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A COMPARATIVE EVALUATION OF DEEP LEARNING METHODS IN DIGITAL IMAGE CLASSIFICATION

Hersh A. Mohammed[1], Shahab W. Kareem[2,3], Amin S. Mohammed[3]

1 Department of Applied Computer, College of Medicals and Applied Sciences, Charmo University, Chamchamal, Sulaimani, Iraq. Email: hersh.abdulrahman@charmouniversity.org
2 Department of Technical Information Systems Engineering, Erbil Technical Engineering College, Erbil Polytechnic University, Erbil, Iraq. Email: shahab.kareem@epu.edu.iq

3 Department of Computer Networking, College of Engineering and Computer science Lebanese French University, Erbil, Iraq. Email: amin.mohammed@su.edu.krd

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ABSTRACT

White Blood Cells are important in determining a person's overall health. The blood disease diagnosis includes characterization and identification of blood samples of a patient. Neural Networks (NN), Convolutional Neural Networks (CNN), and a mix of CNN and NN models are used in recent techniques to improve visual content understanding. From start to finish, The authors were driven to uncover remarkable characteristics in example photographs because of their expertise in medical image analysis. For blood cell classification, the overall performance of individual cell patches extracted using blood smear techniques has been excellent. These approaches, on the other hand, are incapable of dealing with the issue of multiple cells overlapping. Because of the blood cell overlapping pictures, the input image dimension is compressed, the classification time is reduced, as well as the network works better with more accurate parameter estimates. In this review, we are evaluating a detailed scientific comparison of some of the ways used to improve WBC classification. The authors will show some of the ways used to automatically classify their cells. The results of some of the tests used using available data, compared to blood cell classification techniques.

KEYWORDS: Leukemia, Convolutional Neural Networks, White Blood Cell, Classification, Image Extraction, Deep Learning, Comparison.

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1. INTRODUCTION

Leukocytes also called, white blood cells (wbcs), play an essential part in defence of the human organism from illnesses and external enemies like germs. Viruses, etc. Two kinds of wbcs exist. There really are four major types of neutrophils: neutrophils, lymphocytes, monocytes, and macrophages. Monocytes, lymphocytes, and eosinophils (Kareem, 2021).

They're also distinguished by physical and operational qualities. Because these leucocyte subtype counts are so crucial to the healthcare business, in determining the presence and prediction of disorders, a white blood cell count is particularly valuable. The procedure of counting the cells is usually done by hand however, they may be employed in labs without access to mechanized equipment (Shahab Wahhab Kareemab Roojwan ScHawezia, Farah Sami Khoshabaa, 2022). A pathologist counts the wbc in a blood sample that used a microscope and categorizes them using the manual differential method (Amin Salih Mohammed Hersh A. Muhamad , Shahab Wahhab Kareem, 2022). Automated systems frequently employ dynamic and static light scattering, cytochemical blood sample testing methods, and coulter counting. The data is processed and plotted in these techniques to produce distinct groupings that are associated with various types of wbc (Hersh A. Muhamad , Shahab Wahhab Kareem , Amin Salih Mohammed, July 2022 | Volume 20 | Issue 7). When there are unusual or mutant wbcs, however, the automatic findings may be incorrect. Granulocytes are the cells that makeup neutrophils with enzymes that aid in the digestion of infections (Sami H. Ismael, Shahab W. Kareem, Firas H. Almukhtar, 2020). A kind of white blood cell that transforms into macrophages as they mature known as monocytes, which specify in clearing the blood of hazardous foreign invaders, as well as red blood cells and platelets that are old or damaged. Eosinophils kill parasites and help with allergies, whereas basophils help with allergic reactions. The inflammatory mediators enters the system to remove defected internal organs. Whenever it gets to cell-mediated protection, lymphocytes are difficult to balance. Lymphocytes differ from other wbcs in that they recognize entering bacteria (A. Acevedo, S. Alferez, A. Merino, L. Puigv, J. Rodellar,, 2019). In the defence against foreign invaders, each kind of white blood cell has a specific protective function. Neutrophils are a kind of white blood cell that defends the body against infections. Eosinophils kill parasites and help with allergies, whereas basophils help with allergic responses. The monocyte penetrates the cell to remove the injured tissues from the body. But when comes to cell-mediated immunity, lymphocytes might be challenging to balance. From other types of white blood cells lymphocytes are distinct, they memorize invading viruses and microorganisms. The primary classification of wbcs focuses on

several blood cell classification systems. Deep learning's feature engineering approach, according to wbc, patterns, textures, produces appearances, as well as other properties that show a key part of classification in the image. Image processing techniques for feature extraction, classification, segmentation, and identification have all recently been introduced (Patil, A., Patil, M., & Birajdar, G, 2021).

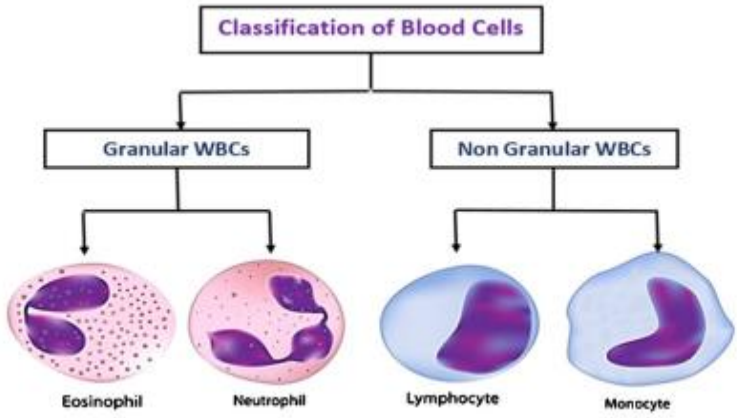

Fig. 1. Structure of WBC classification (Acevedo et ai., 2019).

2. REVIEW OF RELATED LITERATURE

Several deep learning algorithms for classifying white blood cells have been proposed in recent years. Various white blood classification algorithms are briefly covered in this section. Rosyadi et al. created a classification technique for WBC images using a digital microscope and blood smear samples (T. Rosyadi, A. Arif, Nopriadi, B. Achmad and Faridah, 2016)[11]. The KNN grouping approach was utilized in conjunction with the Ostu threshold technique by the authors. According to their findings, after categorizing WBC with k-means clustering, the preset feature produced a 67 per cent accuracy (K. A. S. A. Daqqa, A. Y. A. Maghari and W. F. M. A. Sarraj, 2017). The segmentation of leukocytes with Cyan-Magenta-Yellow-Black (CMYK) colour space was used to create two unique blood streaks to predict and diagnose leukaemia using classification algorithms. proposed using flat texture, colour histogram, and To diagnose pathogens through Giemsasmear blood cell images, researchers used horizontal stripe region granulomatous attributes and a decision tree classifier (L. Malihi, K. Ansari-Asl and A. Behbahani, 2013). It trains the algorithm with parameters such as eccentricity circularity, perimeter, and area using semantic features with naive Bayes classifier. The use of a modified convolutional neural network and Gabor-wavelet model for hyperspectral imaging cell categorization is demonstrated (Yu, S., Jia, S., & Xu, C, 2017). For counting and detecting automatically three kinds of blood cells, a Deep learning technique is recommended. The

algorithm is given accurately counts red, white, and platelet cells. The use of a transfer learning method to classify blood cells automatically has been proposed (Sukhia, K., Ghafoor, A., Riaz, M., & Iltaf, N, 20119). The nuclei of white blood cells are segmented to classify acute lymphoblastic leukaemia using principal component analysis and maximal feature selection. 94 per cent of the time is spent on analysis and sparse representation. classification precision (Pansombut, T., Wikaisuksakul, S., Khongkraphan, K., & Phon-on, A, 2019). To detect and compare lymphocyte image cells, the researchers compared the implementations of CNN, SVMs, MLPs, and randomized forest classifiers. For microscopic blood samples, an automatic categorization and detection strategy for leukocytes is presented (NAZ, I., MUHAMMAD, N., YASMIN, M., SHARIF, M., SHAH, J., & FERNANDES, S, 2019). The input cell pictures are subjected to a discrete wavelet transform after picture augmentation to extract high and low-frequency information, and then CNN-based classification is used. SVM and deep learning are used to construct a technique for classifying abnormal blood cell images. Provide a review of the most up-to-date leukocyte classification, segmentation, and feature extraction approaches issued in the recent two decades. As a result, the scientists discovered various features of improvement over the traditional approach, such as the accuracy percentages reached thus far and the lack of datasets with a larger number of photos to deem the classification models obtained sufficiently dependable. With the development of more efficient algorithms and methodologies, Deep learning algorithms and methods have grown in popularity, mainly deep learning and neural networks in the medical area (Sonu Rajendran and Dr. E. Suresh Kumar,, 2019) (Sahlol, A.T., Kollmannsberger, P., & Ewees, A.A, 2020). Present a WBC classification machine technology that is effective. There are three steps to this approach. They're pre-processing, segmenting, and sorting data with an ANN classifier. A total of 65 optical blood smear images of 5 different WBC cell types were used in the investigation (Astha Ratley, Jasmine Minj, Pooja Patre, 2020). By examining the numerous aspects of white blood cell digital pictures, the authors focus on the methodologies used to segment and diagnose leukaemia. For differences in these traits, the classifier inputs that give knowledge on distinct kinds of leukaemia are applied. The majority of features selected by this bio-inspired optimization technique, as well as features that are highly linked and noisy, are omitted (S. Vatathanavaro, S. Tungjitnob, and K. Pasupa, 2018). The KNN technique is based on the principle that the majority of the k greatest generally takes place in a subspace are from the same category. It's worth noting that the sample shares the same features as the rest of the samples in this category. This method uses the category of the object to determine the classification choice of the adjacent samples to determine the class in which the sample should

be categorized. In the category decision, the KNN approach is only useful for a small number of surrounding samples. Young (1972) used this concept to experiment with 199 cell pictures. He began by segmenting white blood cells using histogram thresholds. a distance classifier was used to classify them. With MRMR feature selection and an extreme learning machine, a fused CNN model for WBC identification was proposed (Arcos-García Á, Álvarez-García JA, Soria-Morillo LM., 2018). described the classification of five categories of white blood cells using two CNN architectures: VGG-16 and ResNet-50. The best classifier is ResNet-50 (S. Vatathanavaro, S. Tungjitnob, and K. Pasupa, 2018).

3. DEEP LEARNING

Deep learning is a branch of Deep learning that allows computers to interpret, learn, and understand data in terms of hierarchy. Deep learning is a subset of Deep learning in which artificial neural networks (ANNs) are used to model the structure and function of the brain (Hongming Chen, Ola Engkvist, Yinhai Wang, Marcus Olivecrona, Thomas Blaschke,, 2018). Chemistry, search engines, biological image and signal processing, Image and video processing, robotics, advertising, finance, natural language processing, and classification are just a few of the disciplines where deep learning is applied. Deep learning differs from typical neural networks in that it can work with numerous layers. This is one of the most essential features. Each cell in a traditional artificial neural network is linked to all cells in the layers above and below it. Each layer performs a variety of mathematical computations. As a result of the rising large amount of data and layers, a large amount of there is a requirement for CPU power. GPU-based and high-memory processors have become popular in recent years for deep learning (Kermany, D.S., Goldbaum, M., Cai, W., Valentim, C.C., Liang, H., Baxter,at el, 2018). Deep learning employs a variety of different types of networks. CNN, LSTM, Limited Boltzmann Machines, deep belief networks, Recurrent Neural Networks, and deep auto-encoders are examples of these networks (Molchanov, P., Tyree, S., Karras, T., Aila, T., Kautz, J., 2016).

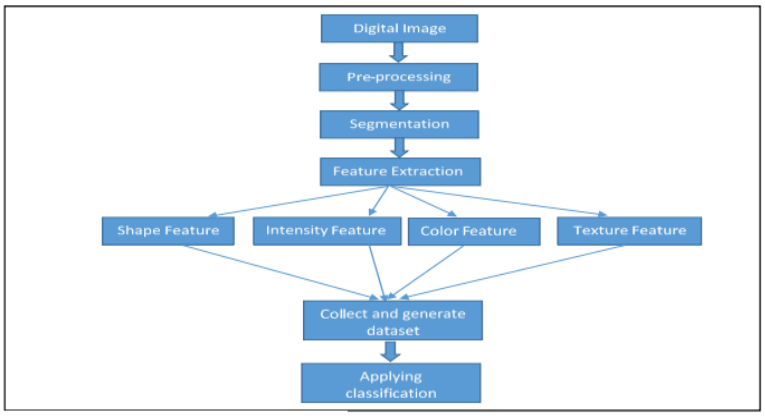

Fig. 2. Steps of the proposed method (Sahlol et al., 2020).

4. NEURAL NETWORK

The neural network is a supervised Deep learning technique based on the organic nervous system. It is made up of three layers: an input layer, a hidden layer, and an output layer, all of which are connected by weighted connections. The performance of the classifier can be approximated to the desired outcome by changing these weights, which are numerical numbers. The form, colour, and texture of the inputs are stored as features in the input layer. Based on weights, the number of neurons in the hidden layer, and the error function, the output layer delivers classified output, namely normal and abnormal WBCs. With a hidden layer of 11 neurons, we used the cross-entropy error function (Hegde, R., Prasad, K., Hebbar, H., & Singh, B, 2016) (Zhimin G, Lei W, Luping Z, Jianjia Z., 2017).

5. MAJOR APPROACHES FOR CLASSIFICATION WBC INVESTIGATING TECHNIQUES

The recommended approach may be implemented in four stages: blood cell categorization, feature extraction, scanning and segmentation. The photos of the cells are then subdivided, which includes the sociological white blood cells classification into distinct groups. The dataset is normally scanned and each segmented image is meticulously scanned in the second different stage. a sufficient amount of prepa ation. The third and last phase involves carefully removing the present shape and complicated texture from a scanned picture. At the end of the process, several Deep learning approaches (Support Vector Machine (SVM), Multilayer Perceptron (MP), and backpropagation (BP)) are often utilized (Kareem, 2021).

This research uses the DenseNet121 model to create deep learning (D.L) model to categorize white blood cells come in a variety of forms. (e the normalization and data augmentation preparation approaches are utilized to optimize the DenseNet121 model. This model's accuracy

was 98.84 per cent, the precision was 99.33 per cent, the sensitivity was 98.85 per cent, and the specificity was 99.61 per cent. The suggested model is tested using the Adam optimizer, four batch sizes (BS), and ten epochs. The results show that, when compared to different batch sizes, the DenseNet121 model outperforms batch size 8 (Sharma, S., Gupta, S., Gupta, D., Juneja, S., Gupta, P., Dhiman, G., & Kautish, S., 2022).

The pre-trained weight parameters for the Image Net dataset are passed to the CNN portion using the transfer learning approach, and to enable our network to train and converge quicker and with more exact weight settings, we deploy a custom loss function. As a consequence, this approach is utilized to detect the irregularity of the cell utilizing segmentation and classification. The classification results displayed the accuracy of KNN was 88.04 per cent, whereas ANN was 54 per cent. The proposed system's performance can be improved further if taking other classifiers into account (V.Loganathan, 2019).

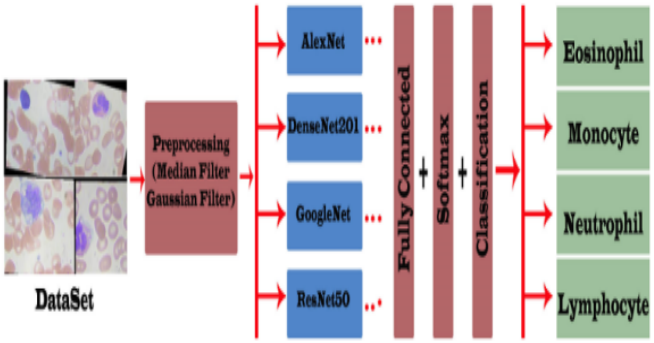

Fig. 3. A framework for improving the categorization of white blood cell types has been proposed (Shahab et al., 2022).

This research demonstrates the categorization of white blood cells into 6 groups: monocytes, lymphocytes, neutrophils, basophils, eosinophils, and aberrant cells. We compared traditional techniques of image processing with deep learning approaches for the categorization of white blood cells. For hand-crafted features, we examined neural network classifier outputs and found an average accuracy of 99.8%. For classification, we employed convolutional neural network complete training and transfer learning methodologies. For full training CNN, an accuracy of roughly 99 per cent was achieved (Hegde, R., Prasad, K., Hebbar, H., & Singh, B, 2016). For data augmentation, investigates image alteration algorithms and generative adversarial networks (GAN), for white blood cell classification into the five categories, and also cutting-edge deep neural networks (VGG-16, DenseNet, and ResNet). We also look at whether the weights of the DNNs

should be pre-trained on the CIFAR-100 dataset or initialized randomly. Our system works immediately with the acquired images, unlike other methods that need extensive picture preprocessing and the extraction of human features prior to classification. According to the results of extensive testing, the suggested technique may correctly identify WBCs. The best DNN model, DenseNet-169, has an accuracy results of 98.8 percent. Current approaches that depend on advanced image processing and human feature engineering, in particular, are outperformed by the proposed method (Almezhghwi, K., & Serte, S., 2020).

Convolutional Neural Network (CNN), is used to discriminate within several kinds of WBC, such as lymphocytes, eosinophils, neutrophils, and monocytes. The CNN was trained with the Kaggle Dataset after being linked with Resnet50, Alexnet GoogleNet and Densenet201. The photos in the database were then subjected to independent Gaussian and median filters. CNN classed the new photos once again with each of the four networks. The outcomes of utilizing the two filters on the photographs were better than the raw data findings. The findings of the study make it easier to diagnose blood disorders (Yildirim, M., & Çinar, A., 20019). A cumulative of 731 blood smear images with 16,450 individual images from 100 normal people, 191 people with virus infection, and 148 people with acute leukemia have been used in testing and training sets, respectively. ResNet101, VGG16, SENet154, and DenseNet121 were tested to see which design was best for acute leukemia classification. To adjust the layers of these pre-trained CNNs to our data, fine-tuning was used. After deciding on the optimum architecture, a two-module system functioning in parallel was set up (ALNet). Lymphocytes, reactive lymphocytes, monocytes, and blasts are examples of mononuclear blood cells, the first module recognized as aberrant promyelocytes. The second test identified whether the blasts originated from myeloid or lymphoid cells. The last technique was to use a blood smear review to forecast patients' first diagnosis of acute lleukaemialineage. Smears of the testing set were used to evaluate ALNet (L. Bold´u, A. Merino, A. Acevedo, A. Molina, and J. Rodellar, 2021).

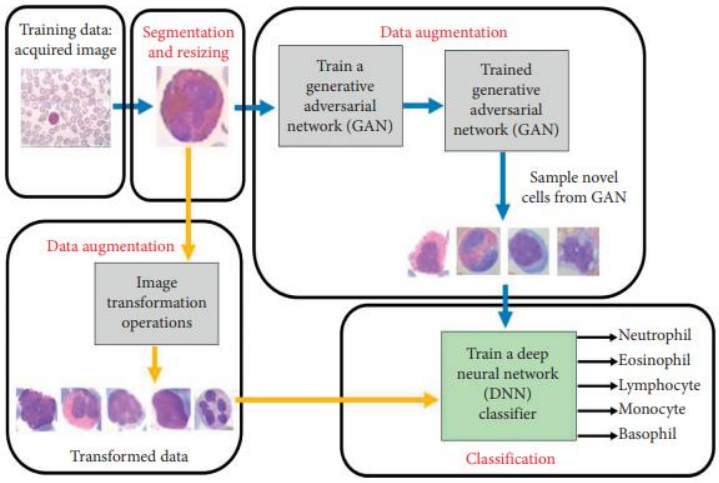

Fig. 4. After preprocessing, data is classified using several architectures (Rajendran and Kumar,, 2019).

6. COMPARISON OF BLOOD CELL IMAGE CLASSIFICATION METHODS

Many ways have been tested to improve the classification of blood cells with various results for each method. In this table below, we will show some of the ways used to classify WBC, we show a short story and the benefits of their models and the algorithms used.

To address this issue, we developed Recurrent Neural Networks (RNNs) (RNN). In particular, we merged the CNN and RNN to present the CNN-RNN framework, which can enhance image content understanding and learn structured features of images, as well as initiate end-to-end large data training in medical image analysis. We use the transfer learning approach to transfer the pre-trained weight parameters from the ImageNet dataset to the CNN section, and we use a custom loss function to make our network train and converge faster and with greater accuracy. Wprecise weight characteristics use dataset BCCD (Liang G, Hong H, Xie W, Zheng L., 2018).

For a Recurrent Convolutional Neural Network (RCNN) based on U-Net models, authors recommend the labels RU-Net and R2U-Net, and also a Recurrent Residual Convolutional Neural Network (RRCNN) based on U-Net models. Residual Network, U-Net and RCNN are all used in the proposed models. These proposed designs for segmentation problems have several advantages.use dataset DRIVE , STRE , CHASE_DB1 (Zahangir Alom Md, Hasan Mahmudul, Yakopcic Chris, Taha Tarek M, Asari Vijayan K, 1802.06955). This research presents a system for automatically detecting and classifying WBCs in peripheral blood pictures. It first presents an algorithm for detecting WBCs in microscope pictures based on a simple color and morphological operation relationship. Then, A specificity attribute (pairwise orientation fitted with a brass cross binarization structure, PRICoLBP characteristic), as well as

SVM, are being used to separate eosinophil and basophil from other WBCs. Use dataset ALL-IDB (Zhao Jianwei, Zhang Minshu, Zhou Zhenghua, Chu Jianjun, Feilong Cao., 2017).

In this paper, Otsuthresholding is employed to segment leukocytes using a basic thresholding technique. Following segmentation, mathematical morphing is employed to remove any components that do not appear to be leukocytes. Furthermore, only the nucleus region was used to extract features. Following that, the Nave Naives classification technique is utilized to classify leukocytes. The classification accuracy on the training dataset of only 20 images and test image dataset of 68 images is about 80.88 percper centth an average time of 22 seconds per image, which is better than other state-of-the-art algorithms.use dataset kaggle (Gautam A, Singh P, Raman B, Bhadauria H., 2016). Using data mining techniques, his study intends to predict the presence of leukleukaemiaevaluating the correlation between blood characteristics and leuleukaemiath gender, age and health status of patients. More than 4,000 patients were kidnapped from the European Gaza Hospital's blood test facility in Gaza. K-nearest neighbour-NN), decision tree (DT), and Support Vector Machine are the three classification methods identified for blood cancer categorization (SVM).use dataset CBC (Daqqa KASA, Maghari AYA, Sarraj WFMA, 2017). The use of support vector machines (SVMs) classifiers to detect WBC for future leuleukaemiaagnosis is investigated in this research. Since SVMs were created to solve two-class problems in the first place, different ways for extending them to this multiclass challenge are examined and compared. The results show that SVMs can be used to diagnose leuleukaemiad and that a hierarchical tree-based multiclass technique would be better suited to a future upgrade of the Leuko system. The dataset Leishman-stained digital photographs were manually captured (Ushizima DM, Lorena AC, de Carvalho ACPLF, 2005).

Use of KNN for segmentation and feature classification to classify RBC and WBC in a peripheral blood smear During the training phase, there is a lack of robustness and it is prone to noise To address both regression and classification issues, use a simple, straightforward supervised learning strategy.use dataset kaggle (Kulkarni Samidha S, Hinge Chhaya S, Ambekar Aarti G., 2013). Segmentation, scanning feature extraction and blood cell classification are the four stages that the suggested technique can be executed. The photos of the cells are then subdivided, which includes the sociological classification of white blood cells into distinct groups. The second stage usually entails carefully scanning each segmented image and properly preparing the dataset. The third and last step is to remove the current form and complex texture from a scanned image with care. Various Deep learning techniques (Support Vector Machine, Multilayer Perceptron (MP), and backpropagation (BP)) are typically used at

the final step (SVM). The discoldiscolourationdure and aesthetic evaluation of raw photographs acquired are mostly automated and depend on human error. One of the main efforts is using Ensemble learning to enhance Deep learning outcomes by mixing different models in a significant way.use data 100 images real (Kareem, 2021).

The goal of this research is to create a deep learning-based system that can use blood cell pictures to predict the diagnosis of acute leuleukaemia clinical practice, artificial intelligence decision support systems show considerable potential in diagnosing haematological malignancy. The prevalence of multiple cross-reactions due to many genes that are common to various bacterial species is the fundamental limitation of bacterial serology. To develop a method that uses WBC pictures to diagnose acute leukaemia. Use the dataset Laboratory of the Hospital Clinic of Barcelona (L. Bold´u, A. Merino, A. Acevedo, A. Molina, and J. Rodellar, 2021). Because there are a limited number of photos in the dataset, an automated method dependent on transfer learning methodology is used to recognize and detect leukocytes into four types: neutrophil, eosinophil, monocyte, and lymphocyte. K-Nearest Neighbor is used in training and assessing the VGG16 deep learning model (KNN). In this case, a trained DL algorithm from a big dataset is utilized for deducing the issue from a smaller dataset. To develop and test a transfer learning system for diagnosing and categorizing WBC pi ctudatasete dataset kaggle (D. Baby and S. J. Devaraj, 2021). For WBC classification, the two-module graded optimized reconfigurable CNN (TWO-DCNN) method was introduced. To begin, the network model should be improved in order to increase the accuracy of classification; second, WBC data sets should be expanded in terms of WBC samples and WBC types for more reliable performance evaluation; and third, more types of optimizers, in addition to the Radam optimizer, should be investigated in future work to address the problem of overfitting. TWO-the DCNN for WBC classification method to be implemented.use dataset BCCD (X. Yao, K. Sun, X. Bu, C. Zhao, and Y. Jin,, 2021). In the MGCNN architecture, a modulated Gabor wavelet is combined with deep convolutional neural network (CNN) kernels. Hyperspectral imaging is superior to standard optical microscopic imaging. For blood cell categorization, a Gabor wavelet and deep CNN termed MGCNN is used on medical hyperspectral imaging.use dataset LISC Database (Q. Huang, W. Li, B. Zhang, Q. Li, R. Tao, and N. H. Lovell, 2019). We present a deep learning methodology that uses convolutional neural networks to automate the entire process for a binary class with an acper centof 96 percent and multiclass classification with an aper cent of 87 percent. offer a deep learning methodology that uses convolutional neural networks to automate the entire procedure for a binary class with a high level of accuracy.

A change in one type of white blood cell usually corresponds to a change in one type of antigen. WBC categorization will be implemented utilizing a deep learning system using CNN.use dataset BCCD (M. Sharma, A. Bhave, and R. R. Janghel, 2019).

A collection of 17,092 images of eight distinct kinds of normal peripherwereblood cells was collected using the CellaVisin DM96 analyzer. Image segmentation is not required; feature extraction is automated, and current models can be fine-tuned to provide specialized classifiers. Usof ing a transfer instructional strategies with convolutional neural networks, develop a system for high-accuracy categorization of 8 blood c ell categories.use dataset Laboratory of the Hospital Clinic of Barcelona (A. Acevedo, S. Alferez, A. Merino, L. Puigv, J. Rodellar,, 2019).

7. CONCLUSION

This review is written in a literary style. It is proposed that it be utilized to assist medical pathologists in the diagnosis of early leukemia during blood smear examination. It has been shown to differentiate between neoplastic (leukemia) and non-neoplastic (infections) disorders, as well as the leukemia lineage. Deep learning, deep learning layers, and deep learning models, which have received a lot of attention in recent years, are investigated for classification in this study Showing, evaluating, and comparing the different ways used in classifying blood cells, a literary review of many of its effective classification styles.

Table 1. Comparison of blood cells image classification method.

Algorithm	Use Dataset	Description	Advantages	Limitations
(Liang G, Hong H, Xie W, Zheng L., 2018) CNN + RNN	BCCD Dataset	Classification of blood cells applying a mixture of convolutional and recursive neural networks	The proposed approach effectively represents all of the key elements from the picture by highlighting retrieved characteristics	The time of computation is long, the emphasis is on a specifica cell nucleus, and high-performance computer is required
(Zahangir Alom Md, Hasan Mahmudul, Yakopcic Chris, Taha Tarek M, Asari Vijayan K, 1802.06955)	DRIVE , STARE , CHASE DB1	Medical image processing with a U-Net-based recurrent residual convolutional neural network (R2U-Net)	It has a history and can model a succession of data	The distribution of pixel values throughout the grid might cause underfitting issues

(Zhao Jianwei, Zhang Minshu, Zhou Zhenghua, Chu Jianjun, Feilong Cao., 2017) – CNN	ALL-IDB	Using smear images, a Convolutional Neural Network was used to segment and classify leukocytes.	An artificial neural network that is different from the others. In image and natural language processing, CNN outperforms other algorithms	Computational complexity expense; for improved classification rate, a million training examples points are required
(Gautam A, Singh P, Raman B, Bhadauria H., 2016) Naive Bayes	kaggle	The morphological properties of leukocytes are automatically classified	It's a Bayesian classification strategy that calculates the posterior probability using the Bayes Theorem	There's a chance to lose your precision. If there are dependencies between the variables, the classifier cannot change them
(Daqqa KASA, Maghari AYA, Sarraj WFMA, 2017) Decision Tree	CBC	Detecting blood disorders utilizing a decision tree and analyzing blood cell patterns, as well as forecasting blood cell count	By learning decision rules, a learning algorithm may be used to predict the class or value of target variables	Complexity, instability, and inaccuracy in identifying continuous values using regression
(Ushizima DM, Lorena AC, de Carvalho ACPLF, 2005) - SVM	Leishman-stained digital photographs were manually captured.	The data is classified in a non-linear manner and clustered	The use of an SVM classifier to detect WBC for early Leukemia diagnosis and for multiclass tasks is being researched	Large datasets take a very long time to training, and visualization is tough
(Kulkarni Samidha S, Hinge Chhaya S, Ambekar Aarti G., 2013) - KNN	kaggle	KNN is used for edge detection and feature categorization in a microscopic examination to categorize RBC and WBC.	To address both regression and classification issues, use a simple, straightforward supervised learning strategy	During the training phase, there is a lack of robustness and it is prone to noise
(Kareem, 2021) [BP-SVM-MP	Reall Data	An Assessment of Leukocyte Image Classification Algorithms	One of the main efforts is using Ensemble learning to enhance Deep learning outcomes by mixing different models in a significant way	The discoloration procedure and aesthetic evaluation of raw photographs acquired are mostly automated and depend on human error
(L. Bold´u, A. Merino, A. Acevedo, A. Molina, and J. Rodellar, 2021) CNN	Laboratory of the Hospital Clinic of Barcelona	In clinical practice, artificial intelligence decision support systems show considerable potential in diagnosing hematological malignancy.	To develop a method that uses WBC pictures to diagnosis acute leukemia	The prevalence of multiple cross-reactions due to many genes that are common to various bacterial species is the fundamental limitation of bacterial serology.
(D. Baby and S. J. Devaraj, 2021) VGG16, KNN, CNN	kaggle	To examine the data, deep learning-based approaches are used.	To develop and test a transfer learning system for diagnosing and	In this case, a trained DL algorithm from a big dataset is utilized to deduce the issue from a smaller dataset

			categorizing WBC pictures	
(X. Yao, K. Sun, X. Bu, C. Zhao, and Y. Jin,, 2021) CNN, VGG16, VGG19, Inception-V3, ResNet-50	BCCD Dataset	For WBC categorization, the multiple scaled optimised reconfigurable convolutional neural networks (TWO-DCNN) approach has been introduced.	TWO-DCNN for WBC classification method to be implemented	To begin, the network model should be improved to improve classification accuracy; second, WBC data sets should be expanded in terms of WBC samples and WBC types for more reliable performance evaluation; and third, more types of optimizers, in addition to the Radam optimizer, should be investigated in future work to address the problem of overfitting
(Q. Huang, W. Li, B. Zhang, Q. Li, R. Tao, and N. H. Lovell, 2019) CNN, MGCNN	LISC Database	In the MGCNN design, a modulated Gabor wavelet is merged with deep convolutional neural network (CNN) kernels.	For blood cell categorization, a Gabor wavelet and deep CNN termed MGCNN is used on medical hyperspectral imaging	Hyperspectral imaging is superior to standard optical microscopic imaging.
[49] CNN, LeNet, VGG16, xception	BCCD Dataset	offer a deep learning methodology that uses convolutional neural networks to automate the entire procedure for a binary class with a high level of accuracy.	WBC categorization will be implemented utilizing a deep learning system using CNN	A change in one type of white blood cell usually corresponds to a change in one type of antigen.
[50] CNN, VGG16	Laboratory of the Hospital Clinic of Barcelona	A collection of 17,092 images of eight distinct kinds of normal peripheral blood cells was collected using the CellaVision DM96 analyzer	Using a transfer instructional strategies with convolutional neural networks, develop a system for high-accuracy categorization of 8 blood cell categories	Image segmentation is not required; feature extraction is automated, and current models can be fine-tuned to provide specialized classifiers.

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