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Prediction of Heart Disease using Swarm Intelligence based Machine Learning Algorithms

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Abstract. In the present era heart disease is considered to be one of the major diseases and many people are suffering due to this disease and the foremost challenge is identification and prediction before it causes any consequences or deaths. There are some techniques available for prognosticate heart disease since this disease is increasing rapidly throughout the universe, this prediction process may save life. Time and efficient play important role in identifying heart disease in healthcare industry particularly in the field of cardiology. In this paper we developed a dynamic and accurate system for heart disease prediction using machine learning techniques. There are two phases which can identify and predict heart disease: 1) Feature selection 2) classification stage. Feature selection is one of the methods for selecting attributes and feature subset as it eliminates unwanted data and apply classification algorithms and dataset comprises of patient's attributes like age, gender, blood pressure, glucose level, blood sugar etc… by processing these attributes we can predict the chance of occurring heart disease. This paper proposes a optimization techniques like Grey wolf optimization, Particle swarm optimization combined with Ant colony optimization for performing supervised classification algorithms.PSO is for finding optimum solutions and ACO is for finding good paths and the mixed proposed algorithm is applied and result are estimated to identify the efficiency and robustness.

INTRODUCTION

E-health is the electronic process and communication technology in healthcare which is to predict the disease during a pandemic situation and make people comfort. In such pandemic situations internets are available for patients and doctors communication. Internets are responsible for the health risk and life of patients. The heart disease dataset is taken from UCI repository and make use it for predicting disease [1].

The ML techniques are used for prediction that identifies the hidden disease.ML is of three types supervised, unsupervised and semi supervised. These machine learning models have parameters which is considered as hyper parameters. Hyper parameters control the behavior of training algorithm. Patient's data are divided into two ways either normal or abnormal. The attributes are chosen through involvement [2]. In this paper accurate heart disease prognostic model GWO+PSO+ACO along with classification algorithms is developed.

The "GWO algorithm is a feature selection method which removes the unwanted attributes, noisy and redundant attributes" [22]. Here we use 14 attributes out of this 7 are selected as a best feature. It majorly improves the performance of prediction. PSO technique is applied to find the optimum solutions [3]. ACO for finding good paths [4]. After feature selection apply classification methods. Using a single optimization algorithm may have the drawback of lower accuracy and low performance in solving complex problems. This paper implements a three optimization technique for better performance.

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RELATED WORK

Heart disease the major health related issue around the universe which may leads to death. Heart failure may cause because of hypertension, smoking, obesity, and diabetes. In this paper pathos psychological factors are observed with HF and reduced LVEF [2].

There is no literature review for traditional medicine. In this paper application of data mining methods in traditional medicine is applied for identifying heart disease [3]. This paper solves two real-time problem for determining the ability of the proposed method. The accuracy is achieved by k-fold cross validation. This observed accuracy values of 84.24%, 86.8% for diabetics dataset [4]. Heart attack supposed to release fraction and how it may have changed over time are needed while treatment. It should focus on removing the pressure of hospitals in heart failure [5]. Relief based feature selection method detect without examining pair wise combinations. This review concentrate on technical algorithms, iterative scaling, and data type adjustability [6].

The multivariate regression techniques such as time series models [19] Least Square Support Vector Regression (LSSVR) [21] models predict the total vehicle salesmonthly based on the customer reviews from twitter and the values attained in stock market are considered as the input for the forecasting using LSSVR as the time series data models are constructed based on the stock market values [22]. From the tweets the senti-scores are calculated which are further used to denote the positive and negative sentiment information [23].

Hybrid data with de-seasonalizing procedures are employed to compare the forecasting accuracy of monthly total vehicle sales as the results clearly denote that the hybrid approach provides more accuracy when compared to the traditional approaches [24]. The implemented analysis on sentiment analysis based on the mining of opinions which are based on the aspect level sentiment analysis is performed based on the mining of reviews [25]. The information from web pages are extracted using web crawler API [26] extracts information from the webpages.

The aspects that are based on sentiment analysis [31] applied over big data by integrating the semantic information classified into various text representation is done by implementing the neural network model [32] and the various attention mechanisms introduced over neural networks tends tomechanize and compare the sentences with the relevant contextbased vectors are that performs calculations by verifying the weight of each word for making the model that is basically adjustable method of sentiment dictionary tagging which is further used toobtaining the training data effectively improvises the accuracy of sentiment analysis [33].

The process of sentiment analysis which is implemented using Transfer Learning (TL) [34] process which is the industry requirement that prefers distinct commodities that are obtained through the product reviews by carrying the internal emotion obtained in the text that are efficiently mined to help the organizations or enterprises for attaining operative future decisionbrings more opportunities to sentiment analysis using TL algorithms that are employed are based on the “Convolutional Neural Network (CNN) [35] Recurrent Neural Network (RNN) [4] and Hybrid Neural Network(HNN)” [5] models. Applications that are based on of TLput forward to the development trend of sentiment analysis is based on dictionary-based approach that is implemented using NB and Support Vector Machine (SVM) algorithms [33] with small set of opinion words from twitter are collected manually as a seed which is a potentially information that generates pseudo random number [32].

A model called Perceived Derived Attributes (PDA) [36] is used to depicts the importance of the customer reviews in product selection given by online shoppers who usually trust the e-commerce portal for providing the customer reviews for customers who checks the reviews frequently before purchasing anything as the analysis clearly shows the online customer reviews which in turn affects the customer decision to buy a specific productcan influence sales results [8].

By deploying the novel model that combines the Bass or Norton model [9] and sentiment analysis to predict sales for automotive industry based on time series sales data and online user reviews that are considered for predicting the future sales of the product clearly denotes the integration of novel model generated which higher forecasting accuracy will have a huge impact on sales results [37,38].

PROPOSED METHODOLOGY

In this paper firstly we applied “Grey Wolf Optimization” [1] for feature selection along with PSO and ACO optimization technique for feature optimization. This also includes supervised classification ML algorithms like "SVM, Naïve bayes, Random forest, Decision tree and Logistic regression". Existing heart disease prognostic have less efficiency in processing the dataset and possible of low accuracy. In this article, GWO, PSO combined with

ACO methods are proposed for efficient heart disease prediction with high accuracy. The proposed architecture consists of different stepssuch as "data selection, optimization, preprocessing, attribute selection and classification".

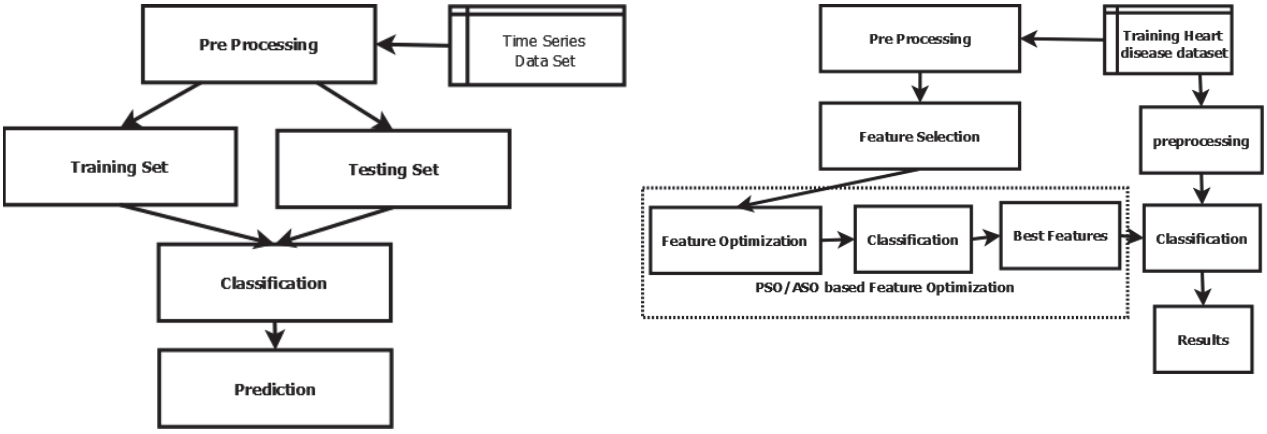

FIGURE 1.(a) proposed phases and (b) proposed architecture

TRAINING DATASET AND PREPROCESSING

Initially we need to train the heart disease dataset. Large amount of data i.e., 70% is used for training process. This makes a program to understand how to apply the technologies to learn and produce the result. After training process completes apply feature selection technique.

Preprocessing fills missing values and extracts data from large dataset. It finds and removes the unwanted data and resolve the unpredictable of data. Raw data may consist of some errors and noises, it is important to remove those noises and an error to get better output from given dataset. Normalization method is used for preprocessing the data.

FEATURE SELECTION USING GREY WOLF OPTIMIZATION ALGORITHM

The "GWO is the feature selection method which selects the attributes to improve the efficiency of the heart disease prediction system whose behavior is based on wolves which searches finds and hunts the pierce as there are four grey wolves alpha, beta, delta and omega"."Alpha is the leader of the group which is used for decision making, where beta helps alpha in decision making". "Delta obeys alpha and beta that protects the boundaries of their groupand Omega wolves are the least prioritized wolves It follows allother category wolves".

GWO eliminates redundant and irrelevant features by searching for best attribute. Once the coefficients alpha, beta is initialized fitness value is estimated. Fitness value is calculated to maximize the classification accuracy. Best solution is selected such as α, β, and δ respectively. Two stages are occurred in proposed system one is attribute selection and another is classification. Initially, Grey Wolf Optimization (GWO) is used which is attribute selection method that selects the best attributes in the heart disease identification dataset. End of first stage 7 attributes is selected as a best feature[39-42]. After optimization applied, the fitness value of GWO is calculated by using classificationalgorithm (SVM).

```
In [1]: runfile ('c:/Grey_wolf.py', wdr="c:/")
(203,13)
Accuracy score for SVM: 0.6247440583607588
GWO is optimizing "F7"
(5,13)
Alpha Position = [5.7861 0.404838 0.0609075 0.0609075 0.040997]
Beta Position = [12.7206 4.60328 3.83717 0.830047 0.12541]
Delta Position = [19.6594 9.51591 4.30162 1.77049 0.196164
GWO is optimizing "F7"
(5,13)
Alpha Position = [4.7511 -0.630162 -0.9740925 -0.9740925 -0.994003]
Beta Position = [11.6856 3.56828 2.80217 -0.204953 -0.90959]
Delta Position = [18.6244 8.48091 3.26662 0.73549 -0.838836]
GWO is optimizing "F7"
(5,13)
Alpha Position = [3.7161 -1.665162 -2.0090925 -2.0090925 -2.029003]
Beta Position = [10.6506 2.53328 1.76717 -1.239953 -1.94459]
Delta Position = [17.5894 7.44591 2.23162 -0.29951 -1.873836]
```

FIGURE 2.(a) denotes reviews related to RAM with price range and (b) denotes reviews related to internal memory with price range

TABLE 1. Values of models to predict the total Samsung mobile phone sales

Sl.No.	Attribute	Is null	Data Type
1	AGE	nonnull	Float64
2	HEIGHT	nonnull	Float64
3	MRI	nonnull	Float64
4	CT	nonnull	Float64
5	REST ECG	nonnull	Float64
6	REST EKG	nonnull	Float64
7	TEE	nonnull	Float64
8	HOLTER	nonnull	Float64

Modified Accuracy score for SVM: 0.6247440583607588
Earlier Accuracy score was: 0.5982636455367748

FEATURE OPTIMIZATION USING PARTICLE SWARM OPTIMIZATION

PSO is generally defined as behavior of birds which are hungry that searches for a food and find it. Likewise it searches and finds the optimum solutions. The random particles are initialized and searches for the optimized solution[43-46]. It is important to define a search space. During iteration each particles will change its position according to its best neighbor. In PSO after initialization each particle updates its position and velocity. This method calculates fitness value to maximize the classification accuracy. The resultant accuracy of prediction is more accurate as compare to individuals[47-49].

```
In [2]: runfile ('c:/Grey_wolf.py', wdr="c:/")
Reloaded Modules: benchmarks
[-1.76568924 -1.30888924 -1.90888924 -1.76568924 -1.30888924 -1.90888924
 -1.76594524 -1.30914524 -0.90914524 -1.76594524 -0.30914524 -0.90914524
 -0.76582284 -1.30902284 -1.90902284 -0.76582284 -1.30902284 -1.90902284
 -0.76607884 -0.30927884 -0.90927884 -1.76607884 -0.30927884 -0.90927884
 -1.76595644 -1.30915644 -1.90915644 -1.76595644 -1.30915644 -1.90915644
 -0.76621244 -0.30941244 -0.90941244 -0.76621244 -1.30941244 -0.90941244
 -1.76609004 -1.30929004 -1.90929004 -1.76609004 -0.30929004 -1.90929004
 -0.76634604 -0.30954604 -1.90954604 -0.76634604 -1.30954604 -0.90954604
 -1.76622364 -0.30942364 -0.90942364 -1.76622364 -0.30942364 -1.90942364
 -0.76647964 -1.30967964 -0.90967964 -0.76647964 -1.30967964 -1.90967964
 -1.76635724 -0.30955724 -1.90955724 -1.76635724]

Evaluate the Fitness Value
[-0.22609216 -0.34307216 -0.46005216 -0.44974216 -0.34974216]

Accuracy for PSO
78.96
```

(a)

```
In [3]: runfile ('c:/Grey_wolf.py', wdr="c:/")
Initialize parameters of PSO
[-1.7756918 -1.3188918 -1.9188918 -1.7756918 -1.3188918 -1.9188918
 -1.7759478 -1.3191478 -1.9191478 -1.7759478 -1.3191478 -1.9191478
 -1.7758254 -1.3190254 -1.9190254 -1.7758254 -1.3190254 -1.9190254
 -1.7760814 -1.3192814 -1.9192814 -1.7760814 -1.3192814 -1.9192814
 -1.775959 -1.319159 -1.919159 -1.775959 -1.319159 -1.919159
 -1.776215 -1.319415 -1.919415 -1.776215 -1.319415 -1.919415
 -1.7760926 -1.3192926 -1.9192926 -1.7760926 -1.3192926 -1.9192926
 -1.7763486 -1.3195486 -1.9195486 -1.7763486 -1.3195486 -1.9195486
 -1.7762262 -1.3194262 -1.9194262 -1.7762262 -1.3194262 -1.9194262
 -1.7764822 -1.3196822 -1.9196822 -1.7764822 -1.3196822 -1.9196822
 -1.7763598 -1.3195598 -1.9195598 -1.7763598]

Evaluate the Fitness Value
[-0.125091904 -0.242071904 -0.359051904 -0.348741904 -0.248741904]

Accuracy for PSO
78.99
```

(b)

FIGURE 3.(a) Evaluation of fitness value for accuracy for PSO Run1,(b) Evaluation of fitness value for accuracy for PSO Run 2

FEATURE OPTIMIZATION BY ANT COLONY OPTIMIZATION

In general ACO is to find good paths or shortest path. It searches for paths based on pheromone values .It finds and updates the values. It minimizes the redundancy between subset features. It receives largest number of pheromone and make a selection by other ants will be increased in subsequent iterations. ACO problems are mapped by graph G =(C, L).

```
[30 rows x 7 coloumns]
--------5-----------
final:
    id             gen_0 * * *  real_value_gen_1 Finalsolution
 6   6  [  0 0 0 0 0 0 ] * * *          1.682548      7.635800
24  24  [  0 0 0 0 0 0 1 ] * * *          1.558898      7.635542
28  28  [  0 0 0 0 1 0 ] * * *         -1.340452      7.636057
 0  31  [  0 0 0 0 1 1 ] * * *         -1.352817      7.635799
 0  41  [  0 0 0 1 0 0 ] * * *          1.806198      7.892957
 0  43  [  1 0 1 1 0 1 ] * * *          1.682548      7.892699
 0  47  [  0 0 0 1 1 0 ] * * *         -1.216802      7.892441
 0  57  [  0 0 0 1 1 1 ] * * *         -1.229167      7.892956
 0  61  [  1 1 1 0 0 0 ] * * *          1.929848      7.892698
 0  65  [  1 0 1 0 0 1 ] * * *          1.806198      7.892440
 0  75  [  0 0 1 0 1 0 ] * * *         -1.093152      7.892955
 0  79  [  0 0 1 0 1 1 ] * * *         -1.105517      7.892697
 0  86  [  0 0 1 1 0 0 ] * * *          1.806198      7.892439
 0 101  [  0 0 1 1 0 1 ] * * *          1.682548      7.892954
 0 112  [  0 0 1 1 1 0 ] * * *         -1.216802      7.892696
 0 116  [  0 0 1 1 1 1 ] * * *         -1.229167      7.892438
 0 132  [  0 1 0 0 0 0 ] * * *          1.929848      7.892953
 0 144  [  1 0 1 1 1 0 ] * * *          1.806198      7.892695
 0 169  [  1 0 0 1 0 0 ] * * *         -1.093152      7.892437
 0 188  [  1 0 0 0 1 1 ] * * *         -1.105517      7.892951
 0 150  [  0 1 1 1 0 0 ] * * *          1.806198      7.892693
```

FIGURE 4. (a)denotes the fin al run being implemented

CLASSIFICATION OF SVM, NAÏVE BAYES, LOGISTIC REGRESSION, DECISION TREE, RANDOM FOREST

Algorithms used for prediction purpose are "SVM, decision tree, naïve bayes, random forest and logistic regression". After applying optimization technique we perform the classification based on five machine learning algorithms. From the above five algorithms SVM, Random forest provide the best accuracy result.

```
Accuracy for training set for svm = 0.9256198347107438
Accuracy for test set for svm = 0.8032786885245902

Accuracy for training set for Naïve Bayes = 0.8677685950413223
Accuracy for test set for Naive Bayes = 0.7868852459016393

Accuracy for training set for Logistic Regression = 0.8636363636363636
Accuracy for test set for Logistic Regression = 0.8032786885245902

Accuracy for training set for Decision Tree = 1.0
Accuracy for test set for Decision Tree = 0.7704918032786885

Accuracy for training set for Random Forest = 0.987603305785124
Accuracy for test set for Random Forest = 0.7704918032786885
```

FIGURE 5. Accuracy attained for training and testing set

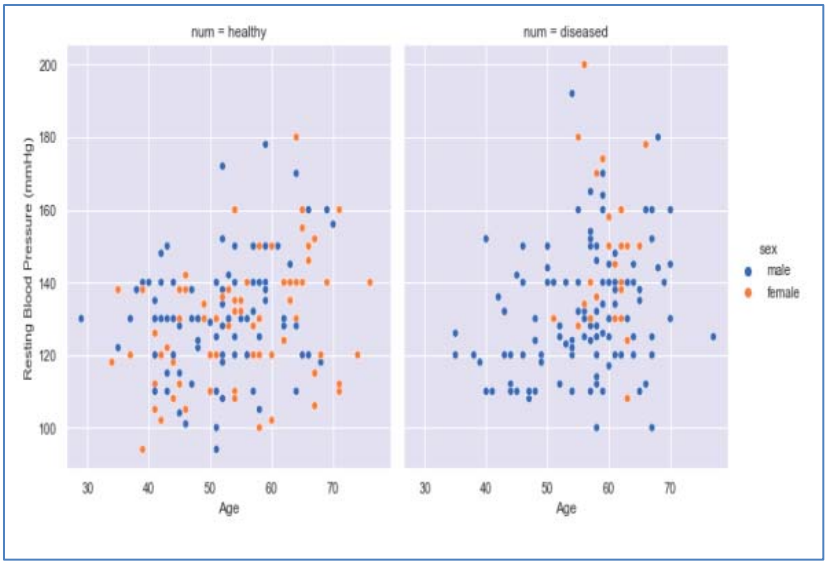

FIGURE 6. Prediction Results attained

CONCLUSION

In this paper, GWO+PSO+ACO method is used for "heart disease prediction" and the GWO is for feature selection as PSO is for finding optimum solution and ACO method is used to find shortest path which removes the redundant and irrelevant attributes. Some classification algorithms are used for prediction purpose. GWO with SVM,PSO achieved 61%,77.05% whereas ACO achieved Updated pheromone value. SVM and Random forest is the best among other algorithms which achieved 92%, 98%.In futurework can be extended by applying hybrid technique and various algorithms for improving the efficiency of identification of different medical disease that can be classified.

REFERENCES

1. Z. Xiang, Q. Du, Y. Ma, and W. Fan, ‘‘A comparative analysis of major online review platforms: Implications for social media analytics in hospitality and tourism,’’ Tourism Manage., vol. 58, pp. 51–65, Feb. 2017.
2. I. Erkan and C. Evans, ‘‘The influence of eWOM in social media on consumers’ purchase intentions: An extended approach to information adoption,’’ Comput. Hum. Behav., vol. 61, pp. 47–55, Aug. 2016.
3. N. Kim and W. Kim, ``Do your social media lead youto make social deal purchases? Consumer-generated social referrals for sales via social commerce," Int. J. Inform. Manage., vol. 39, pp. 38_48, 2018.
4. A. Alalwan, N. P. Rana, Y. K. Dwivedi, and R. Algharabat, ‘‘Social media in marketing: A review and analysis of the existing literature,’’ Telematics Inform., vol. 34, no. 7, pp. 1177–1190, 2017.
5. Mohammed Ali Shaik and DhanrajVerma, (2020), Enhanced ANN training model to smooth and time series forecast, 2020 IOP Conf. Ser.: Mater. Sci. Eng. 981 022038 https://doi.org/10.1088/1757-899X/981/2/022038
6. Mohammed Ali Shaik, DhanrajVerma, P Praveen, K Ranganath and BonthalaPrabhanjanYadav, (2020), RNN based prediction of spatiotemporal data mining, 2020 IOP Conf. Ser.: Mater. Sci. Eng. 981 022027 https://doi.org/10.1088/1757-899X/981/2/022027
7. Veenadhari, S., Misra, B., & Singh, C. D. (2014). Machine learning approach for forecasting crop yield based on climatic parameters. In 2014 International Conference on Computer Communication and Informatics (pp. 1-5).
8. Mohammed Ali Shaik, “Time Series Forecasting using Vector quantization”, International Journal of Advanced Science and Technology (IJAST), ISSN: 2005-4238, Volume-29, Issue-4 (2020), Pp. 169-175.

9. Mohammed Ali Shaik, (2019), "A Survey on Text Classification methods through Machine Learning Methods", International Journal of Control and Automation (IJCA), ISSN: 2005-4297, Volume-12, Issue-6 (2019), Pp. 390-396.
10. T. SampathKumar,B. Manjula, D. Srinivas, (2017), A New Technique to Secure Data Over Cloud Jour of Adv Research in Dynamical & Control Systems vol 11 pp 145-149
11. T. Sampath Kumar, B. Manjula, Mohammed Ali Shaik, Dr. P. Praveen, (2019), A Comprehensive Study on Single Sign on Technique International Journal of Advanced Science and Technology (IJAST) Vol-127 pp 156-162
12. Mohammed Ali Shaik, T. Sampath Kumar, P. Praveen, R. Vijayaprakash, (2019), "Research on Multi-Agent Experiment in Clustering", International Journal of Recent Technology and Engineering (IJRTE), ISSN: 2277-3878, Volume-8, Issue-1S4, June 2019. Pp. 1126-1129.
13. R. Ravi Kumar, M. Babu Reddy and P. Praveen, (2017), A review of feature subset selection on unsupervised learning Third International Conference on Advances in Electrical, Electronics, Information, Communication and Bio-Informatics (AEEICB), pp163-167
14. P.Praveen, B.Rama, (2019), An Efficient Smart Search Using R Tree on Spatial Data Journal of Advanced Research in Dynamical and Control Systems vol 4 pp1943-1949.
15. P. Praveen, B. Rama and T. Sampath Kumar, (2017), An efficient clustering algorithm of minimum Spanning Tree Third International Conference on Advances in Electrical, Electronics, Information, Communication and Bio-Informatics (AEEICB pp 131-135
16. Naresh Kumar S, Pramod Kumar P, Sandeep C, Thirupathi V, Shwetha S, (2019), A study on deep Q-learning and single stream Q-network architecture Int J AdvSciTechnolvol 28(20) pp 586-592
17. Kumar RR, Reddy MB, Praveen P. (2019), Text classification performance analysis on machine learning Int J AdvSciTechnolvol 28(20) pp 691-697
18. Ravi Kumar R, Babu Reddy M, Praveen P, (2019), An evaluation of feature selection algorithms in machine learning Int J SciTechnol Res vol 8(12) pp 2071-2074
19. Jamalpur, Bhavana, (2020), Data Exploration As A Process Of Knowledge Finding And The Role Of Mining Data Towards Information Security Journal Of Mechanics Of Continua And Mathematical Sciences vol 15(6) pp 2020-2028
20. JamalpurBhavana, KomuravellySudheer Kumar, (2019), Implementation of Bovw Model Towards Obtaining Discriminative Features of the Images International Journal of Advanced Science and Technology vol 28(17) pp 205-213
21. J.Bhavana, KomuravellySudheer Kumar, (2019), A Study on the Enhanced Approach of Data Mining Towards Providing Security for Cloud Computing Indian Journal of Public Health Research & Development vol 9(11) pp 225-232
22. Kothandaraman D, Sheshikala M, SeenaNaik K, Chanti Y, Vijaykumar B. (2019), Design of an optimized multicast routing algorithm for internet of things Int J Recent TechnolEngvol 8(2) pp 4048-4053
23. Dr.SeenaNaik, (2016), An Effective use of Data Mining Techniques to Creation International Journal Of Advancement In Engineering vol 3(10) pp 157-163
24. D.Ramesh, Syed Nawaz Pasha, G.Roopa, (2017), A Comparative Analysis of Classification Algorithms on Weather Dataset Using Data Mining Tool Oriental Journal of Computer Science and Technology vol 10(4) pp1-5
25. Chythanya KR, Kumar KS, Rajesh M, Tharun Reddy S, (2020), Sensor Cloud: A Breakdown information on the Utilization of Wireless Sensor Network by Means of Cloud Computing Test Eng Manage vol 82 pp13945-13954
26. P. Praveen and B. Rama, (2016), An empirical comparison of Clustering using hierarchical methods and K-means International Conference on Advances in Electrical, Electronics, Information, Communication and Bio-Informatics (AEEICB) pp.445-449
27. SallauddinMohmmad, G. Sunil, RanganathKanakam, (2017), A Survey On New Approaches Of Internet Of Things Data Mining International Journal of Advanced Research in Computer Science vol 8(8) pp 123-135
28. Mohammed Ali Shaik, DhanrajVerma, (2021), Agent-MB-DivClues: Multi Agent Mean based Divisive Clustering, Ilkogretim Online - Elementary Education, Vol 20(5), pp. 5597-5603, doi:10.17051/ilkonline.2021.05.629
29. SallauddinMohmmad, Dr.M.Sheshikala, Shabana, (2018), Software Defined Security (SDSec): Reliable centralized security system to decentralized applications in SDN and their challenges Jour of Adv Research in Dynamical & Control Systems Vol 10(10) pp 147-152

30. SallauddinMohmmad, Shabana, RanganathKanakam, (2017), Provisioning Elasticity On IoT's Data In Shared-Nothing Nodes International Journal of Pure and Applied Mathematics vol 117(7) pp 165-173
31. Pramod Kumar P, Naresh Kumar S., Thirupathi V. and Sandeep C, (2019), QOS and security problems in 4G networks and QOS mechanisms offered by 4G. International Journal of Advanced Science and Technology 28(20) 600-606.
32. Mohammed Ali Shaik and DhanrajVerma 2020 Enhanced ANN training model to smooth and time series forecast IOP ConfSer: Mater SciEngVol (981) 022038 https://doiorg/101088/1757-899X/981/2/022038
33. Pramod Kumar P and Sagar K, (2019), Vertical Handover Decision Algorithm Based On Several Specifications in Heterogeneous Wireless Networks International Journal of Innovative Technology and Exploring Engineering, 8(9) 972-82.
34. Mohammed Ali Shaik and DhanrajVerma 2020 Deep learning time series to forecast COVID-19 active cases in INDIA: a comparative study IOP ConfSer: Mater SciEngVol (981) 022041 https://doiorg/101088/1757-899X/981/2/022041
35. YerrollaChanti, BandiBhaskar, NagendarYamsani, "Li-Fi Technology Utilized In Leveraged To Power In Aviation System Entertainment Through Wireless Communication", J. Mech. Cont.& Math. Sci., Vol.-15, No.-6, June (2020) pp 405-412.
36. Chanti, Y., Korra, S.N., Bhaskar, B., Harshavardhan, A., Srinivas, V., 2020. "Sturdy goals coverage for power harvesting Wi-Fi detector coterie". IOP Conf. Ser.: Mater. Sci. Eng. 981, 022070.
37. D. Kothandaraman and C. Chellappan, (2019), "Node Rank Based Energy Efficient Routing Algorithm for Mobile Ad-hoc Network", International Journal of Computer Networks & Communications (IJCNC) vol.11, No.1, January 2019, pp 45-61,
38. D. Kothandaraman, C. Chellappan and P. sivasankar (2019), "Context-aware Energy Conserving Algorithm for Internet of Things", International Journal Computer Networks and Communication, Vol.11, No.3, pp. 15-32.
39. Mannanuddin, K., Aluvala, S., Sneha, Y., Kumaraswamy, E., Sudarshan, E. and Mahender, K., 2020, December. Confluence of Machine Learning with Edge Computing for IoT Accession. In IOP Conference Series: Materials Science and Engineering (Vol. 981, No. 4, p. 042003). IOP Publishing.
40. Yadav, B.P., Ghate, S., Harshavardhan, A., Jhansi, G., Kumar, K.S. and Sudarshan, E., 2020, December. Text categorization Performance examination Using Machine Learning Algorithms. In IOP Conference Series: Materials Science and Engineering (Vol. 981, No. 2, p. 022044). IOP Publishing.
41. Yadav, B.P., Prasad, C.S.S., Padmaja, C., Korra, S.N. and Sudarshan, E., 2020, December. A Coherent and Privacy-Protecting Biometric Authentication Strategy in Cloud Computing. In IOP Conference Series: Materials Science and Engineering (Vol. 981, No. 2, p. 022043). IOP Publishing.
42. Yadav, B.P., Sheshikala, M., Swathi, N., Chythanya, K.R. and Sudarshan, E., 2020, December. Women Wellbeing Assessment in Indian Metropolises Using Machine Learning models. In IOP Conference Series: Materials Science and Engineering (Vol. 981, No. 2, p. 022042). IOP Publishing.
43. Shabana, Mohmmad, S., Shaik, M.A., Mahender, K., Kanakam, R., Yadav, B.P.Average Response Time (ART):Real-Time Traffic Management in VFC Enabled Smart Cities(2020) IOP Conference Series: Materials Science and Engineering, 981 (2), art. no. 022054.
44. Sudarshan, E., Korra, S.N., Rajasekharaiah, K.P., Venkatesulu, S. and Harshavardhan, A., 2020, December. IoT Based Smart Solar Atmospheric Water Harvesting System. In IOP Conference Series: Materials Science and Engineering (Vol. 981, No. 4, p. 042004). IOP Publishing.
45. Venkatesulu, S., Sudarshan, E., Korra, S.N., Kumari, D.R., Yadav, B.P. and Mahender, K., 2020, December. Real Time Fitness Analysis of Bitumen Road and Vehicle through Their Acoustic Signals. In IOP Conference Series: Materials Science and Engineering (Vol. 981, No. 3, p. 032004). IOP Publishing.
46. Korra, S.N., Sudarshan, E., Venkatesulu, S., Kumar, P.P. and Yadav, B.P., 2020, December. Portable manure dispenser machine. In IOP Conference Series: Materials Science and Engineering (Vol. 981, No. 2, p. 022026). IOP Publishing.
47. Sravanthi, T., Hema, V., Tharun Reddy, S., Mahender, K., Venkateshwarlu, S.Detection of Mentally Distressed Social Media Profiles Using Machine Learning Techniques(2020) IOP Conference Series: Materials Science and Engineering, 981 (2), art. no. 022056.
48. Akarapu, M., Martha, S., Donthamala, K.R., Prashanth, B., Sunil, G., Mahender, K.Checking for Identity-Based Remote Data Integrity Cloud Storage with Perfect Data Privacy(2020) IOP Conference Series: Materials Science and Engineering, 981 (2), art. no. 022034.

49. Prasad, C.H.S.S., Yadav, B.P., Mohmmad, S., Gopal, M., Mahender, K.Study of threats associated with cloud infrastructure systems(2020) IOP Conference Series: Materials Science and Engineering, 981 (2), art. no. 022055.