Chapter

Ensemble Machine Learning Algorithms for Prediction and Classification of Medical Images

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Abstract

The employment of machine learning algorithms in disease classification has evolved as a precision medicine for scientific innovation. The geometric growth in various machine learning systems has paved the way for more research in the medical imaging process. This research aims to promote the development of machine learning algorithms for the classification of medical images. Automated classification of medical images is a fascinating application of machine learning and they have the possibility of higher predictability and accuracy. The technological advancement in the processing of medical imaging will help to reduce the complexities of diseases and some existing constraints will be greatly minimized. This research exposes the main ensemble learning techniques as it covers the theoretical background of machine learning, applications, comparison of machine learning and deep learning, ensemble learning with reviews of state-of the art literature, framework, and analysis. The work extends to medical image types, applications, benefits, and operations. We proposed the application of the ensemble machine learning approach in the classification of medical images for better performance and accuracy. The integration of advanced technology in clinical imaging will help in the prompt classification, prediction, early detection, and a better interpretation of medical images, this will, in turn, improves the quality of life and expands the clinical bearing for machine learning applications.

Keywords: machine learning, medical image, classification, ensemble method

1. Introduction

The application of technology to the health field is growing at a rapid pace and medical imaging techniques is part of the advancement of technology in the simplification of the medical imaging processes. It refers to an aspect of medical operations in this dispensation as it has overridden the traditional processes. Technological advancement is majorly responsible for the improvement in medicine via enhancement of imaging. The traditional perspectives on the clarification and diagnosis of the outcome of image processes require lot of processing time, human errors are foreseeable and the general outcome is unable to properly aligned with the history as the former ones is not easily available for comparison. These limitations motivated this research work so as to give insight to the applications of Ensemble Machine-Learning Algorithms for the Prediction and Classification of Medical Images.

1.1 Medical imaging

Medical Imaging refers to the application of different techniques to get various image modalities from the human body especially the affected area for further processing and to assist in diagnosis and the treatment of the patients [1]. Medical Image analysis is very important in today's world to be able to meet up with the growing population and in the current trend of a low medical expert in an expanding population. The healthcare industry has witnessed different technological disruptions that benefit humankind and more progress are being made. Having precision in the medical analysis of images will enhance the faster diagnosis and the treatment plan will be predicted along the line, this process increases the turnaround time with lots of lives being saved. It was reported that the market capacity of medical image analysis of software was estimated at USD 2.41 Billion in 2019, globally. In addition, the medical image processing market is forecast to reach about 8.1% in 2027 [2].

In medical imaging, radiology is a branch of medicine that uses imaging technology to diagnose and treat disease. The different types of diagnostic radiology examination comprise, Ultrasound, Plain X-Rays, Mammography, Fluoroscopy, Computed tomography (CT), including CT angiography, Magnetic Resonance Imaging (MRI), and Magnetic Resonance Angiography (MRA), Nuclear medicine, and Positron Emission Tomography [3]. Furthermore, the recent advancements in image processing as of the year 2020 are, EVP (Enhanced Visualization Processing) Plus, Bone Suppression, Pediatric Capabilities, Tube and Line Visualization, Long-length Imaging, and Pneumothorax Visualization. The operation of computer-mediated imaging processing is done using some computational framework, programming language, and algorithms which will make the prediction and classification to be an automated process and produce the result analysis [4].

The techniques involve professional in the medical field to use a particular device to create computerized images of an affected area in the body for diagnosis that will lead to treatment. The process may not necessarily include the opening of the affected part before using the radiological equipment in viewing the area that needed diagnosis. The medical personnel will later produce the image of the affected part from the device and then summarized the image analysis. Moreover, some medical imaging involves not just bones, blood vessels, and tissue without tearing apart the affected skin. Generally, the imaging techniques allow the healthcare providers to determine the type of treatment that is required for the ailment. Medical imaging has brought a major improvement in medicine as the difficult part or layers of the internal system of humans and animals can now be done using technological devices. The major technological improvement has decreased the manual work of the health providers and thereby give rise to specific and better treatment.

1.1.1 Medical image applications

The utilization of medical image in ultrasound, presents the internal part of a human or even animals; to be examined under an ultrasound device applicable joints, muscles, breast, blood vessels, pelvic, bones, and kidneys to say the least [5]. The X-ray is another category that employ the electromagnetic radiation and penetrates through the outer skin, layer to disclose the internal components [6]. Computer

Tomography is a medical image that has an opening area in a circular form, the patient will be placed on it and slide inside; it produces images in a cross-sectional way [7].

Magnetic Resonance Imaging harness radio waves with magnetic fields to develop images with no harmful radiation compared to x-rays. It can generate images from soft tissue, bones, organs, cartilage, brains breast, spinal cord, liver, prostate, and ligaments, etc. [8]. Positron emission tomography (PET) scan can be used to scan the whole body or part of it. It uses a type of tool called tracer which will be swallowed or injected by the patient and then lie on the PET scanner to be examined by detecting the gamma rays by the device which is converted to images. PET scans can be applied in the diagnosis of conditions like brain disorders, tumors, and heart-related diseases, etc. [9]. The application of Ensemble Machine Learning technologies will improve the processing of medical images as it allows management, monitoring, early detection, diagnosis, assessment, and treatment of various medical challenges.

1.1.2 Challenges in medical image classifications

The application of Machine Learning vis-à-vis image generations promised a better way to visualize images and generally improves the medical condition of humans. This has brought out candid information from the input sample and it has encouraged a better decision to the treatment pattern of the concerned patient with the overall benefit of good living. These techniques are mostly used in the radiology field and pathology. The traditional model of result interpretation presents the problems of data bottlenecks, reliability, accuracy, and speed, and most of the issues with the traditional methods are being addressed with the machine learning algorithms and techniques. The more the technology is advancing, the more there is a need to have better analysis and clarity in medical imaging prediction and classification. The challenges that are associated with Machine Learning applications are; data availability, validation of methods, patient-specific model faster and accurate algorithms [10]. The learning models should be built into clinical operations and be intuitive so as not to cause serious damages. Training of the care providers and the documentations of analysis of the algorithms is another challenge that is needed to be looked into for future adaptation of research students and the users [11].

1.1.3 The benefits of medical image processing

The main advantage of medical image processing is the opportunity to explore the internal system of the human organ called anatomy, it is such an interesting thing to be able to view the inner system and see how things work. The rate of death is drastically reduced as more outcomes of the image processes allows timely intervention and prompt treatment of the ailment. Another benefit is the deep knowledge of the internal anatomy which helps to enhance treatment and diagnosis outcomes.

1.1.4 Medical image professional

The professionals that are involved in the operation of medical imaging is the clinicians, radiologist, and engineers' radiographers, radiologists, and engineers to know the anatomy patients. The medical imaging device is used to do imaging is operated by the radiographers and the result is sent to the caregiver to interpret it to the patient. One of the significant of Machine Learning in the aspect imaging is the enhancement, interpretation and analysis of results better than the manual result from human.

1.2 Machine learning

The advancement in computational applications and frameworks provides solutions to our everyday problems. Machine learning is one of the computational applications of algorithms and statistical models with the use of algorithms and statistical models, to carry out a task without explicit instructions but with the use of patterns to give inference. Machine learning is referred to the use of computer algorithms that support systems operation in training to automatically learn and enhance data to predict or classify the nature of such data through the use of patterns [12]. Generally, machine learning is a subfield of artificial intelligence that allows the systems to make decisions autonomously with no external support. The decision is made by finding valuable hidden layers of patterns within the complex data.

The machine-learning approach depends on the data type for input and output operation and problem type which is based on the applications on data for decision making and an embedded instruction to carry out the assignment with minimum supervision from the programmers [12]. Machine learning is classified as supervised learning, semi-supervised learning, and unsupervised and reinforcement learning while there are few hybrid approaches and other common methods [13].

1.2.1 Machine learning techniques

The categories of Machine Learning Techniques are mainly divided into four categories: Supervised learning, Unsupervised learning, Semi-supervised learning, and Reinforcement learning [12]. The techniques are discussed further according to their applicability of solving real-world problems.

1.2.1.1 Supervised learning

In the supervised learning category of machine learning, the algorithms (step by step method of solving a problem in a particular format) operates in such a way that it will develop a mathematical model (translating or encoding a problem into a mathematical formulations) of the data which comprises the inputs (data sent to a computer system) and the expected outputs (processed information sent out from a computer) [14]. The data supplied is also categorized as the training data which comprises the sets of training examples with one or more inputs. The mathematical modeling is applied in the supervised learning uses array vector (feature vector for extraction) and the data to be trained by matrix. The algorithm that enhances and improves the outcomes in the accuracy of the outputs for classification or prediction purposes has learned the task and therefore it can give a good outcome [15].

1.2.1.2 Unsupervised learning

Unsupervised learning algorithms operate in such a way that it takes set of data and detect the patterns in it for grouping or clustering purpose. Unsupervised learning algorithms identify resemblance in the data and react based on the presence or absence of such identity in each new piece of data. The algorithms learn from test data that is not labeled, classified, or categorized. Unsupervised learning analyzes unlabeled datasets without the need for human interference, i.e., a data-driven process [16]. The unsupervised learning tasks that are common are anomaly detection, dimension reduction, clustering, density estimation, feature learning, finding association rules, etc. [17].

1.2.1.3 Semi-supervised learning

The semi-supervised learning is situated between unsupervised learning (with no labeled training data) and supervised learning (with labeled training data). It is a hybrid form of machine learning techniques because it operates on labeled and unlabeled data which brings a better accuracy. The major aim of unsupervised learning is to give great outcomes for prediction than the ones done with labeled data. The application areas of semi-supervised learning are text classification, fraud detection, machine translation, etc. [18].

1.2.1.4 Reinforcement learning

Reinforcement learning in machine learning parlance refers is concerned with the use of software agents and machines to make the decision automatically in an environment to improve efficiency. Generally, reinforcement learning is used in operation research, game theory, information theory, swarm-intelligence, and genetics algorithms, etc. The learning uses the reward or penalty system, and the primary goal is to use leading obtained from environmental parameters to validate the reward or to minimize the risk involved. The algorithms are used in autonomous vehicles or in learning to play a game against a human opponent, it is an effective tool in training AI models for increase automation which is used in robotics, autonomous driving tasks, manufacturing, and supply chain logistics [12].

1.2.2 Applications of machine learning

The areas of applications of machine learning to various fields are enormous such as agriculture, engineering, medical diagnosis, natural language processing, banking, bioinformatics, games, insurance speech recognition, and recommended system etc. [19], used machine learning technology to make a medical diagnosis in developing a cure for Covid-19. Similarly, machine learning is also applied in [20] work to predict visitors' behavior in marine protected areas, while [21] applied machine learning to smartphone performance optimization. According to [22] by Mayo, the most common data science/machine learning methods used from the period of 2018–2019 are regression, decision trees/rules, clustering, visualization, random forests, statistics, K-nearest neighbors, time series, ensemble methods, text mining, principal component analysis (PCA), boosting, neural networks (deep learning), gradient boosted machines, anomaly/deviation detection, neural networks Convolutional Neural Networks (CNN) and support vector machine (SVM).

1.2.3 Machine learning and deep learning

Deep learning refers to a distinctive subtype variant in the machine learning, also a subclass in the domain of artificial intelligence (AI). Furthermore, Machine learning primarily means a computer that learns from data and makes predictions using algorithms. Machine learning yields to some environmental parameters, conversely, the deep learning operates in a quick manner and adapt to it using constant feedback in building on the models. Deep Learning system leverage on the Neural Networks which imitates the brain of human with an embedded multiple-layer architecture. It also learns through the data to carry intelligent decisions [23].

1.2.4 Ensemble machine learning

Ensemble learning is a general meta-approach to machine learning as it looks for the best predictive performance using a combination of the methods to achieve the best accuracy [24]. The use of different machine learning algorithms individually may not be able to give the best outcomes, hence the combination of the algorithms will combine all the strength of the model and brings out a better accuracy. The diagram below shows different Machine learning algorithms. The Ensemble learning methodology for the prediction and classification of medical images has been established to have a better result than using a single classifier. The reviews on elated works in artificial intelligence systems to detect fractures in the body cited few works on Convolutional Neural Networks (CNN) for fracture detection [25].

The authors also noted that stacking with Random Forest and Support Vector algorithm, with neural networks were mostly engaged. The development of an Ensemble deep learning application for ear disease using otoendoscopy images by [26]. They perform well with the average of accuracy taken as 93.67% for the five-fold cross-validation using learning models based on ResNet101 and Inception-V3. Furthermore, another author developed a three-dimensional bone model system which is based on employment of x-ray images for distal forearm engaging the convolutional neural networks [27]. The deep learning framework is employed in estimating and to construct a high accuracy for three-dimensional model of bones. The result gives correctness of the evaluation of CNN to reduce exposure to computer tomograph device and cost. In summary, the application of Ensemble methods to medical imaging can be perused with all intent as the accuracy recorded is far more than the single classifiers or the traditional methods.

There are three classes of ensemble learning, bagging, stacking and boosting. The bagging is concerned with having many decisions on a different sample of the very same dataset and get the average of the prediction; while the stacking is concerned with the fitting of many different types of models on the same data while using another type of model to learn the combined predictions. The boosting involves the addition of ensemble members in a sequential manner that will correct the former prediction by the other models then gives the average of the predictions (**Figure 1**) [24].

1.3 Neural networks

The Neural Networks is an aspect of machine-learning that comprises different node layers which include the input, hidden, and output layers. The Network is used in most deep learning architectures. Neural Networks works in a manner that the nodes connect with their different weight and threshold. More so, if a node for instance has an output that is more than that of the threshold, then it will be triggered and will send the data involved to the layer that is next and if not, there will be no data being activated to the succeeding layer in the network.

1.3.1 Convolutional neural network

The traditional manual process employed in the prediction and classification of images convincingly, wastes time, wrong diagnosis is another major problem

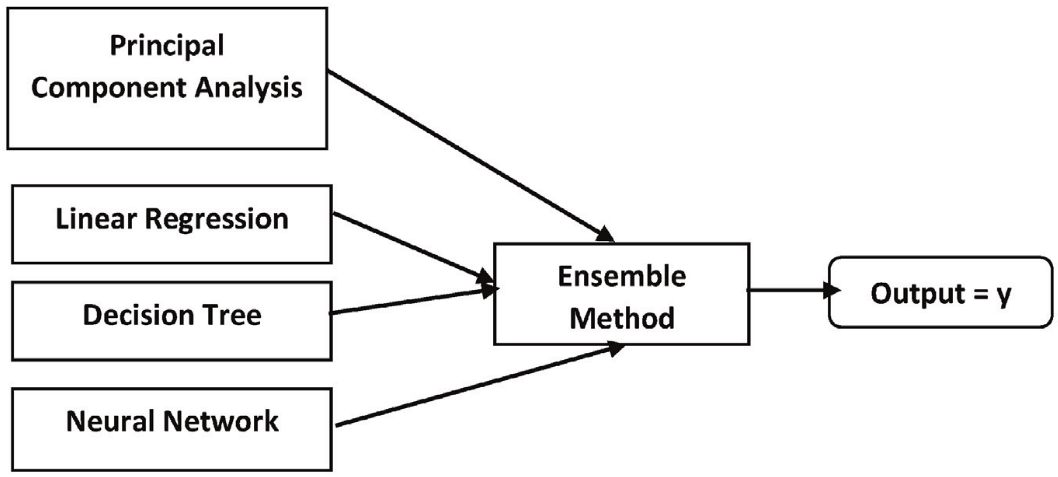

Figure 1.
Ensemble machine learning combine several models for better accuracy.

attributed to it. The convolutional neural network provides a better and more scalable method in the medical imaging process. The CNN involves the identification of images through a computational approach that combines linear algebra and matrix multiplications. CNN outperformed other networks in applications like image processing and speech recognition, The CNN has three parts, the convolutional, pooling, and fully-connected layer. The convolutional part is where the major computation happens to be the building block among the three and it comprises the data, filter, and feature area. Pooling layer is responsible for the data sample dimension reduction known as downsampling. The pooling layers also holds a filter and it moves over the input but may not have weight. The pooling is sub-divided into Max and Average pooling with the functions of calculating the maximum and or average value respectively [28]. The fully-connected layer, output layers are fully joined via a node to former layer and do classification tasks through the feature extracted from the preceding layer.

2. Literature review

Visual Attention Mechanism-MCNN was developed using classification Algorithm According to the authors, the motivation was a result of the complexity of medical images as a traditional way of analyzing medical images is presented with some disadvantages and it may not be able to meet up with the growing demands. The methodology is based on a medical classification algorithm that uses visual attention mechanism multiscale convolutional neural network. The results show that the medical image classification was more accurate with stability, robustness and improved with the employment of the deep learning methods than the traditional methods [29].

In the article titled "Machine Learning: Algorithms, Real-World Applications and Research Directions", they stated the positive impact and the present challenges of Machine Learning algorithms to the real-world application and research direction. The authors explained further that is an enormous advantage to the intelligent and automatic operations of machine learning to a different field of study [13].

The primary goal of machine learning is in the automation of human assistance by training an algorithm on suitable data Machine Learning as they focused on learning types. The author stated different machine learning techniques and the ways to apply them to various operations. The algorithms are used for many applications that include data classification, prediction, or pattern recognition [30].

Medical image analysis based on a deep learning approach which helps in different clinical applications as it occurs in medical procedures for monitoring, diagnosis, and detection was proposed for early detection, monitoring, diagnosis, and treatment evaluation of various medical conditions. The methodology employed artificial neural networks and the detailed analysis of deep learning algorithms and delivers great medical imaging applications [31].

The applications of Machine Learning Predictive Models in the Chronic Disease Diagnosis, presented different reviews on the employment of machine learning predictive models for the diagnosis of chronic diseases. The motivation of the authors arises from the major health cost of disease especially for those that attract lifelong treatment. The methodology of the predictive models involves the analysis of 453 papers from 2015 and 2019, PubMed (Medline), and Cumulative Index to Nursing and Allied Health Literature (CINAHL) libraries. The result of the investigation shows that the support vector machines (SVM), logistic regression (LR), clustering was among the most commonly used models [32].

An ensemble approach in the classification of bone fracture using different CNN is presented. The authors were motivated by the need to help the emergency nature of bone fracture for a prompt response than the usual process of going through the X-ray and then forwarded to the doctors for better interpretations of the result. The process can take a long time as nothing significant can be until the result is out. To increase the processes that are involved in carrying out this important aspect of a medical emergency, a new method is proposed by the author. The research employs ensemble machine learning techniques using CNN to classify the bone fracture images with stacking methodology for reliable and robust classification. The result shows that the ensemble method is more reliable and forms a robust output than the manual works from the providers [33].

The classification of shoulder images using X-ray images with deep learning ensemble models for diagnosis, with the data gathered from the X-ray images from magnetic resonance imaging and computer tomography. The target of the research is to determine the state of the images through classification using artificial intelligence. The study employs twenty-six deep learning models to detect the shoulder fracture and evaluate using the musculoskeletal radiographs datasets, together with ensemble learning models. The twenty-eight classification was performed and the overall accuracy was from Cohen's kappa. The best score was 0.6942, taking an ensemble of ResNet34, DenseNet169, DenseNet201, and a sub-ensemble of different convolution networks [34].

In 2019 some authors constructed Xception, Resnet, and Inception-V3 CNNs to determine appearance of fractures on the ankle through ensemble methods. The approach involved using five hundred and ninety-six ankle cases both the normal and abnormal for the processing. The programming language applied is Python with the TensorFlow framework. The outputs were in radiographic views of one and three. The ensembles were made from combined convolutional networks, and the voting approach was applied to incorporate results from the views and ensemble models. The results show 81% accuracy despite the small dataset used [35].

Furthermore, in 2021 an investigation was done for the detection of tuberculosis in x-ray images of the chest via Ensemble Learning method together with hybrid feature descriptors as Tuberculosis (TB) is a major health challenge that has a record of high mortality and early diagnosis is key to early control of the disease. The author proposed an innovative approach to TB detection that combines hand-crafted features with deep features using convolutional neural networks through Ensemble Learning. The dataset captured from Montgomery and Shenzhen for the critical evaluation of the system. The result shows the distinction of the Ensemble machine Learning method over the other classifier as a single unit in classifications as the operating characteristics curve reaches 0.99 and 0.97 respectively from the Shenzhen and Montgomery [36].

In the Ensembles Learning for COVID-19 Detection using Chest X-Rays. The development applied Ensemble approach for the X-ray classification in detecting pulmonary manifestation of COVID-19 is established. The methodology entails a customized convolutional neural network and ImageNet pre-trained models while the dataset is from publicly available collections. The best predictions from the best accurate models are combined via different Ensemble approaches for better performance evaluation. The result shows a major improvement of 99.01% accuracy and the area under the curve to be 0.9972 for the detection of COVID-19 on the dataset collections. The blend of the iterative, Ensemble, and modality bases knowledge transfer shows a major improvement in the prediction level [37].

3. Ensemble methods and design analysis

The ensemble system of machine learning application is a type of method that allows the combination of multiple models to produce an output that is improved and enhanced than applying the single model. The ensemble predictive model generated is to have a decrease in variance (bagging), bias (boosting), or to improve the predictions (stacking). The ensemble machine learning methods consist of sequential, parallel, homogenous and heterogenous ensemble, while the technical classifications of ensemble method are, bagging, boosting, stacking, and random forest [38].

3.1 Ensemble methods

In the continuous method, the base learners (where the data dependency stays) are being initiated successively. Moreover, there is a dependency on the former data of all other data in the base level and to get the performance analysis of the system, the wrongfully-labeled are adjusted based on the weight. An example of this type of analysis is the boosting method. The parallel methodology ensures that the base learner is initiated in a parallel manner and the data dependency is not available, and all the data are generated separately. A very good example of this model is the stacking method [38].

The homogenous ensemble method can be applied to a large number of the dataset as it employed the combination of the very same types of classifiers. The dataset is always different for each classifier and the model works well following the results collection for each of the classifier models. The feature selection method is the same for different training of data. The major disadvantage of this type of model is that the computational cost is very expensive. The popular type of this model is the bagging and boosting method. Conversely, the heterogeneous ensemble method combines different classifiers and each of them is generated on the same data, these types of methods are used for small datasets and the feature selection method is different for the same training dataset. An example of this type of classifier is stacking [38].

3.2 Technical classification of ensemble approach

3.2.1 Bagging

The bagging method ensemble learning represents the bootstrapping and aggregation of combining two models into one ensemble model. Bagging uses random sampling to reduce the variance of the model by creating more data at the training stage of the model and every element in bagging has a way to appear in the new dataset. This method decreases the variance and narrowly changes the prediction to an expected output [38].

3.2.2 Boosting

The boosting method of ensemble classification makes use of a continuous method of classifying based on the features that the next model will utilize. The boosting methods make a stronger learner out of a weak learner model using weight average. The much stronger trained model relies on the multiple weak trained models. The weak learner is the one with the less correlated true classification and the next one is improved over the last one which will be a bit more correlated, the aggregation of the weak learners makes up the strong learner that is well correlated with accurate classification [38].

3.2.3 Stacking

In the stacking method, a different classifier is also used using the regression techniques or multiple combinations of the models. The operation involves training the lower-level with the entire dataset in which the outcomes are used to train the combined model. This is different from boosting in the sense that the lower level is in line with parallel trained. The prediction from the outcome of the lower level forms the next model as a stack. The stack operation is such that the top of the stack is the most trained and has goo prediction while the down of the stack is the least trained. The predictions continue until the best surfaced with fewer errors [38].

3.2.4 Random forest

The random forest models employ tree operations to carry out the sampling of the dataset. The tree is fitted on bootstrap samples and the output is aggregated together to reduce variance. It uses the features to sample the dataset in a random subset for the creation of the tree to reduce the correlation of the outputs. This model of random forest is best for determining the missing data as it selects a random subset of the sample to reduce the possibility of having common prediction values, with each tree having a different structure. The resultant variance result from the average of the lesser prediction from different trees gives better output [38].

3.3 Ensemble framework

In machine learning, ensemble methods and/or models employ the blend of different learning algorithms to give a better predictive performance that displays an outcome that surpasses what could be gathered from the single application of any of the learning models. Experimentally, ensembles models produce a more improved

DOI: http://dx.doi.org/10.5772/intechopen.100602

output as there is major distinctiveness among the model. The ensemble framework is depicted in **Figures 2** and **3** below.

3.4 Ensemble framework component

The framework of ensemble learning as depicted in **Figure 2** consists of the dataset, samples of data, different types of learners and the predicted output.

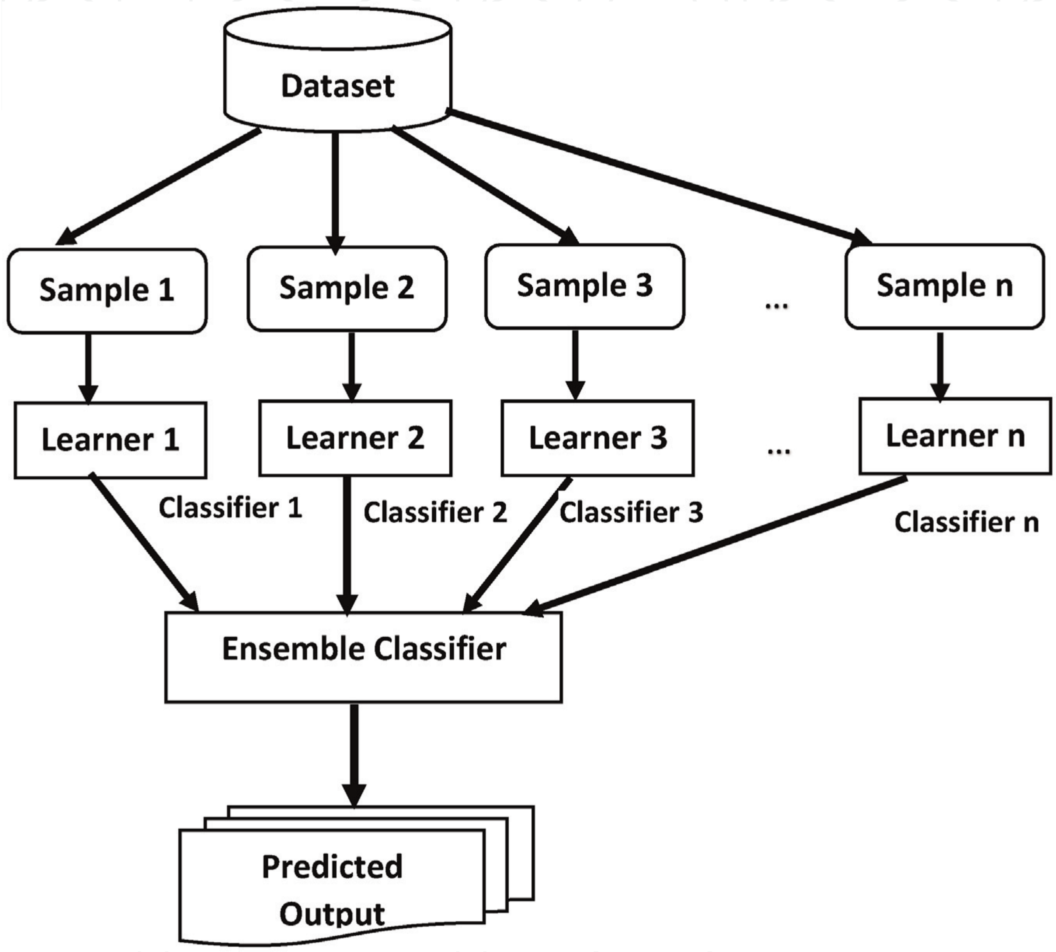

Figure 2.
Ensemble framework for prediction and classification of medical images.

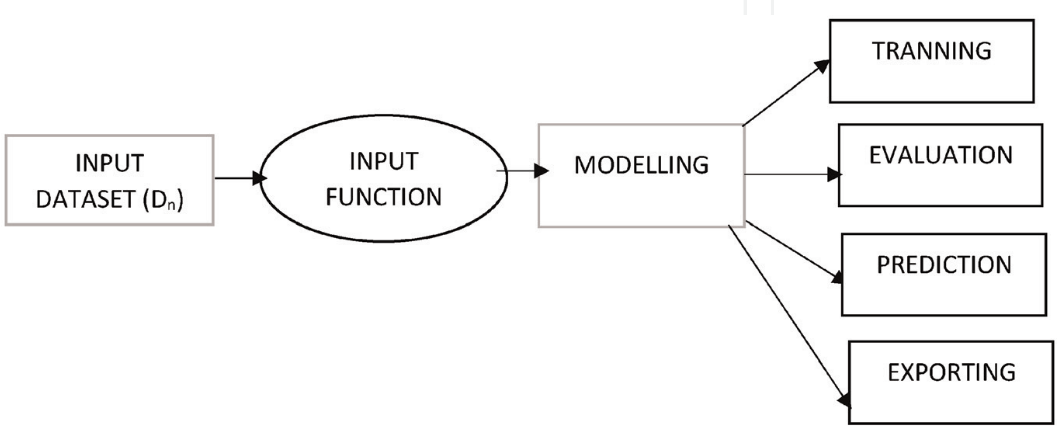

Figure 3.
Block diagram of the classification and prediction.

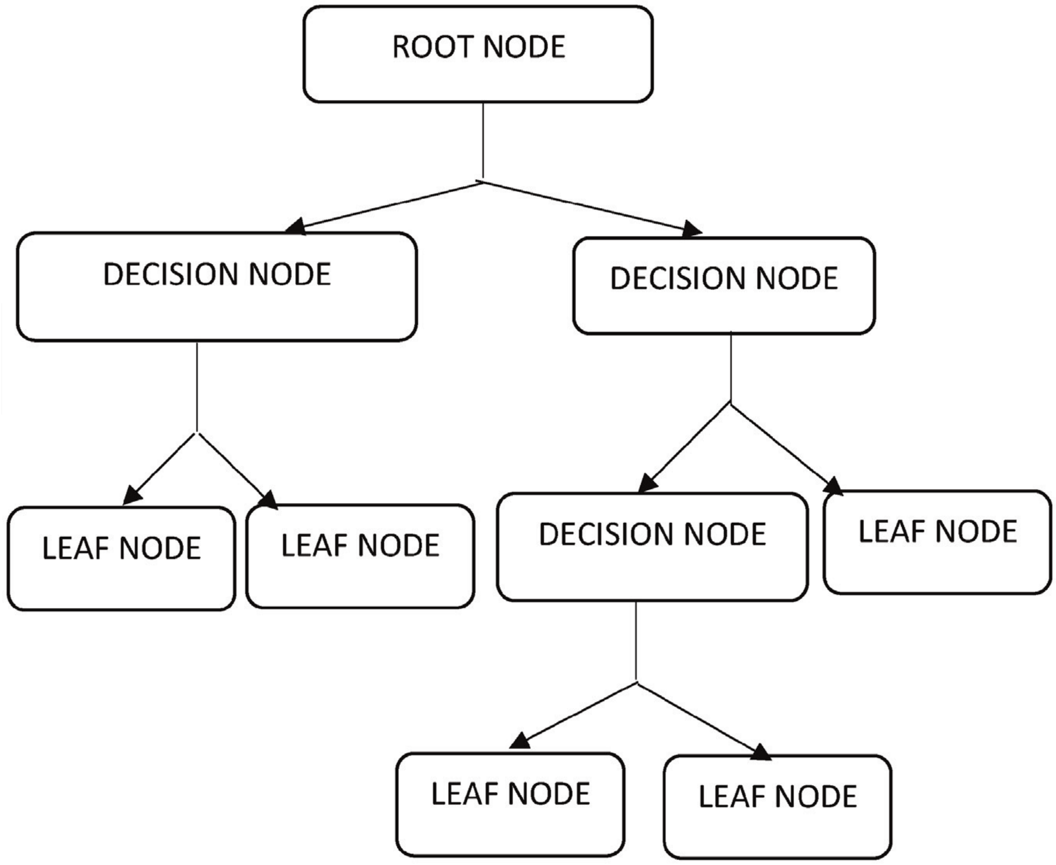

Figure 4.
Decision tree structure with tree and subtree.

The dataset denotes the medical images such as Ultrasound, Plain X-Rays, Mammography, Fluoroscopy, Computed tomography (CT), including CT angiography, Magnetic Resonance Imaging (MRI), and Magnetic Resonance Angiography (MRA), Nuclear medicine, and Positron Emission Tomography e.tc. The samples are the data to be trained by each model of the classifier before combing them together for the ensemble classifier to aggregate all the model predictions.

3.5 The classification and prediction block diagram

The block diagram of the system incorporates the following: The dataset is the preprocessed images that will be divided into training and validation set. The input function is then activated while estimate or facilitates construction and training of the models with appropriate APIs that include four sequential actions, they are training, evaluation, prediction, and export. The training and evaluation will be looped. The training setcompute the loss and adjust the weights of the model using gradient descent, the evaluation set validate the model while training and adjust the learning rate then and take the best version of the model, while the test set is used to compare different model approaches, and report the final result of the model (**Figure 4**).

3.6 Methodology

3.6.1 Techniques/method(s)

Different tools that can be adopted for this type of research include the following:

i. TensorFlow image recognition with object detection.

ii. Python programming language for scripting.

iii. Evaluation using MATLAB

3.6.2 Data extraction

Data will be extracted from the medical images represented by the distribution of pixels. To improve the data, standardization of the data is necessary before the application of the principal component analysis and these will enable each of the feature to have its mean = 0 while the variance = 1 Mathematically, this can be done by subtracting the mean and dividing by the standard deviation for each value of each variable. PCA makes maximum variability in the dataset more visible by rotating the axes.

$$Z = \frac{x - \mu}{\sigma} \tag{1}$$

3.6.3 The use of covariance matrix

The next step is to create a covariance matrix by constructing a square matrix to express the correlation between two or more features in a multidimensional dataset.

3.6.3.1 Principal component analysis

The PCA is used for technique dimensionality reduction with the operation of using measurement vector for distance classification, it explores the pattern recognition techniques [39]. It is best used for feature extraction, removal of redundancy, and feature extractions. A simple analysis of the PCA algorithm for image classification is given below. The PCA employs the Eigenvectors and Eigenvalues by the sorting of the eigenvectors in highest to lowest order, then select the number of principal components using the following equations:

$$\mathrm{PC1} = \mathrm{w}_{1,1}\ (\text{Feature A}) + \mathrm{w}_{2,1}\ (\text{Feature B}) \dots . + \mathrm{w}_{n,1}\ (\text{Feature N}) \tag{2}$$

$$\mathrm{PC1} = \mathrm{w}_{1,2}\ (\text{Feature A}) + \mathrm{w}_{2,2}\ (\text{Feature B}) \dots . + \mathrm{w}_{n,2}\ (\text{Feature N}) \tag{3}$$

$$\mathrm{PC1} = \mathrm{w}_{1,3}\ (\text{Feature A}) + \mathrm{w}_{2,3}\ (\text{Feature B}) \dots . + \mathrm{w}_{n,3}\ (\text{Feature N}) \tag{4}$$

The first of the principal components (PC1) is a synthetic variable built as a linear combination to determine the magnitude and the direction of the maximum variance in the dataset. The second principal component (PC2) is also a synthetic linear combination that captures the remaining variance in the data set and is not correlated with PC1. The rest of the principal components likewise capture the remaining variation without being correlated with the previous component. PCA allows resizing of medical images, patterns recognition, dimensionality reduction, and visualization of multidimensional data. The covariance matrix is symmetrical and has the form:

$$\mathrm{C} = \begin{matrix} w11 & w12 & w13 \\ w21 & w22 & w23 \\ wn1 & wn2 & wn3 \end{matrix} \tag{5}$$

eigenvalues of matrix C are the variances of the principal components.

$$PCi = w_{i1}X1 + w_{i2}X2 + \ldots .wipXp \tag{6}$$

Where $var(Pci_i)$ = λ_i and the constants w_{i1}, $w_{i2}, \ldots, w_{ip}$ are the elements of the corresponding eigenvector,

$$\text{Therefore, } w^2{}_{i1} + w^2{}_{i2} + \ldots . + w^2{}_{ip} = 1 \tag{7}$$

The sum of variances of the PCA is equal to the sum of variances of the original variances. The principal components contain all the variation of the original data.

3.6.3.2 Logistic regressions

Logistic regression is a linear algorithm (with a non-linear transform on output). It can have a linear relationship between the input variables and the output. Data transformation can come from the input variables result in a more accurate model [40]. In the following Eqs. (8)-(10) z is the output variable, x is the input variable where w and b will be initialized as zeros, to begin with, and they will be modified by numbers of iterations while training the model. The output z is passed through a non-linear function. The commonly used nonlinear function is the sigmoid function that returns a value between 0 and 1. The logistic regression uses the basic linear regression formula as:

$$\text{for a } 0 \le h\ \theta(x) \le 1\ (\text{binary}) \tag{8}$$

$$h_{\theta^{(x)}} = (\omega x + b), \text{where } \theta \text{ is the vector of parameters } (w, b) \tag{9}$$

$$g(z) = \frac{1}{1 + e^{-z}}\ \text{Where } g(z) \text{ is the Sigmoid function} \tag{10}$$

$$h_{\theta^{(x)}} = \frac{1}{1 + e^{-(\omega x + b)}} \tag{11}$$

To train a logistic classifier $h_{\theta^{(x)}}$ for each class of y prediction gives:

$$y_{predict} = g(z) = \frac{1}{1 + e^{-z}}\ (\text{Sigmoid Function}) \text{ which is optimized.} \tag{12}$$

3.6.3.3 Decision tree

The building of the decision tree begins with the root and then moves to the sub-nodes. The nodes represent characteristics features that represent the decision points, hence the information is classified. The nodes are linked at different levels to each other by branches that represent different decisions made by testing the status of the features in the node. It is a type of supervised machine learning algorithm that uses the if and else statement with a tree data structure for its operation [41].

The decision tree algorithm is based on the use of Shannon Entropy which determine the amounts of information of an event. If the probability distribution is given P as P = (p1, p2, P3, …, Pn), with a sample data S, the information carried by this distribution is called the Entropy of P and is given by the following equation, where (Pi) is the probability that the number (i) will appear during the process.

DOI: http://dx.doi.org/10.5772/intechopen.100602

$$\mathrm{P} = (\mathrm{p1}, \mathrm{p2}, \mathrm{P3}, \ \dots, \mathrm{Pn}) \tag{13}$$

$$\text{Entropy } (P) = \sum_{i=1}^{n} Pi\ X\ \ log\ (Pi) \tag{14}$$

$$Gain(P, T) = \text{Entropy } (P) - \sum_{j=1}^{n} (Pj\ X\ Entropy(Pj)) \tag{15}$$

Where Pj is a set data of all values of (T).

3.6.3.4 Artificial neural network

Neural networks use set of algorithms to recognize patterns in medical images through machine perception, labelling of the raw input. The layers are made of *nodes* [42]. loosely patterned. A node combines input from the data with a set of coefficients, or weights, that either amplify or dampen that input, thereby assigning significance to inputs concerning the task the algorithm is trying to learn. These input-weight products are summed and then the sum is passed through a node's so-called activation function, to determine whether and to what extent that signal should progress further through the network to affect the outcome (**Figure 5**).

$$\text{The input layer is denoted by } \mathrm{X_1}, \mathrm{X_2}, \mathrm{X_3}, \dots \mathrm{X_n}, \tag{16}$$

the first input is X_1 and the other several inputs to X_n.

$$\text{The connection weight is also denoted by } \mathrm{W_1}, \mathrm{W_2}, \mathrm{W_3}, \dots \mathrm{W_n}. \tag{17}$$

The weight signifies the strength of the node.

$$\mathrm{a} = \sum_{j=1}^{n} w_{\theta} x_j + \mathrm{b} \tag{18}$$

Where a is the output generated from multiple input. The output is a weighted combination of all the inputs. This output a is fed into a transfer function f to produce y.

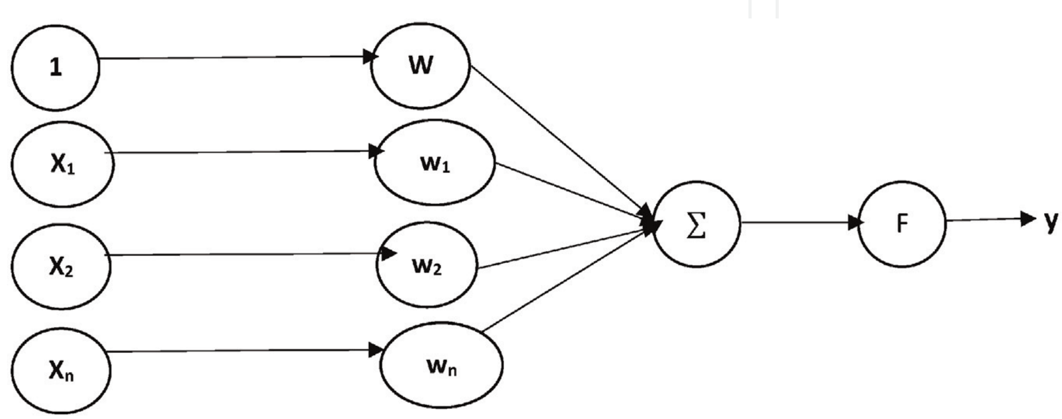

Figure 5.
Neural network modeling and output function.

3.7 The system flowchart

Image Pre-processing: The aim of this process is to improve the image data (features) by suppressing unwanted distortions and enhancement of some important image features so that our Computer Vision models can benefit from this improved

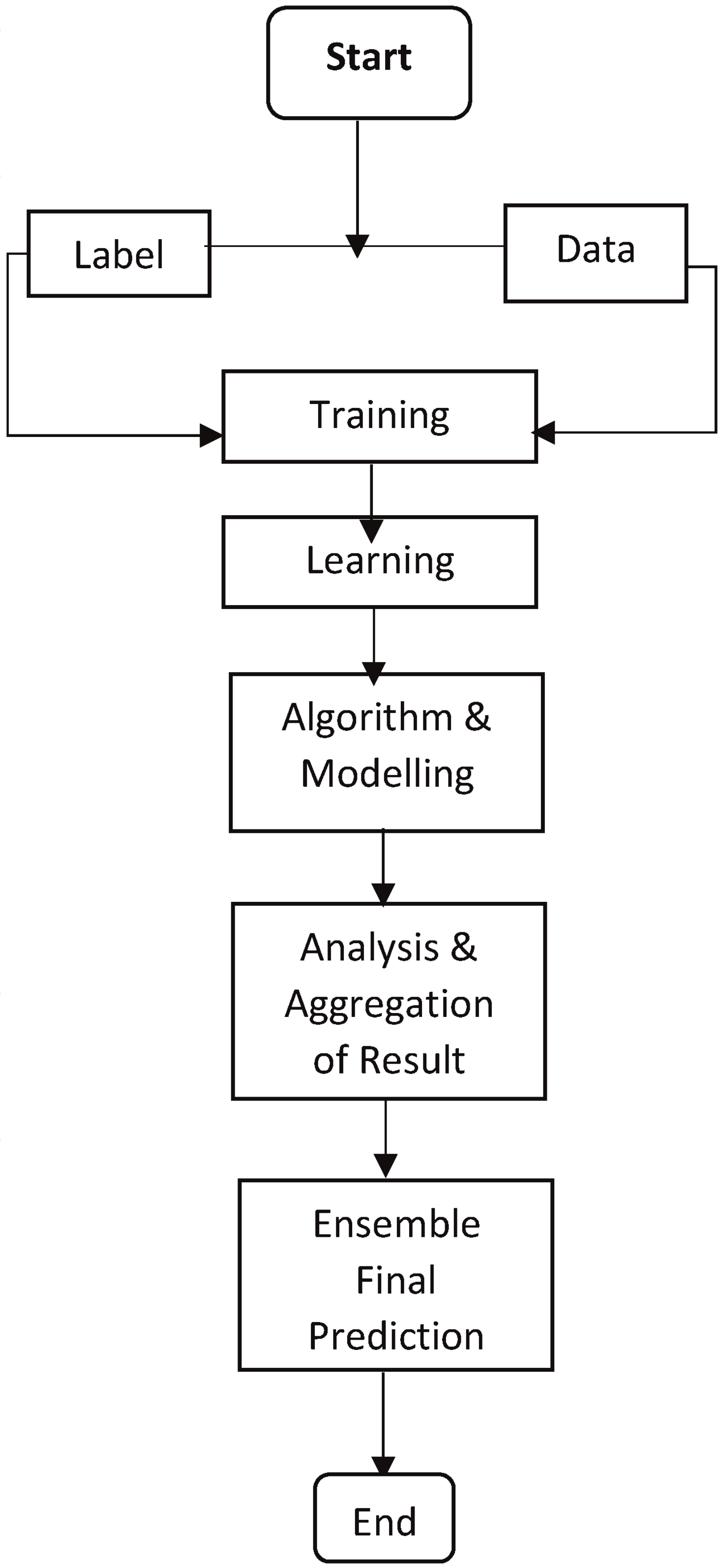

Figure 6.
Flowchart diagram of the classification and prediction.

data to work on. Detection of an object: Detection refers to the localization of an object which means the segmentation of the image and identifying the position of the object of interest. Feature extraction and Training: This is a crucial step wherein statistical or deep learning methods are used to identify the most interesting patterns of the image, features that might be unique to a particular class, and that will, later on, help the model to differentiate between different classes. This process where the model learns the features from the dataset is called model training. Classification of the object: This step categorizes detected objects into predefined classes by using a suitable classification technique that compares the image patterns with the target patterns (**Figure 6**).

4. Discussion

Ensemble machine learning application method for the classification and prediction of medical images is proposed in this study. The study focuses on the use of different machine learning algorithm as a combined model to get better result as a result of the aggregation of the models. The images will be first pre-processed, augmented, fed into the classifier for training and testing for evaluation and then the predicted result.

5. Conclusion

Conclusively, the traditional approach of reading results from medical images by the care providers cannot be devoid of errors as well as the time take to predict the result of such images. In case of emergencies, early detection of any ailment will attract prompt, treatment and time management is also a vital aspect of the process. The application of Ensemble machine learning algorithms to medical imaging is a justifiable approach to obtain a better accuracy compared to the single classifier or even the traditional reading of results from the radiologist. This paper established a brief study that enclosed different machine learning algorithms and the combinations to make an ensemble learning classifier. More so, it stated the positive effect of having an ensemble approach for the prediction and classification of medical imaging. The paper also includes some of the reviews that are relevant to the study area. The explanation of medical images is one of the most demanding aspect of prediction and classification of diseases that occurs daily in medical diagnosis. The application of machine learning in the classification and prediction of medical images is growing at a geometric rate. A high level of precision and knowledge in the specific field may be required for accurate inference. The effectiveness and the efficiency of the combinations of different machine learning algorithm will enable better understanding of biological integration and analysis of knowledge as it improves access and transition in healthcare. The impact will reduce cost, earlier detection of diseases and accurate interpretation of results than using the single model. The research has the potential to cause a major shift in the field of medicine.

Acknowledgements

The authors are grateful to the participants who contributed to this research especially Mr. Gowin Akinbo for his immense contribution in proof reading this paper for publication.

Conflict of interest

The authors declare no conflicts of interest for this publication.

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