International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 2 Volume No.7 March - April – 2023
DOI:10.46647/ijetms.2023.v07i02.058 ISSN: 2581-4621

ADAPTIVE COAL CLASSIFICATION USING DEEP LEARNING

D.Mohanapriya[1], N.Nafreen Banu[2] , K.Vannamathi[3] , L.Sharnitha shri[4]
[1]*Assistant Professor, Computer Science and Engineering, Nandha College of Technology, Erode, Tamil Nadu*
[2,3,4] *UG – Computer Science and Engineering, Nandha College of Technology, Erode, Tamil Nadu*
Corresponding Author Orcid ID : https://orcid.org/0000-0003-3290-0575

ABSTRACT
Coal classification is an essential process in the mining industry, which involves identifying the quality and type of coal extracted from the earth. Traditional methods of coal classification rely on manual inspection and analysis, which can be time-consuming and prone to errors. With the advent of machine learning techniques, it is now possible to automate this process and achieve higher accuracy and speed in coal classification. The first effort in learning about coal is observing coal features. This project developed a coal search system that allows users to do a search even when they do not know the coal name simply by observing coal characteristics. At present, coal classification uses machine vision to extract and analyze color, size, shape, and surface texture. Still, the new extraction margin method can be carried out roughly yet there is still a difference between the margin of extracted polygon, shape and the margin of the shape of original image. The project aims in finding the gangue in the coal. Total gangue percent in the coal data is then calculated and displayed which is based on pixels count of gangue colors. This assists in evaluating the coal quality. If future researchers were to expand to other features, coal gangue, etc., even those that are hard to quantify, can also be quantified. Artificial Neural Network is used for classifying the coal dataset. The project is designed using Python as frontend environment. The coding language used is the Python 3.7.
Keywords: Coal Classification, Centroid Contour, Deep Learning, Object Recognition.

1. Introduction
Nowadays, coal is the most required energy source for new society. It has a complex recovery processes, and can be mixed with considerable amount of Silicon Dioxide Sio2 as which is called as coal gangue. The coal gangue's main components are both a) Al_2o_3 and b) Sio_2, which are sulfur rich and great quantities of the heavy metals like arsenic, cadmium, chromium, copper, etc. Burning these coal gangue will result in emission of hazardous substances which create environmental pollution. Moreover, when comparing with the coal, combustion value of the coal gangue is lower, which minimize the total energy for coal mixed with coal gangues. So, sorting the coal gangue from its main coal is an extremely important process and it also has two traditional sorting formula / methods: i) human sorting and ii) wet cleaning methods. A sieving machine sorts pure / raw coal into coal equal to or > 100 mm and also < 100 mm; a new transportation system is used for transporting the coal from underground to basement ground; and coal equals or >=100 mm is transported to sort workshop in which skilled workers sort coal gangue from its coal based on gray values with texture differences. In addition to these traditional methods, representative research methods also cover ray casting, radar detection, mechanical vibration, color separation, etc., which are having good detection methods and properties, but they also have high requirements also for runtime environments and can impact human health.With the computer technology development, ImageNet is combined with convolutional neural networks (CNNs), as well as deep learning developed rapidly. When Compared with old traditional sorting methods, latest object detection algorithms could learn from sample images using CNN, that extract features of coal with coal gangue and are having most significant advantages, like high identification speed with high precision.
Distinguishing coal from coal gangue is an important working part of coal industry and is mainly conducted by using human sorting at present. Consequently, most considerable man power is required, which adds the risk burden for companies and so results in poor efficiency. As a main

important branch of artificial intelligence, deep learning has been widely applying in numerous fields, main in machine vision/voice recognition, and its performance is enhanced greatly when compared with performances of traditional learning methods, and it is having good a transfer learning ability also.This study proposed an improved Artificial Neural Network algorithm as the classic deep learning method for intelligent and highly accurate recognition of coal gangue. Compared to the YOLO algorithms, this ANN has better anchor value by using cluster analysis application for different data sets, and a good anti-interference ability for minimizing impacts from mine dust/shock and which acquires the more richer detailed information by adding number of layers of feature pyramid.

a) Auto-inspecting and grading system for machine vision to extract and analyze color, size, shape, and surface texture. The proposed extraction margin method could be carried out roughly and there is still a variation between both the margin of extracted shapes, polygons, and shape margins of the original image. Therefore, to improve the method for capturing the coal outline, this project proposes a NN to classify coal features.

As a result, the captured image is consistent with original coal images. Since image recognition technology for quantifying three dimensional features, are difficult, and accuracy of quantified value could not be verified, accuracy of feature search query is definitely impacted and so they cannot be performed. Therefore, this project applied NN to those coal features to accurately quantify them. The rest of this paper is organized as follows: Section 2 reviews the existing security approaches under recent studies and explains previous works and their drawbacks. Section 3 provides proposed methodology of the study. Section 4 provides finds and Section 5 is conclusion of the study.

2. Related Work

2.1 Identification Method of Coal and Coal Gangue based on dielectric characteristics

In this paper [1] the authors stated that to solve the problems of the difficult feature extraction, poor feature credibility and low recognition accuracy of coal and gangue, this paper utilizes the difference in the dielectric properties of coal and gangue and in combination with a support vector machine (SVM) to propose a recognition method based on the dielectric characteristics of coal and gangue. The influence rule of the edge effect of the electrode plate on the capacitance value is analyzed when the thickness of the electrode plate changes. By changing the frequency and voltage of the excitation source, curves of the dielectric constant of coal and gangue versus frequency and voltage are obtained.

Combined with the Kalman filter, the adaptive noise complete set empirical mode decomposition (CEEMDAN) denoising method is improved, which results in a signal with a higher signal-to-noise ratio and lower root mean square error after denoising. The effective value and frequency of the denoised response signal are extracted to construct the feature vector set to form the training set and test set. The data of the training set are input into the SVM to train the intelligent classification model, the test set is used to test the SVM classification effect, and the classification accuracy is 100%. Unlike these of the probabilistic neural network (PNN) intelligent classification model and the learning vector quantization (LVQ) neural network classification model, the recognition and classification accuracies of the three can reach 100%, but the classification speed of SVM is the fastest, only taking 0.007916 s, which fully reflects the feasibility and efficiency of the capacitance method in identifying coal gangue. In this paper, the capacitance method and SVM are applied to identify coal and gangue, and accurate and efficient identification results are obtained, providing a new feasible solution for research on coal gangue identification.

A large amount of coal gangue is produced during coal mining. Coal gangue is a kind of solid waste with low carbon content, and accounts for 10%-15% of raw coal. The main components of coal are hydrocarbon active organic molecules, while the main components of coal gangue are Al_2O_3 and SiO_2. Coal gangue mixed with coal will not only reduce the quality of coal combustion, but also increase the emission of waste gas. To improve the quality of coal combustion and reduce the emission of poisonous and harmful gases, the separation of coal gangue from raw coal is an important problem in coal mine engineering.

DOI:10.46647/ijetms.2023.v07i02.058 ISSN: 2581-4621

Coal gangue recognition is the key technology of gangue separation. Hou et al. [6-8] analyzed the difference data between coal and coal gangue in terms of the surface texture and grayscale characteristics, and combined them with a classification algorithm to study coal gangue recognition. Because the texture and grayscale characteristics of coal and coal gangue are greatly affected by light, the recognition accuracy is not high. Liu et al. [9-13] studied the morphological differences between coal and coal gangue on the basis of studying texture and gray features, and introduced multifractal to extract the geometric features of coal gangue, but the extraction process of multifractals geometric features is complex and has poor adaptability.

Alfarzaeai et al. [14-18] studied the near infrared spectrum, thermal infrared spectrum and multispectral characteristics of coal and coal gangue, and obtained high recognition accuracy in a laboratory environment using a neural network algorithm. However, this technology is not mature, and it is difficult to apply in practice because of the influence of ambient temperature and light. Zhao et al. studied the radiation characteristics and attenuation characteristics of X-rays and γ -rays in coal and coal gangue. Coal gangue can be identified in essence through the attenuation characteristics of X-rays and γ-rays; however, the radiation produced by rays will cause physical harm to workers, and the maintenance cost of equipment is also high. Wang et al. proposed a method of measuring volume by 3D laser scanning technology, which was combined with dynamic weighing technology to identify coal gangue. Because the volume is an estimated value, the measurement error is relatively large.

Yang et al. studied the vibration signals of coal and coal gangue particles colliding with metal plates, and extracted the eigenvalues of the signals in combination with a machine learning algorithm to identify coal gangue, but damage identification, can reduce the quality of coal. Finding a recognition feature with high reliability, easy extraction and few side effects has become a difficult task in the current recognition of coal and coal gangue. Nelson et al. studied the dielectric properties of pulverized coal, and found that the dielectric constant of pulverized coal decreases regularly with increasing frequency, which provides a reference for studying the dielectric properties of coal and coal gangue.

Muhammad et al. conducted cutting-edge and pioneering studies in signal desiccating, signal decomposition and machine learning, with strong references. In this paper, the differences between the dielectric properties of coal and coal gangue are studied, and a recognition method of coal and coal gangue based on dielectric properties is proposed. This method can realize nondestructive testing of coal and coal gangue. X-ray and γ-ray identification equipment, has high radiation intensity; the internal features of coal and coal gangue that cannot be perceived by image recognition can be obtained. In this study, coal and gangue were obtained from the Huainan mining area, and the SVM intelligent classification model was trained by combining the dielectric constant characteristics of coal and gangue with the SVM.

The test results show that the capacitance method has high accuracy and strong timeliness in identifying coal and gangue, and has great research prospects. They concluded that according to the differences in the dielectric properties coal and gangue, the dielectric constants of coal and gangue are first proposed as the identification characteristics, which provides a new method to identify coal and gangue.

In this paper, a capacitance identification method based on coal and gangue with regular shapes are conceived, and remarkable recognition and classification results are obtained by combining the SVM intelligent classification model. The main contributions of this paper are as follows: 1) The capacitance identification model of coal and gangue is established, and the finite element simulation analysis of the capacitor model is carried out. The influence of the edge effect caused by plate thickness on the calculation of the capacitance value is obtained, and the calculation formula of the capacitance value is modified to accurately calculate the capacitance value of the capacitor when the medium changes.

2.2 Distance-Iouloss: Faster and better learning for Bounding Box Regression

In this paper [2] the authors stated that bounding box regression is the crucial step in object detection. In existing methods, while `n-norm loss is widely adopted for bounding box regression, it is not tailored to the valuation metric, i.e., IntersectionoverUnion (IoU). Recently, IoU loss and generalized IoU (GIoU) loss have been proposed to benefit the IoU metric, but still suffer from the problems of slow convergence and inaccurate regression. In this paper, they proposed a Distance-IoU (DIoU) loss by incorporating the normalized distance between the predicted box and the target box, which converges much faster in training than IoU and GIoU losses.

Furthermore, this paper summarizes three geometric factors in bounding box regression,i.e., overlap area, central point distance and aspect ratio, based on which a Complete IoU (CIoU) loss is proposed, thereby leading to faster convergence and better performance. By incorporating DIoU and CIoU losses into state-of-the-art object detection algorithms, e.g., YOLO v3, SSD and Faster RCNN, we achieve notable performance gains in terms of not only IoU metric but also GIoU metric. Moreover, DIoU can be easily adopted into non-maximum suppression (NMS) to act as the criterion, further boosting performance improvement

Object detection is one of the key issues in computer vision tasks, and has received considerable research attention for decades (Redmonetal.2016; Redmon and Farhadi 2018; Ren et al. 2015; He et al. 2017; Yang et al. 2018; Wang et al. 2019; 2018). Generally, existing object detection methods can be categorized as: one-stage detection, such as YOLO series (Redmonetal.2016;Redmonand Farhadi 2017; 2018) and SSD (Liu et al. 2016; Fu et al. 2017), two-stage detection, such as R-CNN series (Girshick et al. 2014; Girshick2015; Renetal.2015;Heetal.2017),and even multistage detection, such as Cascade R-CNN (Cai and Vasconcelos 2018). Despite of these different detection frameworks, bounding box regression is the crucial step to predict a rectangular box to locate the target object.

They concluded that in the paper, they proposed two losses, i.e., DIoU loss and CIoU loss, for bounding box regression along with DIoUNMS for suppressing redundant detection boxes. By directly minimizing the normalized distance of two central points, DIoU loss can achieve faster convergence than GIoU loss CIoU loss takes three geometric properties into account, i.e., overlap area, central point distance and aspect ratio, and leads to faster convergence and better performance. The proposed losses and DIoU-NMS can be easily incorporated to any object detection pipeline, and achieve superior results on benchmarks.

2.3 Adaptive Anchor Box Mechanism to Improve the Accuracy in the Object Detection System

In this paper [3] the authors stated that recently, most state-of-the-art object detection systems adopt anchor box mechanism to simplify the detection model. Neural networks only need to regress the mapping relations from anchor boxes to ground truth boxes, then prediction boxes can be calculated using information from outputs of networks and default anchor boxes. However, when the problem becomes complex, the number of default anchor boxes will increase with large risk of over-fitting during training. In this paper, they adopted an adaptive anchor box mechanism that one anchor box can cover more ground truth boxes. So networks only need a few adoptive anchor boxes to solve the same problem and the model will be more robust. The sizes of adaptive anchor boxes will be adjusted automatically according to the depth collected by a Time of Flight (TOF) camera.

The network adjusts the aspect ratios of anchor boxes to get final prediction boxes. The experimental results demonstrate that the proposed method can get more accurate detection results. Specifically, using the proposed adaptive anchor box mechanism, the Mean Average Precision (MAP) of YOLO-v2 and YOLO-v3 networks increases obviously on open public datasets and their self-built battery image dataset. Moreover, the visual results of prediction comparisons also illustrate that the proposed adaptive anchor box mechanism can achieve better performance than original anchor box mechanism.

3.Experimental Methods or Methodology

3.1 Existing System

In existing system, the image is being visualized manually and gangue presence is checked by professional. Normally images are processed with median filter so that the noise pixels are eliminated and image clarity is improved.

DOI:10.46647/ijetms.2023.v07i02.058 ISSN: 2581-4621

Only through manual checking, gangue content presence could be identified. Some studies classified the tumor types using augmented gangue region of interest, image dilatation, and ring-form partition. They extracted features using intensity histogram, gray level co-occurrence matrix, and bag-of-words models, and achieved some accuracy

- Median filter process required.
- Not effective when gangue data is very low in size.
- Accurate image processing for gangue presence is not possible.
- Manual verification/checking are required.

3.2 Proposed System

In proposed system, the gray scale image is taken. The RGB image if taken, is converted into gray scale image first. Then all the images are resized into same size. Then the training data set image with tumor class factor 'yes' are taken along with 'no'. For each image, all the pixels' grayscale value are found out and written in a row. So the total number of rows is equal to total number of images. The number of columns is the number of pixels in the image.

These data is saved in comma separated file. For testing data, all these operations are carried out and saved in another comma separated value file. Then Convolutional neural network is applied to train the model with test data. The accuracy is found out and displayed. From the given test image, it can be found out as gangue present or not by checking with training data images.

- Median filter process is not required.
- Effective even when tumor data is very low in size.
- Accurate image processing for tumor presence is possible.
- Manual verification/checking are not required.
- CNN is the best algorithm so that accuracy will be more.

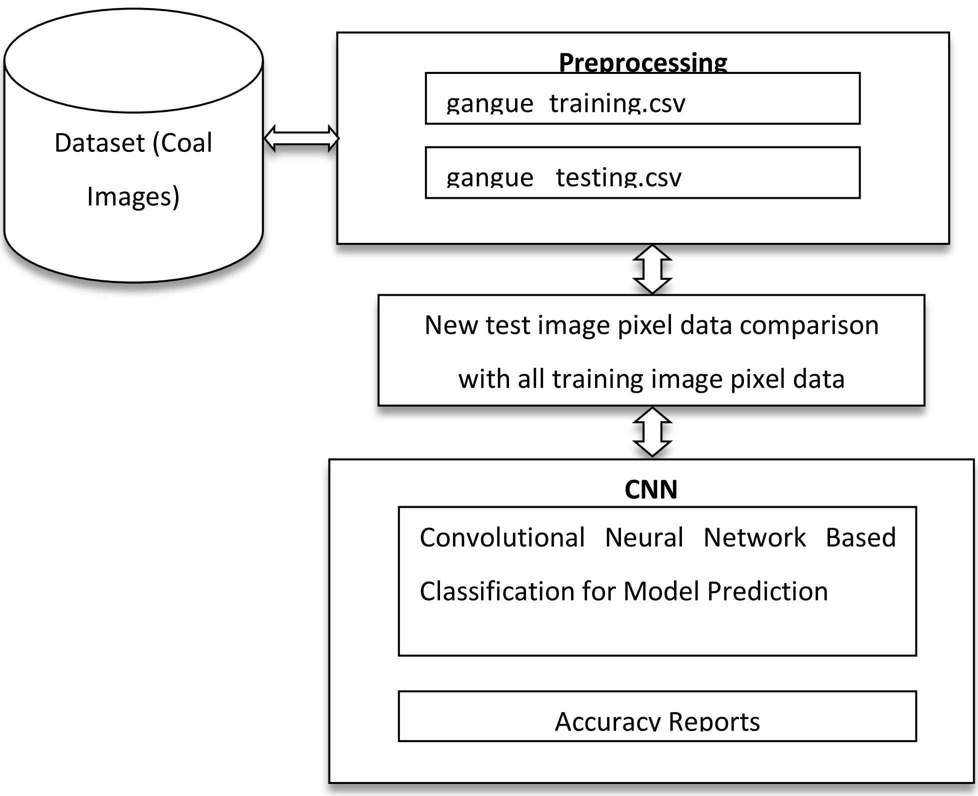

Figure 3. System flow diagram

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 2 Volume No.7 March - April – 2023
DOI:10.46647/ijetms.2023.v07i02.058 ISSN: 2581-4621

4.Results and Discussion

4.1 Finding

- The proposed scheme will be helpful in the diagnosis of coal gangue.
- The proposed method was successfully applied in the coal image with very high precision.
- Extracting gangue features of the coal is implemented.
- The proposed system detects and classifies the examined gangue with high accuracy.

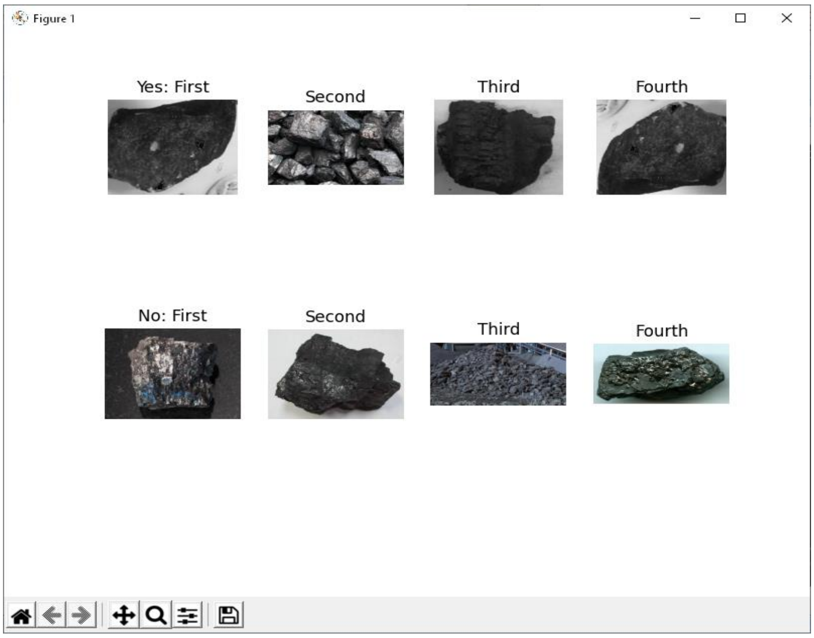

Figure 4.1 Coal images

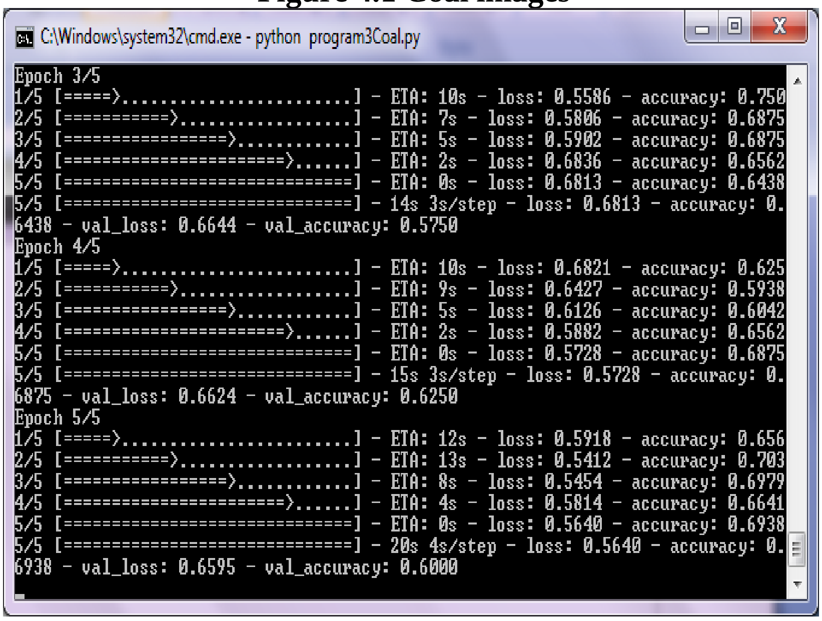

Figure 4.2 Neural Network Iterations

5.CONCLUSION and ENHANCEMENT

This project develops a new CNN architecture to classify people with and without coal gangue and checks whether the image is having gangue or not. With i) good generalization capability and ii) good execution speed, newly developed CNN architecture is being used as an effective decision-support tool for admin to detect the presence of gangue in images. Python is used for development of the

DOI:10.46647/ijetms.2023.v07i02.058 ISSN: 2581-4621

project. If the application is designed as web service, it can be integrated in many network applications. The application is developed such that above said enhancements can be integrated with current modules. ANN works better in the given dataset and accuracy percent is above ninety.

It is believed that almost all the system objectives that have been planned at the commencements of the software development have been net with and the implementation process of the project is completed. A trial run of the system has been made and is giving good results the procedures for processing is simple and regular order. The process of preparing plans been missed out which might be considered for further modification of the application. In future, this project may find the similarity using gangue present in the coal.

References

1. Guo Y, WangX, Wang S, Hu K, Wang W. (2021).“Identificationmethodof coal and coal ganguebased on dielectriccharacteristics,”IEEE Access.,vol. 9, pp. 9845-9854,Jan. 202
2. ZhaohuiZheng,Ping Wang,Wei Liu, Jinze Li, RongguangYe,DongweiRen. “Distance-IoULoss: Fasterand BetterLearning for Bounding Box Regression,” Presentedat AAAIConference on Artificial Intelligence 2020. Available:https://ojs.aaai.org//index.php/AAAI/article/view/6999.
3. Gao, Mingyu, et al. “Adaptive anchor box mechanism to improve the accuracy in the object detection system,” Multimedia Tools and Applications., vol. 78, no. 19, pp. 27383-27402, Oct. 2019.
4. Jain, Anil K. . “Data clustering:50 years beyondK-means.” PatternRecognitionLetters., vol. 31, no. 8, pp. 651-666,June. 2010.
5. S. Ren, K. He, R. Girshickand J. Sun, “Faster R-CNN:Towards Real-Time Object Detection with Region Proposal Networks,” IEEE Transactions on Pattern Analysis and Machine Intelligence.,vol. 39,no. 6, pp. 1137-1149,June. 2017.
6. Hou, Wei. Identification of Coal and Gangue by Feed-forward Neural Network Based on Data Analysis [J]. International Journal of Coal Preparation and Utilization., vol. 39, no. 1, pp. 33-43, Jan. 2019.
7. Dou, Dongyang; Zhou, Deyang; Yang, Jianguo, et al. Coal and gangue recognition under four operating conditions by using image analysis and Relief-SVM [J]. International Journal of Coal Preparation and Utilization., vol. 40, no. 7, pp.473-482, Jul. 2020.
8. Li, Man; Duan, Yong; He, Xianli, et al. Image positioning and identification method and system for coal and gangue sorting robot [J]. International Journal of Coal Preparation and Utilization., May. 2020. DOI.10.1080/19392699.2020.1760855.

9. Jian Song. “Research on Identification Algorithm of Coal and Gangue Based on Image Feature,” M.S. thesis, Dept. Computer science and technology., Hebei University of Engineering., Hebei, China, 2016.
10. Xianmin Ma, Xiaoru ng. “Coal Gangues Automation Selection System Based on ARM Core and CAN Bus, ”Chinese Journal of Scientific Instrument.,vol. 26, no. 8, pp. 305-307, 318, August.2005.
11. Hailing Zhang, Jialin Wang, Jiansheng Wu, Rong Shi. “Application of Rough Sets Theory to Image Enhancement Processing,” Journal of Tongji University (Natural Science)., vol. 36, no. 2, pp. 254-257, Feb. 2008.
12. Wanzhi Wang, Zengcai Wang. “Characteristic Analysis and Recognition of Coal and Rock Based on Visual Technology,” Coal Technology., vol. 33, no. 10, pp. 272-274,Oct. 2014.
13. Yunxia Wu, Yimin Tian. “Methodof coal-rock image feature extraction and recognition based on dictionary learning,” Journal of China Coal Society., vol. 41, no. 12, pp. 3190-3196, Dec. 2016.
14. J. Redmon, S. Divvala,R. Girshickand A. Farhadi, “You only look once: Unified real-time object detection,” in Proc. CVPR, Las Vegas, NV, United States, 2016, pp. 779-788.
15. Ping Huo, Hanlin Zeng, KeyanHuo. “Research on density identification system of coal and refuse based on image processing technology, ”Goal Preparation Technology., no. 2, pp. 69-73, Apr.2015.

16. Guo Y, Wang, X, Wang S, Hu K, Wang W. (2021).“Identification method of coal and coal gangue based on dielectric characteristics,” IEEE Access., vol. 9, pp. 9845-9854,Jan. 2021.
17. Xijie Dou, Shibo Wang, Yang Xie, Tong Xuan. “Coal and gangue identification based on IMF energy moment and SVM, ” Journal of Vibration and Shock, vol. 39, no. 24, pp. 39-45, Dec. 2020.
18. Wei Hou. “Identification of Coal and Gangue by Feed-forward Neural Network Based on Data Analysis,” International Journal of Coal Preparation and Utilization, vol. 39, no. 1, pp.33-43, Jan. 2019.
19. Shwetasaibal Samanta Sahoo; Mousime Xalxo; B G Mukunda. "A Study on Tourist Behaviour Towards Sustainable Tourism in Karnataka". *International Research Journal on Advanced Science Hub*, 2, 5, 2020, 27-33. doi: 10.47392/irjash.2020.28
20. Muniyandy Elangovan; Mohamed Yousuf; Mohamed Nauman; Mohammed Nayeem. "Design and Development of Delivery Robot for Commercial Purpose". *International Research Journal on Advanced Science Hub*, 4, 07, 2022, 192-197. doi: 10.47392/irjash.2022.047
21. Manikandan N; Swaminathan G; Dinesh J; Manish Kumar S; Kishore T; Vignesh R. "Significant Attention in Industry and Academia for Wire Arc Additive Manufacturing (WAAM) - A Review". *International Research Journal on Advanced Science Hub*, 4, 07, 2022, 198-204. doi: 10.47392/irjash.2022.048
22. Shoeb Ahmed Syed; Steve Ales; Rajesh Kumar Behera; Kamalakanta Muduli. "Challenges, Opportunities and Analysis of the Machining Characteristics in hybrid Aluminium Composites (Al6061-SiC-Al2O3) Produced by Stir Casting Method". *International Research Journal on Advanced Science Hub*, 4, 08, 2022, 205-216. doi: 10.47392/irjash.2022.051
23. Ashima Saxena; Preeti Chawla. "A Study on the Role of Demographic Variables on Online Payment in Delhi NCR". *International Research Journal on Advanced Science Hub*, 4, 08, 2022, 217-221. doi: 10.47392/irjash.2022.052
24. Vishnupriya S; Nirsandh Ganesan; Ms. Piriyanga; Kiruthiga Devi. "Introducing Fuzzy Logic for Software Reliability Admeasurement". *International Research Journal on Advanced Science Hub*, 4, 09, 2022, 222-226. doi: 10.47392/irjash.2022.056
25. GANESAN M; Mahesh G; Baskar N. "An user friendly Scheme of Numerical Representation for Music Chords". *International Research Journal on Advanced Science Hub*, 4, 09, 2022, 227-236. doi: 10.47392/irjash.2022.057
26. Nirsandh Ganesan; Nithya Sri Chandrasekar; Ms. Gokila; Ms. Varsha. "Decision Model Based Reliability Prediction Framework". *International Research Journal on Advanced Science Hub*, 4, 10, 2022, 236-242. doi: 10.47392/irjash.2022.061
27. Vishnupriya S; Nithya Sri Chandrasekar; Nirsandh Ganesan; Ms. Mithilaa; Ms. Jeyashree. "Comprehensive Analysis of Power and Handloom Market Failures and Potential Regrowth Options". *International Research Journal on Advanced Science Hub*, 4, 10, 2022, 243-250. doi: 10.47392/irjash.2022.062
28. Minh Duc Ly; Que Nguyen Kieu Viet. "Improvement Productivity and Quality by Using Lean Six Sigma: A Case Study in Mechanical Manufacturing". *International Research Journal on Advanced Science Hub*, 4, 11, 2022, 251-266. doi: 10.47392/irjash.2022.066
29. Ragunath A; Poonam Syal. "Net Zero Energy Buildings Initiatives - A Review". *International Research Journal on Advanced Science Hub*, 4, 11, 2022, 267-271. doi: 10.47392/irjash.2022.067
30. Suresh P; Justin Jayaraj K; Aravintha Prasad VC; Abishek Velavan; Mr Gokulnath. "Deep Learning for Covid-19 Identification: A Comparative Analysis". *International Research Journal on Advanced Science Hub*, 4, 11, 2022, 272-280. doi: 10.47392/irjash.2022.068
31. Chirag H B; Darshan M; Rakesh M D; Priyanka D S; Manjunath Aradya. "Prediction of Concrete Compressive Strength Using Artificial Neural Network". *International Research Journal on Advanced Science Hub*, 4, 11, 2022, 281-287. doi: 10.47392/irjash.2022.069

32. Minh Ly Duc; Que Nguyen Kieu Viet. "Analysis Affect Factors of Smart Meter A PLS-SEM Neural Network". *International Research Journal on Advanced Science Hub*, 4, 12, 2022, 288-301. doi: 10.47392/irjash.2022.071
33. Lely Novia; Muhammad Basri Wello. "Analysis of Interpersonal Skill Learning Outcomes in Business English Students Class". *International Research Journal on Advanced Science Hub*, 4, 12, 2022, 302-305. doi: 10.47392/irjash.2022.072
34. Ms. Nikita; Sandeep Kumar; Prabhakar Agarwal; Manisha Bharti. "Comparison of multi-class motor imagery classification methods for EEG signals". *International Research Journal on Advanced Science Hub*, 4, 12, 2022, 306-311. doi: 10.47392/irjash.2022.073
35. Aniket Manash; Ratan Kumar; Rakesh Kumar; Pandey S C; Saurabh Kumar. "Elastic properties of ferrite nanomaterials: A compilation and a review". *International Research Journal on Advanced Science Hub*, 4, 12, 2022, 312-317. doi: 10.47392/irjash.2022.074
36. Prabin Kumar; Rahul Kumar; Ragul Kumar; Vivek Rai; Aniket Manash. "A Review on coating of steel with nanocomposite for industrial applications". *International Research Journal on Advanced Science Hub*, 4, 12, 2022, 318-323. doi: 10.47392/irjash.2022.075
37. Twinkle Beniwal; Vidhu K. Mathur. "Cloud Kitchens and its impact on the restaurant industry". International Research Journal on Advanced Science Hub, 4, 12, 2022, 324-335. doi: 10.47392/irjash.2022.076
38. T. Pravin, C. Somu, R. Rajavel, M. Subramanian, P. Prince Reynold, Integrated Taguchi cum grey relational experimental analysis technique (GREAT) for optimization and material characterization of FSP surface composites on AA6061 aluminium alloys, Materials Today: Proceedings,Volume 33, Part 8, 2020, Pages 5156-5161, ISSN 2214-7853. doi.org/10.1016/j.matpr.2020.02.863.
39. R. Ranjith, C. Somu, G. Tharanitharan, Venkatajalapathi.T, Naveenkumar M, Integrated Taguchi cum Grey Relational Experimental Analysis (GREAT) for Optimization and Machining Characterization of Cryogenic Cooled AA6063 Aluminium Alloys, Materials Today: Proceedings, Volume 18, Part 7, 2019,Pages 3597- 605, https://doi.org/10.1016/j.matpr.2019.07. 291.
40. R. Devi Priya, R. Sivaraj, Ajith Abraham, T. Pravin, P. Sivasankar and N. Anitha. "Multi-Objective Particle Swarm Optimization Based Preprocessing of Multi-Class Extremely Imbalanced Datasets". International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems Vol. 30, No. 05, pp. 735-755 (2022). Doi: 10.1142/S0218488522500209
41. M. S. N. K. Nijamudeen, G. Muthuarasu, G. Gokulkumar, A. Nagarjunan, and T. Pravin, “Investigation on mechanical properties of aluminium with copper and silicon carbide using powder metallurgy technique,” Advances in Natural and Applied Sciences, vol. 11, no. 4, pp. 277–280, 2017.
42. Pravin T, M. Subramanian, R. Ranjith,Clarifying the phenomenon of Ultrasonic Assisted Electric discharge machining, “Journal of the Indian Chemical Society”, Volume 99, Issue 10, 2022, 100705, ISSN 0019-4522, Doi: 10.1016/j.jics.2022.100705
43. V.S. Rajashekhar; T. Pravin; K. Thiruppathi , “Control of a snake robot with 3R joint mechanism”, International Journal of Mechanisms and Robotic Systems (IJMRS), Vol. 4, No. 3, 2018. Doi: 10.1504/IJMRS.2018.10017186
44. T. Pravin, M. Sadhasivam, and S. Raghuraman, “Optimization of process parameters of Al-10% Cu compacts through powder metallurgy,” Applied Mechanics and Materials, vol. 813-814, pp. 603–607, 2010.
45. Rajashekhar, V., Pravin, T., Thiruppathi, K.: A review on droplet deposition manufacturing-a rapid prototyping technique. Int. J. Manuf. Technol. Manage. 33(5), 362–383 (2019) https://doi.org/10.1504/IJMTM.2019.103277
46. Rajashekhar V S, Pravin T, Thirupathi K, Raghuraman S.Modeling and Simulation of Gravity based Zig-zag Material Handling System for Transferring Materials in Multi Floor Industries. Indian Journal of Science and Technology.2015 Sep, 8(22), pp.1-6.