Artificial Neural Networks are a set of algorithms that are used to classify, cluster, and many other things. There are many types of artificial neural networks, such as Adversarial Networks that generate new information by learning the style and methodology from previously existing data, regular neural networks that function to classify, cluster, and more. Finally, there are convolutional neural networks which transforms images into readable data by a computer. Convolutional Neural Networks are the response to using image data for predictions (such as the weather), classification (such as whether a tumor is malignant or benign), and more.

A Convolutional Neural Network is an algorithm that takes in an image and outputs the class or a value. The Convolutional Neural Network (or CNN) is comprised of three main layer-types. The first layer-type, which includes the input layer, is the convolutional layer. The convolutional layer takes in an image, transforms it into a matrix that is m pixels tall and n pixels wide with input values from 0 to 255. The values 0 to 255 represent intensity, if the image is colored, then the convolutional layer receives 3 matrices each representing one of the three basic colors per pixel (or RGB values). Once the image has been transformed into its raw matrix representation(s), a kernel is then used to convolve the original image matrix and outputs a matrix that emphasizes the desired features. The kernel is defined as a filter or function that transforms the image, by increasing the contrast within the image, rotating the image, or even changing the brightness of certain features within the image. As the kernel and the original matrix of the image are not the same size, the kernel will shift x number of times depending on the stride length (number of columns over the kernel moves) until the kernel parses the entire width of the matrix, Then the kernel proceeds to move the same stride length for the rows and starts the same procedure for the columns. If there are multiple matrices each representing one of the three values (RGB), then the result of the kernels’ parsing is summarized before placed into the output matrix. This output matrix contains the high-level features, such as image edges, intensity, colors, gradient orientation and many more features from the image. The resulting matrix is either of the same dimensions as the original matrix or higher dimensions (this technique is called same padding). The resulting matrix can also be of a lower dimension than the original matrix this technique is called valid padding. The same padding technique is done by first padding the original matrix (or matrices), parse the padded matrix with a kernel, and the output results in a matrix whose dimensions is equivalent to the original matrix. The Valid Padding technique also performs the same operation without any padding and allows the output matrix dimension to decrease. Now that the output matrix with the features emphasized within has been created, the matrix passes through the second main layer, called the Pooling layer.

The pooling layer is responsible for reducing the dimensions of the output matrix from the convolution layer. The main purpose of this layer is to increase the efficiency of the calculation phase via dimensionality reduction (A series of techniques to reduce the number of random variables). The two main pooling techniques are average pooling and max pooling, a third technique that may be of interest is the global pooling technique. The average pooling technique smoothes images by averaging numbers on specified regions (example: averaging values that fit into unique 2x2 matrices within a 4x4 matrix). This functions to remove features, such as the sharpness of objects within an image that may be emphasized because the resolution of the image itself is bad. The other main technique, max pooling, follows a similar procedure to the average pooling technique, except that rather than averaging the values it chooses the highest value instead. This technique is best for when one is observing an image with a dark background or for when looking to remove any possible noise within the image. Although there is no best-case scenario for either pooling technique, it can be stated that Max pooling is best when trying to minimize the computation time and complexity of the output, whereas the average pooling technique is best for when one wishes to maximize the data gathered. Once the data has been pooled and the matrix reduced further, the data is then flattened through a flattening layer (that transforms the data from a matrix to a single vector). This vector leads to the Neural network that classifies, clusters, provides the desired output.

From this point on, the Convolutional Neural Network (CNN) functions as a regular Neural Network. The biggest difference between an Artificial Neural Network and a CNN is the convolutional and pooling layers that exist before the data reached the neural network layers. This portion of the CNN is called the Fully Connected Layer and its is comprised to an input layer, a set of hidden layers, and an output layer. The input layer can be the Flatten layer that was mentioned before, its purpose is to transform an mxn matrix into a 1xb matrix. The hidden layers have the same purpose as the hidden layers within ANNs, to further transform the data until it can be used to finally classify in the output layer. The greatest advantage of a CNN is its ability to classify images. In the medical field, the visual identification of tumors that are deemed malignant, or benign can be very difficult, but with a CNN one should be able to develop an algorithm that assists one with this issue. Another way in which a CNN can be utilized is to classify DNA sequences for cancer type prediction.

Cancer is the second leading cause of death worldwide, making early diagnosis and treatment a priority throughout the world. Although there are Doctors’ that are knowledgeable enough to diagnose cancer based on images among other data, the variation on how a cancerous tumor develops makes it difficult for even experienced professionals to determine whether the tumor is benign or malignant. Artificial Neural Networks are unfortunately very limited when it comes to assisting in determining whether a cancer is malignant or benign as the dimensions of the tumor due to the task being very computationally intensive. Convolutional Neural Networks function to resolve these issues by reducing the dimensionality of the features within the data set into data that can be computed and effectively create a model that can be utilized at a hospital. There are many CNN Architectures that can be used to develop machine learning models to predict whether someone is likely to develop cancer, and/or if a tumor is malignant vs benign. Some of these architectures are called LeNet, AlexNet, ZFNet, GoogLeNet, VGG Net, and ResNet. The CNN Architecture that one will be focusing upon is the ResNet.

The ResNet, or the Residual Neural Network Architecture, is an algorithm created for a challenge set by the Image-Net community to encourage the creation of new algorithms. This algorithm functions by using gated units/gated recurrent units that are skippable layers in the case where the classification of the image or DNA sequence does not require to pass through certain layers, it skips them. This results in an increase in performance and a decrease in computation time while maintaining the accuracy required to properly classify DNA Sequences or tumor images as either possible risk of cancer or no risk/benign vs malignant. This neural network can possess an error rate of 3.6%, which in the medical field is an incredibly accurate metric that provides not only trust within the algorithm itself, but also meets or falls close to the criteria required to evaluate a computer’s evaluation of a patient as legitimate. The biggest challenge may be in collecting the data and training the machine learning model based on the said data. Medical data regarding cancer is very limited due to data silos, requiring data processing and data collection that would validate and assure the anonymity of the patients. Connecting multiple data silos allows one to obtain the data, and proper digitization provides a myriad of factors, such as medical images, past tumor data, and/or diet that can be used to develop the machine learning model for predicting cancer or classifying tumors based on whether the tumor is benign or malignant. The second Challenge associated with the neural network may be the computational power required to create the model. Based on the original challenge, the model itself contained approximately 152 total layers, of which there were many which were skippable. Finetuning the data and retraining the model may take an extensive amount of time, yet this still would not be a large enough factor to consider not developing the model as the accuracy of the ResNet Architecture is a viable alternative to misdiagnosis from a doctor (which an article from 2013 previously estimated it to be around 28%).

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