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CRIME RATE ANALYSIS AND MAPPING USING DEEP NEURAL NETWORKS FROM SOCIO-ECONOMIC DATA

Santhosh S
Research Scholar, Department of Information Technology, Noorul Islam Centre for Higher Education, Kumaracoil, Kanyakumari, Tamilnadu, India
Scientist-E/Joint Director, Communications and Software Technology Group, Centre for Development of Advanced Computing (C-DAC), Vellayambalam, Thiruvananthapuram, Kerala, India
Email:santhosh.vattappara@gmail.com

Dr. N Sugitha
Associate Professor, Department of Electronics and Communication Engineering, Saveetha College of Engineering, Thandalam, Chennai, Tamilnadu, India
sugithavinukumar@gmail.com

Abstract
Crime prediction is an attempt to identify and reducing the future crime. Crime, on other hand, is typically “unpredictable”; in other words, they cannot be predicted in advance. Addressing the roots of crime has long been a priority for researchers. While extracting causality from data is difficult if the relevant data aspects not selected. Feature selection is often regarded as a crucial step in any pattern identification procedure. Its purpose is to reduce the amount of memory used, the processing time, and the computational overhead of the classification process in order to improve, or not to improve, classification efficiency. In this research, initially, the pre-processing step is carried out based on Lagrange polynomial interpolation method for filling the missing values. Nextly, the feature selection is employed using the Whale optimization algorithm (WOA). The suggested feature selection and WOA method is used for selecting the important socio economic data’s based on their influence in crime rate prediction. Finally, the crime rate is analyzed for the data’s and categorized as less prone, medium prone and high prone to crime activities using the Deep Learning algorithm.
Keywords: Whale optimization algorithm (WOA), Deep learning algorithm, Lagrange polynomial interpolation method.

Introduction

Methods for predicting future crime with location employ historic socioeconomic data and, after evaluating it, predict future crime with area. In today's world, serial criminal instances occur often, making it difficult to effectively forecast future crime and improve performance. A crime rate has turned into a subject of real concern absolutely to restrict the advancement of good administration and expanding step by step. With improving personal satisfaction, social

interest for protection from crime will increment [1]. Regardless of not expressly encountering crimes, fiascos, and mishaps, individuals experience such circumstances vicariously through the media and their groups of friends, prompting a rising trepidation of crime in people [2, 3]. Numerous crime type display comparable spatial examples, are related with a similar arrangement of hazard factors, and are deciphered utilizing the equivalent biological speculations [4]. Crime examination is an orderly approach for distinguishing and investigating examples and patterns in crime [5]. Criminal investigation follows up on criminal cases like homicide cases, kid misuse, dangers, hacking, and monetary crime location like illegal tax avoidance, psychological oppression financing, extortion, and so forth. So the criminal investigation group should utilize systems with the goal that they can foresee the future crime slants based on accessible verifiable criminal information and thusly the future crime rate will diminish [6, 7, and 8].

Because there is a large amount of crime information available, crime forecasting and criminal distinguishing proof are important difficulties for the police department [9]. Hence the need for innovation so that cases can be resolved more quickly [10]. Although the expected consequences cannot be guaranteed to be 100 percent accurate, the results show that our app helps to reduce crime rates to a limited extent by providing security in crime-prone areas [11]. Information mining and AI algorithm are acquainted with buildup spatio-temporal pattern in and their algorithm utilizes the lattice cell of 800-meter by 800-meter to foresee private robbery [12, 13]. Information Mining is an activity that dissects information from different points of view and outlines or sums it up into valuable data or connections. In any case, it doesn't give exactness result [14, 15].

Lately they have numerous systems to distinguish the crime. Along these lines, the Deep Neutral Network can be utilized. A deep neural network has demonstrated the capability of playing out a non-straight mapping from an info space to a yield space. It is an AI approach where the algorithm can remove the highlights from the crude information, conquering the confinements of other AI techniques [16, 17].

Literature Survey

An intelligent human focused information science approach towards crime pattern investigation has created by Qazi, N., et al. [18] in 2019. In this research, we used content mining to examine unstructured crime records in order to identify possible affiliations. We used this model in conjunction with segment bunching to create an intelligent, human learning disclosure and data mining strategy. This proposed has a major test of incorporating compelling human connection with the machine learning algorithms through a representation input circle.

Hooghe, M., et al. [19] examined the connection between ethnic decent variety and dread of crime an examination on police files and study information in Belgian people group. The investigation depended on a mix of recently accessible authority police records and review information for neighborhood districts in Belgium. The outcome appeared there was no huge connection between announced crime and dread of crime. The discoveries recommend that

uses of gathering risk hypothesis ought to center around financial and social danger, yet additionally on the apparent effect of decent variety on crime and wellbeing.

Information stream examination and representation for spatiotemporal factual information without direction data was created by Kim, S., et al. [20]. The nonstop dissemination of the occasions over reality, and concentrate stream fields for three-dimensional and temporal change used a gravity model. The direction data in a starting point goal dataset and applied system to the information and look at the determined directions and the first. It is hard to separate and imagined information stream patterns and investigation.

Jing, X., et al. [21] was clarified security information accumulation and information examination in the web on an overview. The creator proposed a few extra prerequisites for security-related information investigation so as to make the examination adaptable and versatile. In view of the utilization of information classifications and the kinds of information investigative strategies, we assessed current location techniques for Distributed Denial of Service (DDoS) flooding and worm assaults viautilizing the recommended prerequisites that assess its exhibition.An investigation of dread of crime utilizing multimodal estimation was created by Kim, S.K., et al. [22]. Trial result demonstrated that the physiological sign were reliant on cognizant their very own individual was dread of crime. The creator found huge contrasts between the two gatherings for all video clasps aside from daytime Commercial Street and evening time Natural Street; these information recommend that individual qualities are significant in estimating trepidation of crime.

The impact of fierce crime on monetary versatility was broke down by Sharkey, P., et al. [23]. The creator concentrated on one explicit element of urban territories, the degree of savage crime. Utilizing longitudinal information and a variety of observational methodologies, we discover solid proof that the degree of fierce crime in a region causally affected the degree of upward financial versatility among people brought up in families at the 25th percentile of the salary appropriation. It isn't productive and furthermore precision.
Vomfell, L., et al. [24] built up an improving crime check estimates utilizing twitter and taxi information. It assesses the informative and prescient estimation of human movement patterns got from taxi excursion, twitter and foursquare information. Investigation of a six-month time of crime information for New York City demonstrated that these information sources improved prescient precision for property crime by 19% contrasted with utilizing just statistic information. Crime forecast was urgent to criminal equity leaders is a fundamental restriction.

Non-stationary model for crime rate induction utilizing present day urban information was created Wang, H., et al. [25]. In this paper, the creator utilized an enormous scale data and taxi flowinformation in the city of Chicago. In comparison to using standard highlights, we saw significantly better performance in crime rate induction. In the element relevance investigation, we established that these current sourceswere crucial.The correlations among crime and different watched highlights were not constant over the entire city. We also use the Geographically Weighted Regression on Top of Negative Binomial Model to solve this

spatially non-stationary characteristic (GWNBR). Test result demonstrated that GWNBR beats the negative binomial model.

Proposed Methodology

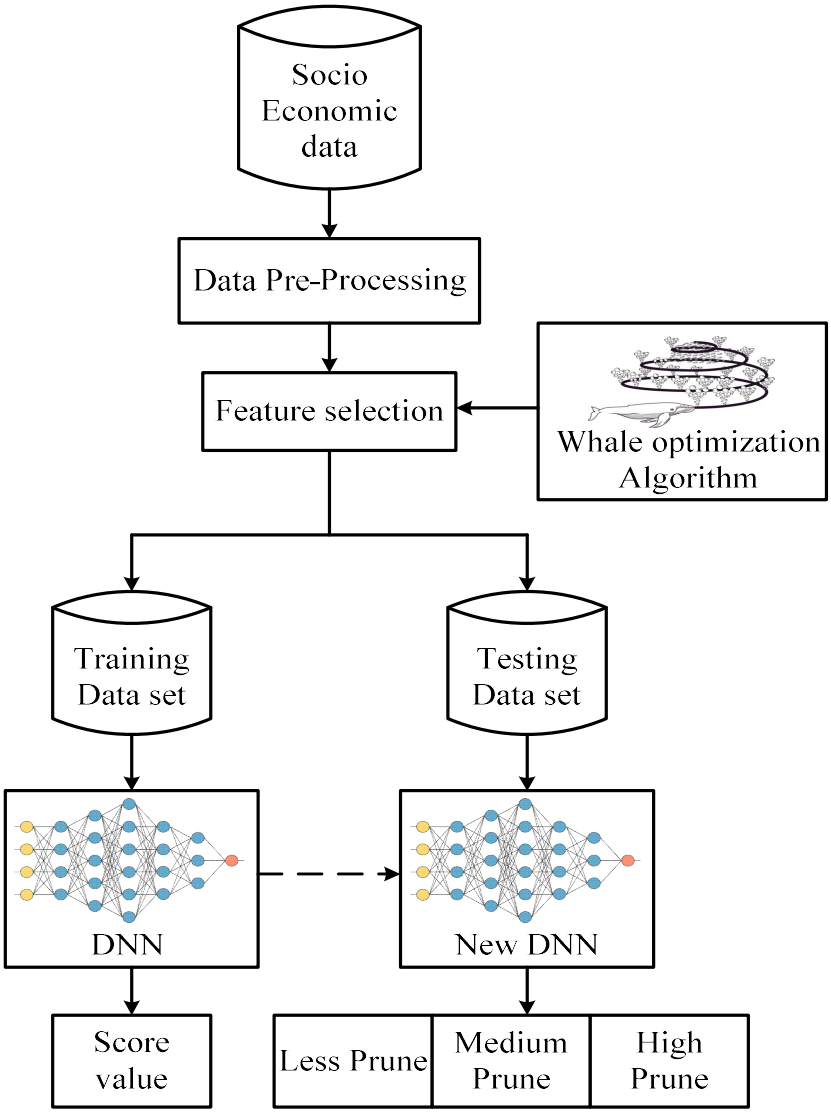

Figure1: Overview of a Proposed Architecture

As shown in figure 1; in order to selecting the important socio-economic data's this paper presents a novel classification framework in the way of following steps: Pre-processing, feature selection as well as classification. In the pre-processing step, Lagrange polynomial interpolation method is used to filling the missing values. The best features should be chosen to produce good classification results. To choose the optimum characteristics WOA is used in the step of feature selection. Next is classification, for training phase Deep Neural Network (DNN) is used and testing phase new DNN is used. With the help of training and testing phase DNN is classifies the socio economic crime data in several classes. Finally, the crime rate is

analyzed for the data's and categorized as less prone, medium prone and high prone to crime activities using the Deep Learning algorithm.

3.1 Pre-processing Stage:

In pre-processing step, the socio-economic data are selected to precede the further process. The dataset used in this research is annual, state code, administrative unit status, name of executive branch, number of murders, crimes, riots, and arson-related crimes; the strength of the civil police, actual armed police strength and total police strength. Because managing missing values and redundant data, we can undertake data cleansing, data integration, and data removal.Pre-processing phase prepares the dataset for control and it is viewed as an important advance to deal with socio economic data. In this, Lagrange polynomial interpolation method is used to filling the missing values. In this research, the Lagrange interpolation method is used to predict missing values. This procedure is used to transform the data value to the actual value predictor variable. In a dataset, if an attribute depends on other than using known values, then unknown values can be found.

3.1.1 Interpolation:

The method of determining unknown values from known ones is known as interpolation. Interpolation is one of the most basic approaches, requiring only two points and a constant rate of change.The cost of storing indexed functions in a system's memory is higher. It's easier to do this by using a method to calculate the value of any arbitrary function, such as sine values of argument.Consider the values (xi, yi) of any function y=f(x), where I = 0, 1,... n. Interpolation is considered as anapproach of calculating the values of y and the intermediary number of x.The procedure for determining y's value.

3.1.2 Lagrange Interpolation:

An interesting feature of this formula is that Lagrange gives the following interpolation polynomial p (X) of degrees n given by n + 1 points (x_i, y_i), and its purpose is to preserve the generalization of x, i (x_i) = 1 and j (x_i) = 0 (j6 = i), giving y = y_i.

$$p(x) = \sum_{j=1}^{n} p_j(x) \quad (1)$$

$$p_j(x) = y_j \prod_{\substack{k=1 \\ k \mp j}}^{n} \frac{x - x_k}{x_j - x_k} \quad (2)$$

The entire formula is mathematically represented as follows;

$y = f(x) = (x - x_1)(x - x_2)...(x - x_n) * y_0/(x_0 - x_1)(x_0 - x_2)...(x_0 - x_n)$
$+ (x - x_0)(x - x_2)...(x - x_n) * y_1/(x_1 - x_0)(x_1 - x_2)...(x_1 - x_n)$
$+ .... +$
$(x - x_0)(x - x_1)(x - x_2)...(x - x_{n-1}) * y_n/(x_n - x_0)(x_n - x_1)...(x_n - x_{n-1})$ (3)

Algorithm1: Lagrange Interpolation

```
Step1 Read number of data (n)
Step2 Read data Xi and Yi for i=0 to n-1
Step3 Read value of independent variables say xp whose corresponding value of dependent say yp is to be
determined.
Step4 Initialize: yp = 0
Step 5 For i = 0 to n-1
        Set p = 1
        For j =0 to n-1
          If i ≠ j then
          Calculate p = p * (xp - Xj)/(Xi - Xj)
          End If
        Next j
        Calculate yp = yp + p * Yi
        Next i
Step 6. Display value of yp as interpolated value.
Stop
```

3.2 Feature Selection:

In this, feature selections are used for the crime rate analysis over various locations with the help of Whale Optimization algorithm (WOA). Proposed feature selection utilizes the optimization method for selecting the important socio economic data's based on their influence in crime rate prediction. Finally, the crime rate is analyzed for the data's and categorized as less prone, medium prone and high prone to crime activities using the DNN algorithm. So, this will be helpful in proposing resources or infrastructure recommendations, like setting up a new police station in a higher crime prone area. In our work, feature selection improves the performance of classification by removing irrelevant as well as attributes of a redundant datasets. It scales down the training time and dimensionality.

3.3 Whale Optimization Algorithm (WOA):

The whale optimization method includes a recently developed meta-heuristic based upon humpback whales' bubble-net hunting tactic. This system describes how humpback whales behave.Two types of uncommon behaviour presented to this whale include encircling prey and bubble-net hunt.When whales encircle prey, they try to encircle the prey (small fish) as close to the water's surface as possible while blowing bubbles in a circle. The humpback whales use the bubble-net hunting technique, which involves diving approximately 12 metres below the surface and then swimming toward the surface while blowing bubbles in a loop around the prey.

3.3.1 Encircling the prey strategy:-

Initially, when encircling prey, whales kept a close eye on the prey's location (fishes). The whales then encircle their prey. The best candidate answer is prey that is quite close to the whales. The other whales adjust their positions in relation to the b hunting agent after the best hunt agent has been found. Equation depicts the surrounding process (5).

$$D=|U.Y^*(k)-Y(k)| \quad (4)$$

$$Y(k+1) = Y^*(k)-V.D \quad (5)$$

Where U and V are coefficients, k is the current number of repetitions, Y*(k) is the best solution's vector sum, Y (t) is the present position vector, and || is an absolute value. The coefficient vectors U, Vare computed in the following way:

V=2.v.r-v (6)

U = 2.r(7)

Where, V is a variable that decreases gradually from 2 to 0 during the period of iteration, and r is a random value between 0 and 1.

3.3.2 Bubble-net attacking strategy (exploitation phase):-

Two enhanced methodologies are created in order to quantitatively predict humpback whale bubble-net behaviour:

- Shrinking encircling mechanism
- Spiral updating position

i) Shrinking encircling mechanism:-

The method was accomplished throughreducing the quantity with in formula (6). It's worth noting that v reduces the fluctuation range of 'V'. In another terms, V indicates randomized numberwithin range [v, v], with v decreasing between 2 to 0 over repetitions. A search agent's new position can be calculated anywhere between the agent's initial position and existingoptimal agent's position using randomizednumber for V in [1, 1].

ii) Spiral updating position:-

Humpback whales first hunt for prey before computing difference between them and the prey. The humpback whales then assault the fish herds by spiralling in a circular exponential movement.It is suggested that each humpback whale update its position in accordance with the spiral flight route. This behaviour can be stated statistically as follows:

$$Y(k+1) = D'.e^{bt} * \cos(2\pi k) + Y^*(k) \quad (8)$$

$$D' = |Y^*(k) - Y(k)| \quad (9)$$

Where b is a constant that defines a geometry of the logarithmic spiral, t is a randomized value within range [1, 1], and "*" is a multiplication of components by components. Humpback whales swim in a decreasing circle around their prey while also swimming in a spiral pattern.

To reflect this simultaneous behaviour, we assume that changing the location of whales after optimizingbothreducing encircling process or the spiral model has a 50% likelihood.The following is the mathematical formula:

$$\vec{X}(t+1)=\begin{cases}\vec{X}^{*}(i)-\vec{V}.\vec{D} & if\ R<0.5\\ \vec{D}'.e^{bk}.\cos(2\prod k)+\vec{X}^{*}(t) & if\ R\geq 0.5\end{cases} \quad (10)$$

Where, R is a randomizedinteger in [0, 1]. In addition to using bubble nets, humpback whales hunt for prey at random.

3.3.3 Search for prey (Exploration period)

If their locations are aligned with one another, humpback whales will search for prey at random. We want to concentrate our efforts in this phase on promising portions of the searching area and drive the search agency to move far to the desired whale.As a result, during prey exploration, the vector 'V' is used, which has a value higher than or less than 1. In contrast to the exploitation period, the exploration period will update a search agent's position based on a newly chosen hunt agent instead of the best agents found so far.We use |V|>1 for force WOA algorithm investigation in order to discover the globally maximum while avoiding local maxima.The theoretical model can be expressed in the following way:

$D = |C.\ Xr_{and} - X|$ (11)

$X\ (t + 1) = Xr_{and} - V.D$ (12)

Where Xr_{and}, is a randomly chosen position vector (a whale) from the existing population.

At the end of each repetition, search agents evaluateits position to randomly selected agent or the finest answer found so far. The value' a' is decreased from 2 to 0 to make investigation and exploiting easier.When |V>1|, a randomized searching agent is chosen, whereas |V1|, selects the best solution for updating the search agents' locations. Calculating the value of R, WOA an flip among a helical and a cyclical movement.

3.4 Feature Selection using Whale Optimization Algorithm (WOA):

Optimum features should be chosen to produce good classification results. The greatest properties are chosen using the Whale Optimization Algorithm.WOA will determine the best global solution with the maximum classification results. In comparison to other state-of-the-art algorithms, WOA is more effective at selecting optimal features and optimising a range of restricted engineering design issues. We create the WOA algorithm for picking the best features in our research.To choose optimal features the subsequent processing stages are utilized.

Step 1: Initialization

Initialization, or solution creation, is a key phase in an optimization process that aids in the rapid identification of the best solution.In this, the data base contains socio economic data. Methods for predicting future crime with location employ historic socioeconomic data and,

after evaluating it, predict future crime with location.In this, SF represents the selected features, the selected features are represented as SF= {i=1, 2, 3…n}. Achieved resolution is proposed for following stage, which is fitness evaluation, in order to increase performance and identify an optimal solution.

Step 2: Fitness Calculation

Fitness function evaluates the resolution after it is generated and then selects the best option. The majority of the time, an optimization algorithm's fitness function helps to determine the best alternative. To discover the best solution, the optimization method mostly focuses on its fitness value.The classification accuracy is considered as the solution qualifier in this paper using the DNN. The feature data set is split into two halves, one for training and the other for testing. DNN is learned by the input features throughout the training process. The new DNN classifier is provided feature data after the training is completed. Out of 100 data sets, 80 percent are used for training and 20% are used for testing. The updation is based on the results of DNN testing and training accuracy. The range of classification accuracy is [0; 1]; each Search Agent represents this range.The selection of the fitness is a fundamental aspect in WOA.

$$Fitness_{gr,t} = \sum_{K=1}^{N} \frac{accuracy_{gr,t,k}}{N} \quad (13)$$

Where f (g, t) the fitness value for whale optimization g in iteration t, N speaks to the quantity of features selected for further process and accuracy, t, k is the accuracy resultant. WOA upgrades the underlying arbitrary populace on the test capacities and attractively enhances the accuracy of the approximated optimum is mathematically represented as describes;

$$\text{accuracy} = \frac{\text{TN} + \text{TP}}{(\text{TN} + \text{TP} + \text{FN} + \text{FP})} \quad (14)$$

Where the TP denoted as true positive, TN denoted as the true negative, FP denoted as the false positive and FN denoted as the false negative.

Step 3: WOA based updation solution

During the fitness evaluation, modify the response with the help of WOA.With the help of equation (15) we could update the solution. Situation or position of the whale optimization can be characterized mathematically as given below,

$$S(I-1) = \vec{S}*(I) - \vec{U}.\vec{V} \quad (15)$$

Where, I which specifies the current iteration $\vec{S}$ specify the vector position and $\vec{S}*(i)$ specify the vector position of best solution. On computing the location of the present optimalsolution the algorithm is used to determine a new search position (15),

$$\vec{S}(I+1) = \vec{A}_{rand} - \vec{U}.\vec{V} \quad (16)$$

During the exploration phase, a randomly selected search agent will update the location of the search agents using formula (16)

$$\vec{S}(I+1) = \left| S*\vec{(I)} \right| .h^{st}.\cos(2\prod t) + \vec{S}*(I) \quad (17)$$

Next, the agent positions and locations are updated in the manner of spiral by using the equation (17).

Step 4: Termination criteria:

We stopped the whole process by setting a maximum iteration. The algorithm only continues if the optimum quantity of cycles has been completed and the option with the highest fitness number has been chosen. When the best fitness is achieved using WOA methods, a feature is chosen for classification.

3.5 Deep Learning Network (DNN):

DNN is among the most effective classification methods.Still, DNN isn't appropriate for classification of huge amount data sets because the complexity of DNN is extremely reliant on the input size. So, in this Multi-kernel DNN's are used to manage highly dimensional data and providing high classification accuracy with optimal features and achieve optimal performance metrics with low computational cost. Compared to the other classification DNN classifier has good accuracy as well as significantly faster than other classifiers. The entire feature data set is split into two halves, one for training and the other for testing in this method.During training, input features are trained. After the completion of training feature data's are given to the DNN classifier. Out of some data sets selecting the important socio economic data's based on their influence in crime rate prediction 80 % of data's are used for teaching and 30% of informationgroups are used for examine after completing the testing phase the data's are given to the new DNN and finally the crime rate is analyzed for the data's and categorized as the classes of less prune, medium prune as well as high prune.

Result and discussion

In this category, our implemented Lagrange polynomial interpolation technique for filling missing values in the step of pre-processing and WOA for selecting the important socio economic data's based on their influence in crime rate prediction and for classification DNN techniques have been executed in the operating platform of JAVA. This procedure is carried out on a Windows machine with the following specifications: processor® Dual-core CPU, RAM: 1 GB, Speed: 2.70 GHz, Microsoft Window7 professional operating system.

Experimentation Findings:

It can be used to examine the effectiveness of all of the comparable algorithms, including our suggested WOA and DNN. Not all of the characteristics are used for classification in particular. The best features should be chosen to produce better classification results. he Whale Optimization Algorithm is used to choose the best characteristics, resulting in the most accurate comprehensive solution. In our experience, DNN is ideal for categorization.DNN is being used to anticipate and classify vital socio economic data's based on their influence in crime rate prediction. Finally, the crime rate is analyzed for the data's and categorized as less prone, medium prone and high prone to crime activities using the Deep Learning algorithm. Our

proposed model will give high classification accuracy with optimal features and achieve optimal performance metrics compared to other existing developed model.

The following figure 2 to 8 shows the Execution time, Memory, Training Time, Testing Time, Sensitivity, Specificity and Accuracy of the proposed approaches.

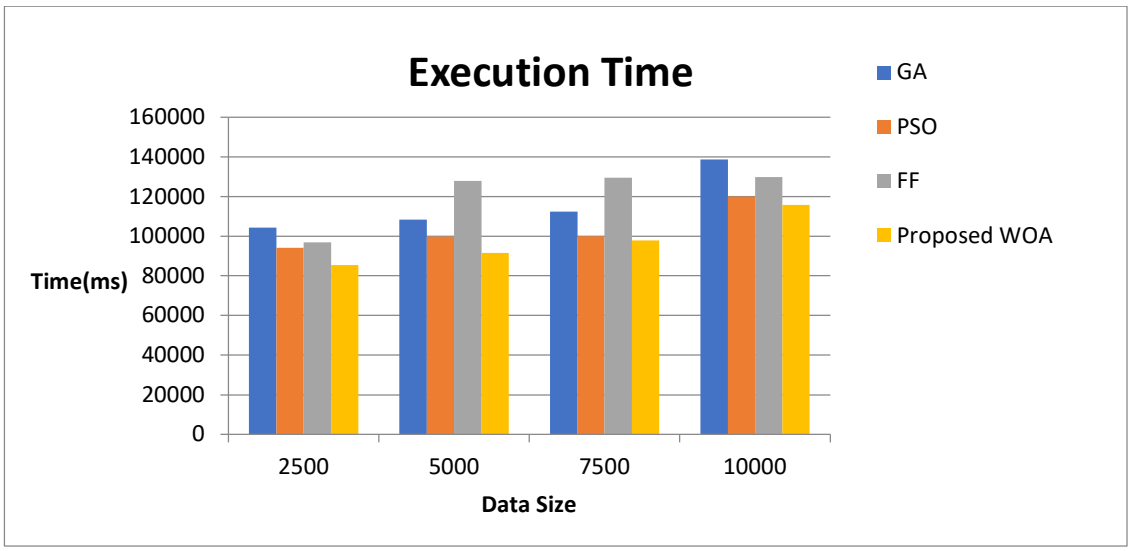

Figure 2: Performance analysis for execution time

When analyzing figure 2 the proposed WOA obtains the less execution time of 85441, 91547, 97858, and 115787. Comparing these existing genetic algorithm (GA), particle swarm optimization (PSO), Fire Fly (FF) the proposed WOA achieves less execution time. Figure 2 illustrates how our proposed strategy exceeds existing approaches in terms of results.

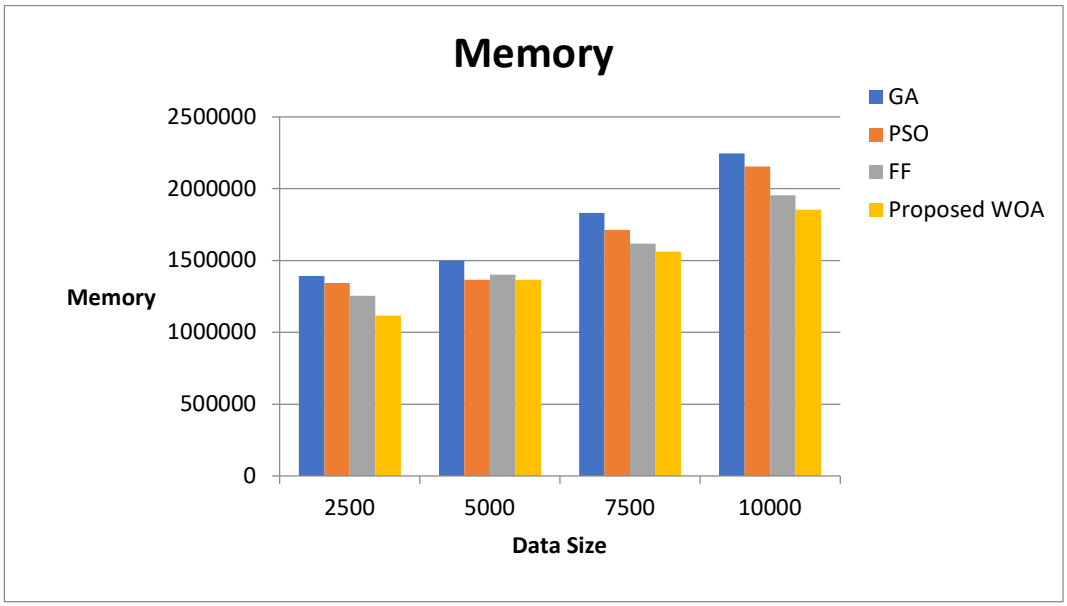

Figure 3: Performance analysis for Memory Utilization

The above graph represents the comparison analysis of the memory utilization of a proposed method with the existing methods. When examining figure 3 the suggested WOA obtains minimal memory utilization of 1115484, 1364945, 1561475, and 1854456. Comparing these existing GA, PSO, FF the proposed WOA achieves minimum memory utilization. Figure 3 illustrates how our proposed strategy exceeds existing approaches in terms of results.

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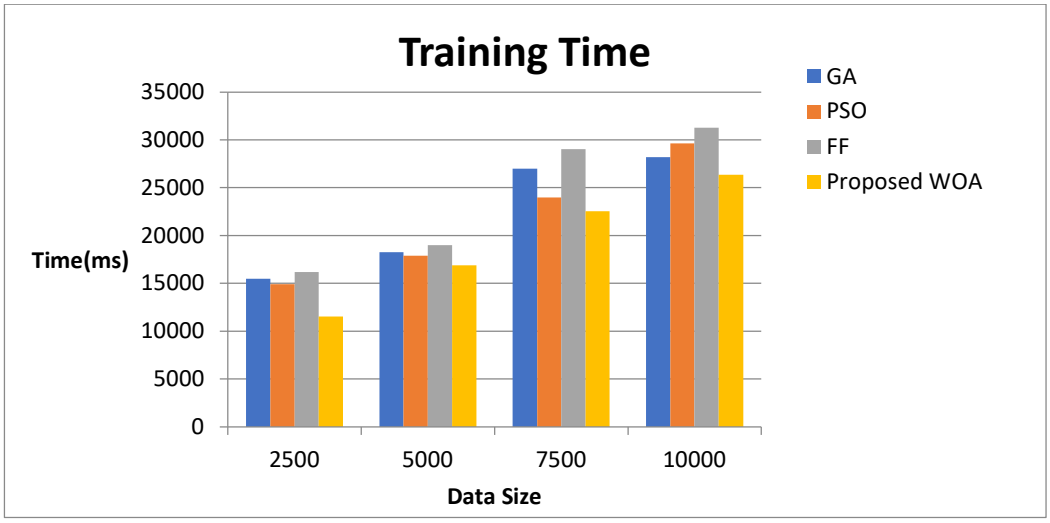

Figure 4: Performance analysis for Training Time

When analyzing figure 4 the proposed WOA obtains the minimum training time of 11547, 16884, 22545, and 26365. Comparing these existing GA, PSO, FF the proposed WOA achieves minimum training time. Figure 4 illustrates how our proposed strategy exceeds existing approaches in terms of results.

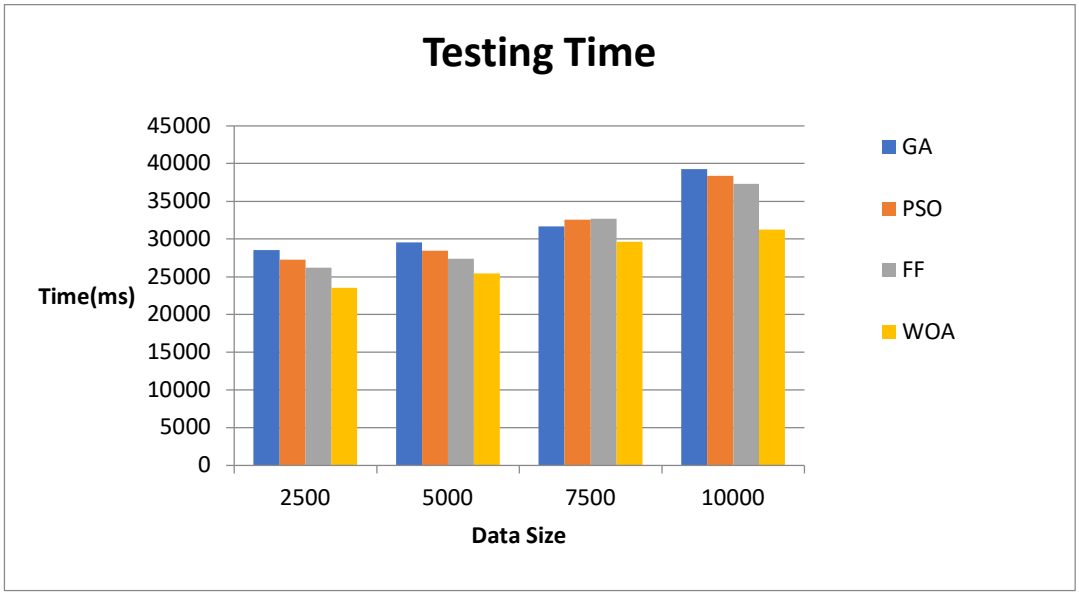

Figure 5: Performance analysis for Testing Time

The above graph represents the comparison analysis of the testing time of a proposed method with the existing methods. When examining figure 5 the suggested WOA obtains the minimal testing time of 23544, 25465, 29658, and 31254. Comparing these existing GA, PSO, FF the

proposed WOA achieves minimum testing time. Figure 5 illustrates how our proposed strategy exceeds existing approaches in terms of results.

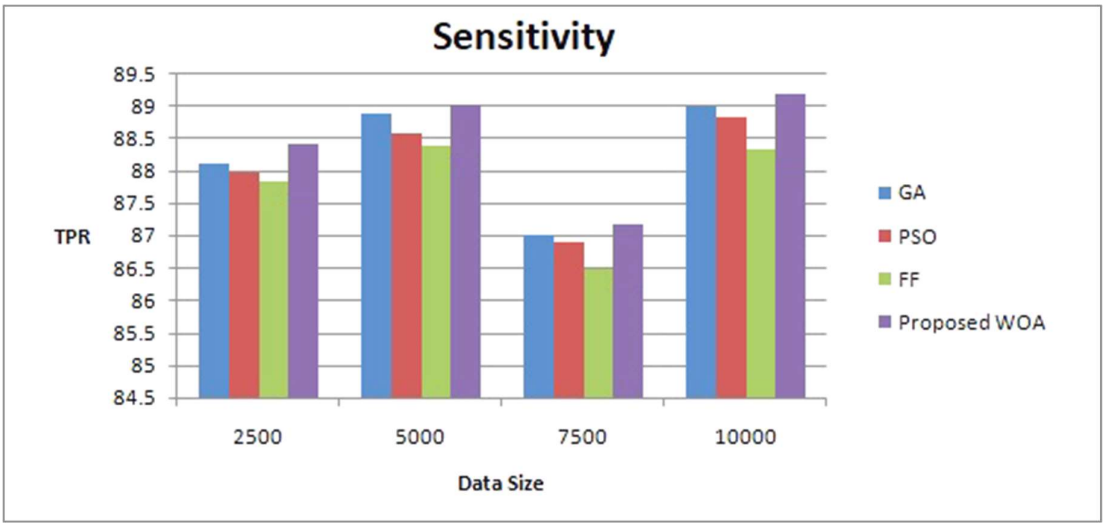

Figure 6: performance evaluation for sensitivity

The above graph represents the comparison analysis of the sensitivity of a suggesting method with the existing approaches. When analyzingfigure, the proposed WOA obtains the maximum TPR (True Positive Rate) i.e., sensitivity of 88.4, 89, 87.25, 89.15. Comparing these with existing GA, PSO, FF, and the proposed WOA achieves maximum sensitivity.

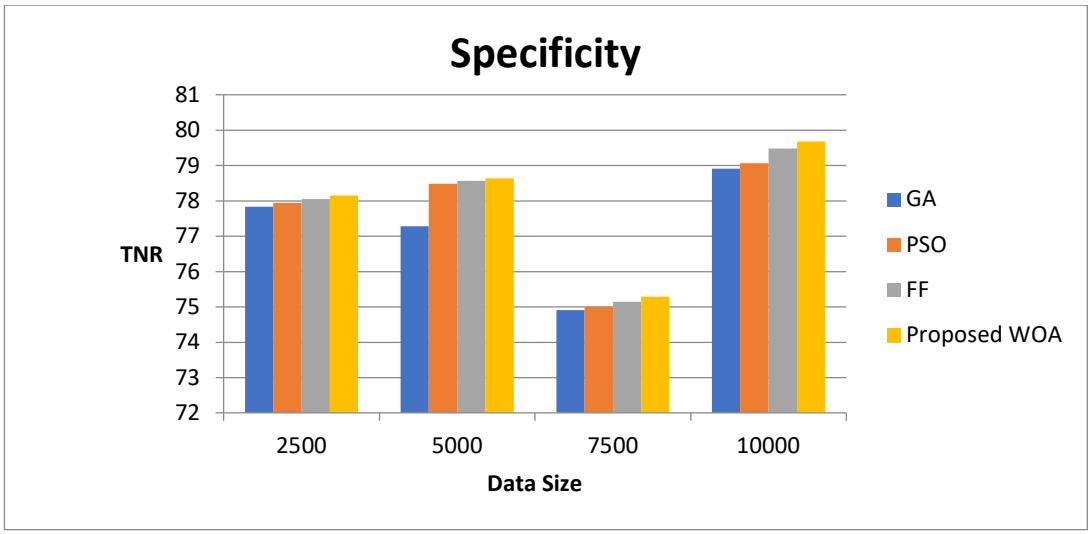

Figure 7: performance analysis for specificity

When analyzing figure 7 the proposed WOA obtains the maximum specificity of 78.15, 78.64, 75.29, and 79.68. Existing techniques of GA, PSO and FF are not identifying the TNR's clearly but proposed WOA correctly identifies the TNR. Comparing these existing proposed WOA achieves higher specificity. Figure 7 illustrates how our proposed strategy exceeds existing approaches in terms of results.

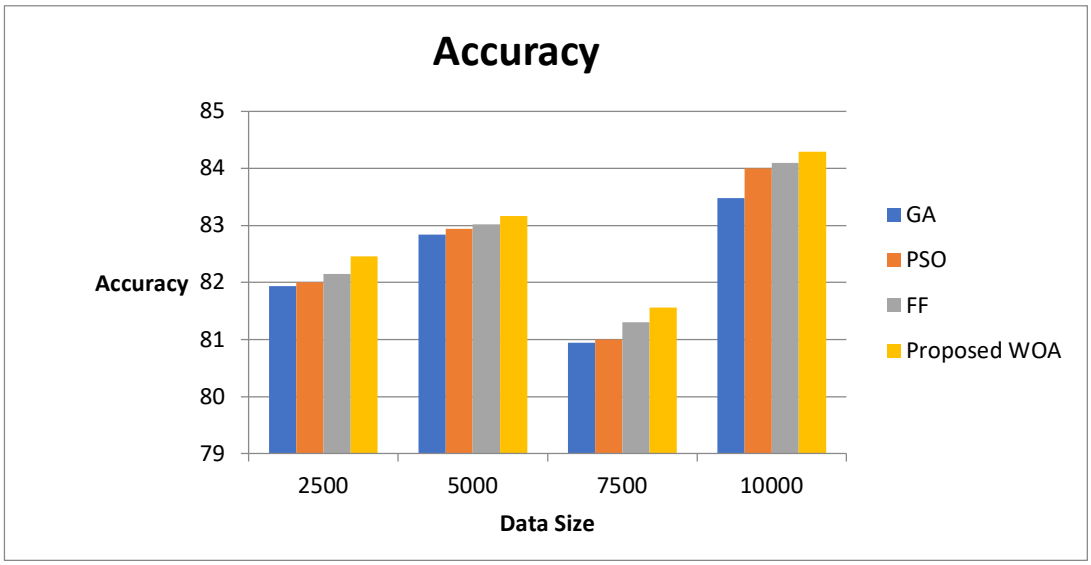

Figure 8: performance analysis for Accuracy

The above graph specifies the performance analysis for maximum accuracy. Accuracy is our preliminary or initial point. In this, the proposed WOA identifies all the sensitivity, specificity, execution time, memory utilization after identifying these; it will measure the maximum accuracy. It's computed by dividing the quantity of accurate suggestions made by the total number of forecasts and multiplying by a hundred to get a percent.GA, PSO, FF are existing techniques which can't properly identifies the sensitivity, specificity,execution time and memory utilization this is one the main drawbacks. Analyzing figure 8 the proposed WOA obtains the maximum accuracy comparing to the other existing techniques.

Conclusion:

With today's rapid occurrence of repeated criminal instances, it's a difficult challenge to precisely predict future crime and improve performance.In order to predict the socio economic crime data, this paper presents a novel classification framework in the way of the following steps: Pre-processing, feature selection as well as classification. The ideal features should be chosen to produce good classification results.Whale Optimization is a technique for selecting the optimal characteristics. WOA will determine the optimal overall solution with the improved classification accuracy.With the help of these features, DNN is used to classify the crime data. The proposed model will give high classification accuracy with optimal features and achieve optimal performance metrics compared to other existing developed model.

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