Journal of Theoretical and Applied Information Technology
31st July 2022. Vol.100. No 14

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

CNN-GRU-BASED HYBRID APPROACH FOR COVID-19 DETECTION THROUGH CHEST X-RAY IMAGES

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ABSTRACT

All intelligent devices using the current world generate a massive amount of data every day. Medical field also facing challenges to classify large datasets to trace out disease cause. Automatic disease detection frame work is suitable to the current world. Programmed discovery of disease has now become an important problem in clinical science as a result of rapid population growth. A programmed location of the disease structure helps professionals identify infections and provides accurate, predictable and rapid results and reduces the rate of passage. Covid (Coronavirus) has probably had the latest and most intense illnesses and has spread all around the world. As the quickest indicative alternative, a mechanized recognition framework should therefore be used to prevent the spread of coronavirus. Coronavirus disease (COVID-19) is a contagious infection caused by a newly identified coronavirus. Automatic Disease Identification is still challenging thing at present situation. COVID-19 outbreak is the most recent risk to global health. There are currently only few COVID-19 collection is available for protecting privacy, while large data sets for CXRs are available. COVID-19 biomedical papers are growing rapidly at the same time, including reports on radiological findings. These massive data were easily identified using convolutional neural networks by classification and object identification. CNN is a popular technique for object recognition using different CNN algorithms. This paper proposes an amalgam of Deep Learning approach based on Convolutional Neural Network-CNN to extract features from Chest X-ray images, it also proposes Gated Recurrent Units GRU which can be used for the purpose of classification of Chest X-ray images. The results generated by our proposed model are as 0.94, 0.96, and 0.97 in terms of Precision. This model can aid the doctors to perform early detection of Covid-19 and makes world as Covid Free.

Keywords: *Covid-19, Detection, Chest X-ray image, Convolutional Neural Network, Gated Recurrent Units, Classification*

1. INTRODUCTION

Coronavirus is an extreme sickness issue where an enormous number of individuals lose their lives each day [1]. This sickness influences not just a solitary country, and surprisingly the entire world endured in view of this infection illness [2]. In the previous decade, a few sorts of infections like SARS, MERS, Influenza, and so forth came into the image, yet they represent a couple of days or few months [3]. Numerous researchers are chipping away at these sorts of infections, and not many of them are analysed because of the accessibility of immunizations arranged by them (i.e., Researchers or specialists). In right now, the entire world is influenced by Coronavirus illness, and the main thing is no single country researchers can set up an immunization for the equivalent [4]. In the interim, a lot more expectations came into an image like plasma treatment, X-ray pictures and some more, yet the specific arrangement of this ghastly infection isn't found [5]. Consistently, individuals lose their life due to Coronavirus and the symptomatic expense of this illness is high with regards to a nation. The patients'-X-ray pictures of solid individuals and Coronavirus tainted people groups were accessible online in various storehouses like GitHub, Kaggle for investigation [6]. Coronavirus is a scourge sickness that compromises people at a worldwide level and transformed into a pandemic [7]. To determine Coronavirus contaminated patients to have sound patients is a basic errand [8]. The dialysis of Coronavirus tainted patients' needs more safety measure and should be relieved under exceptionally exacting strategies to lessen the danger of patients

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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

unaffected with Coronavirus [9]. The epic Covid illness started things out as a throat contamination, and out of nowhere individuals confronted trouble in relaxing [10]. The Coronavirus sickness is a secret adversary where nobody is equipped for battling [11]. Contaminated patients of Coronavirus are needed to being separation, do legitimate screening, and take sufficient insurance with counteraction to ensure sound individuals [12]. This disease is following a chain cycle that moves starting with one individual then onto the next in the wake of interacting with Coronavirus contaminated people [13]. Clinic staff, attendants, specialists, and clinical offices assume a fundamental part in the conclusion of this scourge [14]. A lot more systems have been applied to diminish the effect of Coronavirus [15]. Clinical imaging is additionally a technique for investigating and foreseeing the impacts of Coronavirus on the human body [16]. In this, sound individuals and Coronavirus contaminated patients can be breaking down in corresponding with the assistance of chest X-ray pictures [17]. Revolutionary modifications have been made to the medical classification by applying for classification and the application of feature removal from Deep Learning algorithms by providing equal analytics to persons in medical photographs [18]. Medical anomalies have been extensively studied through the application of machine-based learning detection [19]. Corona virus disease was characterised as a fast-growing epidemic (COVID-19). Many COVID-19 infests have been discovered early on [20]. COVID-19 may be wrongly identified as pneumonia or cancer of the lung leading to death, due to rapidly spreading thoracic cells [21]. The most prevalent way to the detection of these three disorders are chest X-rays and computer tomography [22]. The impact of COVID-19 on people is different [23]. Most people with infection will experience mild to moderate symptoms and will recover without hospitalization [24]. The Figure-1 represents the Process workflow of classifying the Chest X-rays using deep learning. The Chest X-ray images are served as input to the model. The model then process the images splitting train and test categories initially using deep learning methods. The Neural network of the model classify the images to covid positive or negative depending the on the features extracted.

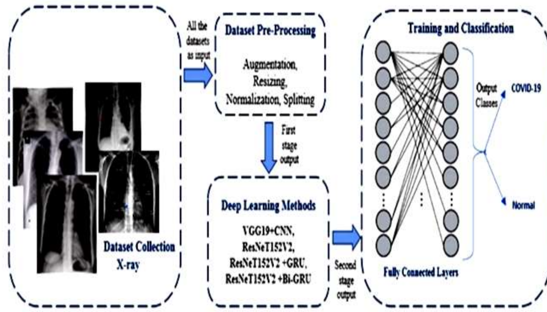

Fig-1 Overall Representation

2. LITERATURE STUDY

Deep learning algorithms have become prominent in the classification and recognition of all articles based on image technology. CNN may recognize Covid-19 automatically [32]. CT scans are used by radiologists to determine any detecting condition [33]. One of the key screening tools, one of the significant developments in the fight against coronavirus, is the strong radiographic tests of infected patients with chest [34]. Early studies found that patients have chest X-ray abnormalities that are frequent among coronaviral infections [35]. The table given below is a summary of the techniques used for detecting covid-19. Most of them are dependent on the Technique Machine Learning.

Table-1 Literature Summary Of Techniques Used For Covid-19

Sl.no	Title	Technique	Ref
1	Coronavirus disease (COVID-19) cases analysis using machine-learning applications	Machine Learning	[1]
2	Common pitfalls and recommendations for using machine learning to detect and prognosticate for COVID-19 using chest radiographs and CT scans	Machine Learning	[2]
3	Drawing insights from COVID-19-infected patients using CT scan images and machine learning techniques	Machine Learning	[20]
4	A novel comparative study for detection of Covid-19 on CT lung images using texture	Machine Learning and Deep Learning	[29]

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	analysis, machine learning, and deep learning methods		
5	A Novel Bayesian Optimization-Based Machine Learning Framework for COVID-19 Detection from Inpatient Facility Data	Machine Learning	[36]
6	COVID-CT-MD, COVID-19 computed tomography scan dataset applicable in machine learning and deep learning	Machine Learning and Deep Learning	[37]
7	A tailored deep convolutional neural network design for detection of COVID-19 cases from chest X-ray images	CNN	[38]

3. LIMITATIONS OF EXISTING WORK

Memory for Long Speed (LSTM) CNN LSTM is a profound, recurrent architecture of the neuro network (RNN). In contrast to common neural feedback networks, LSTM has feedback connections. Individual data points (e.g., images) cannot be managed only (such as speech or video). For example, LSTM applies to non-segmented handwriting, voicing connected or IDS detection (intrusion detection systems). A standard LSTM unit is comprised of a cell, an interior door, an exit door and a left door. In the event that you are inexperienced with Intermittent Neural Organizations, it suggests perusing my concise presentation. For a superior comprehension of LSTM, numerous individuals suggest Christopher Olah's article. This research would likewise add this paper which gives a reasonable qualification among GRU and LSTM.As referenced above, GRUs are improved adaptation of standard repetitive neural organization. In any case, what makes them so exceptional and powerful? The Table-2 is a list of Applications that uses GRU Technique in respective domains.

Table-2 Applications Of GRU

SNO	Application	Performance
1	Robo Monitoring	Excellent
2	Image Classification	Excellent
3	Pattern Recognition	Excellent
4	Drug Design	Excellent
5	Hand Written recognition	Excellent
6	Prediction of Medical Image cells	Outstanding
7	Anomaly Detection	Excellent

4. METHODOLOGY AND PROPOSED WORK

LSTM's probably give good results but **Gated Recurrent Units** (GRU) can give good performance when compared with LSTM's. The main difference between GRU and LSTM is that the GRU bag has two reset and refreshed portals while the LSTM has three inputs, output and forget gates. Because it has less gates, GRU is less complex than LSTM. GRU exposes the entire memory and covered layers, but does not expose LSTM. Recurring containers (RCs) in recurring neural networks are a gating mechanism. The GRU is like a long short-range storage (LSTM) gate with no output door, but less than LSTM. GRU performance was similar to that of LSTM with certain tasks of polyphonic musical modelling, voice signal modelling and natural language processing. GRUs have been shown to perform better on some smaller and less common datasets So in this paper CNN with **Gated Recurrent Units** is proposed to detect covid-19.

CNN, LSTM, GRU, OBJECT RECOGNITION:

A ton of examination has been going on in the field of AI and Profound Realizing which has made such countless new applications and one of them is Article Location. Item location looks simple from the front yet at the rear of the innovation, there are part numerous different things that have been going on, which makes the interaction of article identification conceivable. CNN, RNN, LSTM and GRU every one of them are utilized for the cycle of item identification so here let us see them in little detail and will likewise attempt to comprehend object discovery.

CNN:

In Deep Learning, Convolutional Neural Net (CNN) is a kind of a Fake Neural Organization. CNN or ConvNet is a class of profound, feed-forward counterfeit neural frameworks, most regularly associated with analyzing visual portrayals. The Fig-

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2 represents the feature identification of x-ray images using CNN.

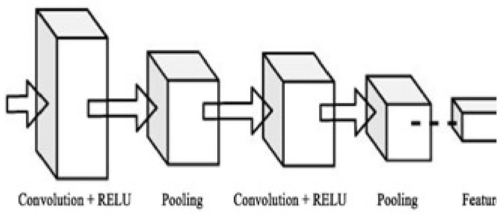

Fig-2 Cnn Architecture

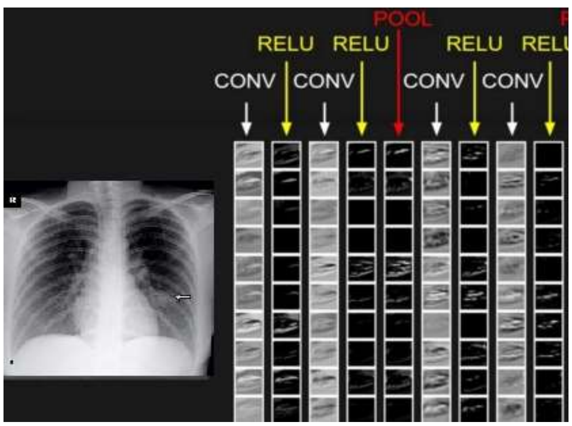

Fig-3 Cnn Covid-19 Detection

Fig-3 represents the process flow of processing the Chest X-ray image using CNN Architecture for detection of Covid positive or Covid Negative by classifying the features extracted from the Network. CNN is made up of layers, each of which converts one volume of enactments to another using a differentiable capacity. The three types of layers used to generate CNN models are Convolutional Layer, Pooling Layer, and Completely Associated Layer. Each layer is made up of a certain configuration of neurons, and each layer is related to the overall population of neurons in that layer. The information is three-dimensional because these layers are aligned in three dimensions: height, width, and depth. The Convolutional Layer is the core structure square of CNN since it performs the majority of the computing effort. Convolution is a numerical activity that uses two skills to create a new image, with one of them being the ability to remove highlights from the existing picture.

Model: This will utilize basic CNN for CIFAR-10 grouping which could have the engineering [INPUT — CONV — RELU — POOL — FC].

LSTM:

Memory for Long Speed (LSTM) CNN LSTM is a profound, recurrent architecture of the neuro network (RNN). In contrast to common neural feedback networks, LSTM has feedback connections. Individual data points (e.g., images) cannot be managed only (such as speech or video). For example, LSTM applies to non-segmented handwriting, voicing connected or IDS detection (intrusion detection systems). A standard LSTM unit is comprised of a cell, an interior door, an exit door and a left door.

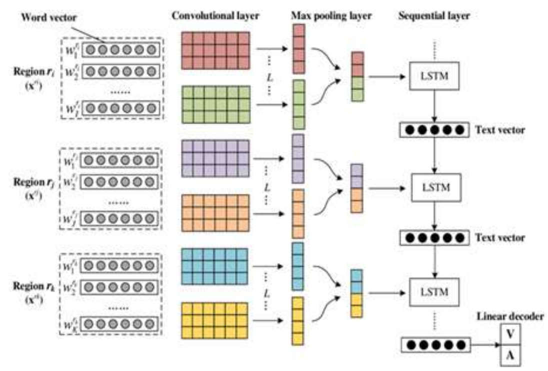

Fig-4 CNN Architecture With LSTM

In Figure-4, a combination strategy was used to automatically detect COVID-19 cases using of X-ray images. The CNN and LSTM networks were combined to form this architecture's structure, with the CNN retrieving complex features from images and the LSTM acting as a classifier's are an uncommon sort of RNN which is fit for learning long haul conditions. Because they can recall data for extended periods of time, LSTMs are designed to circumvent the problem of long-term reliance. RNNs have a problem with long-term reliance, as we all know that an RNN can go back and get data, or we can say that it can anticipate data, but only a few times out of every odd time because it is not always easy to foresee and at times they do require a setting to anticipate a specific word, for example, consider a language model attempting to predict the next word based on previous ones, on the off chance that research is attempting to predict the next word." fishes lives inside the water " then, at that point we further don't need any setting since clearly fishes live inside water and can't get by outside, yet with specific sentences you'll discover a hole and you will require a unique circumstance , suppose for the sentence " I was brought into the world in Britain and I'm conversant in English", here in this explanation it is required a setting as English is one of numerous dialects accessible and henceforth there may be an opportunity of hole here and as this hole becomes

RNN's can't learn and associate new data. Fortunately, LSTMS doesn't have these issues and that is the motivation behind why they are called as Long Momentary Memory. The LSTM units are the units of an Intermittent Neural Organization (RNN) and an RNN made out of LSTM units is regularly called as a LSTM Organization. A typical LSTM unit comprises of a cell express, an information entryway, a yield door and a neglect door. LSTMs likewise have chain-like design; however, the rehashing module has an alternate construction. Dataset: An informational index is an assortment of information. On account of plain information, an informational collection compares to at least one data set tables, where each section of a table addresses a specific variable, and each line relates to a given record of the informational GRU allegedly uses an enhanced door and a reset entry index to deal with the evaporation route of a typical RNN issue. These are, essentially, two vectors that select the returned data. It is surprising that information can be retained from time to time without being cleaned up or removed to meet their expectations. This research investigates a single unit using the recurring neural arrangement to understand the arithmetic behind this interaction:

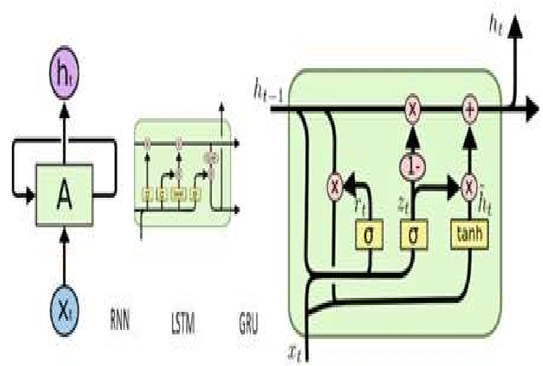

Fig-5 Recurrent Neural Network With Gated Recurrent Unit

In Figure-5 three types of neural networks RNN, LSTM and GRU are projected with their functionalities. Here is a more itemized rendition of that solitary GRU:

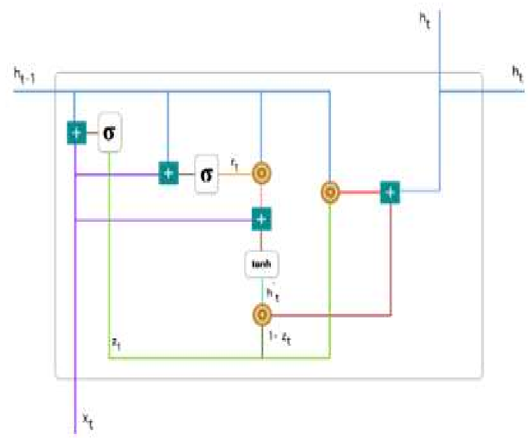

Fig-6 GRU With Notations

Various Notation mentioned in Figure-6 such as Plus operation, Sigmoid function, Hadamard operation and tanh function. Start with computing the update entryway z, t for time step t utilizing the recipe:

$$z_t = \sigma(W^{(z)}x_t + U^{(z)}h_{t-1}) \quad (1)$$

When x_t is attached, W is twice as large (z). The equivalent for the previous t-1 units is h (t-1) and their own weight U. (z). Both results are blended with a sigmoid task in order to generate results between 0 and 1. This research got the following pattern:

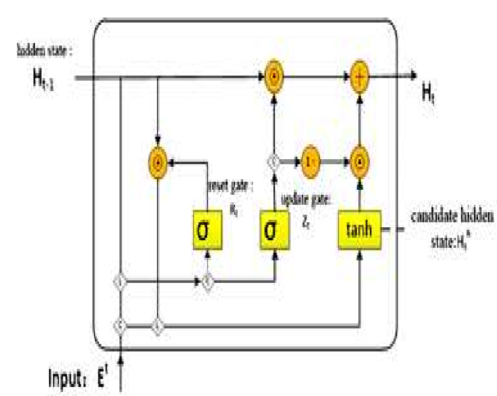

Fig-7 Updated And Reset GRU

Figure-7 is the updated door lets the model decide if the previous data will be supplied in future (from

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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

prior stages). This is simply magnificent because the model allows all previous data to be doubled and avoid evaporation risk. In future will learn how to use the update entry later. The equation for t should be remembered. The main purpose of this door is to collect the amount of information previously ignored in the model. It uses the following in order to find out:

$$r_t = \sigma(W^{(r)}x_t + U^{(r)}h_{t-1} \quad (2)$$

The same goes for the retrofitting door. It differs from the fees and usage of the single-piece entry. In the following diagram the reset input is shown:

GRU-CNN:

GRU-CNN is a new gated method, it is same as LSTM-CNN but it will be useful when our dataset is small. Unlike its competitors it has only two gates reset and update and also it hides information and transfers through hidden layer as shown in Figure: the following equations are training parameters of GRU

$$x(t) = Wvnv(t) + Bvm \quad (3)$$

Initially, for t=0 the output vector is h=0,

$$n(t) = \emptyset(Whn^{(t)} + Bhz + Wvzv(t) + Bvz) \quad (4)$$

The CARU has the same update gate as the GRU, but instead of a reset gate,

$$z(t) = \sigma(Whzh^{(t)} + Bhz + WvzV(t) + Bvz) \quad (5)$$

it has a content-adaptive gate.

$$l(t) = \sigma(xt)\odot z(t) \quad (6)$$

$$h^{(t+1)} = (1 - l(t))\odot h(t) + l(t)\odot n(t) \quad (7)$$

The goal of CARU was to address the issue of long-term reliance on RNN models. It was discovered that it outperforms the GRU on NLP tasks while having less parameters.

$$z1 = \sigma(Wzxt + Uzht - 1 + bz \quad (8)$$

Where xt is input vector and ht is output vector

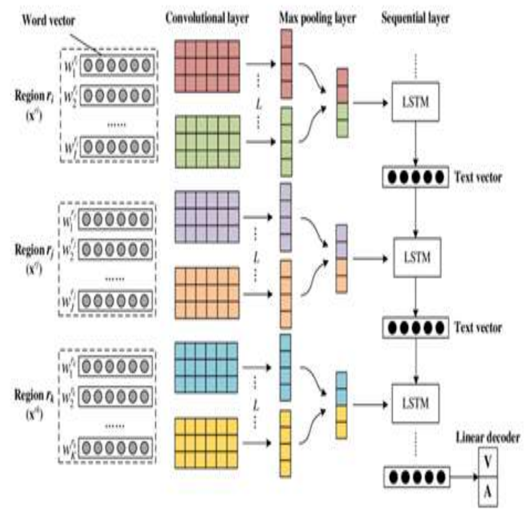

Fig-8 Cnn Architecture With Gru

Combining the gated recurrent unit (GRU) with convolutional neural networks yielded a GRU-CNN hybrid neural network model (CNN). Figure-8 is the Gated Recurrent Unit, which launched in 2014 with a novel gating mechanism, is a newer version of RNN. LSTM and GRU are comparable, although GRU has been found to perform better on smaller datasets. Unlike LSTM, GRU only has two gates: a reset and an update gate. There is no output gate.

The feature vector of time sequence data is extracted by the GRU module, whereas the feature vector of other high-dimensional data is extracted by the CNN module. The proposed model was tested in a real-world experiment, and among the BPNN, GRU, and CNN forecasting methods, the GRU-CNN model had the lowest mean absolute percentage error (MAPE) and root mean square error (RMSE); the proposed GRU-CNN model can better utilize data and achieve more accurate short-term load forecasting.

Dataset Generation

For this paper dataset are taken from various open-source resources like Kaggle with name Covid-19 X-ray image classification. It consists of 15,264 images for training and 400 images for testing consisting 10% of positive samples. This is standard dataset used for competition for covid19 cases classification from chest X-rays images. Below are the examples of positive and negative samples shown in Fig-9 Dataset samples.

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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

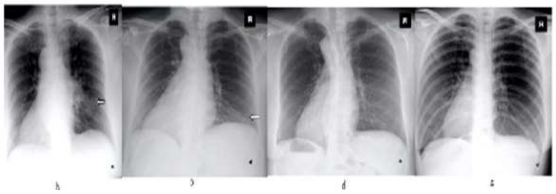
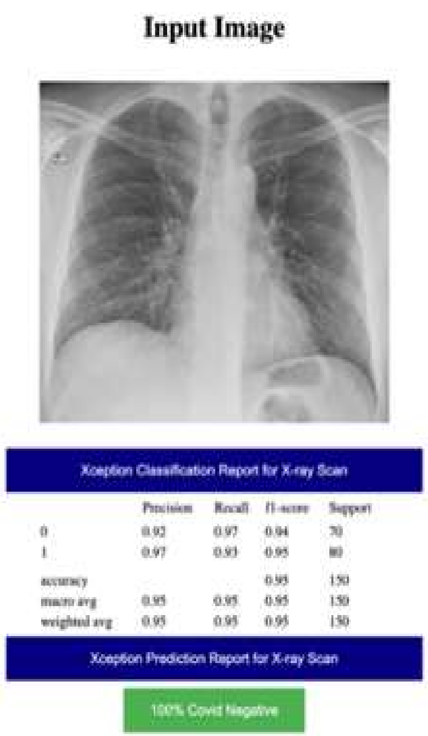


Fig-9 Dataset Samples

5. Results and Implementation

Patients with heart disease, obesity, hypertension, diabetes, and chronic renal disease were more likely to have positive chest X-ray findings. The mean serum albumin, white blood cell count, neutrophil count, and serum C-reactive protein all went up statistically.



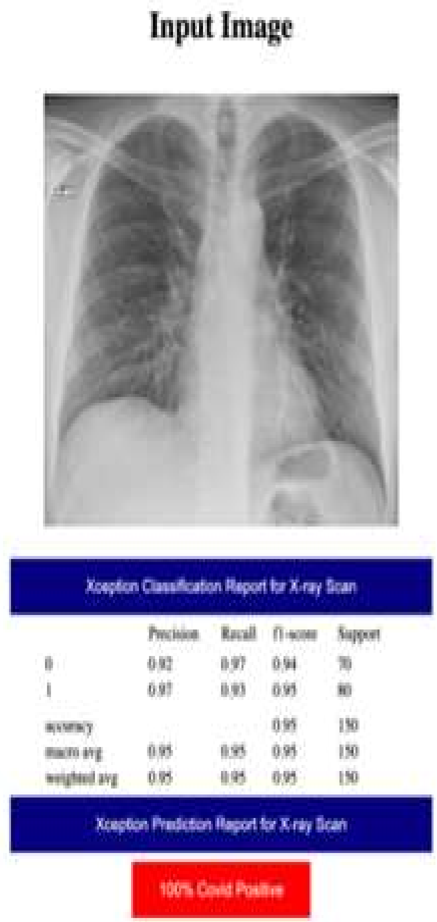


Fig.10: Covid Positive & Negative X-Ray Result

COVID-19 was validated by reverse transcription-polymerase chain reaction in these people who had chest radiography within 72 hours of the swab test. The gold standard for diagnosing COVID-19 was a positive reverse transcription-polymerase chain reaction result. In Figure-10 Chest radiography's sensitivity was calculated. The majority of the patients had opacities on both sides, with the opacities mostly appearing in the peripheral and lower lung zones. In certain cases, pleural effusion was discovered. Positive chest X-ray findings were connected to increased age, Southeast Asian nationality, fever, or a history of fever and diarrhea. A greater radiographic severity score was connected to the presence of liver enzymes and total bilirubin.

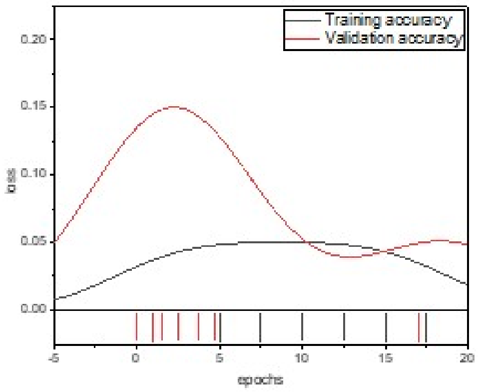


Fig 11: Training Loss

As the plot of accuracy history shows in figure-11, the train's accuracy increased rapidly after each era. The initial epoch's accuracy was 77 percent, and it improved with each epoch. The validation accuracy of the model was 94 percent, and it improved until the last epoch. On the model accuracy plot, an increasing line for training accuracy has been drawn, and a line for test accuracy has been drawn that is around the range of 94 percent –98 percent accuracy throughout the era.

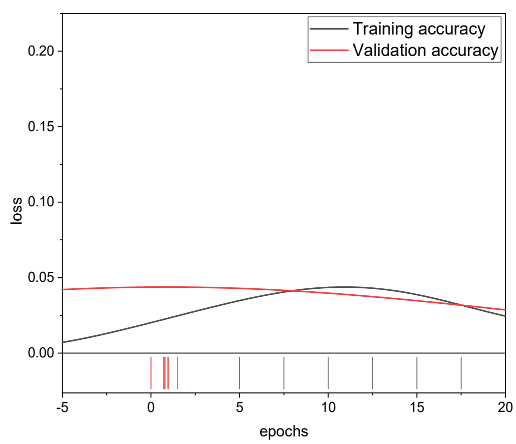


Fig 12: Training Accuracy

According to the model loss plot shown in figure-12, both the training and test loss lines have gradually decreased. After the first epoch, the train loss was 45 percent, and after ten epochs, it was just 7 percent. The validation loss had fallen to 9% after 10 epochs. Figure depicts the loss of the model. Table -3 is the various testing outcomes with GRU, CNN, GRU-CNN integrated values generated by the proposed system are tabulated for Training data.

Table-3 Comparison Evaluation Of Tests On Training Data

Test	GRU (%)	CNN (%)	GRU-CNN (%)
Test 1	5.0142	4.1974	4.1480
Test 2	5.8877	4.0290	2.5528
Test 3	5.9622	4.1971	2.8855
Test 4	5.5516	4.8850	2.8688
Test 5	5.7281	4.5980	2.9557
Test 6	5.6518	4.5102	4.0957
Test 7	5.7146	4.4682	2.8045
Test 8	5.6047	4.4271	2.8845
Test avg	5.6477	4.4890	2.8849

Other recent tests completed by other researchers were gathered and analyzed in order to compare the performance outcomes of the proposed CNN-based methodology for the current application domain a predicted values of CNN-GRU have been visualized in figure-13.

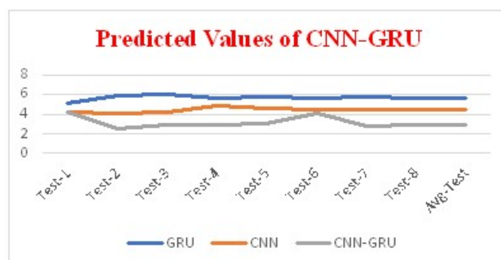


Fig 13: Predicted Training Values

A comparison of these scientific findings with the mythology used is shown in the table-3.

Table-4 Comparison Evaluation Of Tests On Testing Data

Test	GRU (%)	CNN (%)	GRU-CNN (%)
Test 1	2.7.0132	3.1973	3.1380
Test 2	2.7.8877	3.0290	2.2.72.728
Test 3	2.7.9622	3.1971	2.882.72.7
Test 4	2.7.2.72.716	3.882.70	2.8688
Test 5	2.7.7281	3.2.7980	2.92.72.77
Test 6	2.7.62.718	3.2.7102	3.092.77

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Test 7	2.7.7136	3.3682	2.8032.7
Test 8	2.7.6037	3.3271	2.8832.7
Test avg	2.7.6377	3.3890	2.8839

Several deep learning techniques can be applied to optimize the parameters and produce a reliable model that will benefit humanity. Table -4 is the various testing outcomes with GRU, CNN, GRU-CNN integrated values of testing data are generated by the proposed system are tabulated. In the future, the metaheuristic-based deep COVID-19 model could be a promising technique to investigate. More transfer learning-based models, as well as a huge dataset of normal and COVID-19 patients, can be added in the future to compare the accuracy and optimization of parameters. Phase-II testing predicted values are visualized in figure-14.

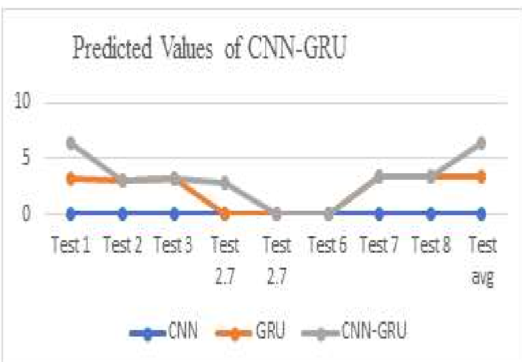


Fig 14: Predicted Testing values

This breakthrough will have a significant impact on the medical field. COVID-19 patients can be detected promptly with this technique, which could help with the present pandemic scenario. Chest radiography is comparable to taking a sample from a patient's nose in terms of safety. This type of technology will aid diagnostics in the future.

6. DIFFERENCE FROM PRIOR WORK

A CNN is used to prize features in the proposed model, and a GRU is used as a classifier. The model was trained on images, and the results demonstrate how deep literacy can prop in the early discovery of COVID-19 in cases through X-ray checkup analysis. Similar pointers could pave the way for the complaint's impact to be reduced. We believe that this model can be a useful tool for medical interpreters in terms of early discovery.

7. CONCLUSION AND FUTURE SCOPE

As talked about previously, the early location and determination of Coronavirus by DL procedures and with the most minimal expense and inconveniences are the essential strides in forestalling the sickness and the movement of the pandemic. Sooner rather than later, with the fuse of DL calculations in the hardware of radiology focuses, it will be feasible to accomplish a quicker, less expensive, and more secure finding of this illness. The utilization of these procedures in fast symptomatic dynamic of Coronavirus can be a useful asset for radiologists to lessen human mistake and can help them to settle on choices in basic conditions and at the pinnacle of the sickness. This examination upholds the possibility that DL calculations are a promising path for enhancing medical care and improving the aftereffects of analytic and helpful methodology. Despite the fact that DL is perhaps the most remarkable registering instruments in analysis of pneumonia, particularly Coronavirus, designers ought to be mindful so as to stay away from overfitting and to augment the generalizability and helpfulness of Coronavirus DL demonstrative models; these models should be prepared on huge, heterogeneous datasets to cover all the accessible information space. Depends on the application. However, here are some alternatives: Hidden Markov Model: HMM can be used for sequence clustering, time series prediction similar to the LSTM. HMM unlike the LSTM is a generative model. Conditional Random Field (CRF): It is a discriminative model like the LSTM for time series and sequential prediction. Gated Recurrent Unit (GRU): Another popular version of RNN, used to solve the vanishing grading problem. This one also is a discriminative model. RIMA, AR, VAR, more classical time series methods for time series prediction. GRU can likewise be considered as a minor departure from the LSTM in light of the fact that both are planned also and, sometimes, produce similarly incredible outcomes.

REFERENCES

[1] Kwekha-Rashid, A. S., Abduljabbar, H. N., & Alhayani, B. (2021). Coronavirus disease (COVID-19) cases analysis using machine-learning applications. *Applied Nanoscience*, 1-13.

[2] Roberts, M., Driggs, D., Thorpe, M., Gilbey, J., Yeung, M., Ursprung, S., ... & Schönlieb, C. B.

(2021). Common pitfalls and recommendations for using machine learning to detect and prognosticate for COVID-19 using chest radiographs and CT scans. *Nature Machine Intelligence*, *3*(3), 199-217.

[3] Metsky, H. C., Freije, C. A., Kosoko-Thoroddsen, T. S. F., Sabeti, P. C., & Myhrvold, C. (2020). CRISPR-based surveillance for COVID-19 using genomically-comprehensive machine learning design. *BioRxiv*.

[4] Syeda, H. B., Syed, M., Sexton, K. W., Syed, S., Begum, S., Syed, F., ... & Yu Jr, F. (2021). Role of machine learning techniques to tackle the COVID-19 crisis: Systematic review. *JMIR medical informatics*, *9*(1), e23811.

[5] Kassani, S. H., Kassasni, P. H., Wesolowski, M. J., Schneider, K. A., & Deters, R. (2020). Automatic detection of coronavirus disease (covid-19) in x-ray and ct images: A machine learning-based approach. *arXiv preprint arXiv:2004.10641*.

[6] Roberts, M., Driggs, D., Thorpe, M., Gilbey, J., Yeung, M., Ursprung, S., ... & Schönlieb, C. B. (2020). Machine learning for COVID-19 detection and prognostication using chest radiographs and CT scans: a systematic methodological review. *arXiv preprint arXiv:2008.06388*.

[7] Vaid, S., Cakan, C., & Bhandari, M. (2020). Using machine learning to estimate unobserved COVID-19 infections in North America. *The Journal of bone and joint surgery. American volume*.

[8] Cabitza, F., Campagner, A., Ferrari, D., Di Resta, C., Ceriotti, D., Sabetta, E., ... & Carobene, A. (2020). Development, evaluation, and validation of machine learning models for COVID-19 detection based on routine blood tests. *Clinical Chemistry and Laboratory Medicine (CCLM)*, *1*(ahead-of-print).

[9] Metsky, H. C., Freije, C. A., Kosoko-Thoroddsen, T. S. F., Sabeti, P. C., & Myhrvold, C. (2020). CRISPR-based COVID-19 surveillance using a genomically-comprehensive machine learning approach. *BioRxiv*.

[10] Saha, P., Sadi, M. S., & Islam, M. M. (2021). EMCNet: Automated COVID-19 diagnosis from X-ray images using convolutional neural network and ensemble of machine learning classifiers. *Informatics in medicine unlocked*, *22*, 100505.

[11] Dairi, A., Harrou, F., Zeroual, A., Hittawe, M. M., & Sun, Y. (2021). Comparative study of machine learning methods for COVID-19 transmission forecasting. *Journal of Biomedical Informatics*, *118*, 103791.

[12] Saba, T., Abunadi, I., Shahzad, M. N., & Khan, A. R. (2021). Machine learning techniques to detect and forecast the daily total COVID-19 infected and deaths cases under different lockdown types. *Microscopy Research and Technique*.

[13] Kumar, R., Arora, R., Bansal, V., Sahayasheela, V. J., Buckchash, H., Imran, J., ... & Raman, B. (2020). Accurate prediction of COVID-19 using chest x-ray images through deep feature learning model with smote and machine learning classifiers. *MedRxiv*.

[14] Kumar, K. K., Kumar, M. D., Samsonu, C., & Krishna, K. V. (2021). Role of convolutional neural networks for any real time image classification, recognition and analysis. *Materials Today: Proceedings*.

[15] D. N. V. S. L. S. Indira, Ch. Suresh Babu, K. Kranthi Kumar, Ch. Venkateswara Rao. (2021). A Comprehensive Review on Sentiment Analysis Techniques and Machine Learning Libraries in Image Processing. Annals of the Romanian Society for Cell Biology, 25(2), 4260–4267.

[16] Konduru Kranthi kumar, Paladugu Rama Krishna, Pulicherla Siva Prasad, B. Srikanth. (2021). Identification of Malware content in IoT Technology Enabled Device related files Using Machine Learning Algorithms. Annals of the Romanian Society for Cell Biology, 25(6), 6747–6757.

[17] Asif, S., & Wenhui, Y. (2020). Automatic detection of COVID-19 using X-ray images with deep convolutional neural networks and machine learning. *medRxiv*.

[18] Yao, H., Zhang, N., Zhang, R., Duan, M., Xie, T., Pan, J., & Wang, G. (2020). Severity detection for the coronavirus disease 2019 (covid-19) patients using a machine learning model based on the blood and urine tests. *Frontiers in cell and developmental biology*, *8*, 683.

[19] Khanday, A. M. U. D., Rabani, S. T., Khan, Q. R., Rouf, N., & Din, M. M. U. (2020). Machine learning based approaches for detecting COVID-19 using clinical text data. *International Journal of Information Technology*, *12*(3), 731-739.

[20] Sharma, S. (2020). Drawing insights from COVID-19-infected patients using CT scan images and machine learning techniques: a study on 200 patients. *Environmental Science and Pollution Research*, *27*(29), 37155-37163.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[21] Sohan, M. F. (2020). So You Need Datasets for Your COVID-19 Detection Research Using Machine Learning?. *arXiv preprint arXiv:2008.05906*.

[22] Cury, R. C., Megyeri, I., Lindsey, T., Macedo, R., Batlle, J., Kim, S., ... & Clark, R. H. (2021). Natural Language Processing and Machine Learning for Detection of Respiratory Illness by Chest CT Imaging and Tracking of COVID-19 Pandemic in the United States. *Radiology: Cardiothoracic Imaging*, *3*(1), e200596.

[23] Shahid, O., Nasajpour, M., Pouriyeh, S., Parizi, R. M., Han, M., Valero, M., ... & Sheng, Q. Z. (2021). Machine learning research towards combating COVID-19: Virus detection, spread prevention, and medical assistance. *Journal of Biomedical Informatics*, *117*, 103751.

[24] Satu, M. S., Khan, M. I., Mahmud, M., Uddin, S., Summers, M. A., Quinn, J. M., & Moni, M. A. (2021). Tclustvid: a novel machine learning classification model to investigate topics and sentiment in covid-19 tweets. *Knowledge-Based Systems*, 107126.

[25] Georgescu, B., Chaganti, S., Aleman, G., Cabrero, J., Chabin, G., Flohr, T., ... & Comaniciu, D. (2021). Machine learning automatically detects COVID-19 using chest CTs in a large multicenter cohort. *European Radiology*, 1-11.

[26] Zhang, W., Zhou, T., Lu, Q., Wang, X., Zhu, C., Sun, H., ... & Wang, F. Y. (2021). Dynamic fusion-based federated learning for COVID-19 detection. *IEEE Internet of Things Journal*.

[27] Prakash, K. B., Imambi, S. S., Ismail, M., Kumar, T. P., & Pawan, Y. N. (2020). Analysis, prediction and evaluation of covid-19 datasets using machine learning algorithms. *International Journal*, *8*(5).

[28] Prakash, K. B., Imambi, S. S., Ismail, M., Kumar, T. P., & Pawan, Y. N. (2020). Analysis, prediction and evaluation of covid-19 datasets using machine learning algorithms. *International Journal*, *8*(5).

[29] Yasar, H., & Ceylan, M. (2021). A novel comparative study for detection of Covid-19 on CT lung images using texture analysis, machine learning, and deep learning methods. *Multimedia Tools and Applications*, *80*(4), 5423-5447.

[30] Yasar, H., & Ceylan, M. (2021). A novel comparative study for detection of Covid-19 on CT lung images using texture analysis, machine learning, and deep learning methods. *Multimedia Tools and Applications*, *80*(4), 5423-5447.

[31] Marcos, M., Belhassen-García, M., Sánchez-Puente, A., Sampedro-Gomez, J., Azibeiro, R., Dorado-Díaz, P. I., ... & Martín-Oterino, J. Á. (2021). Development of a severity of disease score and classification model by machine learning for hospitalized COVID-19 patients. *PloS one*, *16*(4), e0240200.

[32] Narendra Kumar Mishra, Pushpendra Singh, Shiv Dutt Joshi,Automated detection of COVID-19 from CT scan using convolutional neural network,Biocybernetics and Biomedical Engineering,Volume 41, Issue 2,2021,Pages 572-588,ISSN 0208-5216,https://doi.org/10.1016/j.bbe.2021.04.006.

[33] Saygılı, A. (2021). A new approach for computer-aided detection of coronavirus (COVID-19) from CT and X-ray images using machine learning methods. *Applied Soft Computing*, *105*, 107323.

[34] Kumar, S. A., Kumar, H., Dutt, V., & Dixit, P. (2020). Deep Analysis of COVID-19 Pandemic using Machine Learning Techniques. *Global Journal on Innovation, Opportunities and Challenges in Applied Artificial Intelligence and Machine Learning [ISSN: 2581-5156 (online)]*, *4*(2).

[35] Muhammad, L. J., Algehyne, E. A., Usman, S. S., Ahmad, A., Chakraborty, C., & Mohammed, I. A. (2021). Supervised machine learning models for prediction of COVID-19 infection using epidemiology dataset. *SN computer science*, *2*(1), 1-13.

[36] Awal, M. A., Masud, M., Hossain, M. S., Bulbul, A. A. M., Mahmud, S. H., & Bairagi, A. K. (2021). A Novel Bayesian Optimization-Based Machine Learning Framework for COVID-19 Detection From Inpatient Facility Data. IEEE Access, 9, 10263-10281.

[37] Afshar, P., Heidarian, S., Enshaei, N., Naderkhani, F., Rafiee, M. J., Oikonomou, A., ... & Mohammadi, A. (2021). COVID-CT-MD, COVID-19 computed tomography scan dataset applicable in machine learning and deep learning. Scientific Data, 8(1), 1-8.

[38] LINDA, W. (2020). A tailored deep convolutional neural network design for detection of covid-19 cases from chest radiography images. Journal of Network & Computer Applications, 20, 1-12.