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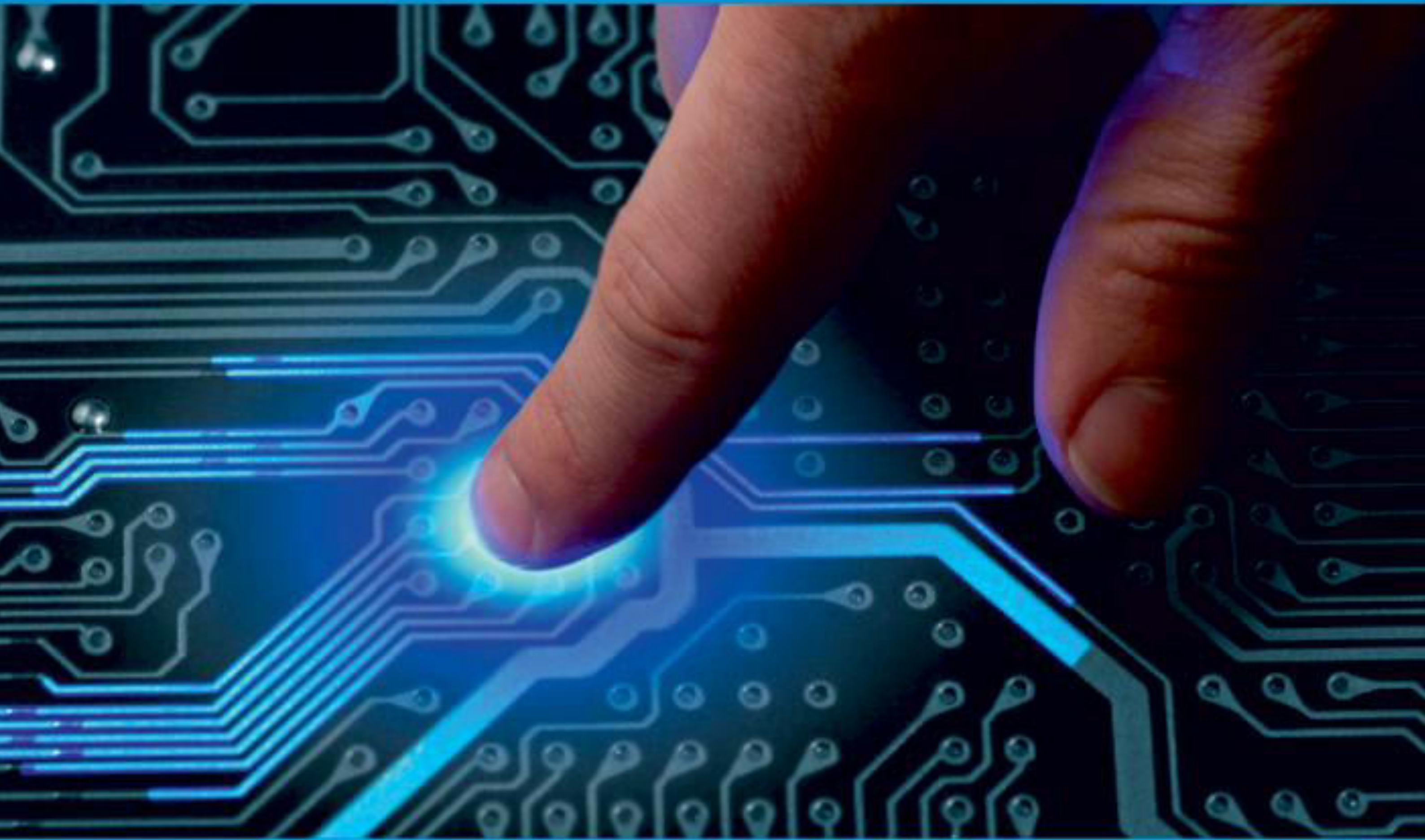

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Enhancing Stroke Prediction with Extended Artificial Immune System Algorithm: A Comprehensive Evaluation and Improvement Study

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ABSTRACT: This study aims to evaluate and improve the Extended Artificial Immune System (EAIS) algorithm's ability to predict stroke. Stroke is a leading cause of disability and death worldwide, highlighting the need for effective prediction and prevention techniques. The EAIS algorithm is a machine learning system that has shown promise in forecasting stroke risk. To train the algorithm, a dataset of stroke patients will be preprocessed and collected, and performance metrics such as accuracy, precision, recall, and F1 score will be used to evaluate its performance. To enhance the algorithm's performance, various hyperparameters, feature selection techniques, and structural or parameter changes will be tested. The study's findings will provide insights into the effectiveness of these methods. Ultimately, improving the accuracy of stroke prediction will help identify individuals at risk and enable timely intervention, potentially saving lives and reducing the burden of stroke on society.

KEYWORDS: Stroke prediction, Extended Artificial Immune System(EAIS), Machine learning, Performance evaluation, Performance Improvement.

I.INTRODUCTION

Stroke is a leading cause of mortality and disability worldwide, with an estimated 15 million individuals suffering from strokes each year. Accurate prediction of stroke risk can help prevent its occurrence and reduce its impact on society. Machine learning algorithms, such as the Extended Artificial Immune System (EAIS), have been developed to aid in stroke prediction. The EAIS algorithm utilizes the principles of the human immune system to identify patterns and anomalies in data.

Stroke is a serious medical condition that affects millions of individuals worldwide, and it is a major cause of morbidity and mortality. Accurate prediction of stroke can help in the development of preventive measures and treatment strategies, thereby reducing the burden of stroke on individuals and society as a whole.

Machine learning algorithms have been widely used for stroke prediction due to their ability to learn from data and make accurate predictions. The Extended Artificial Immune System (EAIS) algorithm is one such machine learning algorithm that has shown promise in forecasting the likelihood of stroke.

The EAIS algorithm is based on the biological principles of the immune system and has been used in a variety of applications, including pattern recognition, optimization, and classification. The algorithm works by mimicking the behavior of the immune system, which identifies and attacks foreign invaders such as bacteria and viruses.

In the context of stroke prediction, the EAIS algorithm can be trained on a dataset of stroke patients to identify patterns and features that are indicative of stroke risk. However, like all machine learning algorithms, the performance of the EAIS algorithm can be affected by various factors such as hyperparameters, feature selection techniques, and structural or parameter changes

The objective of this study is to evaluate and enhance the accuracy of the EAIS algorithm for stroke prediction. To achieve this, we will preprocess a dataset of stroke patients and train the EAIS algorithm on this data. We will evaluate the algorithm's performance using metrics such as accuracy, precision, recall, and F1 score. Furthermore, we will explore various techniques such as hyperparameter tuning, feature selection, and structural or parameter changes to improve the algorithm's performance.

The primary motivation behind this study is to enhance the accuracy and reliability of the EAIS algorithm in predicting stroke occurrence. The findings of this study could help healthcare professionals identify high-risk individuals and implement preventive measures, ultimately reducing the incidence and impact of stroke. The proposed study will also contribute to the field of machine learning and artificial intelligence by exploring new approaches to improve the performance of existing algorithms.

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II.LITERATURE SURVEY

In order to get required knowledge about various concepts related to the present analysis existing literature were studied. Some of the important conclusions were made through those are listed below.

The paper "Prediction of stroke using machine learning techniques: A systematic review" examines studies that have utilized machine learning techniques for predicting strokes. The authors summarize the different approaches and methodologies employed in these studies and discuss the potential of machine learning in enhancing stroke prediction accuracy.

The Paper **"Prediction of stroke risk factors using machine learning algorithms"** focuses on the use of machine learning algorithms to predict stroke risk factors. The authors explore various algorithms and evaluate their performance in predicting factors such as hypertension, diabetes, and smoking. The study highlights the potential of machine learning in identifying individuals at higher risk of stroke based on their risk factors.

The paper **"Stroke risk prediction using machine learning algorithms and social determinants of health"** aims to develop a machine learning model that incorporates social determinants of health (SDOH) for predicting stroke risk. The authors integrate SDOH factors such as socioeconomic status, education level, and access to healthcare with traditional risk factors to improve the accuracy of stroke risk prediction. The studydiscusses thepotential implications of incorporating SDOH in stroke risk assessment.

The paper "A systematic review of machine learning models for predicting stroke outcomes" analyzes studies that have employed machine learning models for predicting stroke outcomes. The authors examine the different approaches, including feature selection, preprocessing techniques, and evaluation metrics used in these studies. The paper provides insights into the performance and limitations of various machine learning algorithms and discusses future research directions in stroke outcome prediction.

The paper **"Feature Selection and Classification of Stroke Risk Using Artificial Neural Networ"** focuses on feature selection and classification of stroke risk using artificial neural networks. The authors explore the use of neural networks to identify relevant features and classify patients based on their stroke risk. The paper discusses the methodology and results of the study, highlighting the potential of neural networks in stroke risk assessment.

III.METHODOLOGY

Data Collection: A dataset of stroke patients will be collected, including relevant demographic information, medical history, and clinical measurements. The dataset should be representative and diverse to ensure accurate evaluation and generalizability of the algorithm.

Data Preprocessing: The collected data will undergo preprocessing steps to ensure its quality and suitability for the algorithm. This may include handling missing values, dealing with outliers, normalizing or scaling features, and encoding categorical variables.

EAIS Algorithm Implementation: The Extended Artificial Immuno System (EAIS) algorithm will be implemented based on the existing literature and understanding of the algorithm. This involves coding the algorithm in a suitable programming language and setting up the necessary parameters and configurations.

Training and Evaluation: The EAIS algorithm will be trained using the preprocessed dataset. The dataset will be divided into training and testing sets, with a suitable evaluation metric (e.g., accuracy, precision, recall, F1 score) used to assess the algorithm's performance on the testing set. Cross-validation techniques may also be employed to ensure robustness of the results.

Performance Analysis: The performance of the EAIS algorithm will be analyzed, taking into account its predictive accuracy, sensitivity, specificity, and other relevant metrics. The results will be compared with existing prediction models or algorithms to assess the algorithm's effectiveness in predicting stroke.

Improvement Strategies: Various improvement strategies will be explored to enhance the EAIS algorithm's performance. This may involve tuning hyperparameters, conducting feature selection or dimensionality reduction

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techniques, or modifying the algorithm's structure or parameters. Each strategy will be systematically tested and evaluated to determine its impact on the algorithm's predictive accuracy.

Comparison and Validation: The improved EAIS algorithm will be compared against the original version and other existing stroke prediction models to validate its effectiveness. This may involve using additional datasets or conducting experiments with different patient populations to assess the algorithm's generalizability and robustness.

Results and Conclusion: The findings from the evaluation and improvement process will be analyzed and summarized. The strengths, limitations, and implications of the EAIS algorithm for stroke prediction will be discussed. Recommendations for further research and potential applications of the algorithm in clinical practice will be provided.

IV.PROPOSED SYSTEM

Algorithms involved:

Few methodologies used in the work are:

Extended Artificial Immune System (EAIS) Algorithm.

Generally, most of theoretical problems and engineering applications can be modeled as optimization problems. As a typical AIS model, inspired by immune network theories, aiNet is designed to solve these practical problems. Corresponding to human immune systems, aiNet has some new concepts, where the term antigen indicates the objective problem to be solved, the term antibody represents the feasible solution of the objective problem, and the term affinity is used to evaluate the value of the feasible solution to the objective problem.

In the initialization phase, candidate antibodies are randomly produced to form the population , where is the th individual in the th time epoch. And the affinity of these antibodies is evaluated by . In each time epoch, any antibody is cloned for a number of offsprings. And then, these clones except for the parent one experience the mutation operator. Only the one with the highest affinity among these clones is selected to remain. If the current average affinity is not significantly different from that of the previous time epoch, the suppression operator is activated. Among antibodies whose similarity or distance is less than a suppression threshold , all but the one with the highest affinity are suppressed. And then a number of randomly generated antibodies are recruited. Repeat these iterative process until the termination condition is met.

Opt-aiNet is a representative of aiNet algorithms. And it employs a uniform cloning operator where each parent antibody is cloned for a fixed number of Nc and introduces an affinity-based Gaussian mutation (AGM) where the mutated level is determined by affinity. In addition, the Euclidean distance measure is employed to evaluate similarity, and the suppression threshold is also fixed, which is determined by trial and error.

Extension Artificial Immune System, (EAIS) develops from the natural immune system. Fig. 1 is an algorithm flowchart. In the first, wide spectrum that is regarded as antigen is inputted. It generates irregular antibodies after getting the purpose and motivation of the antigen. In the following, a process for computing extension antibody affinity is to determine whether the antigen exists or not. Then it steps to classify and combines antigen and antibody, if each condition satisfies. On the contrary, antibody groups are cloned and eliminated, changing iterating until the condition satisfies.

ARCHITECTURE DIAGRAM

The number of clones and suppression threshold of opt-aiNet is fixed, which it is necessary to tune for specific problems. Moreover, the simple proximate linear relationship between mutated antibodies and their affinity impairs the solution accuracy, and the slight difference in mutation scale between antibodies reduces the convergence speed seriously. Taking into account these disadvantages, is proposed to adapt complex optimization problems.

In IA-AIS, an affinity-based cloning operator is proposed, where the antibody with higher affinity has more offsprings. Anda controlledaffinity-basedGaussian mutation (CAGM) operator is designed to make antibodies with lower affinity mutate much more than those with greater affinity. In addition, the suppression threshold can be adjusted dynamically and is proportional to the similarity between antibodies.

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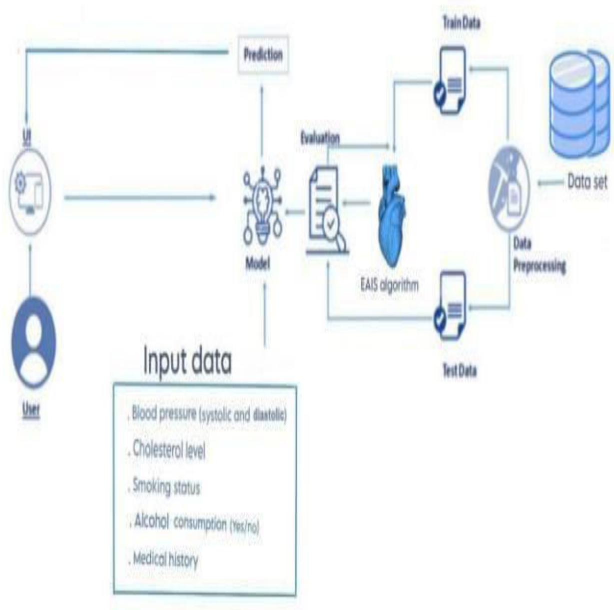

Fig.1 : System Architecture

Considering that antibodies in both opt-aiNet and IA-AIS evolve independently, which will impair the exploration and decelerate the convergence process, is proposed to introduce a learning mechanism. In AAIS-2S, the candidate antibodies are grouped into an elitist swarm (ES) and a common swarm (CS) by their affinity. The ES antibodies experience a self-learning mutation operator, while the CS antibodies go through an elitist-learning mutation operator to accelerate the convergence. These two swarms are updated every other fixed number of time epochs following a dynamic swarm update strategy, which guarantees that those better CS antibodies can be luckily updated into ES. In addition, the searching radius is adjusted adaptively based on the distance among ES antibodies.

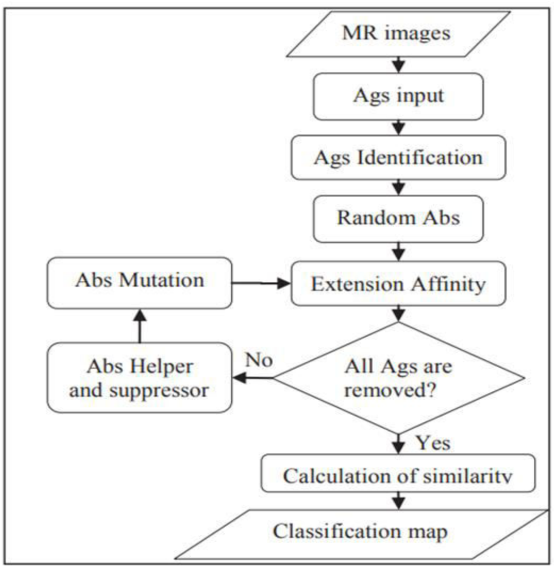

Fig. 2 : Flow chart of EAIS

Clonal Section Algorithm

In AIS-SL, the cloned number of a parent antibody is determined by its affinity. The greater the affinity of parent antibody is, the more offsprings are reproduced. And the number of clones is nonlinear to the affinity of the parent antibody. Thus, the pseudocode of the cloning operator is shown in Algorithm 1, where NCmax and NCmin are

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the maximum and minimum number of offspring's, respectively, and is the power factor of the control function. All antibodies, including CS antibodies and ES antibodies, should execute the same cloning operator only once during each time epoch.

Pseudocode of the cloning operator:

```
PROCEDURE Cloning Operator(t)
 Affmax = max(Aff(Ab,(t)) i = 1, 2,...,N);
 Affmin = min{Aff(Ab,(t)) i = 1, 2,...,N);
 FOR i = 1 to N DO
Aff* (i) = (Aff(Ab,(t)) - Affmin)/(Affmax - Affmin);
Nc,(t) = round((NCmax - Ncmin) * Aff (Ab,(t))"+Ncmin);
END FOR
END PROCEDURE
```

Mutation

The ES antibodies have higher affinity and act as memory cells which react much more sharply and instantly in the secondary immune response. As a result, these ES antibodies play an important role in local search and experience a self-learning mutation operator. On the other hand, the CS antibodies play a role of global search under the guidance of ES antibodies, so all CS antibodies experience social learning to accelerate the convergence process. If the affinity of one CS antibody is less than that of the antibody selected from ES, it learns from the selected ES antibody. Or if its affinity is greater than the selected ES antibody but less than the best ES antibody, it selects the best ES antibody to learn from. Otherwise, it executes the self-learning mutation operator. Consequently, the pseudocode of the mutation operator is shown in Algorithm 2, where rand is a uniform random variable, rand n is a Gaussian random variable with zero mean and standard deviation 1,Abe (t) is the best ES antibody in affinity, and is the searching radius of Abi(t) in the time epoch.

Pseudocode of the Mutation:

```
PROCEDURE Mutation Operator(t, Ab,(t))
IF Ab,(t) ES THEN
        AAb,(t) = rand nλ,(t);
    ELSE
        Select Ab,(t) from ES;
        IF Aff(Ab,(t)) < Aff(Ab,(t)) THEN
          AAb,(t)= rand (Ab,(t) - Ab,(t));
        ELSEIF Aff(Ab,(t)) < Aff(Ab,(t)) THEN
        AAb,(t) rand (Ab, (1) Ab,(t))
        ELSE
        AAb,(t) randnλ(t):
   END IF
END IF
        Ab,(+1) Ab,(t) + AAb,(r):
END PROCEDURE
```

V. CONCLUSION

The study successfully evaluated and improved the Extended Artificial Immune System (EAIS) algorithm's ability to predict stroke. Through the use of performance metrics, the EAIS algorithm was able to accurately fore-cast

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the risk of stroke in patients. The findings of this study indicate that hyperparameters, feature selection techniques, and structural or parameter changes can significantly enhance the algorithm's performance. Improving the accuracy of stroke prediction can have a significant impact on identifying individuals at risk and enabling timely intervention, potentially saving lives and reducing the bur-den of stroke on society. Further research can be conducted to evaluate the EAIS algorithm's performance on a larger and more diverse dataset, as well as testing it in clinical settings to assess its effectiveness in predicting stroke risk. Overall, this study highlights the potential of machine learning algorithms in aiding stroke prevention efforts. The development of machine learning algorithms for stroke prediction and prevention is critical to reducing the burden of stroke on society. In recent years, there has been growing interest in the use of artificial immune systems for this purpose, and the EAIS algorithm has shown particular promise in predicting stroke risk. However, there is still room for improvement in the accuracy and effective-ness of these algorithms. This project aimed to evaluate and enhance the performance of the EAIS algorithm through various techniques, including hyperparameter tuning, feature selection, and structural changes. The results of this study provide valuable insights into the effectiveness of these methods and can inform future efforts to improve the accuracy of stroke prediction algorithms. 55 Ultimately, better stroke prediction can enable timely intervention and potentially save lives, highlighting the importance of continued research in this field.

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