MACHINE LEARNING APPROACHES TO PREDICT COVID-19 SEVERITY

Richa Mathur[1], Devesh Kumar Bandil[2], Vibhakar Pathak[3]
[1]Research Scholar, Department of CS & Applications, SGVU Jaipur, Rajasthan, India
[2]Professor, Computer Applications, Suresh Gyan Vihar University Jaipur, Rajasthan, India
[3]Professor CS/IT, Arya College of Engineering and IT, Jaipur, Rajasthan, India
Email: richa0058@gmail.com, mcagwailor@gmail.com,vibhakarp@rediffmail.com

Abstract

Machine learning has been successfully used in the medical field for the last few years. The emergence of covid-19 pandemic has seen researchers using machine learning approaches to detect and predict whether a patient has been infected by covid-19 or not. Cough and fevers are the two most likely symptoms of the covid-19. In this paper, the journals regarding the prediction of covid-19 severity based on symptoms have been discussed. Several researchers have established deep learning-based models for the prediction. They have used the test data from the hospitals for their research process. The KNN models, ANN models, and SVM models have been discussed. The limitations of the past research process have been evaluated to be the biased test data set and missing values. The methodology that was used for the research process has been described. Mixed method of data collection was used for the research processes. The secondary data was collected from reliable sources for this research process. Kaggle website was used to collect the test data regarding the covid-19 patients. The data analysis was done on the weka tool using various machine learning models.

Keywords- Covid-19, SVM, RNN, ANN.

DOI Number: 10.14704/nq.2022.20.12.NQ77010 **NeuroQuantology 2022; 20(12): 91-103**

1.0 Introduction

Machine learning has been successfully used in the medical field for the last few years. The emergence of covid-19 pandemic has seen researchers using machine learning approaches to detect and predict whether a patient has been infected by covid-19 or not. Due to the enhancement of severity of covid-19 the researchers have stated to predict the severity of covid-19 based on the patient's symptom. This research was conducted to provide a solution regarding whether machine learning could be successfully used to predict the severity of covid-19 based on a patient's symptoms or not. The weka tool was used to establish the model. Machine learning has long been used in the medical field including disease severity prediction, automated organ segmentation, analysis of medical data etc. The researchers have successfully used machine learning in the past few years to predict the risk based on covid-19 pandemic. The burden of the medical care system was mitigated by inventing effective screening modules. Machine learning prediction approaches such as KNN, SVM have been deemed significantly helpful during this time. Previously machine learning models used data from hospital patients and this is the reason why it was not effective for the general people.

The main aim of the research was to predict the severity of the diseases covid-19 based on the symptoms of the patients. One of the main parts of the research was also to study the journals of previous researchers who have given

their valuable opinion on the topic. The research also had the purpose to establish the best machine learning model for this prediction process.

With the help of ML we can enlighten upon few things and those are:

1. To predict the severity of covid-19 using machine learning models.
2. To establish the best machine learning approach to develop the model.
3. To use the weka tool for machine learning prediction on covid-19 based on symptoms.
4. To study the journals of previous research to learn the various points of view.

The main reason behind conducting the research process was to establish the best model for assessing the severity of the research process. One of the main reasons behind conducting the research process was to create the model which would help the doctors to treat covid-19 patients successfully. One of the main motivations of the research process was that this paper would help the future researchers to gain an overall idea about the topic and go to the next step of the topic. To summarize, this section has provided an overview of the mini research that has been conducted. The main purpose of the research was to predict the severity of the covid-19 patients based on symptoms. Machine learning has been popularly used in the medical field for the last few years and the emergence of covid-19 pandemic has seen the predictive models to use in the diagnosis of the disease.

2.0 Literature Review

Researchers in the past few years have given their valuable opinion regarding using machine learning approaches to predict the severity of covid-19 based on symptoms. In this section those renowned research papers will be thoroughly studied and reviewed to help the readers understand about the background of the study. The theories and models of machine learning such as ANN, SVM models will also be discussed in this section. The drawbacks and limitations of the discussed research papers will also be discussed.

According to Shomron *et al* 2021, effective diagnosis of covid-19 can only be done with the best screening process. The researchers have established a model using machine learning approaches based on human features such as sex, age, known contact, and main symtoms. This model can predict the severity based on a few questions as well as testing. The researchers have established the model based on the SARS-Cov-2 testing.

As the figure is suggesting this is the proposed model performance. The test data used form the Israeli ministry of health and based on the test data the sensitivity information were calculated as 87.76% and the value of specificity can be calculated as 98 percent. This signifies that the predictive value is positive. The figure is implying that the higher feature value has higher importance. This means cough and fevers are the two most likely symptoms of the covid-19. After the development of the model the test was performed accordingly. However, the figure is implying some negative values due to some biased data (Mueller *et al* 2022). The authors have used python language for their coding part for this model and they have concluded the most important symptoms for covid-19 in the graph.

eISSN 1303-5150

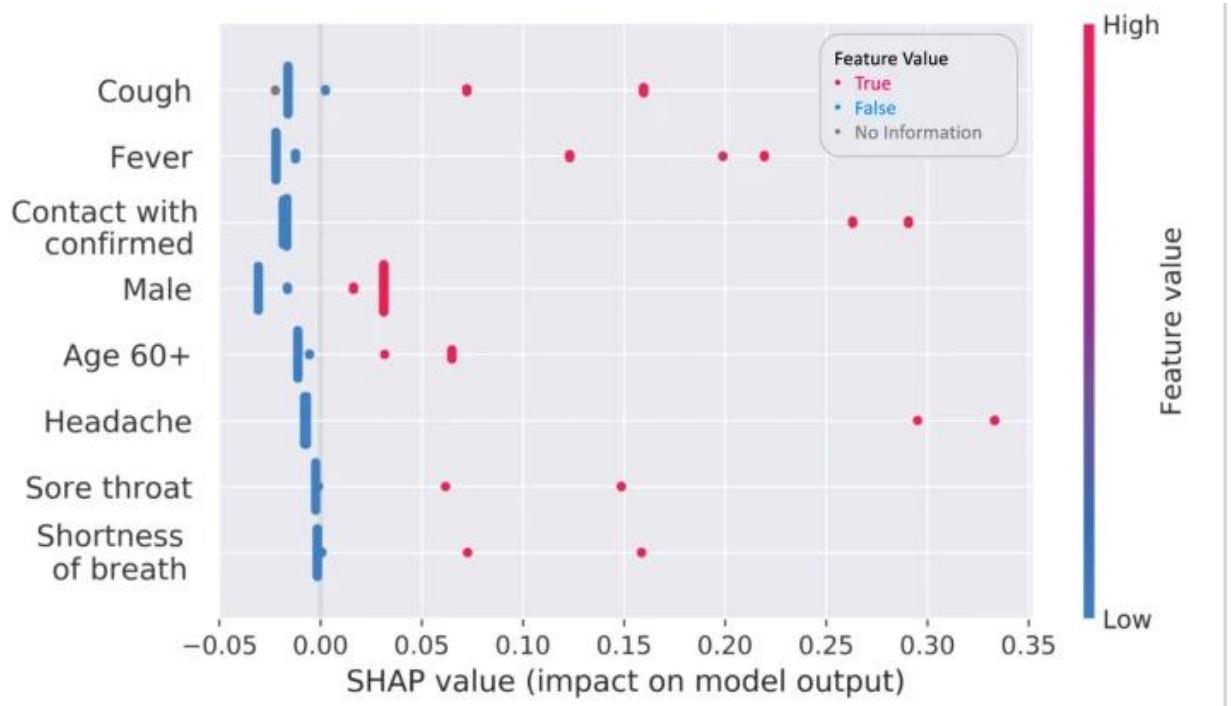

Figure 1: Model Performance (Source: https://www.nature.net/)

According to Kollias et al 2022 Medical imaging helps to reveal the internal structure of the human body. It helps to know the activity of the body parts. CNN is used in machine learning as an image classifier. The CNN uses the CT scan images to predict non covid and covid cases. In this study the author discussed some 3-D ResNet model to detect the covid. The deep learning model plays an important role to predict the covid cases. Deep learning helps to drive medical devices automatically. Deep learning has the ability to detect objects. Deep learning is used during covid 19 as an image recognizer. It helps to CT scan images of the covid patient. The machine learning approach helps to predict the risk factors of covid-19. Fever and cough are the main symptoms covid (Kollias*et al.* 2022). Machine learning approaches help to predict these symptoms in the human body. There are various algorithms which are used in machine learning that play an important role for prediction. KNN regression is used in machine learning. The KNN is used in machine learning as a classifier. The ML is the subset of AI technology. It helps to solve complex problems and makes human life sophisticated. The KNN algorithm is used during the covid to predict the outcome possibilities of the patient and helps to know the possibilities of recovery. In the CT scan X Ray is used. The "Deep neural networks'' is used to solve the medical imaging problem. Deep learning is used in the Chabot which helps to identify patterns in patient symptoms. During the covid 19 ANN plays an important role. ANN was widely used all over the world during that time. The ANN is used for different purposes. The purposes are diagnosis, "medical image analysis", "electronics signal analysis" etc.

According to Nacir*iet al* 2022, the authors have used 337 test data of positive patients with covid-19 and they have the objective to predict the severity of the covid-19 based on severity. The test data was grouped together based on severity for the study. Both the non-biological and biological information were collected for the research purpose (Singh *et al* 2020). The

eISSN 1303-5150

SVM, ANN, KNN and other logistic regressions have been popularly used in the prediction of severity. Artificial intelligence can successfully predict where the virus can attack in the future. This would successfully help the doctors to diagnose the patients.

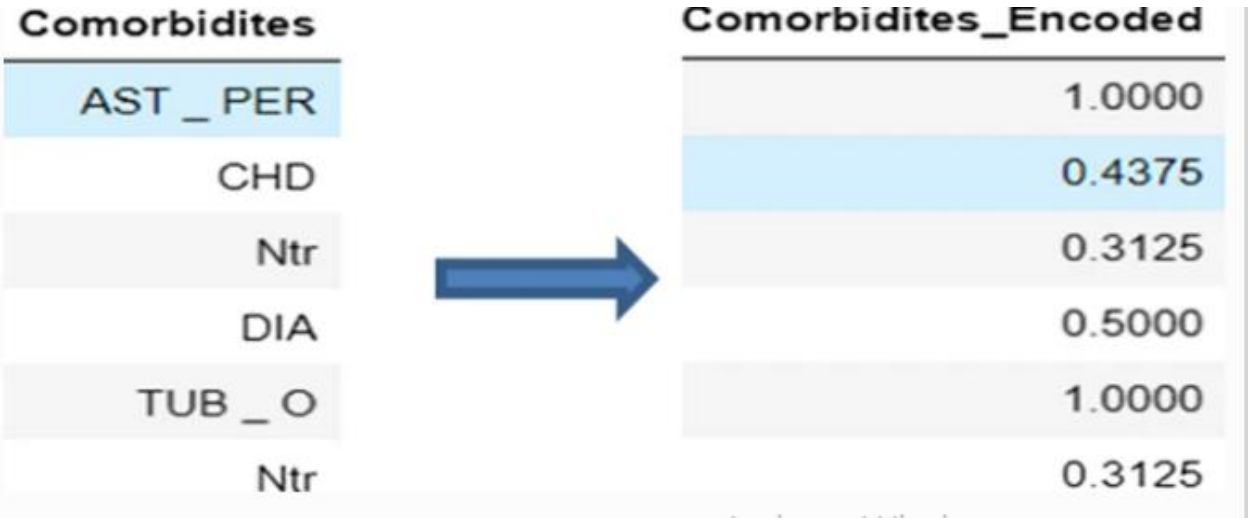

Figure 2: Encoding Features (Source: https://journalofbigdata.springeropen.net/)

The figure is implying the features before the encoding and after the encoding. After the analysis the authors have found that based on the dataset 54 % of male are in the severe category and 37.58 % of females are in the severe category. The collected data set was processed by eliminating the values that are missing and encoding with some categorical attribute. Some of the information had missing attributes due to error of data, inability of data collection etc. (Navlakha *et al* 2021) The missing value would have changed the result of the model and this is the reason why those were replaced with estimated values. However, this could also change the result as the medical records vary from person to person. The authors have completely eliminated the patient data which were incomplete.

According to Singh *et al* 2021, the covid-19 pandemic has burdened the doctors significantly while diagnosing the patients. The authors have the purpose to establish a model which would give a practical system to predict the severity of persons with covid-19. The authors have used an AI based network and collected 8427 test patient data for the research process. The covid-19 can distress the patient from fever and severe respiratory problems. A DNN trained model was used for the research purpose. All the patient information was divided into two categories, those were training data and test data into 2 : 1 ratio. This was done to avoid the bias.

Based on this flowchart the authors have established the model. The authors have categorized the severity ranges into 4 categories (Nuthalapati*et al.* 2022). The level 0 patients do not have any respiratory problems. The levels are in severe distress and chances of mortality are low. The authors have used their model on the test data and they have also used that model in a separate covid-19 data. The model independently predicted the severity of the covid-19 for the patients.

eISSN 1303-5150

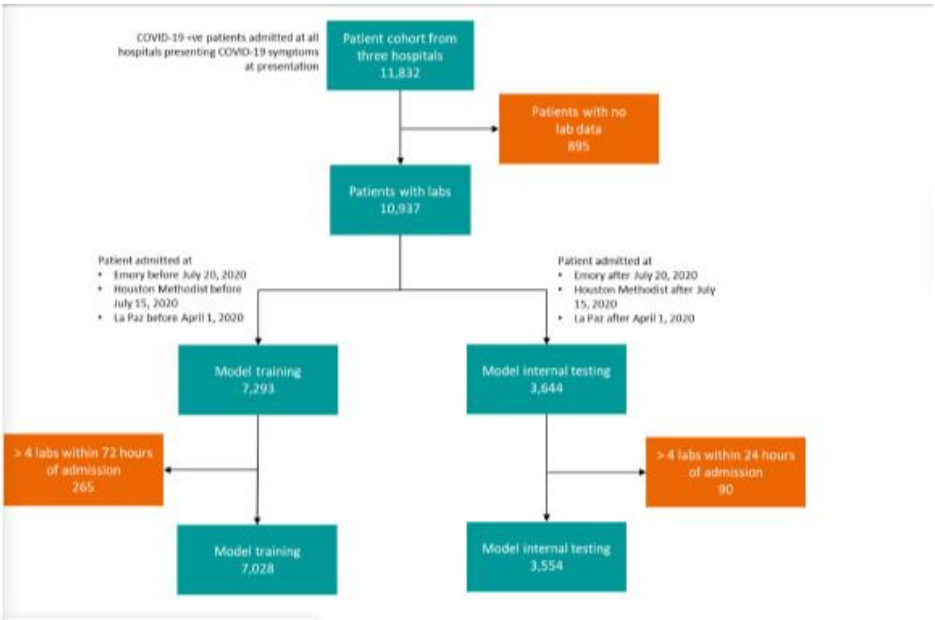

Figure 3: Consort Diagram for the Study (Source: https://www.sciencedirect.com/)

Literature Gap

The researchers have proposed models for predicting severity of covid-19 based on symptoms. They have proposed their models but there were some limitations and shortcomings of the research papers. The authors have not provided a suitable solution for missing information as they have completely discarded those samples. They have acknowledged those shortcomings but could not provide proper solutions. The models are not suitable for biased conditions. They also have not relied on severe conditions or symptoms for their research process. The symptom differences with various samples also provided different results and this was a major limitation of the research processes.

3.0 Problem Statement

Selection of methodology was one of the most significant stages of the whole research process. It has been established that the weka tool was used for developing the model. KNN, SVM etc. models were used for the research (Portugal *et al.* 2022). In this section the method of data selection and analysis will be discussed. The schedule management for the research process will also be discussed in this section.

4.0 Theories and Models

This is one of the most important sections of the whole research process as in here the models of machine learning will be discussed in-depth.

ANN Model

Ann is a machine learning model which is developed based on the neurons of the human brain. This is a part of AI which has the purpose to mimic the human brain so that machines can make decisions like human beings. ANN primarily has three layers (Kumar *et al*. 2022). The input layer, hidden layer, and input layer.

eISSN 1303-5150

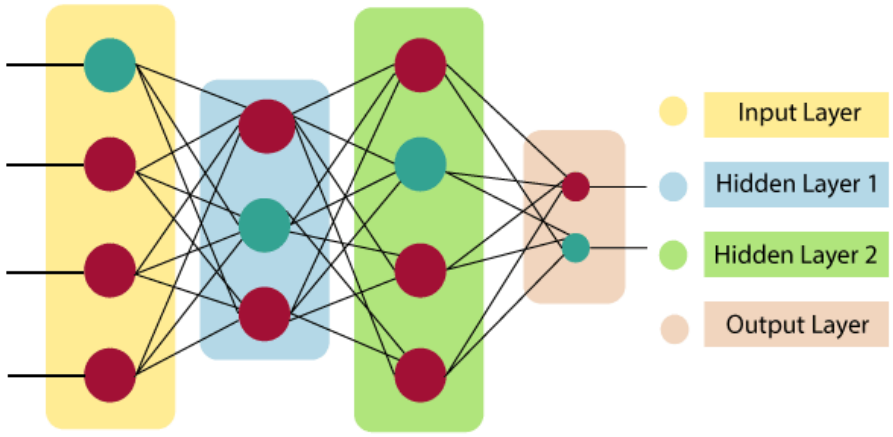

Figure 4: ANN Layers (Source: https://www.javatpoint.net/)

The input layer accepts the human input while the output layer shows the output to the human. The input goes through the required transformations in the hidden layers. All the layers are internally connected with each other. ANN can be popularly used in the voice search and medical field. ANN can also be categorized into two categories: Feedback and Feed-Forward ANN. In the feedback type of ANN the output is fed back to the network (Khan *et al.* 2022).This optimizes the predicted result. The Feed-Forward is the most common type of ANN which is constructed of input, output, and hidden layer.

RNN Model

RNN is a sequential model of deep learning which is popularly used in AI. It was developed in the 1980's as part of the statistical models. In this model each and every element is assigned the same weightage (Douzi*et al* 2022). As neural networks have the purpose to copy the activity of the human brains, this signifies that all the nodes in the model are connected with each other. Like ANN models, RNN models can also be divided into three layers. Both the Input, output, and hidden layer are independent. It has the memory which has the role to save all the calculations inside the hidden layers.

SVM Model

SVM model is a model which can be used in the classification and regression models. This model has the purpose to create a boundary for decision in the n-dimensional space. Based on this functionality, future data points can be put in the right space. This means the future can be predicted using this model based on the test data. The most optimum boundary of decision is known as hyperplane.

eISSN 1303-5150

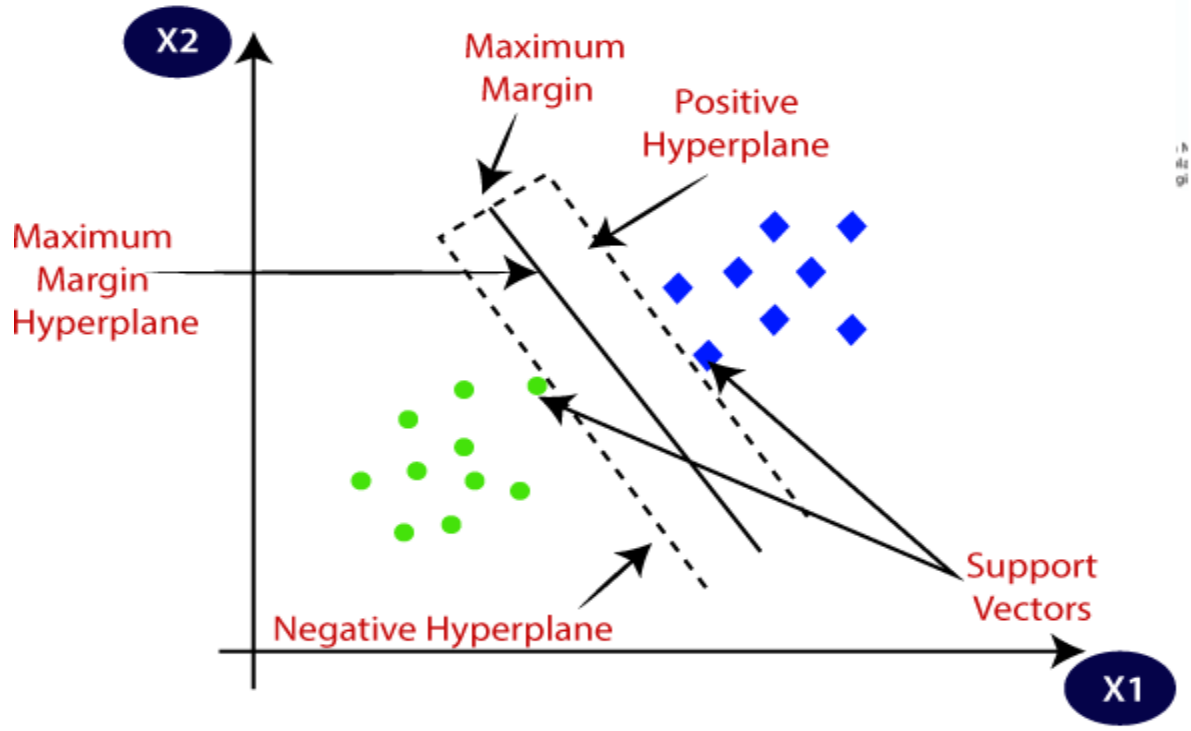

Figure 5: SVM Model graph(Source: https://www.javatpoint.com/)

SVM can be categorized into two types: linear SVM and non-linear SVM. The linear SVM is used for the data which can be linearly separable (Nassif *et al.* 2022). The non-linear SVM data is used for the non-linear data. SVM is popularly used in various real-life scenarios including facial expression, classification of tests, recognition of speech etc.

After the development of the model the test was performed accordingly. This model has the purpose to create a boundary for decision in the n-dimensional space. Based on this functionality, future data points can be put in the right space.

5.0 System Architecture

The methodology that was used for the research process has been described. Mixed method of data collection was used for the research processes. The secondary data was collected from reliable sources for this research process. Kaggle website was used to collect the test data regarding the covid-19 patients. The data analysis was done on the weka tool using various machine learning models.

This section of the project has a brief discussion of the future scope of machine learning. It is important for the designer to utilize proper data collection methods. This also makes it easier for the users to use the machines (Xiang *et al* 2020). They also implemented the ML application of COVID-19 which provides innovative ways to develop machine learning. In recent times, it has also enabled machine learning in this COVID-19 situation. The designer must be able to explore the additional clinical information of CXR images and make improvement of prediction performance.

Data Collection Methods

To conclude, the research had the objective to develop a model using machine learning to predict the severity of the diseases based on patient symptoms. In the past few years machine learning models have been

eISSN 1303-5150

successfully used to accurately detect the covid-19. However, the researchers have started to use machine learning to detect the severity of covid-19. The test data was collected from the Kaggle website and the weka tool was used for the analysis. The researchers have emphasized on collecting unbiased test data for the best results. Secondary data was collected for the research process and a mixed method of data collection was also used for the research process. Mixed method of data collection was used for the research process. This means both the qualitative data and quantitative data were collected (Painuli*et al* 2020). The test data was one of the most crucial parts of the whole research process and that was collected from the Kaggle website. As it has been established from the literature review that test data has been crucial in the machine learning study and missing data would change the result of the model. "Covid-19 symptoms checker" is the area in the website to be the most authentic data for this research purpose. For the theoretical study, google scholar was used to collect the journals and only the famous and relevant journals were studied before the research process. "Mean encoding target is a method of substituting a category value with the target variable mean". This mean encoding also determines the target variable which depends on every value of the feature (Blagojević*et al.* 2022). In the case of this machine learning the designers also use the ML application. This ML application is essential for COVID-19 and successfully applied in numerous fields (Yan *et al,* 2020). The application of ML in health care also improves the diagnosis, prognosis, monitoring and administration of treatment. The Ml application also increases the patients' health outcome. There are some authentic machine learning applications that are able to control the Covid-19 issues and handlings. ML application helps the diagnosis process of COVID-19 and mortality risk prediction. The current ML application technique is able to detect the RT-PCR test. Automated image analysis due to deep learning has great potential to optimize the role of CXR images for fast diagnosis in terms of COVID-19. "The high-quality data collection of CXT images also contains 76 positive and 26 negative PA views".These are the data that also helps to know about machine learning procedures in disease prediction with severity.The author is able to detect the processes that are conducted on machine learning. The designer also uses the re-sampling methods to recollect all the data which are associated with the machine learning.

6.0 Analysis Methods

Secondary analysis of data was done in the research process. This means the data was collected from the reputed journals and then analysis was made. Weka tool was used for establishing the machine learning model and analysis was done according to the result. While developing the model ANN and SVM models of machine learning were used (Wang *et al.* 2022). After the completion of the model, the training data was used to test the developed model. After the testing was done the model was finalized. A decision tree is defined as an algorithm that is able to produce a model which is based on the tree structure. The decision tree also describes the relationship between attributes and a class of labels. Random forest or RF is a method that can enable multiple trees with the help of re-sampling process. There are a lot of DTs that are conducted with the re-sampling. The nodes of the tree are split using a subset of the attributes. On the other hand, the Gradient-boosted DT(GBDT) is one of the essential methods in terms of machine learning (Hatmal*et al,* 202 1). In recent times, to examine the COVID-19 situation, this GBDT is applicable. In each iteration of GBDT, the trees are improved on the basis of its performance. The artificial neural network also plays a key

eISSN 1303-5150

role in terms of machine learning with network layers. Theauthoralso utilizes the data visualization method in terms of machine learning. Data visualization is also able to detect certain biomarkers. These biomarkers are also able to associate with the viral infection. The infrastructure alsosimplifies and re adapting. “The route of infection also takes place and causes a significant inflammatory reaction”. The high-quality data collection of CXT images also contains 76 positive PA views. This data set also helps to know about machine learning. The designer is able to detect the issues that are conducted on machine learning.

7.0 Discussion

This section of the project has briefly described the various kinds of journals and discussion about COVID-19 with the impact of machine learning. Different kinds of research efforts also provide a prediction of COVID-19. This prediction is also classified into statistical and data analysis methods The experimental result for a different statistical and mathematical model also provides poor predictions. The data analysis is also based on different and previous data and does not consider external factors. This external factor also spreads infection in the population and median age. The paper also demonstrates the technique of ML application in terms of machine learning. ML application is able to manage the novel COVID-19 crisis and also faced several problems with the complex of decision making (Chen *et al,* 2020). This ML application method is used for COVID-19 diagnosis to prevent severity and mortality risk. This ML application is alsoable to follow the XGBoost, SVM. These models are applicable in reported diagnostics in terms of machine learning. ML applications also focus on clinical and laboratory data. It is also important to compare the Chi-square set to create a mutual information set and this is also based on PLR and LDH which are respectively platelet Lymphocyte ratio and lactate dehydrogenase.On the other hand, Ml application with UMAP are also capable of producing the best outcomes with three main components.

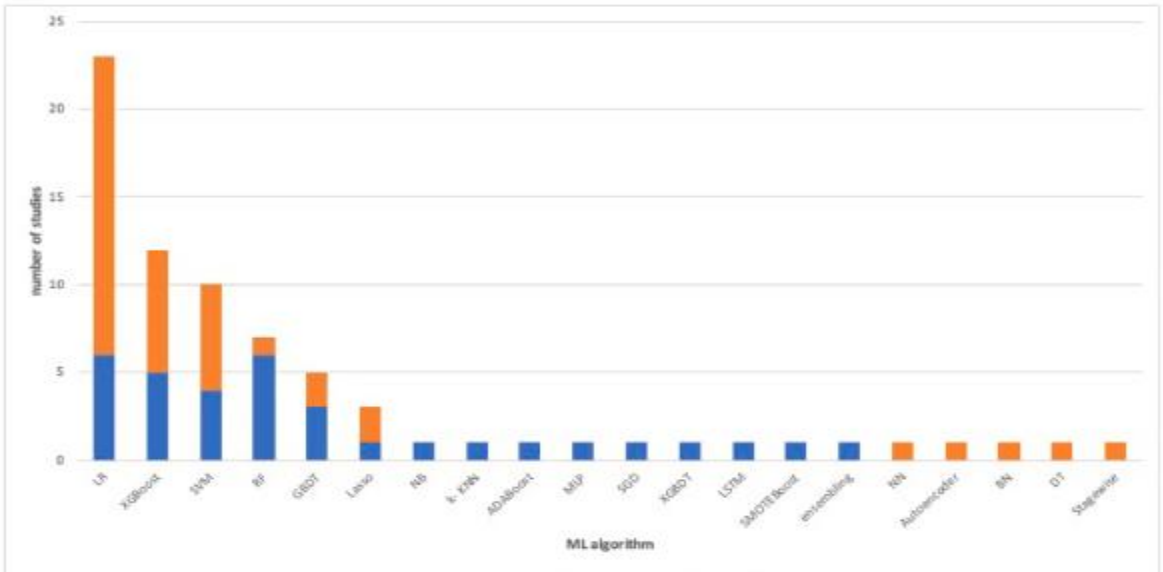

Figure 6: ML algorithm(Source: https://www.sciencedirect.com)

eISSN 1303-5150

8.0 Result

This section of the project briefly described the outcome of various applications which are associated with machine learning. The result also indicates an under-representation in the laboratory in terms of COVID-19. This also includes the limitation of numbers which are based on microbiology of COVID-19. This also includes pathogenesis and transmission. Theauthormust be capable of choosing the UMAP to create better results in terms of machine learning. This UMAP is a reduction method that provides help to extract the embedding features. This also helps to compare the result of the state of COVID-19 and risk prediction models (Kolliaset *al,* 2022). These models are applicable in reported diagnostics in terms of machine learning. ML applications also focus on clinical and laboratory data. It is also important to compare the Chi-square set to create a mutual information set. Machine learning also faced several troubles with severity of COVID-19 (Casiraghi *et al,* 2021). These applications also generate the best result of 96.98% in terms of machine learning. The result of accuracy rate is 96.21% and the result of DL is 94.73% in UMAP.

Time Horizon

	Name	Duration	Start	Finish	Predecessors
1	Initiation of Research	1 day	5/3/22 8:00 AM	5/3/22 5:00 PM	
2	Identification of Resources	2 days	5/4/22 8:00 AM	5/5/22 5:00 PM	1
3	Analysis of literature	3 days	5/6/22 8:00 AM	5/10/22 5:00 PM	2
4	Selection of Data	3 days	5/11/22 8:00 AM	5/13/22 5:00 PM	3
5	Selection of Approach	2 days	5/16/22 8:00 AM	5/17/22 5:00 PM	4
6	Sampling of journals	2 days	5/18/22 8:00 AM	5/19/22 5:00 PM	5
7	Data analysis technique	4 days	5/20/22 8:00 AM	5/25/22 5:00 PM	6
8	Analysis of Data	6 days	5/26/22 8:00 AM	6/2/22 5:00 PM	7
9	Identification of Ethics	1 day	6/3/22 8:00 AM	6/3/22 5:00 PM	8
10	Implementation of the design	2 days	6/6/22 8:00 AM	6/7/22 5:00 PM	9
11	Discussion on Results	2 days	6/8/22 8:00 AM	6/9/22 5:00 PM	10
12	Analysis of Findings	5 days	6/10/22 8:00 AM	6/16/22 5:00 PM	11
13	Limitaion	1 day	6/17/22 8:00 AM	6/17/22 5:00 PM	12
14	Identification of Fututre scope	1 day	6/20/22 8:00 AM	6/20/22 5:00 PM	13
15	Conclusion and Project closure	1 day	6/21/22 8:00 AM	6/21/22 5:00 PM	14

(Source: Project Libra)

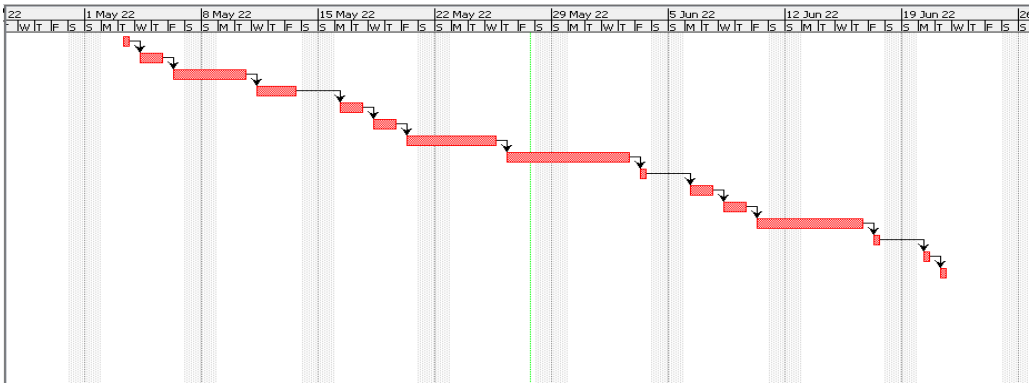

Figure 8: Gantt chart (Source: Project Libra)

eISSN 1303-5150

Reference

[1]. Aktar, S., Ahamad, M., Rashed-Al-Mahfuz, M., Azad, A.K.M., Uddin, S., Kamal, A.H.M., Alyami, S.A., Lin, P.I., Islam, S.M.S., Quinn, J.M. and Eapen, V., 2020. Predicting patient COVID-19 disease severity by means of statistical and machine learning analysis of blood cell transcriptome data. *arXiv preprint arXiv:2011.10657*.

[2]. Al Jameel, S.S., Khan, I.U., Aslam, N., Aljabri, M. and Alsulmi, E.S., 2021. Machine learning-based model to predict the disease severity and outcome in COVID-19 patients. *Scientific programming*, *2021*.

[3]. Alotaibi, A., Shiblee, M. and Alshahrani, A., 2021. Prediction of severity of COVID-19-infected patients using machine learning techniques. *Computers*, *10*(3), p.31.

[4]. Blagojević, A., Šušteršič, T., Lorencin, I., Šegota, S.B., Anđelić, N., Milovanović, D., Baskić, D., Car, Z. and Filipović, N., ANALYSIS OF COVID-19 DISEASE USING MACHINE LEARNING-PERSONALIZED MODEL.

[5]. Casiraghi, E., Malchiodi, D., Trucco, G., Frasca, M., Cappelletti, L., Fontana, T., Esposito, A.A., Avola, E., Jachetti, A., Reese, J. and Rizzi, A., 2020. Explainable machine learning for early assessment of COVID-19 risk prediction in emergency departments. *Ieee Access*, *8*, pp.196299-196325.

[6]. Chadaga, K., Prabhu, S., Umakanth, S., Bhat, K., Sampathila, N. and Chadaga, R., 2021. COVID-19 mortality prediction among patients using epidemiological parameters: an ensemble machine learning approach. *Engineered Science*, *16*, pp.221-233.

[7]. Chen, Y., Ouyang, L., Bao, F.S., Li, Q., Han, L., Zhu, B., Xu, M., Liu, J., Ge, Y. and Chen, S., 2020. An interpretable machine learning framework for accurate severe vs non-severe covid-19 clinical type classification. *medRx*.

[8]. Guan, X., Zhang, B., Fu, M., Li, M., Yuan, X., Zhu, Y., Peng, J., Guo, H. and Lu, Y., 2021. Clinical and inflammatory features-based machine learning model for fatal risk prediction of hospitalized COVID-19 patients: results from a retrospective cohort study. *Annals of Medicine*, *53*(1), pp.257-266.

[9]. Hatmal, M.M.M., Al-Hatamleh, M.A., Olaimat, A.N., Hatmal, M., Alhaj-Qasem, D.M., Olaimat, T.M. and Mohamud, R., 2021. Side effects and perceptions following COVID-19 vaccination in Jordan: a randomized, cross-sectional study implementing machine learning for predicting severity of side effects. *Vaccines*, *9*(6), p.556.

[10]. Hu, C., Liu, Z., Jiang, Y., Shi, O., Zhang, X., Xu, K., Suo, C., Wang, Q., Song, Y., Yu, K. and Mao, X., 2020. Early prediction of mortality risk among patients with severe COVID-19, using machine learning. *International Journal of Epidemiology*, *49*(6), pp.1918-1929.

[11]. Hu, C., Liu, Z., Jiang, Y., Zhang, X., Shi, O., Xu, K., Suo, C., Wang, Q., Song, Y., Yu, K. and Mao, X., 2020. Early prediction of mortality risk among severe COVID-19 patients using machine learning. *MedRxiv*.

[12]. Kenneth, C.Y., Xiang, Y. and So, H.C., 2021. Uncovering clinical risk factors and prediction of severe COVID-19: A

eISSN 1303-5150

machine learning approach based on UK Biobank data. *MedRxiv*, pp.2020-09.

[13]. Khan, A., Khan, S.H., Saif, M., Batool, A., Sohail, A. and Khan, M.W., 2022. A Survey of Deep Learning Techniques for the Analysis of COVID-19 and their Usability for Detecting Omicron. *arXiv preprint arXiv:2202.06372*.

[14]. Kollias, D., Arsenos, A. and Kollias, S., 2022. Ai-mia: Covid-19 detection & severity analysis through medical imaging. *arXiv preprint arXiv:2206.04732*.

[15]. Kollias, D., Arsenos, A. and Kollias, S., 2022. Ai-mia: Covid-19 detection & severity analysis through medical imaging. *arXiv preprint arXiv:2206.04732*.

[16]. Kumar, M.J., Santhosh, G., Niranjajn, P. and Manasa, G.R., 2022. A Review on Effectiveness of AI and ML Techniques for Classification of COVID-19 Medical Images. *Recent Advances in Artificial Intelligence and Data Engineering*, pp.171-179.

[17]. Laatifi, M., Douzi, S., Bouklouz, A., Ezzine, H., Jaafari, J., Zaid, Y., El Ouahidi, B. and Naciri, M., 2022. Machine learning approaches in Covid-19 severity risk prediction in Morocco. *Journal of big Data*, *9*(1), pp.1-21.

[18]. Mueller, Y.M., Schrama, T.J., Ruijten, R., Schreurs, M.W., Grashof, D.G., van de Werken, H.J., Lasinio, G.J., Álvarez-Sierra, D., Kiernan, C.H., Castro Eiro, M.D. and van Meurs, M., 2022. Stratification of hospitalized COVID-19 patients into clinical severity progression groups by immuno-phenotyping and machine learning. *Nature communications*, *13*(1), pp.1-13.

[19]. Nassif, A.B., Shahin, I., Bader, M., Hassan, A. and Werghi, N., 2022. COVID-19 detection systems using deep-learning algorithms based on speech and image data. *Mathematics*, *10*(4), p.564.

[20]. Navlakha, S., Morjaria, S., Perez-Johnston, R., Zhang, A. and Taur, Y., 2021. Projecting COVID-19 disease severity in cancer patients using purposefully-designed machine learning. *BMC infectious diseases*, *21*(1), pp.1-8.

[21]. Nuthalapati, S.V., Vizcaychipi, M., Shah, P., Chudzik, P., Leow, C.H., Yousefi, P., Selim, A., Tait, K. and Irving, B., 2022. Using Deep Learning-based Features Extracted from CT scans to Predict Outcomes in COVID-19 Patients. *arXiv preprint arXiv:2205.05009*.

[22]. Painuli, D., Mishra, D., Bhardwaj, S. and Aggarwal, M., 2021. Forecast and prediction of COVID-19 using machine learning. In *Data Science for COVID-19* (pp. 381-397). Academic Press.

[23]. Portugal, L.C., Gama, C.M.F., Gonçalves, R.M., Mendlowicz, M.V., Erthal, F.S., Mocaiber, I., Tsirlis, K., Volchan, E., David, I.A., Pereira, M.G. and Oliveira, L.D., 2022. Vulnerability and Protective Factors for PTSD and Depression Symptoms Among Healthcare Workers During COVID-19: A Machine Learning Approach. *Frontiers in psychiatry*, *12*, p.752870.

[24]. Singh, V., Kamaleswaran, R., Chalfin, D., Buño-Soto, A., San Roman, J., Rojas-Kenney, E., Molinaro, R., von Sengbusch, S., Hodjat, P., Comaniciu, D. and Kamen, A., 2021. A deep learning approach for predicting severity of COVID-19 patients using a

eISSN 1303-5150

parsimonious set of laboratory markers. *Iscience*, *24*(12), p.103523.

[25]. Sun, C., Bai, Y., Chen, D., He, L., Zhu, J., Ding, X., Luo, L., Ren, Y., Xing, H., Jin, X. and Chen, G., 2021. Accurate classification of COVID-19 patients with different severity via machine learning. *Clinical and translational medicine*, *11*(3).

[26]. Wang, J., Yang, X., Zhou, B., Sohn, J.J., Zhou, J., Jacob, J.T., Higgins, K.A., Bradley, J.D. and Liu, T., 2022. Review of Machine Learning in Lung Ultrasound in COVID-19 Pandemic. *Journal of Imaging*, *8*(3), p.65.

[27]. Yan, L., Zhang, H.T., Goncalves, J., Xiao, Y., Wang, M., Guo, Y., Sun, C., Tang, X., Jin, L., Zhang, M. and Huang, X., 2020. A machine learning-based model for survival prediction in patients with severe COVID-19 infection. *MedRxiv*.

[28]. Yan, L., Zhang, H.T., Xiao, Y., Wang, M., Sun, C., Liang, J., Li, S., Zhang, M., Guo, Y., Xiao, Y. and Tang, X., 2020. Prediction of criticality in patients with severe Covid-19 infection using three clinical features: a machine learning-based prognostic model with clinical data in Wuhan. *MedRxiv*, *27*, p.2020.

[29]. Yan, L., Zhang, H.T., Xiao, Y., Wang, M., Sun, C., Liang, J., Li, S., Zhang, M., Guo, Y., Xiao, Y. and Tang, X., 2020. Prediction of criticality in patients with severe Covid-19 infection using three clinical features: a machine learning-based prognostic model with clinical data in Wuhan. *MedRxiv*, *27*, p.2020.

[30]. Yan, L., Zhang, H.T., Xiao, Y., Wang, M., Sun, C., Liang, J., Li, S., Zhang, M., Guo, Y., Xiao, Y. and Tang, X., 2020. Prediction of survival for severe Covid-19 patients with three clinical features: development of a machine learning-based prognostic model with clinical data in Wuhan. *medRxiv*.

[31]. Zandehshahvar, M., van Assen, M., Maleki, H., Kiarashi, Y., De Cecco, C.N. and Adibi, A., 2021. Toward understanding COVID-19 pneumonia: A deep-learning-based approach for severity analysis and monitoring the disease. *Scientific Reports*, *11*(1), pp.1-10.

[32]. Zoabi, Y., Deri-Rozov, S. and Shomron, N., 2021. Machine learning-based prediction of COVID-19 diagnosis based on symptoms. *npj digital medicine*, *4*(1), pp.1-5.

eISSN 1303-5150