Salud, Ciencia y Tecnología. 2024; 4:.921
doi: 10.56294/saludcyt2024.921

ORIGINAL

The Novel Meta-Heuristic Optimization-Based Deep Learning Framework for Predicting Diagnoses with COVID-19 in Patients Undergoing Emergency Treatment

El novedoso marco de aprendizaje profundo basado en optimización metaheurística para predecir diagnósticos con COVID-19 en pacientes sometidos a tratamiento de urgencia

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Cite as: Anandan P, Shrinidhi S, Kalra S, Goyal S, Sharma S, Khurana J. The Novel Meta-Heuristic Optimization-Based Deep Learning Framework for Predicting Diagnoses with COVID-19 in Patients Undergoing Emergency Treatment. Salud, Ciencia y Tecnología. 2024; 4:.921.https://doi.org/10.56294/saludcyt2024.921

Submitted: 25-12-2023 **Revised:** 15-04-2024 **Accepted:** 21-08-2024 **Published:** 22-08-2024

Editor: Dr. William Castillo-González

ABSTRACT

The global medical system has faced enormous challenges as a result of the COVID-19 epidemic. Since emergency facilities are frequently the first places individuals with COVID-19 indications go, they are often in the center of the matter. Finding patients with COVID-19 and treating them appropriately while applying precautions to stop the virus from spreading among other individuals and medical personnel is one of the primary challenges EDs face. This work develops a Covid-19 forecasting system using deep learning via four essential steps. The incoming initial information is initially placed via the pre-processing phase to improve the information accuracy and efficacy evaluation of the suggested model. Data cleansing and normalization are done during the pre-processing phase. The best characteristics are chosen using meta-heuristic-based Belief Net Particle Swarm optimization (MH-Belief Net + PSO). Next, the covid-19 forecasting step is replicated using the newly improved Deep Learning (DL) approach, the optimizing deep belief network (DBN). The parameter modification enhances the system's capacity to forecast disease. An improved DBN's output shows if COVID-19 is present or nonexistent. Because of this, the effectiveness assessment significance of the suggested approaches was greater compared to each of existing approaches, including SVM, RF, CNN, and NB.

Keywords: Drug-Induced Sleep Endoscopy; Obstructive Sleep Apnea; Sleep Disorder.

RESUMEN

El sistema médico mundial se ha enfrentado a enormes retos como consecuencia de la epidemia de COVID-19. Dado que los centros de urgencias suelen ser los primeros lugares a los que acuden las personas con indicios de COVID-19, a menudo se encuentran en el centro de la cuestión. Encontrar pacientes con COVID-19 y tratarlos adecuadamente al tiempo que se aplican precauciones para evitar que el virus se propague entre otras personas y el personal médico es uno de los principales retos a los que se enfrentan los SU. Este trabajo desarrolla un sistema de previsión de Covid-19 mediante aprendizaje profundo a través de cuatro pasos esenciales. La información inicial entrante se coloca inicialmente a través de la fase de preprocesamiento para mejorar la precisión de la información y la evaluación de la eficacia del modelo sugerido. La limpieza y normalización de los datos se realizan durante la fase de preprocesamiento. Las mejores características se eligen mediante una optimización de enjambre de partículas basada en la metaheurística Belief Net (MH-

Belief Net + PSO). A continuación, el paso de previsión covid-19 se replica utilizando el enfoque de aprendizaje profundo (Deep Learning, DL) recientemente mejorado, la red de creencia profunda optimizadora (DBN). La modificación de los parámetros mejora la capacidad del sistema para predecir enfermedades. La salida de una DBN mejorada muestra si COVID-19 está presente o no. Debido a esto, la importancia de la evaluación de la eficacia de los enfoques sugeridos fue mayor en comparación con cada uno de los enfoques existentes, incluyendo SVM, RF, CNN, y NB.

Palabras clave: Endoscopia del Sueño Inducida por Fármacos; Apnea Obstructiva del Sueño; Trastorno del Sueño.

INTRODUCTION

Meta-heuristic optimization corresponds to a class of optimized techniques which are thought to be capable of effectively identifying and taking use of searching spaces in order to identify nearly optimum alternatives. In contrast to conventional optimization strategies that depend on exact techniques or constraints, meta-heuristic frameworks use several computing methods, including randomized analysis, continuous improvement, and localized analysis, to find a solution.(1)

For a certain issue, an innovative meta-heuristic optimization procedure is an optimization technique that is never used or suggested before. To solve the limitations of traditional optimization methodologies, it involves expanding a novel method for optimization or changing current procedures.(2) Combining DL with meta-heuristic optimized can result in the progress of additional accurate and proficient methods for a extensive variety of fields, like language processing, economists, as well as healthcare.(3) Among the methods used to forecast COVID-19 detections in patients undergoing emergency care is the utilization of DL techniques to analyze clinical records and pinpoint those most likely to be infected. Usually, the process entails gathering patient data to train a predictive approach, such as medical records, indications, and results of diagnostic tests.(4) By analyzing vast amounts of data across many people, such models may assist with determining the characteristics and threat elements associated with the disease, enabling medical professionals to develop more effective preventative and therapeutic strategies.(5) The global medical system is being severely strained by the COVID-19 epidemic, and emergency care facilities were in the midst of this catastrophe. Healthcare professionals must quickly and accurately diagnose patients in these scenarios to react quickly and effectively.(6) Additionally, replications can provide views on how the disease progresses and the ideal patient behavior guidelines. In emergency care settings, this approach can assist healthcare personnel in reducing the danger of dissemination, assigning attributes appropriately, and prioritizing patient care.(7) Nevertheless, there are challenges with the newly developed accurate and reliable DL methods for predicting COVID-19 identifications in patients receiving emergency care.(8)

Marwa M et al.(9) provides with an innovative approach that uses a long short-term memory neural network to specifically predict the known properties of the illness. Göreke et al.(10) a novel feature group based on lab outcomes was produced to understand blood information while taking into account traditional and genetic differences. Outcomes that were gained were associated to those of DL classifiers that had been planned in the literature. The study offers a unique method for picking the most useful elements from the existing data and developing techniques powered by machine learning (ML) to forecast illness Procedure's likelihood in COVID-19 patients.(11) The proposed framework provides hybrid mining and meta-heuristic methods to discourse the optimization and diagnostic difficulties. The spiral-shaped direction used by Grey Wolf Optimization (GWO) certifies difference and union. The suggested approach delivers hybrid mining and meta-heuristic approaches to discourse optimization and investigative difficulties. The spiral-shaped route utilized by GWO certifies difference and merging.(12) By decreasing the issues of the depiction and improving the fineness of the information, they hope to growth the effectiveness& presentation of computer-aided diagnostic classifications in the research (13). Three contributions have been recommended to attain this. Comparative studies employing industry ideals and openly accessible medicinal information were used to validate the proposed methods and the attained outcomes. Chauhan et al.(14) examined the use of AI during the pandemic period with an emphasis on quick advancements for population screening and infection risk assessment. Dash et al.(15) a novel feature group based on laboratory results was generated to interpret blood data while taking into account ethnic and genetic variations. The research presents an advanced evaluation of the current ML and DL methods for COVID-19 recognition.(16)

METHOD

This study proposes a novel meta-heuristic optimization-based DL framework for accurately predicting COVID-19 diagnoses in patients undergoing emergency treatment. Figure 1 depicts the flow of the suggested method.

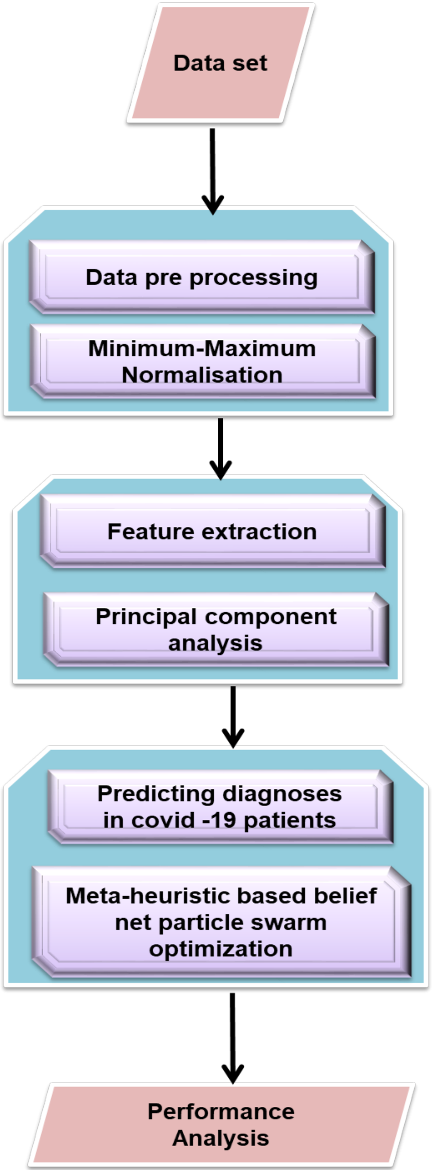

Figure 1. Flow of suggested method

Dataset

The COVID-19 data contains volumetric chest CT scans from 76 healthy persons, sixty patients with community-acquired pneumonia, and CC patients who verified positive for COVID-19 virus. COVID-19 patients are gathered from February 2020 to April 2020, in contrast to Community-based Pneumonia cases, being gathered from April 2018 to December 2019, and Typical instances, which are gathered from January 2019 to May 2020 Afshar, Parnian et al.[17]

Data pre-processing

Data pre-processing is a vital stage in big data studies, aiming to quickly and accurately discover new information. It involves implementing issues and using techniques like Min-Max, Z-score, and Decimal scaling. Implementation is crucial in data processing methods like soft computing and cloud computing, preparing datasets for future studies. The min-max normalization is determined in equation (1).

$$K' = \left(\frac{k - \ value\ of L}{value\ of k - \ value\ of\ k}\right) * (P - H) + H \quad (1)$$

Where [H,P] is the boundaries and K is a Min-Max normalization collection of data. The mapping data scale is N, and the real information scale is K.

Principal Component Analysis (PCA)

The study used Microsoft Excel to extract data on study-related information, patient demographics, diagnostic approaches, degrees of concordance among DISE and additional methods, as well as post-treatment sleep metrics for every study that was covered, such as ESS and AHI.

The PCA solves optimization challenges in a lower-dimensional space by analyzing several factors in a collection, minimizing hidden variables, and obtaining main elements. through the solution of the optimization problem given by equation (2).

Max:

$$Y = x^S Ux) \qquad (2)$$

Subject to:

$$x^S Ux = 1$$

Where V = (1/m) W^S W is the data sampling correlation matrix, and x fulfills the criterion of having a single standard X^S X=1, when W represents a structure consisting of o parameters and n entries. The extreme eigenvalues λ of U, or Ux = λw, is the solution, following an aspect decrease to r elements, to the optimization issue given in equation (2).

MH-Belief Net + PSO

Particle Swarm Optimization (PSO) is a superior optimization strategy compared to group intelligence. It adjusts particle search velocity and range, allowing N particles to search for optimal answers in a D-dimensional space, keeping themselves updated by observing extreme values. The global extremism represents the perfect solution identified by the group, while the individual extremism O_{best} represents the optimum solution found by individual particles. The following D-dimensional vector from equation (3) represents the speed of the ith particle as it traverses the search space.

$$U_j = \left(U_{j1}, U_{j2}, \ldots.. V_{jC}\right), j = 1,2, \ldots, M \qquad (3)$$

Equation (4) depicts the specific extremism of each particle, which is its ideal location in the solution space.

$$O_{best} = \left(O_{j1}, O_{j2}, \ldots.. O_{jC}\right), j = 1,2, \ldots, M \qquad (4)$$

The particle may change its present velocity and location by employing equations (5) and (6) as long as it can find both the local and global extrema.

$$U_j(s+1) = xU_j(s) + d_1 q_1 \left(O_a - O_j(s)\right) + d_2 q_2 (O^* - O_j(s)) \qquad (5)$$
$$O_j(s+1) = O_j(s) + U_j(s+1) \qquad (6)$$

Where w stands for the inertia weight, O* stands for the ideal global location, and the learning factors d1and d2 are randomly chosen between 0 and 2. q1 andq2 are random values between 0 and 1, and Uj denotes the particle velocity. The total amount of supplied units is indicated by M, while the number of concealed units is shown by N. where g = g1, g2...gm, and u= u1,u2,...,un. The RBM energy purpose is represent by the following equation (7).

$$F(u, g; \theta) = -\sum_{j=1}^{n} \sum_{i=1}^{m} x_{ji} u_j g_i - \sum_{j=1}^{m} b_j u_j - \sum_{i=1}^{m} a_i g_i \qquad (7)$$

Where x is an RBM parameter, which includes the relation weight x_{ji} among the nodes in the 2 layers, the hidden layer bias a_i, and the input layer bias b_j.

The two combined distributions equations (8) and (9) that follow are based on the energies functional of the RBM framework:

$$o(u,g) = \frac{1}{Q(\theta)} f^{-F(u,g)} \quad (8)$$
$$Q(\theta) = \sum_{u,g} f^{-F(u,g)} \quad (9)$$

In which the normalize Q(θ) is used. Equation (10) represents the independent probability distribution of the input layer.

$$O(u) = \sum_{m} o(u,g) = \frac{1}{Q(\theta)} \sum_{g} f^{-F(u,g)} \quad (10)$$

Given that there are no connections between the nodes in each corresponding layer; equations (11) and (12) generate the restricted prospect distribution of all layers:

$$O(g_i = 1 | u;\ \theta) = \sigma\left(\sum_{j=1}^{n} x_{ji} u_i + a_i\right) \quad (11)$$
$$O(u_i = 1 | g;\ \theta) = \sigma\left(\sum_{i=1}^{m} x_{ji} g_i + b_j\right) \quad (12)$$

Where, weight x_{ji}, RBM seeks to maximize the probability O (u), the training data may be used to estimate the maximum probability of setting θ = {b_j,a_i,weight x_{ij}} in the RBM specifications. The contrasting diverging method can be used to identify the variable collection θ.

$$x_{ji}^{(s+\Delta s)} = x_{ji}^{(s)} + \frac{\alpha}{\beta}(< u_j g_i > data - < u_j g_i > model) \quad (13)$$
$$b_j^{(s+\Delta s)} = b_i^{(s)} + \frac{\alpha}{\beta}(< u_i > data - < u_i >\ model \quad (14)$$
$$a_i^{(s+\Delta s)} = a_i^{(s)} + \frac{\alpha}{\beta}(< g_i > data - < g_i >\ model \quad (15)$$

The hidden layer will transition to the next MH-BeliefNet + PSO input layer after initial training, classifying deep characteristics produced after training sessions. Figure 2 shows the DBN architecture.

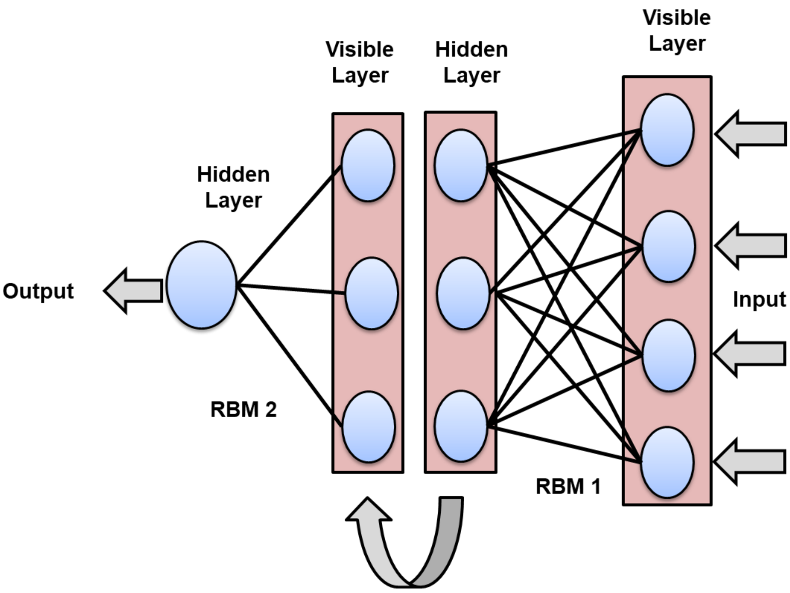

Figure 2. General design of a DBN

RESULTS

This study aimed to progress a novel context that employs both meta-heuristic optimization and DL techniques to forecast identifies with COVID-19 in patients experiencing emergency treatment. Meta-heuristic optimization refers to a class of developments that are used to resolve optimization difficulties. In the setting of healthcare, meta-heuristic optimization can be used to enhance treatment strategies, diagnosis, and recognizing approaches.

https://doi.org/10.56294/saludcyt2024.921

Accuracy

Accuracy is a frequently employed performance measured in DL applications. Its procedures how regular approaches forecasts match the actual outcomes. In the framework of forecasting identifies of covid virus in patients undergoing emergency treatment, accuracy would measure the percentage of correct predictions made by the method. Equation (16) is utilized in the estimation of accuracy. Table 1 and figure 3 depict the accuracy findings.

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} \qquad (16)$$

Table 1. Comparison of accuracy

Methods	Accuracy %
SVM(18)	85,5
RF(18)	87
CNN(18)	88
NB(18)	89,5
MH-Belief Net + PSO [Proposed]	95,5

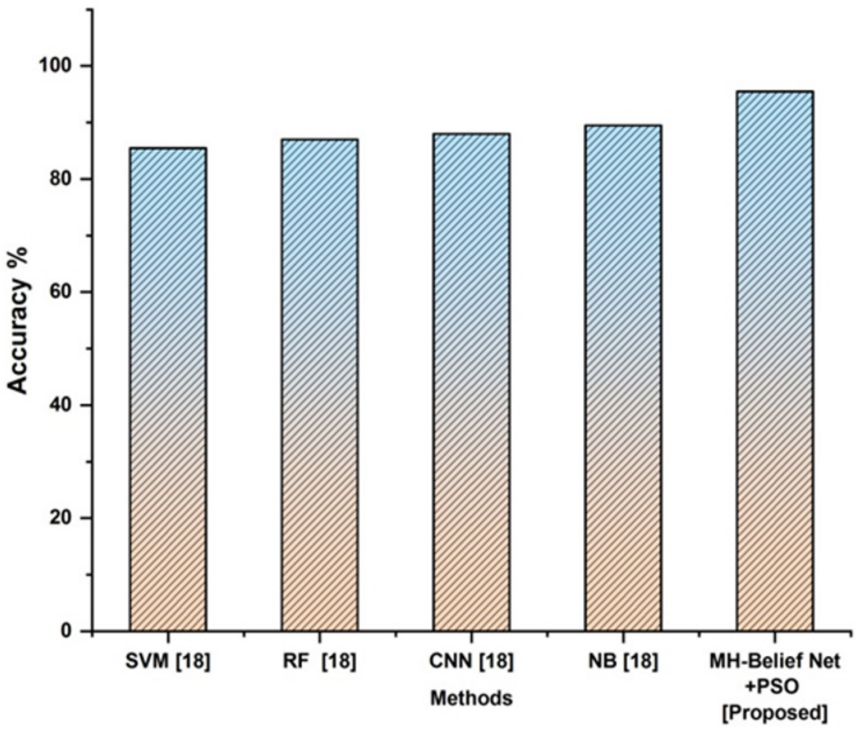

Figure 3. Results of accuracy

The suggested technique outperforms current research approaches in accuracy metrics, with a 95,5 % accuracy rate, surpassing SVM, RF, CNN, and NB, and outperforming existing techniques in data classification.

Precision

Precision is another commonly used performance metric in DL applications, including the prediction of diagnoses with COVID-19 in patients undergoing emergency treatment using a meta-heuristic optimization-based DL framework. By dividing the overall number of positive forecasts, the algorithm generated by the quantity of actual positive estimates, one can calculate the accuracy rate. Equation (17) is used to compute the precision.

$$precision = \frac{TP}{TP+FP} \qquad (17)$$

https://doi.org/10.56294/saludcyt2024.921

Methods	Precision %
SVM[18]	84,2
RF[18]	80,3
CNN[18]	78,9
NB[18]	89,1
MH-Belief Net + PSO [Proposed]	95,3

Table 2. Comparison of precision

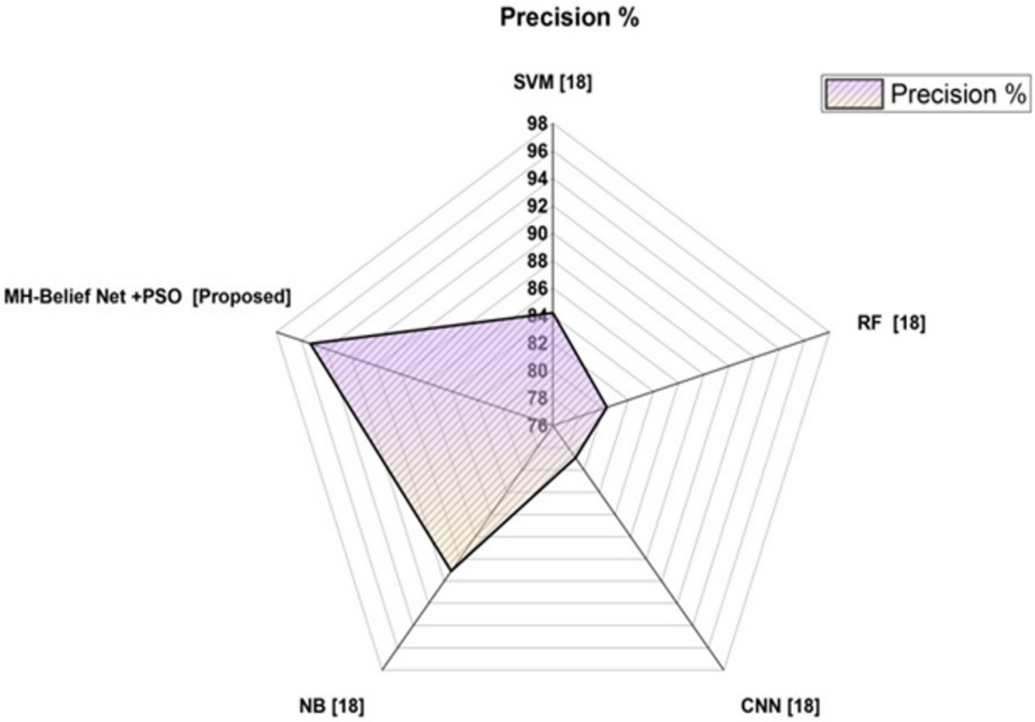

Figure 4. Results of precision

Comparable outcomes for the accuracy measurements are shown in figure 4 and table 2. The proposed approach has an accuracy of 95,3 %, which surpasses the current ones, which are SVM (84,2 %), RF (80,3 %), CNN (78,9 %), and NB (89,1 %). Compared to other approaches already in utilize, the suggested approach obtained higher precision in data classification.

Recall

Recall is another commonly used performance metric in DL applications, including the prediction of diagnoses with COVID-19 in patients undergoing emergency treatment using a meta-heuristic optimization-based DL framework. False negatives can lead to delayed or inadequate treatment, which can result in worse outcomes for the patient and an increased risk of spreading the virus to others. The measurement of recall is conducted with equation (18).

$$Recall = \frac{FN}{FN+TP} \qquad (18)$$

Table 3. Comparison of recall

Methods	Recall %
SVM[18]	84,1
RF[18]	83,6
CNN[18]	82
NB[18]	80,1
MH-Belief Net + PSO [Proposed]	95,3

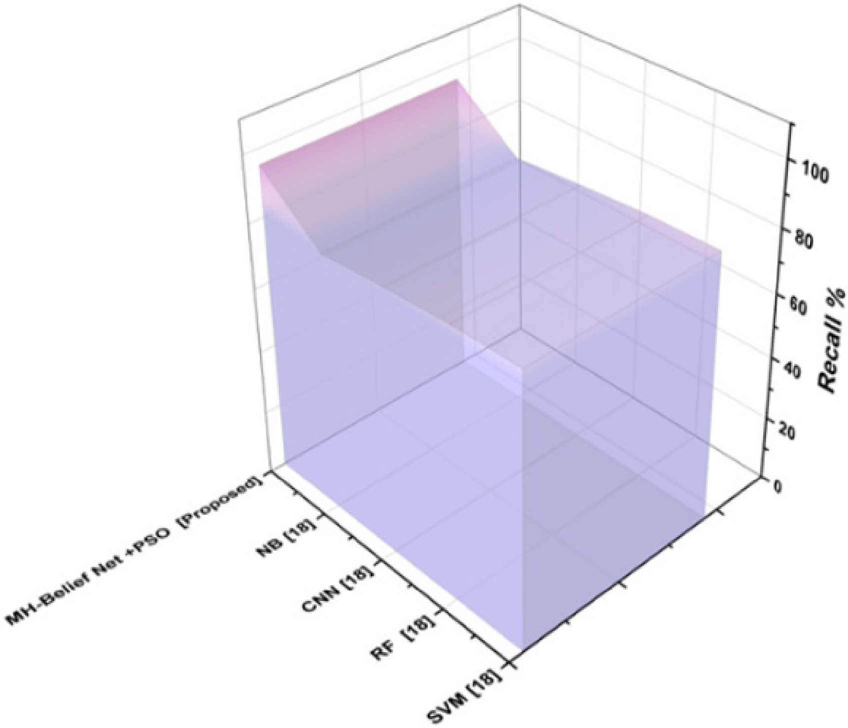

Figure 5. Results of Recall

Table 3 and figure 5 present the recall measures' comparisons. Recall values for SVM are 84,1 %, RF 83,6 %, CNN 82 %, NB 80,1 %, and MH-Belief Net + PSO 95,3 %.

F1-measure

F1-measure is alternative frequently used performance measured in DL techniques, including the forecast of identifies with COVID-19 in patients experiencing emergency treatment employing a meta-heuristic optimization-based DL approach. In the setting of forecasting COVID-19, the F1-measure would indicate how well the meta-heuristic optimization-based DL methods can minimize false positives and false negatives while effectively identifying COVID-19 instances. Equation (19) is used to determine the f1-measure.

$$F1 - measure = \frac{(precision)\times(recall)\times 2}{precision+recall} \qquad (19)$$

Table 4. Comparison of F1-Measure

Methods	F1-Measure %
SVM(18)	83,2
RF(18)	82,3
CNN(18)	81
NB(18)	80
MH-Belief Net + PSO [Proposed]	96

Figure 6 and table 4, MH-Belief Net + PSO scored (96 %) on the f1-measure, followed by SVM (83,2 %), RF (82,3 %), CNN (81 %), and NB (80 %).

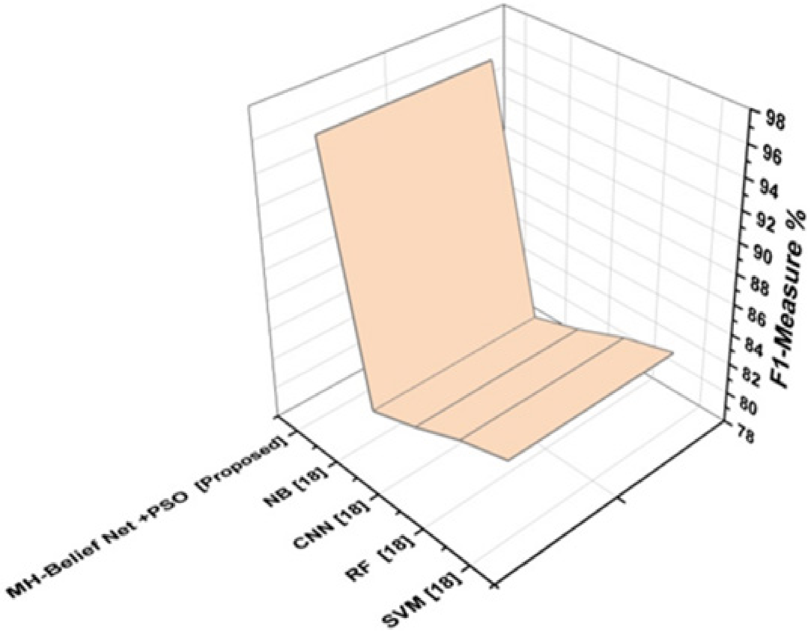

Figure 6. Results of F1-measure

CONCLUSIONS

The unique meta-heuristic optimization-based DL framework that has been suggested for properly predicting COVID-19 diagnoses in patients receiving emergency care has shown encouraging results. To improve diagnostic prediction, this system blends the strength of meta-heuristic optimization techniques with DL models. The pre-processed data is used to extract the most crucial elements, such as Min-Max normalization. Feature extraction using PCA. MH-Belief Net + PSO are used to select the most optimal features. Performance indicators for MH-Belief Net + PSO include accuracy (95,5 %), Precision (95,3 %), Recall (95,3 %), and F1-measure (96 %). Overall, this study provides an innovative solution to the current challenge of diagnosing COVID-19 patients in emergency settings. It opens up avenues for further research in the expansion of more precise and well-organized predictive models for COVID-19 diagnosis.

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CONFLICT OF INTEREST

None.

FUNDING

None.

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Software: P Anandan, Shrinidhi, Simran Kalra, Shobhit Goyal, Shivani Sharma, Jatin Khurana.
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