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Neurological Disorders Detection Based on Computer Brain Interface Using Centralized Blockchain with Intrusion System

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Abstract

A brain-computer interface (BCI) would afford real-time communication, pointedly refining the standard of lifespan, brain-to-internet (B2I) connection, and interaction between the external digital devices and the brain. This assistive technology invents information and transmission advancement patterns, like directly linking the brain and multimedia gadgets to the cyber world. This system will convert brain data to signals which is understandable by multimedia gadgets without physical intervention and exchanges human-related languages with external atmosphere control protocols. These progressive difficulties would limit security severely. Hence, the rate of ransomware, attacks, malware, and other types of vulnerabilities will be rising radically. On the other hand, the necessity to enhance conventional processes for investigating cyberenvironment security facets. This article presents a Neurological Disorders Detection based on Computer Brain Interface Using Centralized Blockchain with Intrusion System (NDDCBI-CBIS). The projected NDDCBI-CBIS technique focuses on the identification of neurological disorders and epileptic seizure detection. To attain this, the presented NDDCBI-CBIS technique pre-processes the biomedical signals. Next, to detect epileptic seizures, long short-term memory (LSTM) model is applied. The experimental evaluation of the NDDCBI-CBIS approach can be tested by making use of the medical dataset and the outcomes inferred from the enhanced outcomes of the NDDCBI-CBIS technique.

Keywords: Blockchain, Intrusion detection, Brain computer interface, Neurological disorder, Deep learning

1. Introduction

Late advances in the examination of brain signals, preparing patients to control these signs, and further developed processing abilities have empowered individuals with serious engine handicaps to think carefully flags for correspondence and control of articles in their current circumstance, in this way bypassing their weakened neuromuscular framework [1]. Harmless, electroencephalogram (EEG)-based brain-computer interface (BCI) innovations can be utilized to control a computer cursor or an appendage orthosis, for word handling and getting to the web, and for different capabilities like natural control or diversion. By restoring some autonomy, BCI innovations can considerably work on the existence of individuals with destroying neurological issues, for example, high level amyotrophic horizontal sclerosis. BCI innovation could likewise re-establish more compelling engine control to individuals after stroke or other horrendous brain issues by assisting with directing movement subordinate brain pliancy by utilization of EEG brain signs to show to the patient the present status of brain activity and to empower the client to bring down strange action in this manner [2]. There are two significant manners by which BCIs can be utilized. The first is clear and has been read up for over 25 years; for this situation, the BCI framework gets brain signal and permits the client, through input, to connect with the BCI yield for control of the climate (light switch, temperature control) or specialized gadgets. A second and recently arising BCI application includes involving the framework as an engine learning-help gadget. For this situation, the BCI might upgrade engine control recuperation by requesting more engaged consideration or directing enactment or deactivation of brain signals [3].

BCI research has encountered a new dramatic development, which can be credited to various variables, as follows: 1) accessibility of quick, continuous complex sign handling techniques; 2) a more noteworthy comprehension of the qualities and utilizations of brain signals; 3) an enthusiasm for the peculiarity of movement subordinate brain versatility; 4) a developing disappointment with ebb and flow restoration strategies and the requirement for further developed techniques for recuperation of capability for those with diligent engine impairment. The Internet of Things (IoT) was developing into a vigorous and alluring help foundation, and for the medical care area, it is known as the Internet of Medical Things (IoMT) [4]. Different applications and administrations taking advantage of sensors, actuators, organizing, and related information have been progressively arising. Government assistance applications will affect individuals' daily existence and reform the well-being business. For example, brilliant structures will empower their inhabitants to deal with life's day to day tasks while arriving at home naturally and change environment boundaries through somewhat controlled frameworks [5]. A similar thought applies to medical care offices and administrations where Internet-associated clinical gadgets accumulate and convey more significant information and direction. This serious utilization will limit direct persistent doctor communication.

In any case, opening and stretching out network to the outside world produce novel difficulties. Such issues raise concerns for individuals' ICT framework security, requesting dependable and strong plans to improve the clinical area, where mistakes can cost lives [6]. BCs assist with trading information, performing activities, and exchanges distributed while keeping deep learning (DL). The BCs are appropriate for the IoMT related to actual items and associating with the actual world (wearables, robots, cell phones, machines, sensors, actuators, and so on) in an indistinguishable dispersed way. The expression "wearables" represents in-body and on-body gadgets in this work. Also, BC innovation depends on open key cryptography and security natives like hash capabilities and computerized marks.

Seizures related to strange brain exercises brought about by an epileptic problem, which is an issue of the brain's Central Nervous System (C·N·S.) are exceptionally normal and have numerous side effects, like loss of mindfulness, surprising way of behaving and disarray [7]. These side effects lead by and large to wounds because of falls, keeping quiet. Recognizing a potential seizure ahead of time is certainly not a simple errand. A large portion of the seizures happen suddenly, and tracking down ways of identifying a potential seizure before it happens has been a difficult undertaking for some scientists. Applying grouping calculations, which is the technique utilized in this paper, can assist with deciding if somebody will have a seizure or not. Numerous analysts have chipped away at figuring out the brain's electrical exercises and dynamic properties and distinguishing the nonlinear deterministic elements found in seizures [8].

Blockchain (BC) is the innovation behind Bitcoin and any remaining cryptographic forms of money. Since its origin, BC innovation has been quickly developing. As a decentralized data set (or disseminated record), BC considers the capacity of data on resources and exchanges in a distributed computer organization [9]. Along these lines, it is feasible to have a common public vault of proprietorship that is accessible to all BC network hubs, in which exchanges are put away in "blocks" of information that are then connected and gotten together in a changeless and unforgeable "chain" through a protected cryptographic framework. The progressive capability of BC innovation lies in its decentralization. In BC-based financial frameworks, cash isn't given by a focal power, responsibility for cash isn't confirmed by a focal power, and exchanges are not controlled by a focal power. By utilizing severe calculations and high level cryptographic methods, BC makes the job of a dependent focal power that checks and controls cash moves and possession out of date.

All things considered, the focal power's job in the BC worldview is supplanted by the organization. All exchanges are put away on the BC in the wake of being numerically approved and affirmed by the hubs in the shared BC network while cryptography guarantees namelessness and security of the put away exchanges. The rise of the first BC innovation (as Bitcoin) in 2008 was reasonably catalysed by the monetary emergency, a period during which the question in establishments like states, organizations, and banks that are generally responsible for making due, getting, and refreshing the monetary record, arrived at its pinnacle. Medical care information exchanges and monetary exchanges depend on a few normal fundamental prerequisites: (1) distinguishing the entertainers in question, (2) appropriately recording exchanges, (3) getting exchanges against potential modifications, and (4) keeping the exchanges put away in a protected, stable, and secure framework. Presently, most medical care information exchanges happen under the intervention of an emergency clinic that addresses the focal power [10]. This system is likewise ordinary in an uncommon neurodegenerative populace-based library: the main organization goes about as the focal expert in overseeing moves of information from the hubs to the vault's focal data set, and, thusly, the hubs of the vault network go about as a focal expert in the exchange of information from the patients to the singular library hubs.

This article presents a Neurological Disorders Detection based on Computer Brain Interface Using Centralized Blockchain with Intrusion System (NDDCBI-CBIS). The projected NDDCBI-CBIS technique focuses on the identification of neurological disorders and epileptic seizure detection. To attain this, the presented NDDCBI-CBIS technique pre-processes the biomedical signals. Next, to detect epileptic seizures, long short-term memory (LSTM) model is applied. The experimental evaluation of the NDDCBI-CBIS method can be tested by making use of the medical dataset and the results inferred the enhanced outcomes of the NDDCBI-CBIS technique.

2. Related Works

Dumitrescu et al. [11] purpose to advance and expand signal process approaches aimed at the application of a brain-computer interface (BCI) founded over nervous singularities logged through motorized errands with motor imagery (MI). The purpose of this study was to excerpt, choice, and categorize the features of encephalogram (EEG) signals that can be related to sensorimotor paces, meant to implement BCI schemes. This object examines organizations related to brain-computer borders, particularly persons who practice the EEG as a technique of gaining MI responsibilities. Asynchronous BCIs could be advantageous after an enhanced classification structure projected in [12]. Persons having severe motor damage would predominantly become help since this feature. Control guidelines remained translated utilizing a rule-related translation method in outmoded BCI classifications, which depend on EEG demos of brain signals. Exploratory BCI expertise's numerous and cross-disciplinary requests, this quarrel produces speculative deductions nearby by what means BCI devices collective through ML approaches might disturb the approaching practices and actions.

In [13], an unsupervised deep-TL-related technique has been projected to pact by the present confines of BCI structures through application of the impression of TL to the organization of motor images EEG signs. The Euclidean space data alignment (EA) method has been accepted toward bring into line the covariant medium of target and source field EEG information in Euclidean spaces. Formerly, the common spatial pattern (CSP) is castoff to excerpt geographies out of the associated data medium, and the deep CNN has been pragmatic for EEG organization. Hameed et al. [14] anticipated an IoT by a cloud-related clinical decisive support scheme for observation and calculation of disease through incorporation of 5G facilities and BC technologies. A BC was a system for sharing and storing data that will be safe due to its slide. BC has several requests in health care and could progress moveable strength requests, nursing policies, storing and sharing the electrical media chronicles, insurance information storage, and clinical trial data.

Rahman et al. [15] grant a broad study of FL through AI for smart healthcare applications. Firstly, the author converses fashionable notions of emergent technologies like XAI, AI, the healthcare system, and FL. The author categorizes and mixes the FL-AI through health care technologies in diverse fields. Additionally, the author discourses the prevailing difficulties which include reliability, security, stability, and privacy in the medical domain. Moreover, the author attendant the booklovers toward resolving policies of health care via AI and FL. In [16], the author assesses the corporal ideologies of BCIs, and primary new techniques for controlling, registering, and studying brain action. Then investigate current fees in BCI training concentrating on their applications for monitoring the undertaking of exoskeletons and androids, see-through and stopping brain pathologies, measuring, and regulating psychophysiological conditions, and controlling and monitoring pathological and normal cognitive action.

3. The Proposed Model

This article presented a new NDDCBI-CBIS approach for neurological disorders detection and classification. The projected NDDCBI-CBIS technique focuses on the identification of neurological disorders and epileptic seizure detection.

3.1. LSTM based Classification

Here, the presented NDDCBI-CBIS technique pre-processes the biomedical signals. LSTM is a new RNN employed in the fields of DL [17]. The core concept of LSTM is to present memory components for cyclic data communication, which records each past data up to the present moment. In comparison to the short-term memory of conventional RNN, LSTM contains long-term memory abilities: gating mechanisms (including output, forget, and input gates) within (0,1) are utilized for controlling the communication path of internal data. Fig. 1 demonstrates the framework of LSTM.
whereby x_t, f_t, i_t, 0_t, c_t, a_t and h_t represents the input, forget gates, input gates, output gates, memory storage units, candidate state, and output of hidden state at t time, correspondingly. c_{t-1} and h_{t-1} indicates the results of memory unit and hidden state at time t- 1. tanh represents the activation function δ, and denotes the logistic sigmoid function.

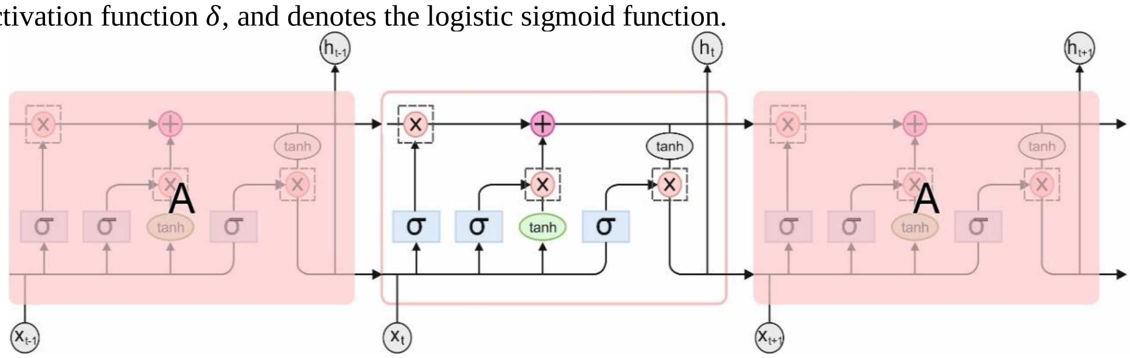

Figure 1. Framework of LSTM

We symbolize the weight connecting memory unit, forget, input, and output gates, as W_{xc} W_{xf},W_{Xi} and W_{xo}, correspondingly. Also, W_{hf}, W_{hi}, W_{ho} and W_{hc} is used to characterize the weights among hidden layers and the forget gates, input gates, output gates, and memory units. b_f, b_i and b_o characterize the bias. ⊙ characterizes product of vector element. The LSTM loop structure units control the data via controlling the degree of closing and opening of output, forget and input gates and it is given below.
Step 1: The forget gate f_t take the input χ_t and the output h_{t-1} of hidden state at the preceding moment as input, and output the outcomes of forget gate that was multiplied with c_{t-1} for controlling what amount of data should be forgotten in the internal state c_{t-1} at the preceding moment. The forget gate can be formulated by the following expression

$$f_t = \sigma\left(W_{xf}x_t + W_{hf}h_{t-1} + b_f\right) \tag{1}$$

Step 2: The input gate randomly stores the present input data and outcome i_t was applied as the data that upgraded as follows

$$i_t = \sigma(W_{xi}x_t + W_{hi}h_{t-1} + b_i) \tag{2}$$

Step 3: 0_t output gate controls the c_t internal state at the present moment, for controlling what amount of data should be output to the h_t external state as follows:

$$o_t = \sigma(W_{xo}x_t + W_{ho}h_{t-1} + b_o) \quad (3)$$

Step 4: The output gate 0_t can be multiplied with the state of memory units processed using the tanh layer in the following

$$h_t = o_t \tanh \odot(c_t) \quad (4)$$

Step 5: The memory unit c_t record the past data up to the existing moment that is evaluated as follows

$$c_t = f_t \odot c_{t-1} + i_t \odot a_t \quad (5)$$

Step 6: The candidate state can be computed as follows:

$$a_t = \tanh(W_{xc}x_t + W_{hc}h_{t-1} + b_c) \quad (6)$$

Adam relies upon data obtained from the average of gradient's second moment [18]. Similarly, exponentially crumbling average of past gradient has been utilized in this technique. Additionally, primary setting of 3 hyperparameters is needed in this optimizer: the 2 exponential decay rates ($\beta_2 = 0.9999$ and $\beta_1 = 0.9$) and α denotes the step size. The enhanced variable of a neural computational system was accepted whenever the gradient of method variables was computed,

$$w_t = w_{t-1} - \alpha \times \frac{\widehat{m}}{\sqrt{v_t} + \mathcal{E}'} \quad (7)$$

Let $\hat{v}_t$ and $\widehat{m_t}$ denotes the bias-corrected second and first raw moment estimate, respectively.

3.2. BC Technology

Here, the BC is applied for the detection of intrusions. A BC was a connected data erection where every block contains 2 principal segments: a body and header [19]. The header segment comprises nonce, past hash, Merkle root hash, timestamp, and trouble target. The body segment has a rundown of exchanges. The primary block was constantly named a beginning, every block is connected through cryptography, and blocks can be circulated between hubs over the network. Numerous standards of BC innovation can be applied to 3 principal layers they are the application, network, and data layers. In the first place, the network layer was viable with the P2P network engineering, which supports decentralized associations and disseminated network systems. The network layer was liable for sending and checking data between hubs. Likewise, BC innovation stores similar chains in every hub on a network; hence, all hubs were coordinated. In this way, whenever another block was created, it can be then confirmed by an agreement calculation. If the new block was legitimate, it broadcasts to any remaining hubs. Fig. 2 depicts the structure of BC technique.

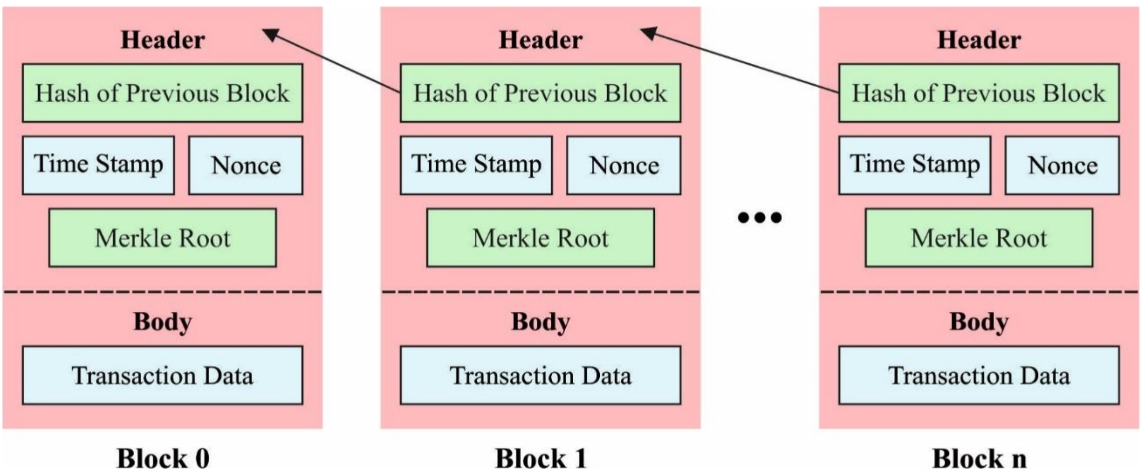

Figure 2. Structure of Blockchain

Likewise, there are a few kinds of agreement calculations that all work on two standards: (i) the newness guideline accomplishes fair rivalry through new assets for every novel block that is included, and (ii) the flightiness rule keeps any member from foreseeing which hub would make another block. Secondly, the data layer grants the blocks data design. Blocks have data or exchanges that don't surpass a few megabytes in size. Every block was connected by a past work field out an excavator. At the point whenever a block tackles cryptographic riddles and gets the past hash, another block was attached to the furthest limit of the chain. Besides, each block has a few fields. The data layer likewise concerns client confirmation and exchange encryption. Every client will be having a public key to approve validations, and this key is noticeable to anybody in the BC network. Computerized marks are utilized to confirm excavators' exchanges, and all approved exchanges are reserved in a public record. Lastly, the application layer can be liable for collaborating with clients, whether they were developers or end clients. The application layer was arranged into 2 unique layers. The principal layer can be intended for designers to construct and test the application's code and was known as the texture layer. The subsequent layer was the application layer, which permits end clients who utilize applications as a black box for performing explicit errands without knowing the subtleties of the code.

4. Results and Discussion

The neurological disorder outcomes of the NDDCBI-CBIS model are investigated under different runs of execution. Table 1 and Fig. 3 reveal the classifier results of the NDDCBI-CBIS model on 5 runs. On run-1, the NDDCBI-CBIS model has provided $accu_y$, $prec_n$, $reca_l$, F_{score}, and MCC of 98.75%, 98.97%, 99.36%, 98.07%, and MCC of 98.05% correspondingly. Moreover, on run-3, the NDDCBI-CBIS technique has provided $accu_y$, $prec_n$, $reca_l$, F_{score}, and MCC of 99.28%, 98.83%, 98.25%, 99%, and MCC of 98.78% correspondingly. Furthermore, on run-5, the NDDCBI-CBIS approach has provided $accu_y$, $prec_n$, $reca_l$, F_{score}, and MCC of 98.14%, 98.65%, 98.05%, 98.68%, and MCC of 99.05% correspondingly.

Table 1 Result analysis of NDDCBI-CBIS approach with distinct runs and measures

No. of Runs	Accuracy	Precision	Recall	F-Score	MCC
Run-1	98.75	98.97	99.36	98.07	98.05
Run-2	99.02	98.47	98.76	98.85	98.41
Run-3	99.28	98.83	98.25	99.00	98.78
Run-4	98.92	98.18	99.29	98.33	98.68
Run-5	98.14	98.65	98.05	98.68	99.05
Average	**98.82**	**98.62**	**98.74**	**98.59**	**98.59**

The training accuracy (TRA) and validation accuracy (VLA) acquired using the NDDCBI-CBIS technique on test dataset are exemplified in Fig. 4. The experimental result implied that the NDDCBI-CBIS method has accomplished highest values of TRA and VLA. Especially, the VLA seemed to be maximum than TRA.

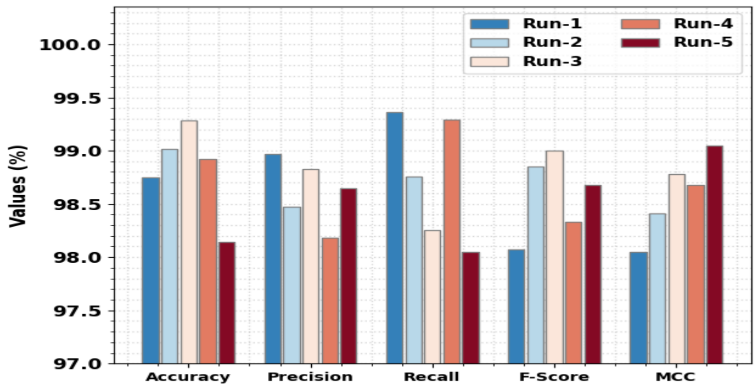

Figure 3. Result analysis of NDDCBI-CBIS approach with distinct runs and measures

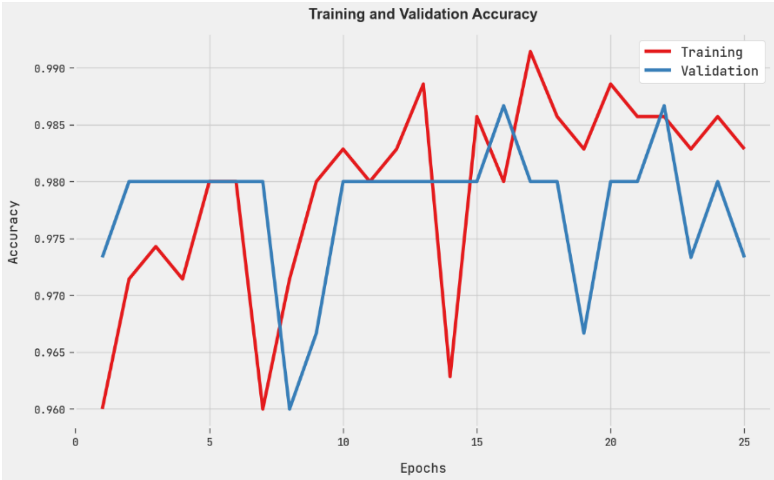

Figure 4. TRA and VLA analysis of NDDCBI-CBIS algorithm

The training loss (TRL) and validation loss (VLL) acquired through the NDDCBI-CBIS methodology on test dataset are shown in Fig. 5. The experimental result demonstrated that the NDDCBI-CBIS process has reached minimum values of TRL and VLL. Particularly, the VLL is lesser than TRL.

Figure 5. TRL and VLL analysis of NDDCBI-CBIS algorithm

A brief ROC analysis of the NDDCBI-CBIS technique on test dataset is illustrated in Fig. 6. The results symbolized the NDDCBI-CBIS methodology has displayed its capability in classifying dissimilar classes on test dataset.

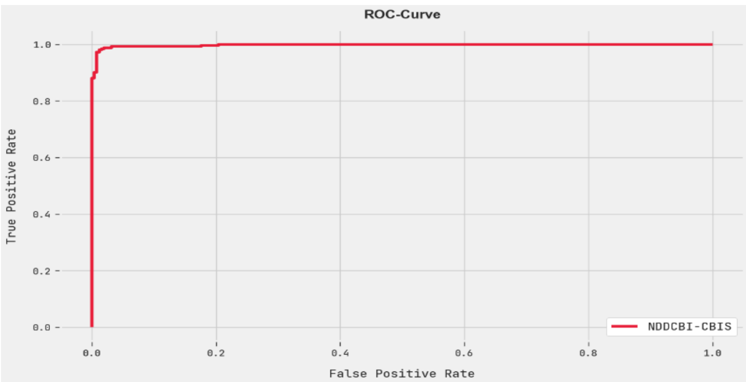

Figure 6. ROC curve analysis of NDDCBI-CBIS algorithm

To exhibit the maximum performance of the NDDCBI-CBIS model, Table 2 demonstrates the comparison study. Fig. 7 shows the $accu_y$ examination of the NDDCBI-CBIS model with other state of art works. The figure represented that the kNN fails to show effectual results. Next, the LDA and RF models have gained slightly enhanced outcomes with $accu_y$ of 96% and 97.70% respectively. Next, the GRNN and SVM-PNN models have reported reasonable $accu_y$ values of 98% and 98.12% respectively. But the presented NDDCBI-CBIS model has depicted maximum $accu_y$ of 98.82%.

Table 2 Comparative analysis of NDDCBI-CBIS approach with existing algorithms

Methods	Accuracy	Precision	Recall	F-Score
NDDCBI-CBIS	98.82	98.62	98.74	98.59
k-NN	88.00	94.95	97.55	93.81
LDA	96.00	97.31	94.68	93.03
RF	97.70	94.53	96.14	97.87
GRNN	98.00	95.47	93.98	93.74
SVM-PNN	98.12	93.69	97.87	96.88

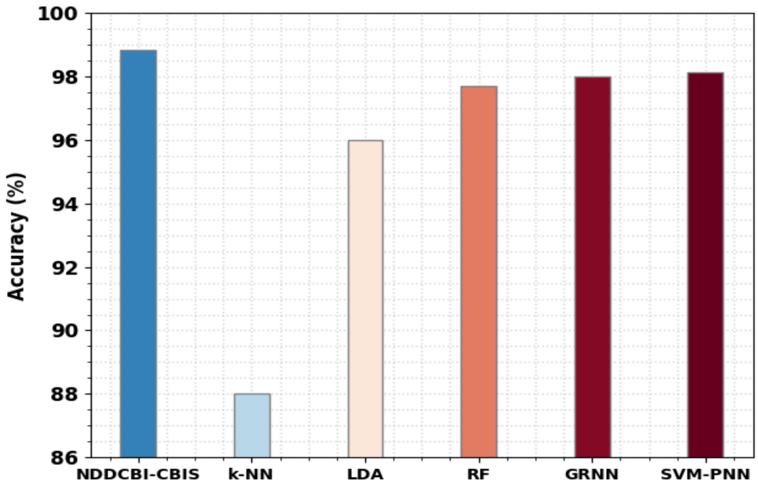

Figure 7. $Accu_y$ analysis of NDDCBI-CBIS algorithm with existing approaches

Fig. 8 displayed the $prec_n$ inspection of the NDDCBI-CBIS algorithm with other state of art works. The figure characterized that the kNN fails to display efficient outcomes. Following, the SVM-PNN and RF approaches have gained somewhat improved results with $prec_n$ of 93.69% and 94.53% correspondingly. Afterward, the GRNN and LDA algorithms have demonstrated reasonable $prec_n$ values of 95.47% and 97.31% correspondingly. But the proposed NDDCBI-CBIS technique has represented maximal $prec_n$ of 98.62%.

Fig. 9 presented the $reca_l$ inspection of the NDDCBI-CBIS technique with other state of art works. The figure denoted that the kNN fails to display efficient outcomes. Following, the LDA and RF techniques have obtained somewhat improved results with $reca_l$ of 94.68% and 96.14% correspondingly. Then, the GRNN and SVM-PNN methods have reported reasonable $reca_l$ values of 93.98% and 97.87% correspondingly. But the proposed NDDCBI-CBIS technique has portrayed maximal $reca_l$ of 98.74%.

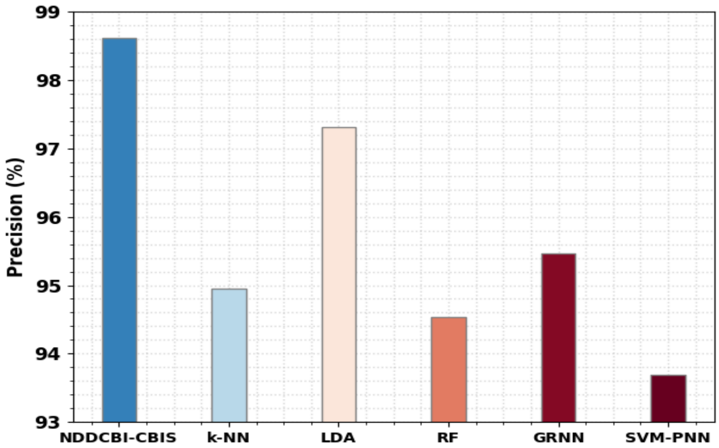

Figure 8. $Prec_n$ analysis of NDDCBI-CBIS algorithm with existing approaches

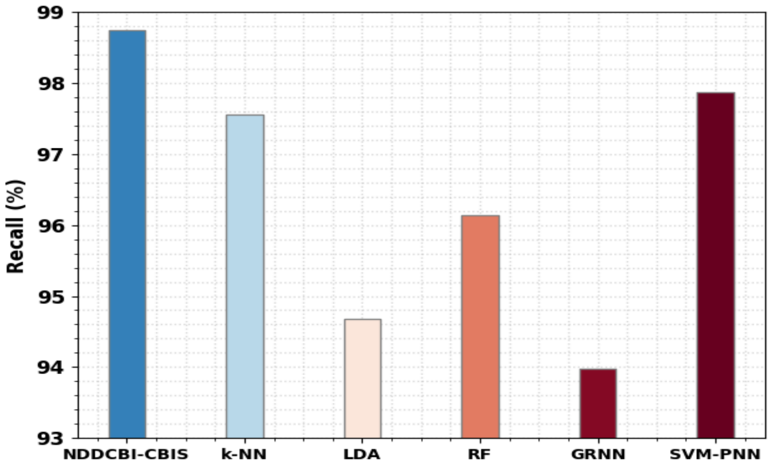

Figure 9. $Reca_l$ analysis of NDDCBI-CBIS algorithm with existing approaches

Fig. 10 represented the F_{score} inspection of the NDDCBI-CBIS method with other state of art works. The figure shows that the kNN fails to display efficient outcomes. Then, the LDA and RF techniques have accomplished slightly improved results with F_{score} of 93.03% and 97.87% correspondingly. Following, the GRNN and SVM-PNN systems have reported reasonable F_{score} values of 93.74% and 96.88% correspondingly. But the proposed NDDCBI-CBIS technique has shown maximal F_{score} of 98.59%.

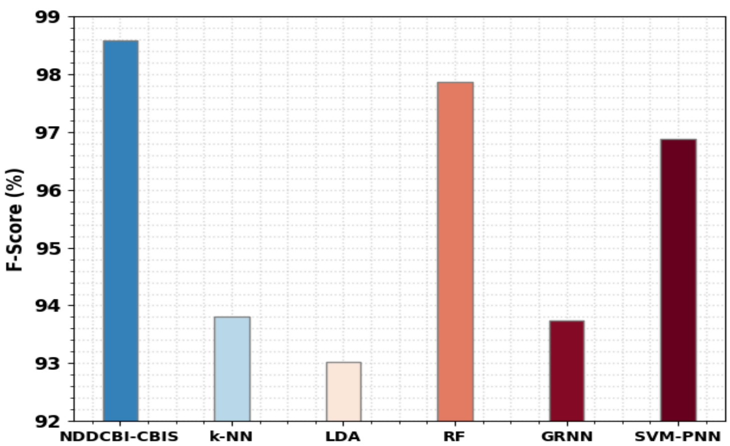

Figure 10. $Reca_l$ analysis of NDDCBI-CBIS algorithm with existing approaches

5. Conclusion

This article presented a new NDDCBI-CBIS technique for neurological disorders detection and classification. The projected NDDCBI-CBIS technique focuses on the identification of neurological disorders and epileptic seizure detection. To attain this, the presented NDDCBI-CBIS technique pre-processes the biomedical signals. Next, to detect epileptic seizures, the LSTM model is applied in this study. The experimental evaluation of the NDDCBI-CBIS algorithm can be tested using the medical dataset and the outcomes inferred from the enhanced outcomes of the NDDCBI-CBIS technique.

Authors' Contributions

All authors contributed toward data analysis, drafting, and revising the paper and agreed to be responsible for all the aspects of this work.

Conflict Of Interest

Authors declare that they have no conflict of interest.

References

[1] Khan, A.A., Laghari, A.A., Shaikh, A.A., Dootio, M.A., Estrela, V.V. and Lopes, R.T., 2021. A Blockchain Security Module for Brain-Computer Interface (BCI) with Multimedia Life Cycle Framework (MLCF). *Neuroscience Informatics*, p.100030.

[2] Yang, W., Aghasian, E., Garg, S., Herbert, D., Disiuta, L. and Kang, B., 2019. A survey on blockchain-based internet service architecture: requirements, challenges, trends, and future. *IEEE Access*, *7*, pp.75845-75872.

[3] Han, X., Zhang, R., Liu, X. and Jiang, F., 2020. Biologically Inspired Smart Contract: A Blockchain-Based DDoS Detection System. In *2020 IEEE International Conference on Networking, Sensing and Control (ICNSC)* (pp. 1-6). IEEE.

[4] Girardi, F., De Gennaro, G., Colizzi, L. and Convertini, N., 2020. Improving the healthcare effectiveness: The possible role of EHR, IoMT and blockchain. *Electronics*, *9*(6), p.884.

[5] Tunc, M.A., Gures, E. and Shayea, I., 2021. A survey on iot smart healthcare: Emerging technologies, applications, challenges, and future trends. *arXiv preprint arXiv:2109.02042*.

[6] Pal, S., Mukhopadhyay, S. and Suryadevara, N., 2021. Development and progress in sensors and technologies for human emotion recognition. *Sensors*, *21*(16), p.5554.

[7] Fetjah, L., Azbeg, K., Ouchetto, O. and Andaloussi, S.J., 2021. Towards a Smart Healthcare System: An Architecture Based on IoT, Blockchain, and Fog Computing. *International Journal of Healthcare Information Systems and Informatics (IJHISI)*, *16*(4), pp.1-18.

[8] Mudgal, S.K., Sharma, S.K., Chaturvedi, J. and Sharma, A., 2020. Brain computer interface advancement in neurosciences: Applications and issues. *Interdisciplinary Neurosurgery*, *20*, p.100694.

[9] Hameed, S.S., Hassan, W.H., Latiff, L.A. and Ghabban, F., 2021. A systematic review of security and privacy issues in the internet of medical things; the role of machine learning approaches. *PeerJ Computer Science*, *7*, p.e414.

[10] Mahmoud, H.H.H., Amer, A.A. and Ismail, T., 2021. 6G: A comprehensive survey on technologies, applications, challenges, and research problems. *Transactions on Emerging Telecommunications Technologies*, *32*(4), p.e4233.

[11] Dumitrescu, C., Costea, I.M. and Semenescu, A., 2021. Using Brain-Computer Interface to Control a Virtual Drone Using Non-Invasive Motor Imagery and Machine Learning. *Applied Sciences*, *11*(24), p.11876.

[12] Ahamad, S., 2022. System Architecture for Brain-Computer Interface based on Machine Learning and Internet of Things. *International Journal of Advanced Computer Science and Applications*, *13*(3).

[13] Wang, X., Yang, R. and Huang, M., 2022. An Unsupervised Deep-Transfer-Learning-Based Motor Imagery EEG Classification Scheme for Brain–Computer Interface. *Sensors*, *22*(6), p.2241.
[14] Hameed, K., Bajwa, I.S., Sarwar, N., Anwar, W., Mushtaq, Z. and Rashid, T., 2021. Integration of 5G and block-chain technologies in smart telemedicine using IoT. *Journal of Healthcare Engineering*, *2021*.
[15] Deshpande, V. (2021). Layered Intrusion Detection System Model for The Attack Detection with The Multi-Class Ensemble Classifier . Machine Learning Applications in Engineering Education and Management, 1(2), 01–06.
[16] Rahman, A., Hossain, M., Muhammad, G., Kundu, D., Debnath, T., Rahman, M., Khan, M., Islam, S., Tiwari, P. and Band, S.S., 2022. Federated learning-based AI approaches in smart healthcare: concepts, taxonomies, challenges and open issues. *Cluster Computing*, pp.1-41.
[17] Hramov, A.E., Maksimenko, V.A. and Pisarchik, A.N., 2021. Physical principles of brain–computer interfaces and their applications for rehabilitation, robotics, and control of human brain states. *Physics Reports*, *918*, pp.1-133.
[18] Zhang, J., Zhu, Y., Zhang, X., Ye, M. and Yang, J., 2018. Developing a Long Short-Term Memory (LSTM) based model for predicting water table depth in agricultural areas. *Journal of hydrology*, *561*, pp.918-929.
[19] Kshirsagar, P. R., Yadav, R. K., Patil, N. N., & Makarand L, M. (2022). Intrusion Detection System Attack Detection and Classification Model with Feed-Forward LSTM Gate in Conventional Dataset. Machine Learning Applications in Engineering Education and Management, 2(1), 20–29\
[20] Hoang, N.D., 2021. Automatic impervious surface area detection using image texture analysis and neural computing models with advanced optimizers. *Computational Intelligence and Neuroscience*, *2021*.
[21] Jing, N., Liu, Q. and Sugumaran, V., 2021. A blockchain-based code copyright management system. *Information Processing & Management*, *58*(3), p.102518.