**CHAPTER TWO**

**LITERATURE REVIEW**

**2.1 History of Covid-19**

Coronavirus popularly known as Covid-19 caused by SARS-Cov-2, a severe acute respiratory syndrome, is an unprecedented and highly infectious disease in the world. It been declared as pandemic by World Health Organization (WHO). The first case was reported in December 2019, reaching approximately 21.3 million confirmed cases and 761,799 deaths as of 16 August 2020 (Lee *et al*., 2020). Due to the high contagious rate of the disease, there is need for early detection of the virus since there is no vaccine as at then. For early diagnosis of COVID-19, the reverse transcription polymerase chain reaction (RT-PCR) test is commonly done. However, it suffers from a high false-negative rate of up to 67% if the test is done during the first five days of exposure. As an alternative, research on the efficacy of deep learning techniques employed in the identification of COVID-19 disease using chest X-ray images is intensely pursued (Science *et al*., 2021).

In the last few years, deep learning has grown exponentially and in the medical imaging world, the potential of automated disease discovery framework has been highlighted by many scientists (Singh *et al*., 2021). Considering the success and potential of AI and deep learning in the medical imaging field, many computer scientists are exploring the possibility of automatic detection of COVID-19 using chest X-rays. However, any deep learning-based solution needs sufficient training data to produce generalizable results. The research community has therefore been pooling a lot of data to enhance the knowledge bank which we use for the purpose of this study. Motivated by the recent progress made by the scientific community, we proposed to explore the use of chest X-rays images for the detection of COVID-19 in this work.

**2.2 Artificial Intelligent**

Artificial intelligent are intelligent behavior demonstrated by machines, just like the natural intelligent usually seen by animals or humans. The term artificial intelligent, Deep learning, Data science, machine learning are words that are co-related to each other. In other view AI indicate the capability of a machine to behave, learn, and think on is own with little or no human intervention (T.Seeniselvi, 2019).

**2.3 Machine Learning Algorithm**

Machine learning (ML) is the scientific study of algorithms and statistical models that computer systems use to perform a specific task without being explicitly programmed (Batta, 2020). ML is used to teach machines how to handle the data more efficiently. Sometimes after viewing the data, we cannot interpret the extracted information from the data. In that case, we apply machine learning algorithm for better understanding and interpretability. With the abundance of datasets available, the machine learning algorithms are needed. Depending on the availability of types and categories of training data one may need to select from the available techniques of “supervised learning”, “unsupervised learning”, “semi supervised learning” and “reinforcement learning” to apply the appropriate machine learning algorithm (Shrestha & Mahmood, 2019).

**2.3.1 Supervised Learning Algorithm**

Supervised learning is the machine learning task of learning a function that maps an input to an output based on example input-output pairs. It infers a function from labeled training data consisting of a set of training examples. The supervised machine learning algorithms are those algorithms which needs external assistance. The input dataset is divided into train and test dataset. The train dataset has output variable which needs to be predicted or classified. Classification and regression are the types of Supervised Learning (Fatima & Pasha, 2017).

**2.3.2 Unsupervised Learning Algorithm**

Unsupervised learning technique tries to find out the similarities between the input data and based on these similarities, un-supervised learning technique classify the data. The unsupervised learning algorithms learn few features from the data. (Batta, 2020). It is mainly used for clustering and feature reduction.

**2.3.3 Semi-Supervised Learning Algorithm**

This learning also used unlabeled data for training purpose (generally a minimum amount of labeled-data with a huge amount of unlabeled-data). Semi-supervised learning lies between unsupervised-learning (unlabeled-data) and supervised learning (labeled-data) (Sarker, 2021).

**2.3.4 Reinforcement Algorithm**

This learning is encouraged by behaviorist psychology. Algorithm is informed when the answer is wrong but does not inform that how to correct it. It has to explore and test various possibilities until it finds the right answer. It is also known as learning with a critic. It does not recommend improvements. Reinforcement learning is different from supervised learning in the sense that accurate input and output sets are not offered, nor sub-optimal actions clearly précised. Moreover, it focuses on on-line performance (Fatima & Pasha, 2017).

**2.4 Deep Learning Models**

The deep neural network algorithm encompasses artificial neural network that mimic the brain of a human in order to automatically learn an important level of features from a dataset. The Deep Neural Network produce better result in comparison to the traditional model such speech recognition, text processing, image processing and recognition (Li et al., 2020). Deep learning can also be defined as an automated learning technique which uses the architecture of what is known as artificial neural network. The word ‘deep’ is tag to as the numbers of hidden layers that are present in a neural network, networks with just one layers is known as the conventional neural network while the deep learning network is made up of multiple layers. They are various type of artificial neural network that are been developed in recent years, this include the Recurrent Neural Network (RNN) and the Convolutional Neural Network (CNN).

**2.4.1 Feedforward Neural Network (FNN)**

The feedforward neural network is build using the basic unit of the artificial neural network family, within the feedforward neural network data are move only from the input layer to the output layer, through a hidden layer that restrict any form of loop. The weighted output of one layer is the input of the next layer (Kortli et al., 2020)(Goyal et al., 2018).

**2.4.2 Recurrent Neural Network (RNN)**

The recurrent neural network (RNN) is a very efficient and effective deep learning algorithm that is capable of solving computational problem of almost any type. The recurrent neural network as varieties depending on the use case and its used to implement smaller set of programs, and finally, to reveal the intricated effect produce by the collaboration of each smaller program. The RNN algorithm is capable of perform the above mentioned operation using two principles; this includes hidden state are by nature are being distributed, and information about the past are been stored efficiently. (Goyal et al., 2018).

**2.4.3 Convolutional Neural Network (CNN)**

The CNN architecture is very efficient in term of image detection and recognition task, they are being employ in may applications (Goyal et al., 2018). From a structural perspective, three different type of layers are the building block of convolutional neural network this includes; the convolutional layers, the pooling layers and the full connected dense layer (Kortli et al., 2020).

1. The Convolutional Layer: in another term the convolutional layer is sometimes called the feature extraction layer, due to the fact that image feature is been automatically extracted at this layer. Spatial relationship between pixel are been preserves by the convolution layer by learning the features of images using a square portion of the input mages. The use of some learnable neuron is being adopted to convolute the input image. Hence, this produces a feature, activation mapping of the inputted image, when the feature maps fed as an input into the next convolutional layer. A rectified Linear Unit (ReLu) activate is used within the convolutional layer to convert all value that are negative to zero. However, this make it efficient computationally, as certain neuron is being activate each time (Kortli et al., 2020).
2. The Pooling Layer: this layer is use in dimensionality reduction, for the primary purpose of minimizing the computational time of extracting most of the essential information after convolution process as taken place. The layer basically minimizes the number of parameter, spatial size, overfitting and computation time within the network. Two main type of operation that occur in this layer, this include; the average pooling and the maximum pooling. The average pooling uses all the element in the sub matrix, then compute their average, and finally store it in the output matrix. While the max pooling search for the maximum number in the submatrix and save it in the output matrix (Kortli et al., 2020).
3. The Fully Connected (Dense) Layer: this layer consist of fully connection neurons; thus, the previous layer are fully connected to the next layer. It’s mostly used in categorizing images of different categories (Kortli et al., 2020).

**2.5 Feature Extraction Techniques**

The selection of features, also known as the selection of variables or attributes in the data, is the process of choosing a subset of unique features (variables, predictors) to use in building machine learning and data science model. It decreases a model’s complexity by eliminating the irrelevant or less important features and allows for faster training of machine learning algorithms (Sarker, 2021). Feature extraction techniques usually provide a better understanding of the data, a way to improve prediction accuracy, and to reduce computational cost or training time. The aim of feature extraction is to reduce the number of features in a dataset by generating new ones from the existing ones and then discarding the original features.

In this research, we will focus on two feature extractions namely: Histogram of Oriented Gradients (HOG) and Local Binary Pattern (LBP).

**2.5.1 Histogram of Oriented Gradients (HOG)**

Dalal(2006) introduced Histogram of Oriented Gradients(HOG) features in 2005. Histogram of Oriented Gradients (HOG) is a feature descriptor used in image processing, mainly for object detection. A feature descriptor is a representation of an image or an image patch that simplifies the image by extracting useful information from it.

The principle behind the histogram of oriented gradients descriptor is that local object appearance and shape within an image can be described by the distribution of intensity gradients or edge directions. The x and y derivatives of an image (Gradients) are useful because the magnitude of gradients is large around edges and corners due to abrupt change in intensity and we know that edges and corners pack in a lot more information about object shape than flat regions. So, the histograms of directions of gradients are used as features in this descriptor.

HOG is standard technique of object. It counts incidences of edge directions in a local neighborhood of an image. This detection task is performed by applying HOG in the acquired image. Before applying HOG, the input image is transformed from RGB into gray scale image for simplicity (Ahamed *et al*., 2018).

**2.5.2 Local Binary Pattern (LBP)**

**Local Binary Pattern**(LBP) is a simple yet very efficient texture operator which labels the pixels of an image by thresholding the neighborhood of each pixel and considers the result as a binary number. Due to its discriminative power and computational simplicity, LBP texture operator has become a popular approach in various applications. It can be seen as a unifying approach to the traditionally divergent statistical and structural models of texture analysis. Perhaps the most important property of the LBP operator in real-world applications is its robustness to monotonic gray-scale changes caused, for example, by illumination variations. Another important property is its computational simplicity, which makes it possible to analyze images in challenging real-time settings (Lahdenoja *et al*., 2005). LBPs are local patterns that describe the relationship between a pixel and its neighborhood.

The LBP combines the structural and statistical image analysis approaches into a single high efficiency transformation which is invariant with respect to monotonic grayscale transformations and scaling (Huang *et al*., 2011).

**2.6 Related Works**

Owing to the outburst of covid-19 pandemic, there are numerous machine learning model developed for classification and prediction. Singh and Singh (2021) proposed an automated method for detection of covid-19 from CXR with improved depth wise convolution network that incorporates spectral analysis. A comparative study is also performed to evaluate the performance of the method with existing methods which yields 95.83%, 95.67%, 96.07%, 95.63% accuracy, precision, sensitivity and F1-score respectively.

Rehman *et al* (2021) proposed a real-time computer aided diagnosis (CAD) approach to support physicians and avoid further spreading of the disease. A convolutional neural network (CNN) -based Residual neural network (Resnet50) was utilized to detect covid-19 through CXR images and achieved 98% accuracy. The CAD system uses advanced load balancer and resilience features to achieve fault tolerance with zero delays and perceives more infected cases during this pandemic. This work used limited number of X-ray images for the diagnosis.

Karim *et al* (2020) proposed an explainable deep neural network (DNN)-based method for automatic detection of COVID-19 symptoms from chest radiography (CXR) images called ‘DeepCOVIDExplainer’. CXR images are first comprehensively preprocessed and augmented before classifying with a neural ensemble method, followed by highlighting class-discriminating regions using gradient-guided class activation maps (Grad-CAM++) and layer-wise relevance propagation (LRP). Furthermore, human-interpretable explanations were provided for the diagnosis. Evaluation results show that the approach can identify COVID-19 cases with a positive predictive value (PPV) of 91.6%, 92.45%, and 96.12%, respectively for normal, pneumonia, and COVID-19 cases, respectively, outperforming recent approaches. This work has problem of overfitting due to limited number of CXR images used to train the models and inability to verify the diagnosis and localization accuracies with radiologists.

Elaziz *et al.* (2020) adopted a new machine learning method to classify CXR into covid-19 patient and non-covid-19 person. The features extracted from the chest x-ray images uses new Fractional Multichannel Exponent Moments (FrMEMs). A parallel multi-core computational framework utilized to accelerate the computational process, then, a modified Manta-Ray Foraging Optimization based on differential evolution used to select the most significant features. The method is evaluated using two COVID-19 x-ray datasets which achieved accuracy rates of 96.09% and 98.09% for the first and second datasets, respectively.

Che Azemin *et al.* (2020) used a deep learning model based on the ResNet-101 convolutional neural network architecture, which was pretrained to recognize objects from a million of images and then retrained to detect abnormality in chest X-ray images. The performance of the model in terms of area under the receiver operating curve, sensitivity, specificity, and accuracy was 0.82, 77.3%, 71.8%, and 71.9%, respectively. The strength of this study lies in the use of labels that have a strong clinical association with COVID-19 cases and the use of mutually exclusive publicly available data for training, validation, and testing.

Ensemble Deep Learning (EDL-COVID) was employed by Tang *et al*. (2021) by combining deep learning and ensemble learning for predicting covid-19 cases. Then, this model will be compared with COVID-Net, which is an open-sourced network architecture for Covid-19 cases detection. The aim of this work is to overcome the shortcomings of high variance and generalization errors caused by noise and limited number of datasets. The results show that EDL-COVID offers better result for covid-19 cases detection with an accuracy of 95% than COVID-Net of 93.3%.

Deb and Jha (2020) proposed a Deep Convolutional Neural Network based ensemble architecture for extracting features from CXR images and then, classify them into three cases: Community Acquired Pneumonia (CAP), Normal and Covid-19. The ensemble network uses three pre-trained DCNN networks: NASNet, MobileNet and DenseNet. The low-level features extracted from the three DCNN architectures are later concatenated and applied to a classifier for final classification. An accuracy of 91.99% was achieved which is slightly better than the state-of-the-art performances.

A new family of models based on the EfficientNetFamily of deep Artificial Neural Network was used by Luz *et al*. (2021) for classifying covid-19 CXR images. The aim of this work is to develop an accurate yet efficient method in terms of memory and processing time for the problem of covid-19 screening in CXRs. This approach produced a high-quality model with an overall accuracy of 93.9%, sensitivity of 96.5%, and positive prediction of 100% with a computational efficiency more than 30 times higher.

Oh *et al*. (2020) proposed a patch-based convolutional neural network approach with a relatively small number of trainable parameters to address the difficulty involved in the collection of large CXR data set for deep neural network training. The method uses statistical analysis of the potential imaging biomarkers of the CXR radiographs. The method achieved state-of-the-art performance and provides clinically interpretable saliency maps, which are useful for covid-19 diagnosis and patient triage.

Hira *et al*. (2021) introduced a deep learning-based approach that can differentiate COVID- 19 disease patients from viral pneumonia, bacterial pneumonia, and healthy (normal) cases. This work used nine convolutional neural network-based architecture (AlexNet, GoogleNet, ResNet-50, Se-ResNet-50, DenseNet121, Inception V4, Inception ResNet V2, ResNeXt-50, and Se-ResNeXt-50). Experimental results indicate that the pre-trained model Se-ResNeXt-50 achieves the highest classification accuracy of 99.32% for binary class and 97.55% for multi-class among all pre-trained models.

Abbas *et al*. (2021) validated a deep CNN, called Decompose, Transfer, and Compose (DeTraC), for the classification of COVID-19 chest X-ray images. DeTraC can deal with any irregularities in the image dataset by investigating its class boundaries using a class decomposition mechanism. The experimental results showed the capability of DeTraC in the detection of COVID-19 cases from a comprehensive image dataset collected from several hospitals around the world. High accuracy of 93.1% (with a sensitivity of 100%) was achieved by DeTraC in the detection of COVID-19 X-ray images from normal, and severe acute respiratory syndrome cases.

It is identify by (Ri et al., 2021) that the deadly coronavirus which also refers to as COVID-19 has infected 20million and above people in a very short period of time, which is now announced to be a global pandemic. Ri also stated in this work title: ” improved *classification coronavirus disease (covid-19) based on the combination of texture feature using CT scan and X-ray images*” that its essential to carry out an initial screening in other to control the rapid spread of the deadly disease. The X-Ray images and the Computed Tomography (CT) are both important data for diagnosing the lung condition of a patient having COVID-19 symptoms. However, it’s important to have a machine learning approach that can early detect the a COVID-19 condition using the CT scan and X-Ray images. The researcher proposed a model that is based on machine learning for COVID-19 classification using textual feature techniques. In the research paper three tactual feature approach is adopted, this include; Gray level co-occurrence matrix (GLCM), Local Binary Pattern (LBP), and the Histogram of Oriented Gradient (HOG) which are used in performing feature extractions. This feature extraction approach is adopted to increase the accuracy and efficient improve computation. The support vector machine (SVM) algorithm is considered for image classification. Training was performed on 1100 CT scan image and 1100 X-ray Images. Accuracy of 97% on CT image and 99% accuracy on X-ray images.

Base on the research paper of (Jumani et al., 2019) titled ‘*facial expression recognition with histogram of oriented gradients using CNN’* . in the paper a new approach is introduce to tackle the classification and recognition of facial expression by considering the FER2013 database which consist of 7 different facial expression class (fear, surprise, angry, sad, neutral, sad, disgust, happy). Considering the past few decades the challenge of facial recognition still remains due to the high variation between class. The researcher adopts two model, this includes; FER using convolutional neural network (FER-CNN) and the Histogram of oriented gradients with convolutional neural networks (FER-HOGCNN). According to the gotten the FER-CNN model was able to give an accuracy of 98%, 72% and the FER-HOGCNN has an accuracy of 97% and 70%. Hence, this shows that the FER-CNN perform better that that of the FER-HOGCNN. in conclusion the research helps in the improvement of FER System for image processing, and the research suggest a future work by hybridizing HOG and LBP for feature extraction before feeding it into the neural network.

**Summary Table 2.1. Related Paper**

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| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Author/Year** | **Title** | **Problem Statement** | **Methodology** | **Result** | **Limitation** |
| **1** | (Oh et al., 2020) | Deep learning Covid-19 Features on CXR using Limited Training Dataset | due to sudden outburst of the convid-19 pandemic, the systematic gathering of CXR dataset for the deep neural network training becomes difficult | A patch based convolutional neural network method or approach is used along with a relatively small number of trainable features for the COVID-19 diagnosis. | The result of the evaluation show that the approach propose was able to achieve a state of the art performance. | The model is only useful for the diagnosis of COVID-19 diagnosis and patient triage. |
| **2.** | (Zulfaezal et al., 2020) | COVID-19 Deep Learning Prediction Model using Publicly Available Radiologist-Adjudicated Chest X-Ray Images as Training Data; Preliminary Findings | Due to the limited availability of publicly dataset of COVID-19 chest X-ray images | A deep learning model was adopted based on ResNet-101 convolutional neural network architecture, which as already been pretrained to recognize millions of images | Accuracy gotten includes 0.82%, 77.3%, 71.8% and 71.9%. | Models developed only for COVID-19 cases. |
| **3** | (Deb & Jha, 2021) | COVID-19 detection from chest X-Ray Images using ensemble of CNN models | The problem identify is based on the current testing mechanism been costly and time consuming. With this the probability of the outbreak coming to end is low. | A deep convolutional neural network based on the architecture of ensemble method is considered for feature extraction form the X-ray images. | And accuracy level of 91.99% is achieved which is slighter better in performance that the current state of art performance | The model is developed only for the prediction of covid-19 pandemic outbreak virus |
| **4** | (R. Karim et al., 2021) | Deep Covid-19 Explainer: Explainable Covid-19 Diagnosis from Chest X-Ray Images | The dataset adopted are severely biased due to the deficient number of covid-19 cases. However most of the result in previous work are not statistically biased due to the fact that most of the diagnosis are based on a single model | The research paper proposed an explainable deep neural network which is based on the Deep neural network (DNN) architecture. | The positive prediction value shows that the COVID-19 diagnosis approach is better with and accuracy of 91.6%, 92.54%, and 96.12% respectively | The research work only considered covid-19, pneumonia, and normal cases |
| **5** | (Hira et al., 2021) | An automatic approach based on CNN architecture to detect covid-19 disease from chest X-ray images | In consideration of the covid-19 rising cases daily, and limited resource to diagnoses covid-19 patient at the hospital. | A deep learning-based approach (CNN) that can different covid-19 disease patient from viral pneumonia. This approach adopts deep transfer learning. Nine convolutional based neural networks are used (AlexNet, GoogleNet, ResNes-50, Se-ResNet-50, Densenet121 etc) | An accuracy of 99.32 is achieved. For the binary classification and 97.55% accuracy for multi-class among all the pre-trained models. | Model are only for covid-19, normal viral pneumonia and bacteria pneumonia. |
| **6** | (Elaziz, Id, et al., 2020) | New machine learning method for image-based diagnosis of COVID-19 | COVID-19 is announce to be a world health organization in 2020 as an epidemic issue. | A machine learning based method for classification and feature extraction process using Fractional Multichannel Exponential Moments (FrMEMs). A parallel multi-core computational framework to improve computation process. | The propose method was able to achieved and accuracy of 96.09% and 98.09% for the first and second dataset given to the machine learning model | The machine learning model is based on only COVID-19 diagnosis |
| **7** | (Luz et al., 2022) | Towards an effective and efficient deep learning model for COVID-19 patterns detection in X-ray images | Considering the standard method for COVID-19 identification, thus the reverse transcription polymerase chain reaction method is time consuming and its in short supply due to the pandemic. | The researcher proposed and accurate and more efficient approach in term of the memory usage and time of processing the COVID-19 chest X-ray images. The EfficientNet family of the deep artificial neural network is used. | A high-quality model was produce by the proposed approach. And overall accuracy of 93.9% was achieved. Covid-19 sensitivity of 96.8% was gotten. | Model are developed for diagnosing covid-19 cases only other cases are not considered in the research work. |
| **8.** | (Abbas et al., 2021) | Classification of COVID-19 in chest X-ray Images using DeTraC deep convolutional neural Network | Considering the scarcity of annotated medical images, the classification and prediction of medical images still stands as the biggest challenge faced in diagnosing COVID-19 cases. | The research adopt the transfer learning approach, and a validated Deep Convolutional Neural Network (CNN), called the decomposer, Transfer, and Compose (DeTraC). | The experiment result as proven high accuracy of 93.1 percent with sensitivity of 100 percent using the DeTraC | Server acute respiratory syndrome cased and X-ram images for normal cased are considered for this research paper |
| **9** | (Rehman et al., 2021) | Real-Time Diagnosis System of COVID-19 using X-Ray images and Deep Learning | The quick spread of COVID-19 situation among humans worldwide remain hazardous to the health system. | The research paper employs a convolutional neural network (CNN) which is based on the Residual neural network (ResNet50), in addition the research work used advanced load balancer and resilience feature | The proposed approach achieved an accuracy of 98% | The limitation identify in this research work is limited number of X-ray images that are used in performing COVID-19 diagnosis. |
| **10** | (Tang et al., 2021) | EDL-COVID: ensemble Deep Learning for COVID-19 Case Detection From Chest X-Ray Images | Many deep learning approach has been propose with good accuracy but many of the research work models as suffer what is termed overfitting, high variance and generalization of errors which is cause by noise and finally limited number of dataset. | The researcher proposed EDL-COVID, which is and ensemble deep learning approach (combined deep learning and ensemble learning) | The experimental result has proved that the proposed EDL-COVID has shown a promising outcome in the prediction of COVID-19 cases. An accuracy of 95% was achieved | The number of COVID-19 CXR images is still in comparison to that of the other CXR images. |
| **11** | (Ri et al., 2021) | Improved Classification of Coronavirus Disease (COVID-19) based on combination of Texture Feature using CT Scan and X-Ray Images | Lack of early detection approach. Which has negative impact in detecting and contain the COVID-19 global pandemic. | In this research work they adopt the use of machine learning model (SVM) for classifying the COVID-19 base on textual features namely, The Gray Level Co-occurrence matrix (GLCM), Local Binary Pattern (LBP) and Histogram of Oriented Pattern (HOG) | The proposed approach shows that combining GLCM, LBP, and HOG features can  Provide an accuracy up to 97percent on CT images and 99 percent accuracy on X-Ray images. | CT and X-Ray image are only used in building the model |
| **12** | (Jumani et al., 2019) | Facial Expression Recognition with Histogram of Oriented Gradient using CNN | Challenging issue due to high-intra class variation. | The research work proposed two approach this include FER using Deep Convolutional Neural Network (FER-CNN) and the Histogram of Oriented Gradient based on CNN (FER-HOGCNN) | Its identify that the FER-HOGCNN model give and accuracy of 97% and 70% accuracy. While FER-CNN gives an accuracy of 98% and 72%. This show that FER-CNN method is better than FER-HOGCNN | The research work is limited to only facial expression prediction. |

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