data science is gathering the necessary datasets, which must be obtained from credible and trustworthy sources. The process of gathering datasets include gathering datasets from a variety of reliable sources and then separating those datasets into train and test data pictures. Data pre-processing is the following phase, and it's one of the methods used to convert raw data into the appropriate format. Images are resized and reshaped to meet required dimensions as part of the pre-processing phase. Data pre-processing includes resizing and rearranging the photos, separating the dataset into a training and testing set, and more. The module is trained and tested using the training and testing datasets. The pixel contrast of some photos may be higher than that of others. Scaling the image to the same range [0 to 1] allows the photos to contribute uniformly to the overall loss in this case, where the high-range image tends to cause larger loss and the low-range image creates weaker loss.

So far, we have heard that CNNs have a straightforward design that looks like a single stack of several convolutional layers. The majority of computer vision research papers use this architecture arrangement. Nonetheless, it is possible to conceive of alternative structures that might be better suited to the job at hand. We must now move on to the use of CNN. Assigning weights and biases to different features of an image and distinguishing them from one another are two goals of this deep learning method, which receives a picture as input. A convolutional neural network (CNN) begins with an input image, much like the human brain. The pixel structure of the input image is examined. There is a break in the pixel pattern, making it a 2D array (22). Maximum pooling takes into consideration randomly selected pixels. Next, the CNN layer is followed by the pooling layer (fig.1).

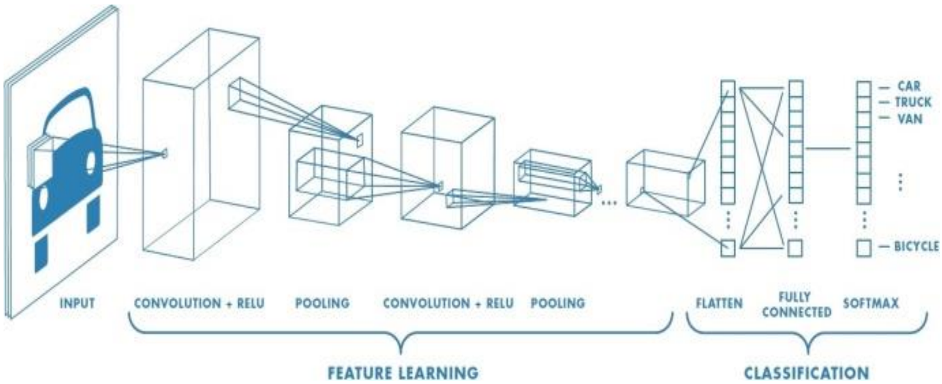

Figure 1. An illustration of a CNN with several convolutional layers to extract the features of an input image (Image source: https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b1164a53, last accessed on 12 April 2022).

There is only one input node and one output node in the CNN model, but there are many hidden layers and numerous neurons in each of those layers. Each hidden layer neuron communicates with every other hidden layer neuron. Non-linear features are introduced into the neural network by use of activation functions. For non-linear complex functional mappings between inputs and outputs, activation functions are required. To improve the module's accuracy throughout the iterative training phase of a neural network, we must minimise the loss function. In order to reduce the loss function, the optimizers will adjust the weight settings. The CNN model is trained using numerous epochs for a single image, and the activation functions and optimizers are changed at each stage of training.

Deep Neural Network

One definition of "deep neural network" is a neural network with more than two hidden layers. Deep neural networks do intricate data processing via elaborate mathematical modelling. An input layer, an output layer, and a hidden layer are the defining components of a deep neural network, according to several professionals. Some people call the process of sorting and organising data performed by each layer a "feature hierarchy." Dealing with unlabeled or otherwise unstructured data is a primary application area for today's state-of-the-art neural networks. The term "deep learning" is also used to refer to various types of neural networks. The term "deep learning" refers to a subfield of machine learning in which complex algorithms are used to sort and categorise data, going beyond the capabilities of traditional input/output systems.

The automatic recognition of speech at a large scale is the first and most compelling example of the success of deep learning. Multi-second time intervals with thousands of discrete time steps between speech occurrences (where one time step is roughly 10 ms) are no problem for LSTM RNNs while learning "Very Deep Learning" tasks. On some tests, LSTM equipped with forget gates outperforms conventional voice recognizers.

Techopedia Explains Deep Neural Network

In general, a neural network is a technological construct designed to mimic the functioning of the human brain, including its capacity for pattern recognition and its ability to process information by passing it via successive layers of artificial neural connections. An input layer, an output layer, and a hidden layer are the defining components of a deep neural network, according to several professionals. Some people call the process of sorting and organising data performed by each layer a "feature hierarchy." Dealing with unlabeled or otherwise unstructured data is a primary application area for today's state-of-the-art neural networks. The term "deep learning" is also used to refer to various types of neural networks. The term "deep learning" refers to a subfield of machine learning in which complex algorithms are used to sort and categorise data, going beyond the capabilities of traditional input/output systems.

For pattern recognition, scientists have developed a set of algorithms called neural networks that are loosely based on the structure of the human brain. The machines use perception, labelling, and raw clustering input to make sense of the sensory data. All data from the physical world, including as sights, sounds, texts, and time series, must be converted into the numerical, vector-based patterns they recognise. Clustering and categorising are made easier with the use of neural networks. Consider them an additional level of analysis and organisation for the information you're responsible for maintaining. They aid in the categorization of unlabeled data by finding patterns of similarity between inputs, and they classify data when given a labelled dataset to learn from.

The key concept of deep neural network

The number of hidden node layers in a deep-learning network is what sets it apart from single-hidden-layer neural networks, which are more commonly used for pattern recognition. The standard approach to machine learning uses shallow nets with only one hidden layer and one input and one output layer. An algorithm with more than three layers (including input and output) is considered "deep" learning. A technical definition of "so deep" specifies that there must be multiple concealed levels. Each layer of nodes in a deep-learning network learns a new set of features from the output of the layer below it. Since each successive layer of a neural net aggregates and recombines the features of its predecessor, the nodes at a given level can recognise increasingly sophisticated features as the network progresses (fig.2).

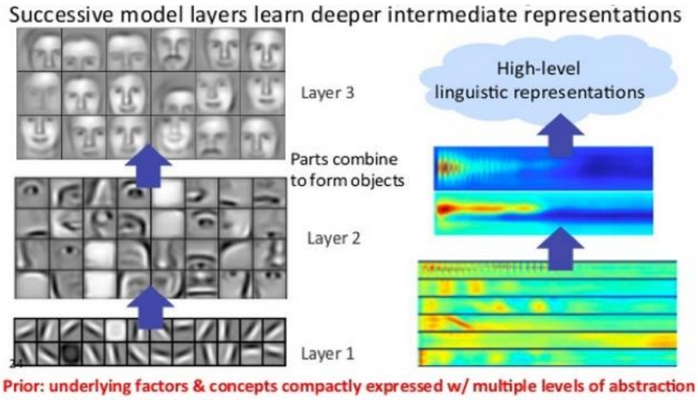

Figure 2: Successive model layers learn deeper intermediate representations
(Retrieved September 8, 2022, from Softwaretestinghelp.com website: https://www.softwaretestinghelp.com/what-is-artificial-intelligence/)

The term "feature hierarchy" describes this structure of progressively more abstract and complicated features. When applied to deep-learning networks, this allows them to process high-dimensional data sets with billions of parameters that involve non-linear operations. Most importantly, these nets can find hidden patterns in the vast bulk of the world's data, which is neither labelled or categorised in any way. Images, texts, videos, and audio recordings are all examples of "raw media," another term for unstructured data. Since no human has ever structured the world's raw, unlabeled media into a relational database or given each piece of data a name, one of the challenges deep learning solves well is analysing and clustering this data.

For instance, a million images can be sorted into categories using deep learning: cats in one, ice breakers in another, and a third of all the pictures of your grandmother in a third. That's the idea behind "smart photo albums," basically. Now extrapolate that to other forms of information: Raw text, like emails or news articles, could be categorised with the help of deep learning. Messages from satisfied customers or spambots may cluster in one area of the vector space, while those from disgruntled consumers may cluster in another. Used in CRM systems, this provides the foundation for a wide range of message filters (CRM). Even with voicemails, the same rule applies. Data from time series may show trends of either typical or unhealthy behaviour, or abnormal or harmful conduct. Time series data generated by a smartphone can shed light on its user's health and behaviour; data generated by an automobile part could be utilised to prevent costly breakdowns. Automatic feature extraction is carried out by deep-learning networks without the need for any human interaction, setting them apart from more conventional machine-learning techniques. Given that feature, extraction can take teams of data scientists years to complete; nevertheless, deep learning can help get over the shortage of specialists. It strengthens the capabilities of small data science teams, who cannot grow as rapidly as larger organisations.

When a deep network is trained on unlabeled data, it automatically learns features at each node layer by making guesses about the input and attempts to minimise the difference between its predictions and the probability distribution of the data. That's the way that restricted Boltzmann machines (RBMs) generate their "reconstructions," for instance. This technique trains neural networks to identify relationships between particular features and desirable outcomes, making links between feature signals and the concepts they represent in full reconstructions or using labelled data.

After being taught on labelled data, a deep-learning network can be applied to unstructured data, providing it more information to work with than machine-learning networks. When compared to older algorithms, deep learning stands out due to its capacity to process and learn from large amounts of unlabeled data. The final stage of a deep learning network is the output layer, typically a logistic or softmax classifier that provides a probability for a given result or label. We use the term predictive, yet it only applies in a general sense. A deep-learning network trained on a picture might conclude, for instance, that the data has a 90% chance of representing a human being.

Deep Neural Network as Gaussian Process

For infinite network width, a deep fully-connected neural network with an I'd prior over its parameters is comparable to a Gaussian process (GP). This mapping makes it possible for neural networks to perform precise Bayesian inference on regression tasks by simply calculating matrices. The covariance function of this GP is well known for single hidden-layer networks. For multi-layer random neural networks, kernel functions have been created recently, but not within a Bayesian one. This means that prior work has not shown a connection between utilising these kernels as the covariance function for a GP and making comprehensive Bayesian predictions using a deep neural network. This study involves deriving this correspondence and creating a computationally efficient pipeline for calculating the covariance functions. We apply the resulting GP to deep neural networks on the MNIST (Modified National Institute of Standards and Technology Database) and CIFAR-10 datasets, and we derive statistical conclusions using Bayesian inference. Predictions made using GP are competitive and can even beat those made by neural networks trained using stochastic gradient descent. We see that the GP uncertainty is significantly connected with prediction error and that, as the layer width of a trained neural network grows, its accuracy approaches that of the corresponding GP-based calculation. We make a connection between our findings and the emerging field of signal propagation in unsupervised neural networks. Using this mapping, precise Bayesian inference can be performed by neural networks for regression problems with only a few matrix multiplications.

Pooling

To a lesser extent than the Convolutional Layer, the Pooling layer also shrinks the size of the Convolved Feature in space. Through dimensionality reduction, this lessens the amount of computing resources needed to process the data. Additionally, it helps in effectively training the model by extracting dominating characteristics that are rotational and position invariant. Max pooling and average pooling are the two main varieties of this method. The maximum value from the region of the picture covered by the Kernel is returned by Max Pooling. However, using Average pooling, you get an average of all the values in the region of the image that the Kernel was able to process. Maximum pooling efficiency is also achieved by reducing background noise. By doing so, it eliminates the noisy activations and reduces the dimensionality of the data. By contrast, Average pooling relies solely on dimensionality reduction to dampen unwanted noise. We can therefore conclude that Max Pooling is superior to Average pooling in terms of performance (fig.3).

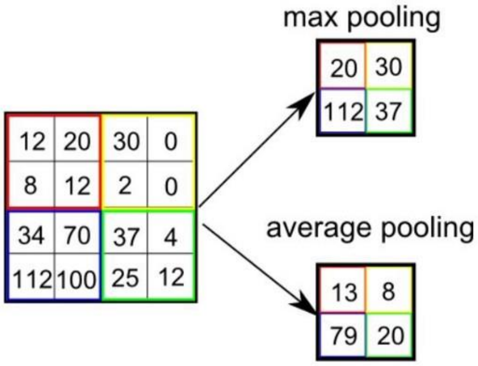

Figure 3: Trying to confirm average pooling is equal to dropping high frequency Fourier coefficients using numpy. (Retrieved December 8, 2022, from Stack Overflow website: https://stackoverflow.com/questions/44287965/trying-to-confirm-average-pooling-is-equal-to-dropping-high-frequency-fourier-co)

Layer I of a Convolutional Neural Network consists of the Convolutional Layer and the Pooling Layer. Increasing the number of these layers to capture low-level information can be done depending on the complexity of the images, but this comes at the expense of greater computer power.

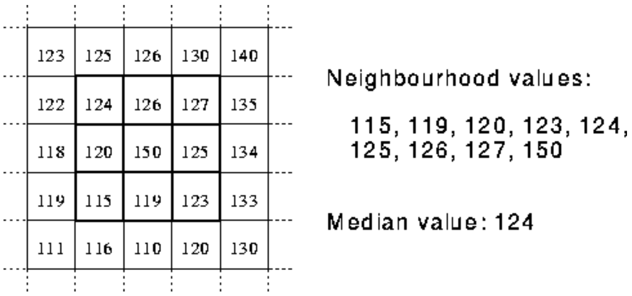

Figure 4: Calculation of pixel values (Retrieved January 11, 2023, from Ed.ac.uk website: https://homepages.inf.ed.ac.uk/rbf/HIPR2/median.htm)

Image 6.2: The method for determining the neighbourhood median value. You can see that the median value of 124 is used to replace the centre pixel's original value of 150, which is not very typical of its neighbours. In this case, we employ a neighbourhood of size 33; using a neighbourhood of a greater size would result in more pronounced smoothing.

In the field of image processing, histogram equalisation is used to modify the contrast of an image by looking at its histogram. A more even distribution of intensities on the histogram is achieved by making this modification. Because of this, places with low local contrast can improve. This is achieved using histogram equalisation, which effectively disperses the most common intensity values. The more general histogram remapping techniques include histogram equalisation as a special example. If the same technique is applied independently to the RGB colour values of the image, it can be utilised on colour images as well. In three-dimensional space, various histogram equalisation strategies exist. Histogram equalisation in 3D colour space was used by Trahanias and Venetsanopoulos. To put it another way, it caused a "whitening." Histogram depicted in Fig. 4 illustrates why there is a greater likelihood of light-colored pixels than dark-colored ones. As a solution, Han et al. developed a new CDF defined by the Iso-luminance plane, which produces a continuous grayscale (fig.5).

Figure 5: After Histogram Equalization (https://en.wikipedia.org/wiki/Histogram_equalization)

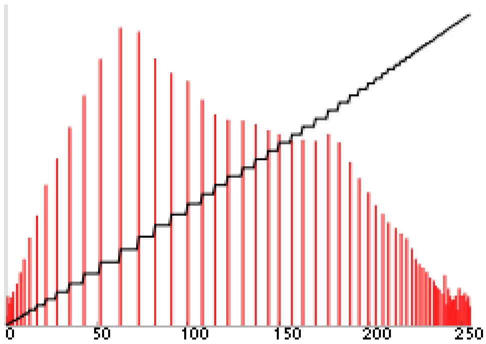

Figure 6: Corresponding histogram (red) and cumulative histogram (black) (https://en.wikipedia.org/wiki/Histogram_equalization)

Anisotropic diffusion, also known as Perona-Malik diffusion, is a technique used in image processing and computer vision to reduce noise in a picture without sacrificing interpretable image features like edges, lines, and other finer details (fig.6). In anisotropic diffusion, one image develops a parameterized family of increasingly blurred images through a diffusion process, analogous to the process that builds a scale space. Each of the output images in this family is represented by the convolution of the input image with an ever wider 2D isotropic Gaussian filter. The image is transformed in a linear and space-invariant manner by this diffusion process. Similar to this diffusion process, anisotropic diffusion generates a set of parameterized images, each of which is a product of combining the original image with a filter that is itself dependent on the local content of the original image. As a result, anisotropic diffusion is a change of the original image that is both non-linear and space-variant. In order to distinguish between different objects in an image and to give matching levels to groups with homogenous properties, classification of remotely sensed data is used. Spectral or spectrally defined features like density, texture, etc. will be used in the classification process.

Conclusion

Synthetic "neurons" in a neural network relay information to one another. During training, the network's numerical weights are adjusted, allowing it to produce accurate results when given with an image or pattern for recognition. Layers upon layers of "neurons" dedicated to identifying specific types of data make up the network. There are many neurons in each layer, and they all react differently to the inputs they receive from the layers below them. Normal CNNs have anywhere from five to twenty-five layers of pattern recognition. Relu, Tanh, and Sigmoid activation functions were combined to improve the model's accuracy to 80.2%. In contrast, when utilising both the Relu and Tanh activation functions, the model achieved just around 50% accuracy. Combining these activation functions yielded the best results. When the functions were combined, the model outperformed its use of either function alone in determining whether or not an image depicted skin cancer or a rash.

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