Segmentation of White Blood Cells with Colour Space Transformation and use of Transfer Learning for Optimization

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Abstract: White blood cells (WBC), or leukocytes, are an essential part of the human immune system, constantly protecting the body against viruses, bacteria and other foreign invaders. Determining the WBC is crucial for curing various diseases, especially leukemia. The abnormality of WBC count causes leukemia, failing the autoimmune system. Image segmentation, an application of pattern recognition techniques, is employed in this paper to find the WBC count. WBC are identified by the colour difference between their nucleus and cytoplasm. Using CNN's U-net architecture, the cell borders of WBC are marked, enabling us to find the area of abnormality in the given sample. This method is trained on the images in the known training data. The model can produce an accuracy of around 87% for segmenting WBC from the blood smear. And for the final output with the concept of swarm intelligence in AI. The WBC count in the image is found with the OpenCV method considering optimization purposes. Secondly, the system transfers and modifies the model with transfer learning models VGG/ResNet and counts cells with the deep neural model. The counting model can be used for other modelling and application purposes.

Keywords: white blood cells, swarm intelligence, transfer learning, image segmentation, HSI, unet.

1. Introduction

Pattern recognition means automated recognition of patterns. In the proposed paper, we have used the automatic image segmentation technique to separate WBC from the blood smear containing RBCs and platelets [37]. The White Blood Cells (WBC) are separated from the blood smear containing platelets and RBC. This paper uses the automatic image segmentation technique [38]. WBCs are essential for human body defence. They safeguard our body against viruses, bacteria and other dangerous external occupants; hence WBCs are called the soldiers of our body. Determining WBC count is crucial for curing various diseases, especially leukemia. Leukemia patients have a high WBC count making them

victims of autoimmune disease. Hence the count of WBC has to be monitored continuously for leukemia patients [39-45]. It also helps understand and monitor the effect of chemotherapy, immunity level, and identifying anaemic diseases and other infections [46]. The proposed system aims at finding the count of WBC by using HSI colour space transformation, marking areas of infection with U-net architecture and tuning the model for cell counts with transfer learning [47-53]. The current system uses a microscopic manual process that takes 2 days, or the automated process can only be applied to test data. If any abnormality is present, the process must be redone multiple times [54].

2. Related Works

The proposed system in the paper denotes different colour space techniques to denote coloured digital images [1]. It applies colour space transformation and further correlates the outcome parallelly in Matlab. HSV colour space is better compatible with round pictures or structures, like a cd or clock. This paper [2] suggests a colour correction method for differentiating nucleus and cytoplasm [55-66]. It transforms RGB to Lab colour space, adjusts input image to template image, then transforms back to RGB and proceeds for segmentation. If an application has fewer complex colours, then it's enough to detect extreme colours. [11] proposes a value-based method that which extreme colours have high value in only one channel [67-71]. Hence, this method can be applied to detect basic colours. When the blood smear image has a similar colour for all blood cells, it is not easy to detect the target. So, the image's hue should be increased, and brightness should be adjusted. [15] proposes a similar HSI colour transformation method and CNN for classification [72].

A greyscale is developed to differentiate nuclei from cytoplasm and background using a Poisson distribution with minimum error thresholding [21]. The cytoplasm is identified using Discrete Wavelet Transform (DWT) and morphological filtering. This has more efficient segmentation compared to existing models. [29] To retrieve spectral reflectance properties, colour correction and auto white balance (AWB) are disemployed. Outcomes of CCD/CMOS sensors give the colour temperature of illuminants with large productivity [73-81]. The colour correction matrix converts the values into sRGB precise colours. This paper [2] says that architectures like E-net and U-net are used for complications of semantic separation of biomedical data as deep neural networks are very costly. U-net is less efficient than E-net. But U-net is 1-2% better efficient than E-net accuracy-wise [82-91]. [8] The paper says manual methods always have cons compared to automatic methods. Hence automated processes are always better efficient than manual processes. The framework for the separation is carried out by advanced digital image processing [92-101]. This obtains 92% and 78% accuracy for separation of nucleus and cytoplasm, respectively [102].

In this paper [12], a network and training strategy depends on the high usage of data augmentation to use annotated samples with better performance. It shows that U-net architecture gets efficient outcomes in biomedical image segmentation [103]. The training time on Nvidia Titan GPU is 10 hours. [16] outlines the YOLO (you look only once) layout as a framework that processes detection in the area of the high probability of expected output [104-115]. This framework can be fitted for many algorithms. One such algorithm is UOLO combining U-net architecture and YOLO that first localizes the image as grids and searches for targets with pixel-wise segmentation. [17] The main purpose of [18] is to automate the segmentation. It provides two types of results, one that differentiates cells from the image called a binary class, and another that classifies the cell into nucleus and cytoplasm called as multiclass. The model's efficiency is evaluated against the intersection over union score (IoU) [116].

In this paper [3], the conventional identification procedure uses handcrafted characteristics that have restrictions on structures [117-121]. Due to the absence of training data, deep learning models operate too slowly. Hence transfer learning is used. The operation for breast cancer has been improved by

transfer learning. This paper [5] uses two models from the transfer learning technique [122-127]. The first process uses the final fully connected layer for categorization before using a classifier. In the second type of process, the higher level called the network fine-tuning is eliminated [128]. Fine-tuning can help in getting more accurate outcomes than a separate classifier for bigger data at the network level. [7]. In this paper, the retina net is used to develop a 13D Net for lung nodule detection and make it more efficient by using transfer learning models 13DR-Net T-LIDC and 13DR-Net T-Image Net [129]. The detection performance and time reduction are enhanced by using weight transfer learning from natural image datasets [130].

This paper categorizes [13] white blood cells and sperms of castles with image processing and compares them with different transfer learning models like InceptionResNetV2, Xception, DenseNet121, DenseNet169, and MobileNetV1. The transfer learning models obtain efficient outcomes for the cattle sperm and WBC segmentation by InceptionResNetV2 and DenseNet121. [25] Deep transfer learning models such as AlexNet, Res-Net18, SqueezeNet, GoogleNet, VGG16, and VGG19 which have lesser layers, are tested here for Diabetic Retinopathy (DR) detection. The preciseness of 97.9% was attained using the AlexNet model, which also has lesser computational complexity and training time [131-145]. [14] uses preprocessing calculations for colour disunion, bounding box distortion and image flipping mirroring to evaluate WBC differential counts [146-155]. Hierarchy topological feature extraction using inception and ResNet architecture are employed for recognition. The detection of bio-medical images faces problems with varying structures of cells [156-167]. So, [19] involves the general adversarial network in the transformation process [168-171]. It uses DNN networks like ResNet and VGG-16 for training classification and data augmentation with GAN, which classifies white blood cells [172].

This paper evolves [22] the knowledge attained around the 1970s on the ideas of transfer learning in neural networks [173]. Mathematical models and geometric representations of transfer learning result from the use of transfer learning in pattern recognition using image datasets. [24] uses pre-trained CNN networks to get the features extracted in the input image [174]. This can recognize various Indian languages while trained in one dataset of Bangla characters. This gives better results than random adjusted weights [175]. This paper drops [4] manual processes and uses computerized systems to identify red blood cells [176-181]. Artificial Neural Networks classify normal and abnormal red blood cells in blood images. With the help of a green colour channel image and a series of post-processing, red blood cells can be categorized from the clusters. [6] This paper explains the method of making leukocyte filters. There is considerably less loss of red blood cells while giving real red blood cell products with these filters [182-189]. In order to eliminate time taking manual process, [10] reviews various papers on automatic WBC segmentation. This tells us which technique can be used for which type of image or output [190].

A clustered image [20] is classified into nuclei, background and cluster of cells using the SVM algorithm. The cytoplasmic shape is developed for overlapping cells using the Space Coding method. Distance Regularized Level Set Evolution (DRLSE) is deployed to form a defined shape and obtain clear nuclear boundaries [191]. The efficiency [26] of convolution network depth is studied in this paper for large-size image recognition. 3x3 convolution filters with increasing depth are the main focus of this paper. For training, ConvNets are processed with the help of RGB values to estimate pixels. [27] The layers in deep neural networks are reformulated in order to ease the training process [192-195]. Using the ImageNet dataset, 8 times deeper than VGG nets, residual nets are evaluated, where only a 3.57% error rate is achieved. [28] This paper advances COCO-Text for recognition and detection. For diversifying the texts, machine and handwritten texts are fine-grained and classified into legible ones with proper transcriptions. Optical Character Recognition (OCR) is also employed. The main [30] idea proposed in this paper is that unet produces model results with high satisfaction giving

lesser training time and precise output. The colour space changed to the HSV model is done for pre-processing [196-199]. The paper also pitches the idea of transfer learning and adhesive cell detection for more model accuracy.
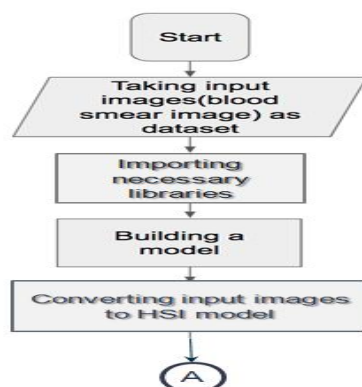
3. **System Architecture**

Figure 1. Input and Colour space module

The input for the proposed system is blood smear images as a data set. Then the necessary modules are imported for building a model (figure 1). With the help of using the HSI colour model, the colour transformation is executed. The image is segmented, and the boundaries of WBC cells are marked with the help of U-net architecture. The model is then fine-tuned with transfer learning to increase efficiency. The data set is now sent, and the result of an image with WBC cells distinguished from RBC cells and platelets is obtained (figures 2 and 3).
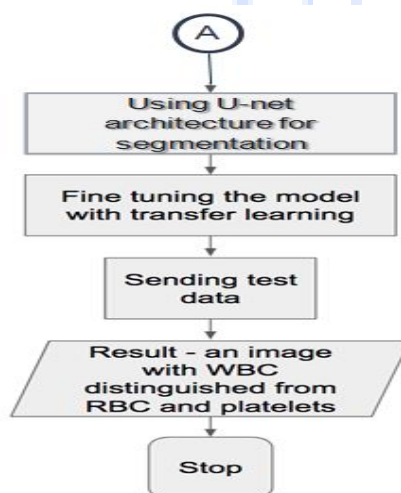

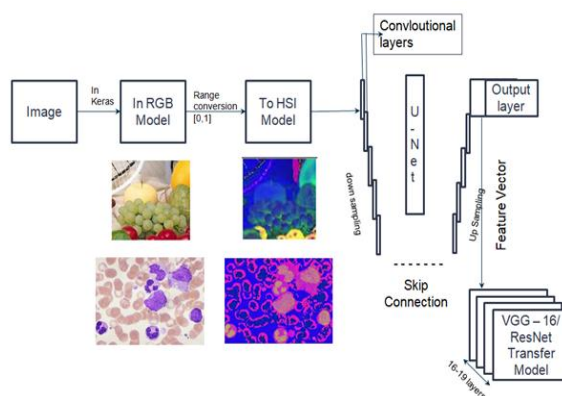**Figure 2. Flowchart for image segmentation.**

Figure 3. Working on the WBC segmentation model

4. Methodology

The model of this system produces three outputs at the end of each module. Firstly, the colour conversion from RGB to HSI colour space. Then the segmented cell image from the blood smears. At last, the final output with two models counting the cells with OpenCV and transfer learning.

4.1 HSI colour model

HSI colour models are more efficient than other models, especially in our proposed system, as it responds the same way humans see and describe colours. Humans describe colours by their hue, saturation and brightness and not by the percentages of different colours present in one particular object. Hue is the colour attribute examples are different colours in their purest form like blue, pink, etc. Saturation is the purity of colours like dark blue or light blue. Brightness is the colour intensity, whether a self-illuminating or reflecting object. To enhance the image quality, the Intensity component has to be changed, while in contrast with other models, all the components have to be changed to get the desired outcome (figure 4).
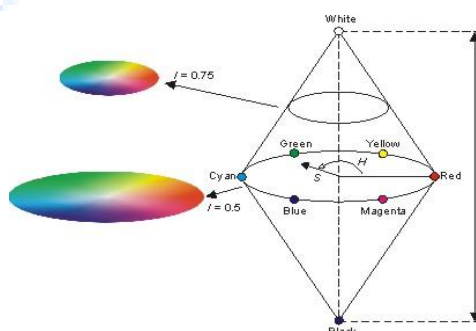

Figure 4: HSI Color Space Representation[32]

The saturation component tells the degree to which white is mixed with the purest form. For example, consider 2pi is 360 degrees, then null pi is red, 2pi/3 is green, 4pi/3 is blue, pi/3 is yellow, and 5pi/3 is magenta. Intensity ranges from 0 to 1, white and black, respectively.
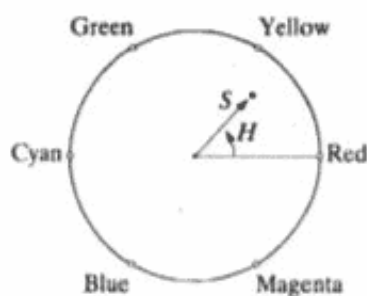
Figure 5. HSI Model

From the above figure 5 [31] above, the angle from the red axis mentioned as H gives a hue. Saturation given as S in the figure is the length of the vector. The intensity can be found from the vertical axis on which the plane's position is obtained.

4.2 U-net

U-net is a Convolution Neural Network (CNN) architecture employed for precise biomedical image segregation. The base notion uses consecutive convolution layers to upsample or interpolate the input. An important feature of U-net is that it can localize, separate and accurately identify the input's borders. This is because the architecture classifies every pixel of the input; as a result, the input and output share the same size. The base architecture of the U-net is in the shape of a U, thus the name. The two essential parts of this symmetrical U-shaped architecture are the left part- the contracting path, and the right part- the expansive path. The contracting path contains the general convolution process, and the expansive path constitutes the transpose 2D convolution layers. U-net architecture learns segmentation on an end-to-end basis. Semantic segmentation is segmentation into a particular class based on pixels. The architecture can be an analogy for an encoder-decoder structured network (figure 6).
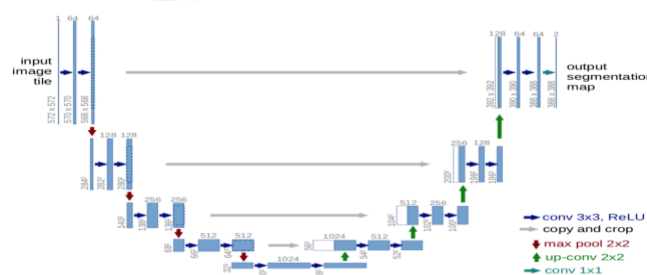

Figure 6: Base U-net architecture [12]

In classification, only the final output of the deep network is the important value. On the other hand, semantic segmentation requires discrimination at the pixel level and a technique to project the discriminative features learnt at various levels of the encoder into pixel space. In the diagram, we can see that the encoder holds the first half of the architecture. Generally, it is a pre-trained set of classification networks like the ResNet or VGG where the convolution sets are applied and are a max pool downsampling follows it to encode the input value of the image to representation features at different levels on the architecture diagram, the last half in the decoder. The decoder aims to semantically produce the discriminative features in lower resolution learnt by the encoder and into the pixel space, which is the higher resolution, so that that thick classification can be made. The decoder includes upsampling and concatenation which is followed by usual convolution operations.

4.3 ResNet

ResNet is short for residual neural networks. ResNet is an artificial neural network (ANN) that works on constructs found in the cerebral cortex's pyramidal cells. This is made possible by ResNets by making use of skip connections and also by using shortcuts so that some layers are skipped or jumped over. Usually, models of ResNets are made to work with double-layer skips or even triple-layer skips, which have nonlinearities (ReLU) and batch normalization in between. In addition, a weight matrix can be employed to learn about the weights to skip. Such models are HighwayNets. DenseNets are models that do various parallel skips. In residual neural networks, a non-residual network may be described as a plain network (figure 7).
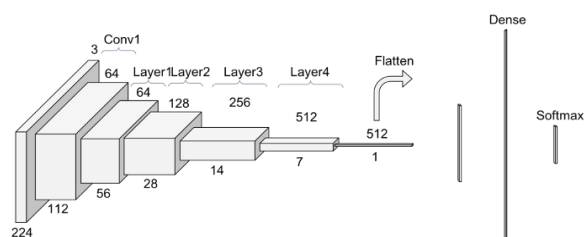

Figure 7: ResNet 34 parameter layers

It has been extrapolated by many researchers that affirm that the convolution neural networks are as better as they get when it is deeper. This is well explained as the capability of the models is increased. This means that the model's flexibility to work in any space is maximized as the spaces have larger parameters to explore. However, after a certain depth, the performance quality starts to decrease. Another problem that ResNets resolve is the infamous vanishing gradient problem. Since the network has high depth, post many applications of the chain rule, the gradients at points where the calculation of loss functions easily becomes zero. As a result, the values of weights are not updated. Thus, learning does not take place. Using ResNets, the gradients can flow through connections that skip backwards from final layers to initial kernels.

4.4 VGG

VGG is a Convolution Neural Network which is pre-trained and is the current most efficient method for visual image segregation. It is mostly employed in the biomedical field, such as heart rate calculation on movement and pavement distress detection. VGG helps identify and classify objects not previously known by the network. VGG uses RGB colour images as input and sends them through convolution layers with a pre-fixed filter. Thus the pooling filters enable down sample the input image (figure 8).
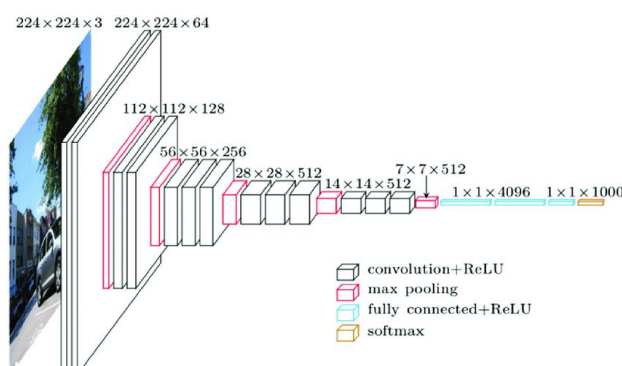

Figure 8. VGG Model [33]

To say, a VGG Network gets an RGB image with 224×224 and sends it through a stack of convolutional layers with the fixed size of the filter of 3×3 and the stride 1. VGG deploys 1x1 convolutional layers, making it more nonlinear without changing its fields. The only few disadvantages of VGG are memory consumption, amount of parameters and computation time (figure 9).
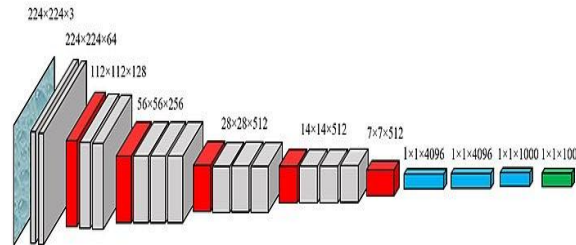

Figure 9. VGG Layered Architecture [34]

5   Implementation

The input of the system is a blood smear image. These images are collectively stored as a dataset. Generally, for application, publicly available images can be fed to this dataset. This dataset is downloaded as a local file on the device. The model is built in python code and runs in local python ide. In the first step, necessary modules are imported, and the dataset is linked to the file. Then following steps are executed for desired output. The input image in the RGB model is converted into the HSI colour space for better enhancement of the image [35] as in HSI, and luminous intensity can be ignored. Here the colour of the nucleus and cytoplasm is varied. After transformation, the convolutional network's U-net architecture is applied. This architecture segments the image for the target in downsampling while upsampling marks the boundary of the target, which is useful for biomedical images. This model is then trained with training data. The count is then identified with OpenCV in python. The system then fine-tunes the model with VGG and ResNet to count and can be extended to diagnose or classify WBC. To analyze the cell count further, the VGG can be used as it compares different parameters and says the condition of leukemia. ResNet in transfer learning can classify WBC to its types. ResNet architecture takes each layer as a learning module, so it references the method instead of the image, classifying unknown data.[27] When the lab's need varies, the model's usage also varies. If the labs wish to detect only leukemia then the count of WBC is enough. So for optimization, OpenCV can be used, and test results can be obtained soon. When the type of WBC is needed, then as swarm intelligence of the system, another module called transfer learning helps extend further.

5.1 Conversion of RGB to HSI

The image from the dataset is selected, and HSI conversion is applied. The transformation process follows the following method. The image's RGB values are calculated and depicted in the [0,1] range. Then all three components, intensity, saturation and hue, must be found. The intensity is the average value of colour components RGB. Saturation is based on the minimum of these colour values. Hue is represented as theta, the inverse of the cosine function given by Rafael Gonzalez and Richard Woods (figure 10). [36]

$$S = 1 - (3/N)*[min(r,g,b)] \qquad (1)$$

$$N = R+G+B \qquad (2)$$

For hue,

$$H = theta, where\ G>=B \qquad (3)$$

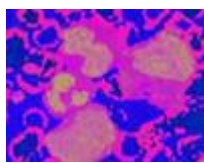$$H = 360\text{-}theta \text{ where } G<B \qquad (4)$$

Figure 10. Image in HSI

5.2　Image segmentation with U-net

U-net is a fully convolutional network. When an image is presented, it is reduced into small sizes or localized. First, object detection happens and is then classified into two classes, each one as target cell and environment.

Step 1 - Taking a full-size input image

Step 2 - Applying convolutional layers.

Each convolutional layer takes on these transformations.

Step 3 - Applying k height filter to get a feature map of magnitude nxnxk

Step 4 - Extracting a convolutional layered matrix called a map.

Step 5 - Max Pooling with 2x2 for precise feature map.

The above steps are called downsampling. For bottleneck or skip connection, the final feature map is doubled. For upsampling, the image is retraced with a feature vector looking for the object's location. In due process, the image restores its original size.

Step 6 - Creating a convolution matrix of size related to the map.

Step 7 - Producing transposed CN and increasing the size of the latest feature map.

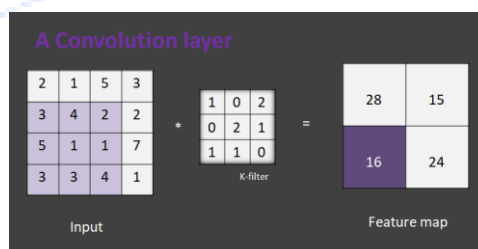Step 8 - Above steps are repeated until they reach the original image's size.

Figure 11. Convolution layer in down sampling

Hence, in this phase, when a blood image is presented, it continuously searches for the indicated cell as the WBC nucleus has the distinct colour of violet visible after transformation. When the nucleus is marked and is separated from the background in downsampling, the cell outline is marked in upsampling, as shown in figure 11.

5.3 Transfer learning

In this module, the identified output image is passed as input to another model for further prediction. The feature vector, like a set of conditions listed or parameters given, is measured. When an external image arrives not from a given source, the resnet checks for the similar features as required by the model rather than a pixel-wise comparison of images; VGG adds the additional layers with scrutinized features to be selected that can be lengthened upto 16-19 layers. It has filters of 1x1 size for

convolution that gives linear output. The Resnet uses residual network modules that allow skipping a few layers of convolution when an image is found to be polluted by that layer (figure 12).
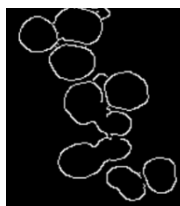

Fig 12. WBC segmented from the background

As for this application, this module transfer learning is carried on by one of the model resnet or vgg, where either of them looks for important features like actual clustered cell boundary and cytoplasm. The additional layered training can find significant differences in normal blood cell images. Resnet can skip layers that tweak the output. These may be the layers where the model still looks for non-valued edges and applies the training recurrently on the executed and final output.

6 Results and Discussions

The model built uses python libraries such as PyTorch and numpy. To fully utilize the benefit of the design, the system must have a GPU. The model can be run in python ide. In the first step of the segmentation, the enhancement of the image called colour transformation happens. This conversion from RGB to HSI makes the visibility of cells better (figures 13 to 15).
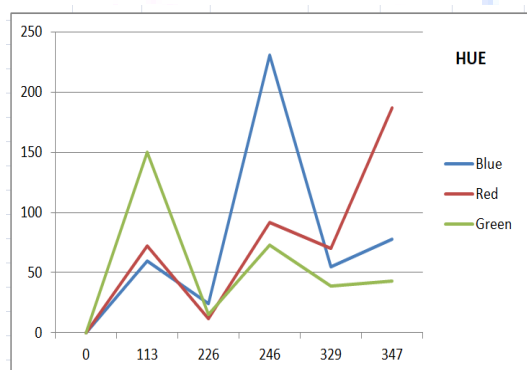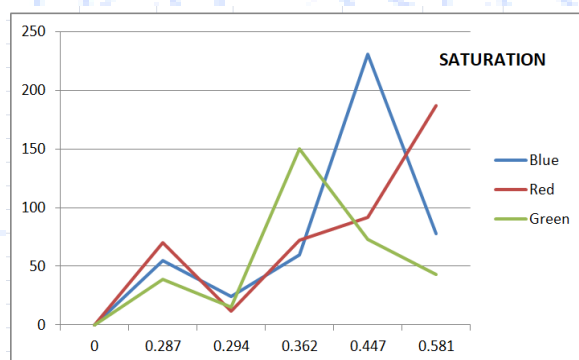

Figure 13. Hue values for RGB
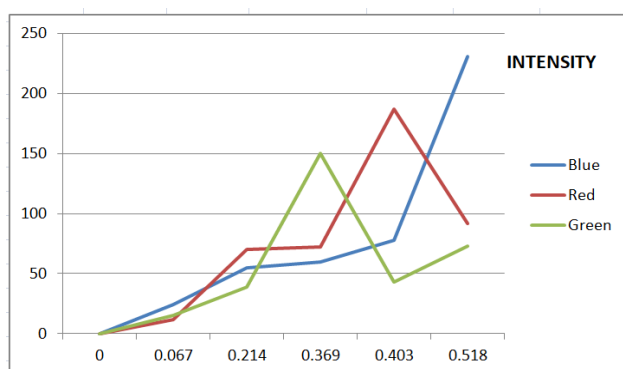

Figure 14. Saturation values for RGB

Figure 15. Intensity values for RGB

The considered RGB values are (table 1),

Table 1. Variations of hue, saturation and intensity with rgb

Red	Green	Blue	H	S	I
0	0	0	0	0	0
12	15	24	226	0.294	0.067
70	39	55	329	0.287	0.214
72	150	60	113	0.362	0.369
92	73	231	246	0.447	0.518
187	43	78	347	0.581	0.403

The biomedical images are not readily available, so the given must be used optimally. Unlike other architectures, U-net takes learnable parameters for the next layers to get precise information about the image. It leaves out edges for the environment. So it is tailor-made for smaller datasets. With transfer learning, the resnet replaces the output layer with feature vector so-called functions. This works well for normal cells and linear arranged cells. For normal clusters, it identifies the clustered and not overlapped cells. The model can get linearly arranged cells for abnormal cell images, and the adhesive cells due to leukemia may mislead and reduce accuracy. With the abnormal clustered cells, the model can get upto 87% of the given data.

7 Conclusion and Future Works

The paper works to segment the WBC cells from the image. The first process is to change colour space to HSI, then image segmentation with CNN's U-net and transfer learning with resnet. It concludes the WBC cells can be identified by automatic image segmentation. These cells can be counted and thus helps in the detection of leukemia. And finally, using two methods to count the cell where one compensates for another under swarm intelligence optimizes the model and increases the system's modelling feature. When transfer learning is used, the time complexity of the model is reduced. In the future, the model's efficiency can be increased with other transfer learning models like the Inception series and large training data.

References

1. Lakhwani, Kamlesh & Murarka, P & Narendra, Mr. (2015). Color Space Transformation for Visual Enhancement of noisy colour Image. IET Image Processing.

2. Karimov, Alexander & Razumov, Artem & Manbatchurina, Ruslana & Simonova, Ksenia & Donets, Irina & Vlasova, Anastasia & Khramtsova, Yulia & Ushenin, Konstantin. (2019). Comparison of UNet, ENet, and BoxENet for Segmentation of Mast Cells in Scans of Histological Slices.

3. Alzubaidi, L.; Al-Shamma, O.; Fadhel, M.A.; Farhan, L.; Zhang, J.; Duan, Y. Optimizing the Performance of Breast Cancer Classification by Employing the Same Domain Transfer Learning from Hybrid Deep Convolutional Neural Network Model. *Electronics* **2020**, *9*, 445.

4. CRazali Tomari, Wan Nurshazwani Wan Zakaria, Muhammad Mahadi Abdul Jamil, Faridah Mohd Nor, Nik Farhan Nik Fuad, Computer Aided System for Red Blood Cell Classification in Blood Smear Image, Procedia Computer Science, Volume 42, 2014, Pages 206-213.

5. Loey, M.; Naman, M.; Zayed, H. Deep Transfer Learning in Diagnosing Leukemia in Blood Cells. *Computers* 2020, *9*, 29.

6. Bruil A, Beugeling T, Feijen J, van Aken WG. The mechanisms of leukocyte removal by filtration. Transfus Med Rev. 1995 Apr;9(2):145-66.

7. Harsono, Ivan & Liawatimena, Suryadiputra & Cenggoro, Tjeng Wawan. (2020). Lung Nodule Detection and Classification from Thorax CT-Scan Using RetinaNet with Transfer Learning. Journal of King Saud University - Computer and Information Sciences. 10.1016/j.jksuci.2020.03.013.

8. Sadeghian, Farnoosh & Seman, Zainina & Ramli, Abdul & Abdul Kahar, Badrul Hisham & Saripan, M Iqbal. (2009). A Framework for White Blood Cell Segmentation in Microscopic Blood Images Using Digital Image Processing. Biological procedures online. 11. 196-206.

9. Zhang, Congcong and Xiao, Xiaoyan and Li, Xiaomei and Chen, Ying-Jie and Zhen, Wu and Chang, Jun and Zheng, Chengyun & Liu, Zhi. (2014). White Blood Cell Segmentation by Color-Space-Based K-Means Clustering. Sensors (Basel, Switzerland). 14. 16128-16147.

10. S., Sapna & Adige, Renuka. (2017). Techniques for Segmentation and Classification of Leukocytes in Blood Smear Images - A Review. 1-5. 10.1109/ICCIC.2017.8524465

11. Forero M.G., Ávila-Navarro J., Herrera-Rivera S. (2020) New Method for Extreme Color Detection in Images. In: Figueroa Mora K., Anzurez Marín J., Cerda J., Carrasco-Ochoa J., Martínez-Trinidad J., Olvera-López J. (eds) Pattern Recognition. MCPR 2020. Lecture Notes in Computer Science, vol 12088. Springer, Cham.

12. Ronneberger O., Fischer P., Brox T. (2015) U-Net: Convolutional Networks for Biomedical Image Segmentation. In: Navab N., Hornegger J., Wells W., Frangi A. (eds) Medical Image Computing and Computer-Assisted Intervention – MICCAI 2015. MICCAI 2015. Lecture Notes in Computer Science, vol 9351. Springer, Cham.

13. Velasco, Jessica & Arago, Nilo & Mamba, Roan & Padilla, Maria Victoria & Ramos, John Peter & Virrey, Glenn. (2020). Cattle Sperm Classification Using Transfer Learning Models. International Journal of Emerging Trends in Engineering Research. 8. 4325-4331.

14. Mehdi Habibzadeh, Mahboobeh Jannesari, Zahra Rezaei, Hossein Baharvand, Mehdi Totonchi, "Automatic white blood cell classification using pre-trained deep learning models: ResNet and Inception," Proc. SPIE 10696, Tenth International Conference on Machine Vision (ICMV 2017), 1069612 (13 April 2018).

15. Lin L, Wang W, Chen B. Leukocyte recognition with convolutional neural network. Journal of Algorithms & Computational Technology. January 2019. doi:10.1177/1748301818813322

16. Islam, Mohammad & Alam, Mohammad. (2019). A Machine Learning Approach of Automatic Identification and Counting of Blood Cells. Healthcare Technology Letters. 6. 10.1049/htl.2018.5098.

17. Araújo, Teresa and Aresta, Guilherme and Galdran, Adrian and Costa, Pedro and Mendonça, Ana Maria and Campilho, Aurélio, UOLO - Automatic Object Detection and Segmentation in Biomedical Images, Lecture Notes in Computer Science, Springer International Publishing, (2018), pg-165-173.

18. Grimmeiss Grahm, Sophia and Nilsson, Desiré, 1404-6342, eng, Student Paper, Master's Theses in Mathematical Sciences, Segmentation of White Blood Cells Using Deep Learning, 2019

19. Khaled Almezhghwi, Sertan Serte, "Improved Classification of White Blood Cells with the Generative Adversarial Network and Deep Convolutional Neural Network", *Computational Intelligence and Neuroscience*, vol. 2020, Article ID 6490479, 12 pages, 2020.

20. Tareef, Afaf & Song, Yang & Cai, Weidong & Huang, Heng & Chang, Hang & Wang, Yue & Fulham, Michael & Feng, David Dagan Feng & Chen, Mei. (2017). Automatic segmentation of overlapping cervical smear cells based on local distinctive features and guided shape deformation. Neurocomputing. 221. 94-107. 10.1016/j.neucom.2016.09.070.

21. A. Tareef, Y. Song, W. Cai, Y. Wang, D. D. Feng and M. Chen, "Automatic nuclei and cytoplasm segmentation of leukocytes with color and texture-based image enhancement," 2016 IEEE 13th International Symposium on Biomedical Imaging (ISBI), Prague, Czech Republic, 2016, pp. 935-938, doi: 10.1109/ISBI.2016.7493418.

22. Bozinovski, Stevo. (2020). Reminder of the First Paper on Transfer Learning in Neural Networks, 1976. Informatica. 44. 10.31449/inf.v44i3.2828.

23. S. Bozinovski, A. Fulgosi (1976). The influence of pattern similarity and transfer of learning upon training of a base perceptron B2. (original in Croatian: Utjecaj slicnosti likova i transfera ucenja na obucavanje baznog perceptrona B2), Proc. Symp. Informatica 3-121-5, Bled.

24. Sen Maitra, Durjoy & Bhattacharya, Ujjwal & Parui, Swapan. (2015). CNN based common approach to handwritten character recognition of multiple scripts. 1021-1025.

25. Khalifa NEM, Loey M, Taha MHN, Mohamed HNET. Deep Transfer Learning Models for Medical Diabetic Retinopathy Detection. *Acta Inform Med*. 2019;27(5):327-332.

26. Simonyan, Karen & Zisserman, Andrew. (2014). Very Deep Convolutional Networks for Large-Scale Image Recognition. arXiv 1409.1556.

27. He, Kaiming & Zhang, Xiangyu & Ren, Shaoqing & Sun, Jian. (2016). Deep Residual Learning for Image Recognition. 770-778. 10.1109/CVPR.2016.90.

28. Veit, Andreas & Matera, Tomas & Neumann, Lukas & Matas, Jiri & Belongie, Serge. (2016). COCO-Text: Dataset and Benchmark for Text Detection and Recognition in Natural Images.

29. Wen-Chung Kao, Sheng-Hong Wang, Chih-Chung Kao, Chi-Wu Huang and Sheng-Yuan Lin, "Color reproduction for digital imaging systems," 2006 IEEE International Symposium on Circuits and Systems, Kos, Greece, 2006, pp. 4 pp.-4602.

30. H. Li, X. Zhao, A. Su, H. Zhang, J. Liu and G. Gu, "Color Space Transformation and Multi-Class Weighted Loss for Adhesive White Blood Cell Segmentation," in IEEE Access, vol. 8, pp. 24808-24818, 2020.

31. https://www.cronj.com/blog/color-space-image-processing/amp/

32. https://www.blackice.com/colorspaceHSI.htm

33. A review of deep learning in the study of materials degradation - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/An-overview-of-the-VGG-16-model-architecture-this-model-uses-simple-convolutional-blocks_fig2_328966158 [accessed 6 Mar, 2021]

34. https://en.everybodywiki.com/File:VGG_structure.jpg#filehistory

35. Allugunti,V.R., Kishor Kumar Reddy, C., Elango, N.M., Anisha, P.R. (2021). Prediction of Diabetes Using Internet of Things (IoT) and Decision Trees: SLDPS. In: Satapathy, S., Zhang, YD., Bhateja, V., Majhi, R. (eds) Intelligent Data Engineering and Analytics. Advances in Intelligent Systems and Computing, vol 1177. Springer, Singapore. https://doi.org/10.1007/978-981-15-5679-1_43

36. Dang, N., Khanna, A., Allugunti, V.R. (2021). TS-GAN with Policy Gradient for Text Summarization. In: Khanna, A., Gupta, D., Pólkowski, Z., Bhattacharyya, S., Castillo, O. (eds) Data Analytics and Management. Lecture Notes on Data Engineering and Communications Technologies, vol 54. Springer, Singapore. https://doi.org/10.1007/978-981-15-8335-3_64

37. V. Reddy Allugunti and N. Elango, "Development of a Generic Secure Framework for Universal Device Interactions in IoT of Fifth Generation Networks," 2018 Second World Conference on Smart Trends in Systems, Security and Sustainability (WorldS4), 2018, pp. 238-245, doi: 10.1109/WorldS4.2018.8611592.

38. D.Jayaramaiah, A.Prasanth, A.Viswanatha Reddy, Dr.Anirban Basu, 2012, Multi Agent Management System for Next Generation Mobile Networks. [MAMS for NGMN], International Journal Of Engineering Research & Technology, Volume 01, Issue 07 (September 2012)

39. Prof. D. Jayaramaiah,A. Viswanatha Reddy,Srikishan. D. Agent based User Interface Design for Mobile Cloud Computing Environment (AUID) , International Journal of Engineering Innovations and Research, Volume 1 Issue 3, May 2012

40. Reddy, V., Allugunti, , M, E. & Reddy, C. K. (2019). Internet of things based early detection of diabetes using machine learning algorithms: Dpa. International Journal of Innovative Technology and Exploring Engineering, 8(10):1443–1447.

41. V. Reddy Allugunti and N. Elango, "Development of a Generic Secure Framework for Universal Device Interactions in IoT of Fifth Generation Networks," 2018 Second World Conference on Smart Trends in Systems, Security and Sustainability (WorldS4),2018,pp.238-245.

42. Allugunti, V., M, E. & Reddy, C. K. (2019). Diabetes kaggle dataset adequacy scrutiny using factor exploration and correlation. International Journal of Recent Technology and Engineering, 8(1 SpecialIssue4):1105–1110.

43. Allugunti V.R (2022). A machine learning model for skin disease classification using convolution neural network. International Journal of Computing, Programming and Database Management 3(1), 141-147

44. Allugunti V.R (2022). Breast cancer detection based on thermographic images using machine learning and deep learning algorithms. International Journal of Engineering in Computer Science 4(1), 49-56

45. H. Shatnawi, C. Lim, F. Ismail and A. Aldossary, "An optimisation study of a solar tower receiver: the influence of geometry and material, heat flux, and heat transfer fluid on thermal and mechanical performance", Heliyon, vol. 7, no. 7, p. e07489, 2021.

46. J. Żywiołek, J. Rosak-Szyrocka, M. A. Khan, and A. Sharif, "Trust in Renewable Energy as Part of Energy-Saving Knowledge," Energies, vol. 15, no. 4, p. 1566, 2022.

47. J. Żywiołek, J. Rosak-Szyrocka, and B. Jereb, "Barriers to Knowledge Sharing in the Field of Information Security," Management Systems in Production Engineering, vol. 29, no. 2, pp. 114–119, 2021.

48. S. Tiwari, J. Rosak-Szyrocka, and J. Żywiołek, "Internet of Things as a Sustainable Energy Management Solution at Tourism Destinations in India," Energies, vol. 15, no. 7, p. 2433, 2022.

49. J. Rosak-Szyrocka, J. Żywiołek, and M. Mrowiec, "Analysis of Customer Satisfaction with the Quality of Energy Market Services in Poland," Energies, vol. 15, no. 10, p. 3622, 2022.

50. J. Rosak-Szyrocka, J. Zywiolek, A. Zaborski, S. Chowdhury, and Y.-C. Hu, "Digitalization of higher education around the Globe during covid-19," IEEE Access, p. 1, 2022.

51. Ravi Kumar Gupta, "A Study on Occupational Health Hazards among Construction Workers in India", International Journal of Enterprise Network Management. Vol. 12, No. 4, pp. 325-339, 2021.

52. Ravi Kumar Gupta, "Adoption of Mobile Wallet Services: An Empirical Analysis", Int. J. of Intellectual Property Management, 2022, DOI: 10.1504/IJIPM.2021.10035526

53. Ravi Kumar Gupta, "Utilization of Digital Network Learning and Healthcare for Verbal Assessment and Counselling During Post COVID-19 Period", Technologies, Artificial Intelligence and the Future of Learning Post-COVID-19. Springer Nature, Switzerland, pp. 117-134, 2022.

54. Deepak Vidhate and Shruti Pophale, "Depression Scale Recognition Over Fusion of Visual and Vocal Expression using Artificial Intellectual Method", International Journal of Computer Applications, vol. 183, no. 24, pp. 16-19, 2021.

55. D. Vidhate et al., "Customer Relationship Management: An IT Success as Multifunctional Domain and it's Future Directions", International Journal of Computer Applications, vol. 183, no. 19, pp. 30-34, 2021.

56. D. Vidhate and P. Kulkarni, "Performance comparison of multiagent cooperative reinforcement learning algorithms for dynamic decision making in retail shop application", International Journal of Computational Systems Engineering, vol. 5, no. 3, p. 169, 2019.

57. D. Vidhate, "Cooperative Multi-Agent Joint Action Learning Algorithm (CMJAL) for Decision Making in Retail Shop Application", International Journal of Agent Technologies and Systems, vol. 9, no. 1, pp. 1-19, 2017.

58. Vidhate, D.A., Kulkarni, P. (2019). "A Framework for Dynamic Decision Making by Multi-agent Cooperative Fault Pair Algorithm (MCFPA) in Retail Shop Application", Information and Communication Technology for Intelligent Systems, Smart Innovation, Systems and Technologies, vol 107. Springer, Singapore.

59. Vidhate, D.A., Kulkarni, P. (2018)." A Novel Approach by Cooperative Multiagent Fault Pair Learning (CMFPL)", Advances in Computing and Data Sciences, ICACDS 2018, Communications in Computer and Information Science, vol 905. Springer, Singapore.

60. Vidhate, D.A., Kulkarni, P. (2018). "Exploring Cooperative Multi-agent Reinforcement Learning Algorithm (CMRLA) for Intelligent Traffic Signal Control", Smart Trends in Information Technology and Computer Communications, SmartCom 2017. Communications in Computer and Information Science, vol 876. Springer, Singapore.

61. Vidhate, D.A., Kulkarni, P. (2018). "Intelligent Traffic Control by Multi-agent Cooperative Q Learning (MCQL)", Intelligent Computing and Information and Communication. Advances in Intelligent Systems and Computing, vol 673. Springer, Singapore.

62. Vidhate, D.A., Kulkarni, P. (2018). "A Novel Approach for Dynamic Decision Making by Reinforcement Learning-Based Cooperation Methods (RLCM)", International Conference on Intelligent Computing and Applications. Advances in Intelligent Systems and Computing, vol 632. Springer, Singapore. https://doi.org/10.1007/978-981-10-5520-1_37

63. Vidhate, D.A., Kulkarni, P. (2018). "Improved decision making in multiagent system for diagnostic application using cooperative learning algorithms", Int. j. inf. tecnol. Vol. 10, pp 201–209. https://doi.org/10.1007/s41870-017-0079-7

64. Vidhate, D.A., Kulkarni, P. (2018). "A Framework for Improved Cooperative Learning Algorithms with Expertness (ICLAE)", Advanced Computing and Communication Technologies. Advances in Intelligent Systems and Computing, vol 562. Springer, Singapore. https://doi.org/10.1007/978-981-10-4603-2_15

65. Vidhate, D. A., & Kulkarni, P. (2017). "Multi-agent cooperation models by reinforcement learning (MCMRL)", Int. J. Comput. Appl, vol 176, issue 1, pp 25-29.

66. Vidhate, D. A. (2017). "Cooperative Multi-Agent Joint Action Learning Algorithm (CMJAL) for Decision Making in Retail Shop Application" International Journal of Agent Technologies and Systems (IJATS), vol 9, no 1, pp 1-19.

67. Vidhate, D. A., & Kulkarni, P. A. (2017). "Performance Evaluation of Cooperative RL Algorithms for Dynamic Decision Making in Retail Shop Application", Machine Learning Research, vol 2, no 4, pp 133.

68. Vidhate, D. A., & Kulkarni, P. A. (2017) "Multiagent Cooperative Reinforcement Learning by Expert Agents (MCRLEA)", International Journal of Intelligent Information Systems, vol 6, no 6, pp72-84.

69. P. Bhadola, B. Kunakhonnuruk, A. Kongbangkerd, and Y. M. Gupta, "Analysis of microenvironment data using low-cost portable data logger based on a microcontroller," ECS Transactions, vol. 107, no. 1, p. 15099, 2022. DOI: 10.1149/10701.15099ecst

70. Y. M. Gupta, K. Buddhachat, S. Peyachoknagul, and S. Homchan, "Novel DNA barcode sequence discovery from transcriptome of Acheta domesticus: a partial mitochondrial DNA," in Materials Science Forum, 2019, vol. 967: Trans Tech Publ, pp. 59-64.

71. Y. M. Gupta, K. Buddhachat, S. Peyachoknagul, and S. Homchan, "Collection of Mitochondrial tRNA Sequences and Anticodon Identification for Acheta domesticus," in Materials Science Forum, 2019, vol. 967: Trans Tech Publ, pp. 65-70.

72. Y. M. Gupta and S. HOMCHAN, "Insect detection using a machine learning model," Nusantara Bioscience, vol. 13, no. 1, 2021.

73. S. Homchan, P. Bhadola, and Y. M. Gupta, "Statistical Analysis of Simple Sequence Repeats in Genome Sequence: A Case of Acheta Domesticus (Orthoptera: Gryllidae)," ECS Transactions, vol. 107, no. 1, p. 14799, 2022.

74. Eliwa, M. M. The effect of some different types of learning within training programs in terms of self-determination theory of motivation on developing self-Academic identity and academic buoyancy and decreasing of mind wandering among university students in Egypt. Journal of Education -Sohag University, 92(92), 1–29, 2021.

75. Eliwa, M. M; Al Badri, A.H. Long and Short-Term Impact of Problem-Based and Example-Based STEM Learning on the Improvement of Cognitive Load among Egyptian and Omani Learners. Journal of Scientific Research in Education (JSRE)- Ain Shams University, 22(3), 713-742, 2021.

76. Eliwa, M. M. The Effectiveness of Digital Transformation of Learning on Students' Learning Experience, Students' Engagement and Perceived Intellectual Competence: A Mixed-Method Approach. Journal of Educational and Psychological Sciences- Fayoum University,15(3), 848-890, 2021.

77. Eliwa, M. M; Alshoukary, H. A. (2022). Modeling Causal Relationships between Academic Adjustment, Academic Striving and Future Expectations on Psychological Resilience and

Cognitive Modifiability among Elementary School Students. Journal of the Faculty of Education Beni-Suef University (JFE), 19(116), 655-694.

78. SS Priscila, M Hemalatha, "Improving the performance of entropy ensembles of neural networks (EENNS) on classification of heart disease prediction", Int J Pure Appl Math 117 (7), 371-386, 2017.

79. S Silvia Priscila, M Hemalatha, " Diagnosisof heart disease with particle bee-neural network" Biomedical Research, Special Issue, pp. S40-S46, 2018.

80. S Silvia Priscila, M Hemalatha, " Heart Disease Prediction Using Integer-Coded Genetic Algorithm (ICGA) Based Particle Clonal Neural Network (ICGA-PCNN)", Bonfring International Journal of Industrial Engineering and Management Science 8 (2), 15-19, 2018.

81. Jalil, N.A., P Prapinit, M Melan, AB Mustaffa (2019). Adoption of Business Intelligence-Technological, Individual and Supply Chain Efficiency. Proceedings of the 2019 International Conference on Machine Learning, Big Data and Business Intelligence. Year: 2019, Volume: 1, Pages: 67-73.

82. Jalil, N.A., Hwang, H.J. (2019). Technological-centric business intelligence: Critical success factors. International Journal of Innovation, Creativity and Change, Volume 5, Issue 2, August, 2019, Pages 1499 to 1516.

83. Nasir Abdul Jalil and Koay Kian Yeik. 2019. Systems, Design and Technologies Anxieties Towards Use of Self-service Checkout. In Proceedings of the 2019 3rd International Conference on Education and E-Learning (ICEEL 2019). Association for Computing Machinery, New York, NY, USA, 122–127.

84. B. Singh, N. A. Jalil, D. K. Sharma, S. R, K. Kumar and D. Jebakumar immanuel, "Computational systems overview and Random Process with Theoretical analysis," 2021 7th International Conference on Advanced Computing and Communication Systems (ICACCS), 2021, pp. 1999-2005.

85. Roy Setiawan, Luigi Pio Leonardo Cavaliere, KartikeyKoti, Gabriel Ayodeji Ogunmola, N. A. Jalil, M. Kalyan Chakravarthi, S. Suman Rajest, R. Regin, Sonia Singh, "The Artificial Intelligence and Inventory Effect on Banking Industrial Performance"Turkish Online Journal of Qualitative Inquiry. Volume 12, Issue 6, July, 2021: 8100-8125.

86. Roespinoedji, D., Juniati, S., Hasan, H., Jalil, N.A., Shamsudin, M.F., 2019. Experimenting the long-haul association between components of consuming renewable energy: ARDL method with special reference to Malaysia. Int. J. Energy Econ. Policy 9, 453–460.

87. D. K. Sharma, N. A. Jalil, V. K. Nassa, S. R. Vadyala, L. S. Senthamil and T. N, "Deep learning Applications to classify Cross-Topic Natural Language Texts Based on Their Argumentative Form," 2021 2nd International Conference on Smart Electronics and Communication (ICOSEC), 2021, pp. 1580-1586.

88. D. K. Sharma, N. A. Jalil, R. Regin, S. S. Rajest, R. K. Tummala and T. N, "Predicting Network Congestion with Machine Learning," 2021 2nd International Conference on Smart Electronics and Communication (ICOSEC), 2021, pp. 1574-1579.

89. Nasir Abdul Jalil and Mikkay Wong Ei Leen. 2021. Learning Analytics in Higher Education: The Student Expectations of Learning Analytics. In 2021 5th International Conference on Education and E-Learning (ICEEL 2021). Association for Computing Machinery, New York, NY, USA, 249–254.

90. Fazle Rabbi , Nasir Abdul Jalil , S. Suman Rajest , R. Regin, " An Approximation For Monitoring The Efficiency Of Cooperative Across Diverse Network Aspects", Webology, Volume 17, No 2, 2020, Pages: 1234-1247.

91. D. Jayalakshmi and D. Kem, "Social informatics: The socio-technical network system," Guru Nanak Journal of Sociology, vol. 25, no. 2, pp. 1-10, 2004.

92. D. Kem, "New Media technologies and the emerging social-technical network," European Journal of Physical Education and Sport Science, vol. 3, no. 12, pp. 653-661, 2017.

93. D. Kem, "New media and adolescents: Portrayals and perspectives," International Journal of Current Advanced Research, vol. 07, no. 4, pp. 11344-11351, 2018.

94. D. Kem, "Victim identification, identification devices, lead information and communication technologies in teaching and learning through open and distance education system: A paradigm shift," International Journal of Current Advanced Research, vol. 07, no. 1, pp. 9192-9198, 2018.

95. D. Kem, "The Role of information communication technology in open and distance learning," The Research Journal Social Sciences, vol. 9, no. 11, pp. 55-59, 2018.

96. Werku Etafa, Getahun Fetensa, Reta Tsegaye, Bizuneh Wakuma, Sundararajan Vasantha Kumari, Getu Bayisa , et al , "Neonatal sepsis risk factorsin public hospitals in Wollega zones, Ethiopia: case control study ," PAMJ - One Health,vol. 7, no. 2,p.1-13,2022.

97. S.Vasanthakumari , "Writing research proposal," World Journal of Advanced Research and Reviews,vol. 10, no.01,p.184-190,2021.

98. S.Vasanthakumari ,"Soft skills and its application in work place," World Journal of Advanced Research and Reviews,vol. 03, no.02,p.66–72,2019.

99. S.Vasanthakumari ," Mental Health Preparedness for School Children during COVID-19 Pandemic," International Journal of Scientific Research,vol. 10, no.05,p.1-4,2021.

100. Farouk, A., Alahmadi, A., Ghose, S., & Mashatan, A. (2020). Blockchain platform for industrial healthcare: Vision and future opportunities. Computer Communications, 154, 223-235.

101. Zhu, F., Zhang, C., Zheng, Z., & Farouk, A. (2021). Practical Network Coding Technologies and Softwarization in Wireless Networks. IEEE Internet of Things Journal, 8(7), 5211-5218.

102. Adil, M., Song, H., Ali, J., Jan, M. A., Attique, M., Abbas, S., & Farouk, A. (2021). EnhancedAODV: A Robust Three Phase Priority-based Traffic Load Balancing Scheme for Internet of Things. IEEE Internet of Things Journal.

103. Adil, M., Jan, M. A., Mastorakis, S., Song, H., Jadoon, M. M., Abbas, S., & Farouk, A. (2021). Hash-MAC-DSDV: Mutual Authentication for Intelligent IoT-Based Cyber-Physical Systems. IEEE Internet of Things Journal.

104. Adil, M., Ali, J., Attique, M., Jadoon, M. M., Abbas, S., Alotaibi, S. R., ... & Farouk, A. (2021). Three Byte-Based Mutual Authentication Scheme for Autonomous Internet of Vehicles. IEEE Transactions on Intelligent Transportation Systems.

105. Adil, M., Khan, M. K., Jamjoom, M., & Farouk, A. (2021). MHADBOR: AI-enabled Administrative Distance based Opportunistic Load Balancing Scheme for an Agriculture Internet of Things Network. IEEE Micro.

106. Mendonça, R. V., Silva, J. C., Rosa, R. L., Saadi, M., Rodriguez, D. Z., & Farouk, A. (2021). A lightweight intelligent intrusion detection system for industrial internet of things using deep learning algorithm. Expert Systems, e12917.

107. Adil, M., Attique, M., Khan, M. M., Ali, J., Farouk, A., & Song, H. (2022). HOPCTP: A Robust Channel Categorization Data Preservation Scheme for Industrial Healthcare Internet of Things. IEEE Transactions on Industrial Informatics.

108. Adil, M., Khan, M. K., Jadoon, M. M., Attique, M., Song, H., & Farouk, A. (2022). An AI-enabled Hybrid lightweight Authentication Scheme for Intelligent IoMT based Cyber-Physical Systems. IEEE Transactions on Network Science and Engineering.

109. Aoudni, Y., Donald, C., Farouk, A., Sahay, K. B., Babu, D. V., Tripathi, V., & Dhabliya, D. (2022). Cloud security based attack detection using transductive learning integrated with Hidden Markov Model. Pattern Recognition Letters, 157, 16-26

110. Naseri, M., Heidari, S., Baghfalaki, M., Gheibi, R., Batle, J., Farouk, A., & Habibi, A. (2017). A new secure quantum watermarking scheme. Optik, 139, 77-86.

111. Abdolmaleky, M., Naseri, M., Batle, J., Farouk, A., & Gong, L. H. (2017). Red-Green-Blue multi-channel quantum representation of digital images. Optik, 128, 121-132.

112. Farouk, A., Batle, J., Elhoseny, M., Naseri, M., Lone, M., Fedorov, A., ... & Abdel-Aty, M. (2018). Robust general N user authentication scheme in a centralized quantum communication network via generalized GHZ states. Frontiers of Physics, 13(2), 1-18.

113. Farouk, A., Zakaria, M., Megahed, A., & Omara, F. A. (2015). A generalized architecture of quantum secure direct communication for N disjointed users with authentication. Scientific reports, 5(1), 1-17.

114. Naseri, M., Raji, M. A., Hantehzadeh, M. R., Farouk, A., Boochani, A., & Solaymani, S. (2015). A scheme for secure quantum communication network with authentication using GHZ-like states and cluster states controlled teleportation. Quantum Information Processing, 14(11), 4279-4295.

115. Metwaly, A. F., Rashad, M. Z., Omara, F. A., & Megahed, A. A. (2014). Architecture of multicast centralized key management scheme using quantum key distribution and classical symmetric encryption. The European Physical Journal Special Topics, 223(8), 1711-1728.

116. Abulkasim, H., Farouk, A., Alsuqaih, H., Hamdan, W., Hamad, S., & Ghose, S. (2018). Improving the security of quantum key agreement protocols with single photon in both polarization and spatial-mode degrees of freedom. Quantum Information Processing, 17(11), 1-11.

117. Abulkasim, H., Farouk, A., Hamad, S., Mashatan, A., & Ghose, S. (2019). Secure dynamic multiparty quantum private comparison. Scientific reports, 9(1), 1-16.

118. Zhou, N. R., Liang, X. R., Zhou, Z. H., & Farouk, A. (2016). Relay selection scheme for amplify-and-forward cooperative communication system with artificial noise. Security and Communication Networks, 9(11), 1398-1404.

119. Abulkasim, H., Alsuqaih, H. N., Hamdan, W. F., Hamad, S., Farouk, A., Mashatan, A., & Ghose, S. (2019). Improved dynamic multi-party quantum private comparison for next-generation mobile network. IEEE Access, 7, 17917-17926.

120. Naseri, M., Abdolmaleky, M., Parandin, F., Fatahi, N., Farouk, A., & Nazari, R. (2018). A new quantum gray-scale image encoding scheme. Communications in Theoretical Physics, 69(2), 215.

121. Naseri, M., Abdolmaleky, M., Laref, A., Parandin, F., Celik, T., Farouk, A., ... & Jalalian, H. (2018). A new cryptography algorithm for quantum images. Optik, 171, 947-959.

122. Heidari, S., Abutalib, M. M., Alkhambashi, M., Farouk, A., & Naseri, M. (2019). A new general model for quantum image histogram (QIH). Quantum Information Processing, 18(6), 1-20.

123. Shakir Khan, Mohammed AlAjmi and Irfan Khan, "Cloud Computing Utilization for E-Learning Pharmaceutical System", International Journal of Scientific & Technology Research, Vol. 3, No. 3, pp. 385-390, 2014. http://www.ijstr.org/final-print/mar2014/Cloud-Computing-Utilization-For-E-learning-Pharmaceutical-System.pdf

124. Mohammed AlAjmi and Shakir Khan, "Collaborative Pharmacy Student Learning Outline for Mobile Atmosphere", International Journal of Advanced Computer Science and Applications, Vol. 5, No. 3, pp. 107-113, 2014.

125. Mohammed AlAjmi, Shakir Khan and Arun Sharma, "Studying Data Mining and Data Warehousing with Different E-Learning System", International Journal of Advanced Computer Science and Applications, Vol. 4, No. 1, pp. 144-147, 2013.

126. Shakir Khan, Mohammed AlAjmi, Abu Sarwar Zamani and Ali Akhtar, "Keeping Data on Clouds: Cloud Computing Significance", International Journal of Engineering & Science Research, Vol. 3, No. 2, pp. 2321-2327, 2013.

127. Shakir Khan, Mohamed F. AlAjmi, "The Open Source Software (OSS) Utilization in Project Scattered Computing Environments", International Journal of Scientific Research, Vol. 2, No. 2, pp. 177-178, 2013.

128. Geno Peter, Anli Sherine, Yuvaraja Teekaraman, Ramya Kuppusamy, Arun Radhakrishnan, Histogram Shifting based Quick Response Steganography method for Secure Communication" Wireless Communications and Mobile Computing. vol. 2022, 10 pages, 2022.

129. Geno Peter, Anli Sherine, Yuvaraja Teekaraman, Ramya Kuppusamy, Arun Radhakrishnan, Design of Automated Deep Learning-based Fusion Model for Copy-Move Image Forgery Detection" Computational Intelligence and Neuroscience. vol. 2022, 9 pages, 2022.

130. Hariprasath Manoharan, Yuvaraja Teekaraman, Ramya Kuppusamy, Arun Radhakrishnan, K Venkatachalam, Acclimatization Of Nano Robots In Medical Applications Using Artificial Intelligence System With Data Transfer Approach" Wireless Communications And Mobile Computing. vol. 2022, 9 pages, 2022. Ashok Kumar L, Ramya Kuppusamy, Yuvaraja Teekarama

131. n, Indragandhi V, Arun Radhakrishnan, Design and Implementation of Automatic Water Spraying System for Solar Photovoltaic Module" Mathematical Problems In Engineering. vol. 2022, 9 pages, 2022.

132. K Veena, K Meena, Yuvaraja Teekaraman, Ramya Kuppusamy, Arun Radhakrishnan, Cybercrime Detection using C SVM and KNN Techniques" Wireless Communications and Mobile Computing. vol. 2022, 8 pages, 2022.

133. Yuvaraja Teekaraman, KA Ramesh Kumar, Ramya Kuppusamy, Amruth Ramesh Thelkar, SSNN Based Energy Management Strategy in Grid-Connected System for Load Scheduling and Load Sharing" Mathematical Problems In Engineering. vol. 2022, Article ID 2447299, 9 pages, 2022.

134. M. Bharathidasan, V. Indragandhi, Ramya Kuppusamy, Yuvaraja Teekaraman, Shabana Urooj, Norah Alwadi, 'Intelligent Fuzzy Based High Gain Non-Isolated Converter for DC Micro-Grids" CMC-Computers, Materials & Continua. Vol 71, No.2, 2022.

135. Hariprasath Manoharan, Yuvaraja Teekaraman, Ramya Kuppusamy, Arun Radhakrishnan, A Novel Optimal Robotized Parking System Using Advanced Wireless Sensor Network" Journal of Sensors. Volume 2021, Page 1-8, 2021.

136. Kamaleshwar T, Lakshminarayanan R, Yuvaraja Teekaraman, Ramya Kuppusamy, Arun Radhakrishnan, A Self-Adaptive framework for Rectification and Detection of Blackhole and Wormhole attacks in 6LoWPAN" Wireless Communications And Mobile Computing. Volume 2021, 2021. Page 1-8.

137. Pavan Babu Bandla, Indragandhi Vairavasundaram, Yuvaraja Teekaraman, Srete Nikolovski, "Real Time Sustainable Power Quality Analysis of Non-Linear Load under Symmetrical Conditions" Energies 2022, 15(01).

138. Hariprasath Manoharan, Yuvaraja Teekaraman, Ramya Kuppusamy, Arun Radhakrishnan, A Prognostic Three-Axis Coordination Model for Supply Chain Regulation Using Machine Learning Algorithm" Scientific Programming. Volume 2021, 2021. Page 1-9.

139. Hariprasath Manoharan, Yuvaraja Teekaraman, Ramya Kuppusamy, Arun Radhakrishnan, An Intellectual Energy Device for Household Appliances Using Artificial Neural Network" Mathematical Problems In Engineering. Volume 2021, 2021. Page 1-9.

140. Nagarajan Manikandan, Rajappa Muthaiah, Yuvaraja Teekaraman, Ramya Kuppusamy, Arun Radhakrishnan, A Novel Random Error Approximate Adder-Based Lightweight Image Encryption Scheme for Secure Remote Monitoring of Reliable Data" Security and Communication Networks. Vol 2021, 2021. Page 1-14.

141. Senthilselvan Natarajan, Subramaniyaswamy Vairavasundaram, Yuvaraja Teekaraman, Ramya Kuppusamy, Arun Radhakrishnan, Schema-Based Mapping Approach for Data Transformation toEnrich Semantic Web" Wireless Communications and Mobile Computing. Vol 2021, 2021. Page 1-15.

142. Yuvaraja Teekaraman, Hariprasath Manoharan, Ramya Kuppusamy, Fadwa Alrowais, Shabana Urooj, Energy Efficient Multi-Hop Routing Protocol for Smart Vehicle Monitoring Using Intelligent Sensor Networks" International Journal Of Distributed Sensor Networks. Vol 17, Issue 12. 2021. Page 1-11.

143. Yuvaraja Teekaraman, Ramya Kuppusamy, V. Indragandhi, 'Modeling and Analysis of PV System with Fuzzy Logic MPPT Technique for a DC Microgrid under Variable Atmospheric Conditions" Electronics. (20) 2541, 2021.

144. Yuvaraja Teekaraman, Ramya Kuppusamy, V. Indragandhi, 'Investigations on the effect of micro-grid using improved NFIS-PID with hybrid algorithms" Computing. Springer 2021. DOI: 10.1007/s00607-021-01006-9.

145. Yuvaraja Teekaraman, Jasmin Pamela, V. Indragandhi, R. Saranya, Shabana Urooj, V. Subramaniyaswamy, Norah Alwadi ''2D Finite Element Analysis of Asynchronous Machine Influenced under Power Quality Perturbations" CMC-Computers, Materials & Continua. Volume 70. Number 03, pp. 5745-5763, 2021.

146. Ratnam Kamala Sarojini, Palanisamy Kaliannan, Yuvaraja Teekaraman, Srete Nikolovski, Hamid Reza Baghaee, "An Enhanced Emulated Inertia Control for Grid-Connected PV Systems with HESS in a Weak Grid"" Energies 2021, 14(06), 1455 (1-21);

147. Subramanian Vasantharaj, Indragandhi Vairavasundaram, Subramaniyaswamy Vairavasundaram, Yuvaraja Teekaraman, Ramya Kuppusamy, Nikolovski Srete, Efficient

Control of DC Microgrid with Hybrid PV—Fuel Cell and Energy Storage Systems" Energies 2021, 14(06), 3234 (1-18);

148. Yuvaraja Teekaraman, Hariprasath Manoharan, "Implementation of Cognitive Radio Model for Agricultural Applications using Hybrid Algorithms". Wireless Personal Communications, Accepted. 2021.

149. Rahul Gopi, Soundarya S, Kavitha P, Yuvaraja Teekaraman, Ramya Kuppusamy, Shabana Urooj "Enhanced Model Reference Adaptive Control Scheme for Tracking Control of Magnetic Levitation System" Energies 2021, 14(05), 1455 (1-13).

150. Shabana Urooj, Fadwa Alrowais, Yuvaraja Teekaraman, Hariprasath Manoharan, Ramya Kuppusamy, "IoT Based Electric Vehicle Application Using Boosting Algorithm for Smart Cities" Energies 2021, 14(04), 1072 (1-15).

151. Shabana Urooj, Fadwa Alrowais, Ramya Kuppusamy, Yuvaraja Teekaraman, Hariprasath Manoharan, "New Gen Controlling Variable using Dragonfly Algorithm in PV Panel" Energies 2021, 14(04), 790 (1-14).

152. Hariprasath Manoharan, Yuvaraja Teekaraman, Pravin R Kshirsagar, Shanmugam Sundaramurthy, Abirami Manoharan, Examining the effect of Aquaculture using Sensor based Technology with Machine Learning Algorithm. Aquaculture Research, 13(15), pp.1-16. 2020.

153. Hariprasath Manoharan, Yuvaraja Teekaraman, Irina Kirpichnikova, Ramya Kuppusamy, Srete Nikolovski, Hamid Reza Baghaee., Smart Grid Monitoring by Wireless Sensors Using Binary Logistic Regression. Energies, 13(15), pp.1-16. 2020.

154. Yuvaraja Teekaraman, Hariprasath Manoharan., Adam Raja Basha, Abirami Manoharan., Hybrid Optimization Algorithms for Resource Allocation in Heterogeneous Cognitive Radio Networks. Neural Processing Letters. http://link.springer.com/article/10.1007/s11063-020- 10255-2. 2020.

155. Yuvaraja.T, KA Ramesh Kumar, "Enhanced Frequency Shift Carrier Modulation for H Bridge Multilevel Converter to Conquer the Impact of Instability in Deputize Condenser Voltage" International Journal Of Electrical Engineering Education, Volume 57 Issue 2, April 2020.

156. Yuvaraja Teekaraman, K Ramya, Srete Nikolovski, "Current Compensation in Grid Connected VSCs using Advanced Fuzzy Logic Based Fluffy Built SVPWM Switching" Energies 2020, 13(05), 1259.

157. Yuvaraja Teekaraman, Pranesh Sthapit, Miheung Choe, Kiseon Kim, "Energy Analysis on Localization Free Routing Protocols in UWSNs" International Journal of Computational Intelligence System, Atlantis Press, Vol.12, Issue 2, pp. 1526-1536, 2019.

158. S. Sudhakar and S.Chenthur Pandian "Secure Packet Encryption and Key Exchange System in Mobile Ad hoc Nerwork", Journal of Computer Science, Vol.8, No. 6, pp : 908-912, 2012, DOI:10.3844/jcssp.2012.908.912.

159. S. Sudhakar and S. Chenthur Pandian, "Hybrid Cluster-based Geographical Routing Protocol to Mitigate Malicious Nodes in Mobile Ad Hoc Network", International Journal of Ad Hoc and Ubiquitous Computing, 2016 Vol.21 No.4, pp.224-236.

160. N. Keerthana, Viji Vinod and S. Sudhakar, "A Novel Method for Multi-Dimensional Cluster to Identify the Malicious Users on Online Social Networks", Journal of Engineering Science and Technology Vol. 15, No. 6, pp: 4107-4122, 2020.

161. A. U. Priyadarshni and S. Sudhakar, "Cluster Based Certificate Revocation by Cluster Head in Mobile Ad-Hoc Network", International Journal of Applied Engineering Research, Vol. 10, No. 20, pp. 16014-16018, 2015.

162. S. Sudhakar and S. Chenthur Pandian, "Investigation of Attribute Aided Data Aggregation Over Dynamic Routing in Wireless Sensor," Journal of Engineering Science and Technology Vol.10, No.11, pp:1465–1476, 2015.

163. S. Sudhakar and S. Chenthur Pandian, "Trustworthy Position Based Routing to Mitigate against the Malicious Attacks to Signifies Secured Data Packet using Geographic Routing Protocol in MANET", WSEAS Transactions on Communications, Vol. 12, No. 11, pp:584- 603, 2013.

164. S. Sudhakar and S. Chenthur Pandian, "A Trust and Co-Operative Nodes with Affects of Malicious Attacks and Measure the Performance Degradation on Geographic Aided Routing in Mobile Ad Hoc Network", Life Science Journal, Vol. 10, No. (4s), pp:158-163, 2013.

165. S. Sudhakar and S. Chenthur Pandian, "An Efficient Agent-Based Intrusion Detection System for Detecting Malicious Nodes in MANET Routing", International Review on Computers and Software, Vol.7, No.6, pp.3037-304,2012.

166. S. Sudhakar and S. Chenthur Pandian, "Authorized Node Detection and Accuracy in Position-Based Information for MANET", European Journal of Scientific Research, Vol.70, No.2, pp.253-265,2012.

167. K. Ganesh Kumar and S. Sudhakar, Improved Network Traffic by Attacking Denial of Service to Protect Resource Using Z-Test Based 4-Tier Geomark Traceback (Z4TGT),Wireless Personal Communications, Vol.114, No. 4, pp:3541–3575, 2020,

168. Aakanksha Singhal and D.K. Sharma, "Seven Divergence Measures by CDF of fitting in Exponential and Normal Distributions of COVID-19 Data", Turkish Journal of Physiotherapy and Rehabilitation, Vol.32(3), pp. 1212 - 1222, 2021.

169. D.K. Sharma and Haldhar Sharma, "A Study of Trend Growth Rate of Confirmed cases, Death cases and Recovery cases in view of Covid-19 of Top Five States of India", Solid State Technology, Vol.64(2), pp. 4526-4541, 2021.

170. D.K. Sharma, "Information Measure Computation and its Impact in MI COCO Dataset", IEEE Conference Proceedings, 7th International Conference on Advanced Computing and Communication Systems (ICACCS), Vol.1, pp. 2011-2014, 2021.

171. Aakanksha Singhal and D.K. Sharma, "Keyword extraction using Renyi entropy: a statistical and domain independent method", IEEE Conference Proceedings, 7th International Conference on Advanced Computing and Communication Systems (ICACCS), Vol.1, pp. 1970-1975, 2021.

172. Aakanksha Singhal and D.K. Sharma, "Generalization of F-Divergence Measures for Probability Distributions with Associated Utilities", Solid State Technology, Vol.64(2), pp. 5525-5531, 2021.

173. Aakanksha Singhal and D.K. Sharma, "A Study of before and after Lockdown Situation of 10 Countries through Visualization of Data along With Entropy Analysis of Top Three Countries", International Journal of Future Generation Communication and Networking, Vol.14(1), pp. 496-525, 2021.

174. Aakanksha Singhal and D.K. Sharma, "Generalized 'Useful' Rényi & Tsallis Information Measures, Some Discussions with Application to Rainfall Data", International Journal of Grid and Distributed Computing, Vol. 13(2), pp. 681-688, 2020.

175. Reetu Kumari and D. K. Sharma, "Generalized `Useful non-symmetric divergence measures and Inequalities", Journal of Mathematical Inequalities, Vol. 13(2), pp. 451-466, 2019.

176. D.S. Hooda and D.K. Sharma, "On Characterization of Joint and Conditional Exponential Survival Entropies", International Journal of Statistics and Reliability Engineering, Vol. 6(1), pp. 29-36, 2019.

177. Reetu Kumari and D. K. Sharma, "Generalized `Useful' AG and `Useful' JS-Divergence Measures and their Bounds", International Journal of Engineering, Science and Mathematics, Vol. 7 (1), pp. 441-450, 2018.

178. D.S. Hooda, Reetu Kumari and D. K. Sharma, "Intuitionistic Fuzzy Soft Set Theory and Its Application in Medical Diagnosis", International Journal of Statistics in Medical Research, Vol. 7, pp. 70-76, 2018.

179. D.K. Sharma and Sonali Saxena, "Generalized Coding Theorem with Different Source Coding Schemes", International Journal on Recent and Innovation Trends in Computing and Communication, Vol. 5(6), pp. 253 – 257, 2017.

180. A.K. Gupta, Y. K. Chauhan, and T Maity, "Experimental investigations and comparison of various MPPT techniques for photovoltaic system," Sādhanā, Vol. 43, no. 8, pp.1-15, 2018.

181. A.K. Gupta, "Sun Irradiance Trappers for Solar PV Module to Operate on Maximum Power: An Experimental Study," Turkish Journal of Computer and Mathematics Education, Vol. 12, no.5, pp.1112-1121, 2021.

182. A.K. Gupta, Y.K Chauhan, and T Maity and R Nanda, "Study of Solar PV Panel Under Partial Vacuum Conditions: A Step Towards Performance Improvement," IETE Journal of Research, pp.1-8, 2020.

183. A.K. Gupta, Y.K Chauhan, and T Maity, "A new gamma scaling maximum power point tracking method for solar photovoltaic panel Feeding energy storage system," IETE Journal of Research, vol.67, no.1, pp.1-21, 2018.

184. A. K. Gupta et al., "Effect of Various Incremental Conductance MPPT Methods on the Charging of Battery Load Feed by Solar Panel," in IEEE Access, vol. 9, pp. 90977-90988, 2021.

185. U. Zulfiqar, S. Mohy-Ul-Din, A. Abu-Rumman, A. E. M. Al-Shraah, And I. Ahmed, "Insurance-Growth Nexus: Aggregation and Disaggregation," The Journal of Asian Finance, Economics and Business, vol. 7, no. 12, pp. 665–675, Dec. 2020.

186. Al-Shqairat, Z. I., Al Shraah, A. E. M., Abu-Rumman, A., "The role of critical success factors of knowledge stations in the development of local communities in Jordan: A managerial perspective," Journal of management Information and Decision Sciences, vol. 23, no.5, pp. 510-526, Dec. 2020.

187. Abu-Rumman, Ayman. "Transformational leadership and human capital within the disruptive business environment of academia." World Journal on Educational Technology: Current Issues 13, no. 2 (2021): 178-187.

188. Almomani, Reham Zuhier Qasim, Lina Hamdan Mahmoud Al-Abbadi, Amani Rajab Abed Alhaleem Abu Rumman, Ayman Abu-Rumman, and Khaled Banyhamdan. "Organizational Memory, Knowledge Management, Marketing Innovation and Cost of Quality: Empirical Effects from Construction Industry in Jordan." Academy of Entrepreneurship Journal 25, no. 3 (2019): 1528-2686.

189. Alshawabkeh, Rawan, Amani Abu Rumman, Lina Al-Abbadi, and Ayman Abu-Rumman. "The intervening role of ambidexterity in the knowledge management project success connection." Problems and Perspectives in Management 18, no. 3 (2020): 56.

190. Abu-Rumman, Ayman. "Gaining competitive advantage through intellectual capital and knowledge management: an exploration of inhibitors and enablers in Jordanian Universities." Problems and Perspectives in Management 16, no. 3 (2018): 259-268.

191. Abu-Rumman, A. Al Shraah, F. Al-Madi, T. Alfalah, "Entrepreneurial networks, entrepreneurial orientation, and performance of small and medium enterprises: are dynamic capabilities the missing link?" Journal of Innovation and Entrepreneurship. Vol 10 Issue 29, pp 1-16. Jul 2021.

192. A.Al Shraah, A. Abu-Rumman, F. Al Madi, F.A. Alhammad, A.A. AlJboor, "The impact of quality management practices on knowledge management processes: a study of a social security corporation in Jordan" The TQM Journal. Vol. ahead-of-print No. Issue ahead-of- print. Apr 2021.

193. Abu-Rumman, A. Al Shraah, F. Al-Madi, T. Alfalah, "The impact of quality framework application on patients' satisfaction", International Journal of Human Rights in Healthcare, Jun2021. DOI: https://doi.org/10.1108/IJHRH-01-2021-0006.

194. Zafar, S.Z., Zhilin, Q., Malik, H., Abu-Rumman, A., Al Shraah, A., Al-Madi, F. and Alfalah, T.F. (2021), "Spatial spillover effects of technological innovation on total factor energy efficiency: taking government environment regulations into account for three continents", Business Process Management Journal, Vol. 27 No. 6, pp. 1874-1891.

195. Rupapara, V., Narra, M., Gonda, N. K., Thipparthy, K., & Gandhi, S. (2020). Auto-Encoders for Content-based Image Retrieval with its Implementation Using Handwritten Dataset. 2020 5th International Conference on Communication and Electronics Systems (ICCES), 289–294.

196. Rupapara, V., Thipparthy, K. R., Gunda, N. K., Narra, M., & Gandhi, S. (2020). Improving video ranking on social video platforms. 2020 7th International Conference on Smart Structures and Systems (ICSSS), 1–5.

197. Rupapara, V., Narra, M., Gonda, N. K., & Thipparthy, K. (2020). Relevant Data Node Extraction: A Web Data Extraction Method for Non Contagious Data. 2020 5th International Conference on Communication and Electronics Systems (ICCES), 500–505.

198. Ishaq, A., Sadiq, S., Umer, M., Ullah, S., Mirjalili, S., Rupapara, V., & Nappi, M. (2021). Improving the Prediction of Heart Failure Patients' Survival Using SMOTE and Effective Data Mining Techniques. IEEE Access, 9, 39707–39716.

199. Rustam, F., Khalid, M., Aslam, W., Rupapara, V., Mehmood, A., & Choi, G. S. (2021). A performance comparison of supervised machine learning models for Covid-19 tweets sentiment analysis. PLOS ONE, 16(2), e0245909.