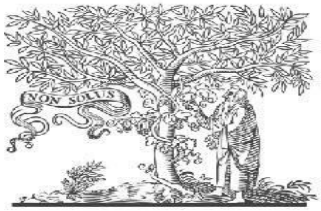
International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

COPY RIGHT



ELSEVIER SSRN

IJIEMR Transactions, online available on 29th Mar 2023. Link :http://www.ijiemr.org/downloads.php?vol=Volume-12&issue=Issue 03

10.48047/IJIEMR/V12/ISSUE 03/60

Title **LIVER DISEASE PREDICTION AND ANALYSIS USING LIVER MEDICAL IMAGES**

Volume 12, ISSUE 03, Pages: 433-441

Paper Authors
Senthilkumar Ramachandran, Dr. Thirupathi Regula

USE THIS BARCODE TO ACCESS YOUR ONLINE PAPER

To Secure Your Paper As Per UGC Guidelines We Are Providing A Electronic Bar Code

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

Liver Disease Prediction and Analysis Using Liver Medical Images

[1]Senthilkumar Ramachandran, [2]Dr. Thirupathi Regula

[1]Research Scholar, Department of Computer Science, Shri Venkateshwara University, Uttar Pradesh, India.
[2]Assistant Professor, Department of Computer Science & Engg., Shri Venkateshwara University, Uttar Pradesh, India.
senthilkumar75.mca@gmail.com , regulathirupathi@gmail.com

Abstract:
Liver is a vital function in the individual body. Artificial Intelligence widely helps to identify the complex medical imaging of the affected liver as it helps the radiologist as well the physicians to do their task with accuracy. The liver diseases are diagnosed by using the popular methods like tissue biopsy, blood test, ultrasound effects, CT scan, MRI to identify its damages and for the further treatments. In this paper consolidated the last five years' efforts in the field of liver diagnosis using the affected liver medical imaging with the help of artificial Intelligence and neural networks algorithms. The proposed study is to diagnosis the liver whether it is normal or it gets affected by the diseases through the classification techniques to identify the normal and abnormal liver using neural network algorithms and to do the necessary feature selection by using the nature inspired algorithms. Then the result will compare with two CNN algorithms and analyze the efficiency of the accurate percentage to identify the liver diseases.

Keywords: Machine Learning, Support Vector Machine, K-Nearest Neighbor, Neural Network, Decision Tree, Random Forest,Literature Review, Comparison of Algorithm & Performance Proposed Methodology.

Introduction

In a modern world, the deadly liver disease affects most of the human being. Such as cirrhosis, Hepatic fibrosis, hepatitis B and C, fatty liver, liver tumor and liver cancer due to virus infection and alcohol consumption. Day by day patients are increasing in the [3] [6] non-alcoholic fatty liver disease which is seriously discussing by the world health communities. Radiologist and physician are faced the complexity to do the accuracy in prediction and identification of the patients' liver disease caused by the medical problems. Machine Learning (ML) and Deep Learning(DL) algorithms will overcome the issues in the guess and study of the affected liver diseases in the early stages of the human [1]. Convolutional neural network(CNN) automated texture analysis and supervised machine learning methods such as K-Nearest Neighbour, NaiveBayes, SVM, and Random Forest(RF) forest will help to classify the affected and non-affected liver. To meet the higher accuracy with the help of patients CT scans images [12]. CNN algorithms will also help in the early identification of the human affected liver as well it provides the guidelines for the treatment and monitoring automated system with the help of deep learning algorithms using Ultra sound images[1]. Performance of ANN with K-fold (10-FOLD) cross validation and hyper- parameter and SVM in the classification of affected and non-affected liver. The ANN with respect to the parameters such as correctness, meticulousness and recollect are shows the results are in percentage likely 70.94, 69.99, 70.94 and 70.27 performs well then SVM [13].

The tuned Multi-coating feed forward Deep Neural Network [MLFFDNN] with

suitable amount of veiled layer and nodes, failure function to overcome over fittings, loss, bias, learning rate and time consumption which is the best way toward recover the accuracy of early detection of liver diseases of the human being. The model shows the presentation into terms of truthfulness is 98% [17]. The Measuring parameter, for instance accuracy, precision, sensitivity and specificity or the algorithms are Logistic Regression, K-NN, SVM and ANN with respect to 10 numbers of neurons. The input attributes of patients age, sex, total bilirubin, Direct Bilirubin, alkaline phosphatase, Al amine phosphatase, total proteins, albumin, albumin and globulin ratio are considered to detect the liver diseases in the earlier stage. Out of three methods ANN shows the better results are as 92.8%, 93.78% ,97.23% and 83% [16]. In the study of Scopus and PubMed 29 papers were SVM method is applied, Naive Bayes in 23 papers is applied, and Random forest algorithm is applied in 17 papers. The comparative study result gives that Random forest providing the highest accuracy in the performance of early identification of the disease as 53% whereas SVM produces as 41% [14].

a) ANN

The genetic neural networks that outline the arrangement of the person mind are from which the phrase "artificial neural network" derives. Artificial neural networks and element in neurons that are organized into new elements, in various levels of the networks, much like the human brains, which has neurons that are consistent to one another. Nodes are the term for these neurons. It makes an effort to recreate the neural network that makes up the human brain, so that all systems would have the ability to understand data and arrive at decisions in a manner equal to that of a human. Computers are skilled to function accurately likely to be another network of interconnected brain cells to generate an artificial neural network.

b) LR

Logistic Regression and Linear Regression (LR) are very similar. While logistic regression is used to explain categorization difficulty, LR is used to solve the problems. In recently many algorithms like ML SV, LR and DT are used to sort out the problem in human neurons. It is used to predict the categorical dependent variable. It provides probabilistic values that range from 0 to 1.

c) NB

The Nave Bayes algorithm is classifier in ML model that has been used to find out the different types of object. It is mostly used in probabilistic models in a bayes theorem in a huge training set. The Naive Bayes Classifier is one of the simplest and reliable classification algorithms and product accurate predictions value. Being a probabilistic classifier, it uses statistics based. There are two independent variable used one is dependent and another one independent.

d) RF

It is based on the decision trees and the basic of machine learning technique for creating and predictive models. Every RF is divided into many trees like Tree-1, Treee-2.....Tree-n all the tree is called as instance. DT process may have no more branches, each end is called leaf node and end node is the result or a predicted class or instance value.

e) SVM

Support Vector Machine, which is used for classification and creating best line or dimensional space in different classes. It is used for face detection, image classification; there are two types of SVM linear and non-linear. Dataset can be classified into two classed, but in case of non-linear dataset cannot be classified

f) K-NN

It will be widely used for the classification then linear regression. As K-NN is a non-parametric approach, it makes rejection of different assumptions regarding dataset. Knn will help to identify similar features in the data set.

g) DT

The most effective and well-liked technique for categorization and prediction is the DT. Each instance variable can be divided into two or more sub-nodes or sub-tree. All sub-trees increase the homogeneity of newly created sub-nodes.

h) DL

Mainly used for CNN algorithm, which is used for large amounts of dataset like GPU computer power, driverless car, image classification, the size of data processing and the amount of data processing logic can be reduced and increase the performance level.

II Review of Literature

One of the research paper [1], Zhou et.al were paid their attention on both ML and DL algorithms to detect the defects in the complex liver images like Ultrasound, Radiology etc. With the help of CNN not only to identify the defect in the liver also to guide the physician for the further treatments and also to automated monitoring of the treatment improvements of liver using Deep Learning. As well, challenges are in the automation of the clinical treatments observation as well for more complex liver disease identifications are more time consuming process. Therefore, the research is proposing the comprehensive model to be developed to fix the challenges [1]. In the another paper, Mounita Ghosh et.al [2], were deeply discussed and used few of the machine learning algorithms like SVM, DT, RF, and XGBOOST, to predict the liver sickness using the liver medical images in the early stage. The RF is the best algorithm to work with almost all the input parameters, which works more accuracy in the guess of the liver illness by means of the medical liver images.

The other research paper published by W Ji et.al [3], which shows about the growth of Non Alcoholic Fatty Liver Disease among the global population. The model for the early detection as well for the classification of the liver problems using machine-learning algorithms. Based on the parameters like Age, BMI, Hypertension diabetes, smoking habits, oil loving, gallbladder issues, diet issues and physical activity of the adults were considering in their model for the early detection and classification of the NAFLD. Moreover, the dataset for the 304,415 records from the national physical examination in their country. The research papers say that the XGBoost algorithms serves the better performance when compared with other algorithms like DT approach, RF,LM, LR, and SMOTE. Therefore, it is the suitable model for the high population with poor economy.

The AI in medical imaging informatics research papers by Panayides AS et.al [4], in that the acquisition of the advanced medical imaging information's and data management efficiently for the research purpose. Authors were concentrated on the area of machine learning and deep learning how it will be useful in the medical diagnosis like image segmentation, and classifying the images. As with the help of the acquisition of the medical imaging like MRI, CT, MAMOGRAPHY etc, will help the researchers and the physician to do the image analysis. Also visualization and integrative analytics, which guide the physician for decision-making purpose.

The Musunuri B et.al [5], Acute-on chronic liver collapse humanity prediction using an ANN in this research Paper-Clinical syndrome and ACLF were discussed and using ANN to predict the mortality of the human within 30 to 90 days with the accuracy of 88% to 94%. The developed ANN Application checking riskier mortality patients in the ACLF automation and ease to identify such patients. The relevance of ANN in this pasture has a huge possible for supplementary clinicians in decision-making system.

The Wu.et al [6] in the guess of greasy liver sickness using ML algorithms, in the paper how the humans are getting affected by Fatty liver diseases are increasing in the population. In this paper used the dataset of 577 people records from Taiwan-new Taipei city hospital, in that 377 were affected by fatty liver disease, which was identified by their model using machine-learning methods. In their classification model, they were used Random Forest, Naive Bayes, ANN, and Logistic Regression. In this model, i.e, Receiver Operating Characteristic Curve-ROC is used as a parameter to evaluate the performance of the model. Among the four methods, Random Forest play the better performance in the accuracy as 87.48%. This model will help the

physicians to detect the disease early as well for the management of the further treatment to save the patient's life.

The Rashid J et.al [7] in an Artificial intelligence approach using optimization technique to predict the chronic diseases like diabetes, Liver diseases, Kidney issues, heart attack and breast cancer is proposed as their model. In the model, there are seven classification algorithms NB, ANN, KNN, DT, RF, LR, SVM and DL used to calculate the performance level of significant predicting the multiple diseases. The proved result show that the performance and its accuracy as 99.67 in the optimized ANN based model prediction. Few of the limitations also observed in the paper and their model is, used the small datasets based on the availability in the public domain. It can be overcoming by using the larger amount of dataset in the near future to predict more accuracy in it. The Sivakumar et.al [8] in the paper deals with the model and the life quality of attributes used as age, gender, blood pressure, habits, stress level, financial burden, body over weight, marital status, hepatitis history, quality of food habits, physical activity, education, bad cholesterol and their profession. To predict and analyze the life style quality of the people to forecast the chronic liver disease with the use of K-mean clustering decision tree approaches, it gives the results as liver disease forecast as 94.36 rates and C4.5 calculations as 94.37 with the help of small amount of online collection of dataset from Bengaluru people in India used. As well, the designed form will help the patients and doctors, to identify the risk in the early stage to maintain their health from the liver disease.

The Wei Runmin et.al [9] medical guess of HBV and HCV, in this paper the ML models with FIB-4, achieve in the dataset of 480 of patients with hepatitis B virus. In addition, it was checked and validated in an independent HBV dataset of 86 patients. As well, the same method used in the two independent hepatitis C virus with the use of dataset of 254 and 230 patients respectively. The GB-Gradient Boosting algorithm performed well at all times, and FIB-4, attain ($P<0.001$) in the forecast of developed HF and cirrhosis. Performance of the region below receiver in use attribute curve of GB algorithm is 0.918 and in FIB-4, is 0.841, as well to classify the cirrhosis, non-Cirrhosis in the GB Model is 0.871, and FIB is 0.830. The N.Nazmun et.al [10], proportional study of the band method for the liver infection guess, in the paper variety of methods used to diagnosis the earlier stage of the disease in the liver, like AdaBoost, LogitBoost, BeggRep, Beggj48 and RF (Random Forest) to analyze and compare the performance of the methods. In that, LogitBoost method shows more accuracy then others with the help of the input parameters like total bilirubin, age, gender, protein, albumin and globulin. The LogitBoost performs as 71.53%, so it can be implemented to improve human health away from liver diseases. In addition, in the near future they can collect the data from many regions with high amount of data to do the same.
The J H Joloudari et.al [11] in system help for choice making for predict liver sickness by means of PSO-based optimization technique in SVM through quality of selection, in this paper, it was experimented with the comparative study of data mining models-ETLA with AI METHODS. The methods are RF, MLP, BN, SVM and PSO methods to take the accurate decision making as well to find the accuracy in the guess of the liver sickness well in advance. Also faced the challenges of the proper feature selection from the dataset. The results show the combined model of PSO and SVM with respect to parameters like specificity(S), accuracy(A), area under the curve, F-Measure, precision, and FP Rate. Estimated performance percentage of the accuracy of RF is 87.50, MLP NN is 78.91, BN is 66.78, SVM is 76.50, and PSO is 95.17. The Nisa M et.al [12] CNN based study of liver infection using the method used to find the accuracy in the prediction of liver diseases using 3000 CT images of 71 patients. The method CNN during automatic quality analysis and SVM learning methods. In that, few of the methods of CNN like K-NN, NB, SVM, and RF used to organize the affected liver and semantic segmentation method used to

identify the liver disease. The results show that abnormalities of liver of the human being is diagnosed by the texture analysis is well and good. So the model may help the physicians as well the radiologist for the early accurate prediction of the liver disease and its severity.

Comparison of Algorithm & Performance

S. No	Authors & year of publication	Tittle	Algorithm /Method used	Dataset	Results /Performance	References
1	M.Wadhwa et.al ,2018	Comparing Classification Models for Predicting Liver Diseases	ANN with K-fold(10-FOLD) cross validation and hyper parameter and SVM	University of California and Irvine machine learning repository of 416 liver affected patients and 167 non-affected liver patients	ANN with parameters Accuracy=>70.94, Precision=>69.99, Recall=>70.94, F-Score=>70.27 results are better than SVM	13
2	Zhu, Ziquan et.al-2021	DL in the Classification of Stage of Liver Fibrosis in Chronic Hepatitis B with Magnetic Resonance ADC Images	Five-layered Deep CNN model for to differentiate the sternness of liver fibrosis in hepatitis B, in that three convolutional layer with 2 totally connected layers along with 3-pooling layers.	123 ADC images were collected from various hospitals, All the data which is collected from ADC images. Every stages can be divided into number of stages like F0, F1, F2, F3, and F4 according to the methods.	Accuracy is 88.13[with plus or minus 1.47]%, Sensitivity is 81.45[with plus or minus 3.69]%, Specificity is 91.12[[with plus or minus 1.72]%, Precision is 80.49[with plus or minus 2.94]%, F1 is 80.90[with plus or minus 2.39]%,MCC is 72.36[with plus or minus 3.39]%,FMI in the 10 values fold cross validation method is 80.94[with plus or minus 2.37]%.	15
3	J.Jacob et.all,2018	Diagnosis of Liver Disease can be analyzed Using ML techniques.	LR,K-NN, SVM and ANN algorithms with respect to 10 numbers of neurons with the attributes of Age, Sex, Total Bilirubin, Direct Bilirubin, Alkaline Phosphatase, Al amine phosphatase, Total Proteins, Albumin, Albumin and Globulin Ratio	dataset having 583 records among that 416 liver affected and the remaining are non-affected	ANN show the results as in Accuracy is 92.8%, Precision is 93.78%, Sensitivity is 97.23 and Specificity is 83	16

4	S V Murthy et.al,2019	Enhanced Classifier techniques are used to find the accuracy in Liver Disease. Diagnosis Using a Novel Multi-Layer Feed Forward to the Deep Neural Network	Multi-layer Feed Forward Deep neural network. In the model Ten nodes of input layers and ten input attributes were taken. The parameter as gender, age, total Bilirubin, direct bilirubin, Asparate Aminotransferase, Albumin, globulin,	dataset contains 822 records from Amritha group of hospital, andhra Pradesh,,India	performance was compared NB, C4.5, Alternate Decision Tree, SVM, RBF, but they were shown the results are 71%, 97%, 92%, 75%, 83%. Whereas MLFFDNN is 98%.	17
5	P. Pesayar et.al, 2021	Hybrid classification of the liver damaged can be predicted by images using deep CNN	Hybrid method – used in CNN for earlier detection of liver diseases. In this method many of the networks are used are ResNeXt, ResNet18, ResNet50, ResNet18, and AlexNet connected in the FCN(fully connected networks).	dataset which contains 216 ultra sound images, in that 72 are normal, 72 are hepatitis the rest of the images are cirrhosis	the accuracy in percentage are 86.4 with the use of ResNet50 in the hybrid classifier of the liver images status according three classes. In respect of normal and cirrhosis of liver and also the normal and hepatitis liver were with the parameters sensitivity and specificity of the group1 expected accuracy are in the percentage are 90.9 and 86.4 are respectively. The other group performance is listed in the percentage as 90.9 and 81.8.	18
6	Zamanian .H et.al, 2021	Implementati of the combinational DL for non-alcoholic liver classification techniques.	combined model of neural network- CNN networks are ResNetv2, GoogleNet, AlexNet and ResNet101, with SVM.with the help of attributes like Age, Gender, BMI of the human.	dataset, which contains 55 patients in that 75% of it were trained and the 25 % is used for testing model.	SVM, the parameter AUC, characteristic, curve, networks, shows the performance as 0.9999 and 0.9864. The results of measuring attributes sensitivity, specificity and accuracy are 97.20%, 100% and 98.64 respectively.	19

7	Rahman et.al, 2019	Comparative study of liver sickness prediction using SVM algorithms	algorithms are LR,K-NN, DT, SVM, NB and RF.	UCI machine learning Repositories and it, contains 583	measuring attributes like accuracy, precision, Recall, F-1 score, specific. The result as 75%, 74%, 62% 69% ,67% and 57% respectively. LR gives the maximum accuracy, when compared with other ML algorithms.	20
8	Singh.J et.al,2020	Software based tools are used to detect the liver illness and classification models used.	machine earning algorithms like Logistic Regression, Naïve Bayes, J48, Sequential Minimal Optimization, Instance based classification and Random Forest with help of variety of the parameters like Age, Gender, direct and total bilirubin, alkhphos,sgpt,sgot,albumin,ratio of globulin etc	dataset from Indian Liver dataset from California, Irvine of total number of liver patients are 583	measuring parameters without feature selection, performance is with correctly classified instances as follows 74.6%,55,74%,71.35% ,64.15%,68.78%,71.53 respectively. With feature selection are 74.36%, 55.99%, 71.36%, 67.41%, 70.67% and 71.87% respectively.	21
9	F Mostafa et.al, 2021	Statistical ML algorithm used to predict for the liver illness for the prediction	Automation of random forest model with attributes like,ALP,BIL,CHE,GGT,AST,GLT,CREA,PROT	615 human data set from University of California, Irvine ML repositories	ML methods performed, the value of the parameter used. In ROCs were 0.98 for RF and exactly 0.95 for SVM. However, for the ANN, the area under the curve was approximately 0.87. The 97% condensed intervals for the ANN, SVM, and RF were 0.87 and 0.94, 0.95 and 0.93, and 0.92 and 0.96, respectively.	22
10	T A Assegie et.al,2022	RF and SVM based on hybrid liver disease.	Hybrid model future as, which is the detection methods, include a SVM classifier and random forest algorithms.	Dataset from the Mayo Clinic study in severe liver PBC of the liver, which took place between 1974 and 1984	The random forest automation system for liver disease diagnosis show the result as 78.3%, Whereas performance can be improved by 10.6% when the REFCV is used for feature selection using prediction method	23

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

Proposed Methodology

The proposed system algorithm and it is analysis aims to apply Convolution Neural Neworks in the classification of liver medical MRI images. To identify whether the patient's liver is normal or it is affected. Here the research proposal is to do proper feature selection using nature inspired algorithm which help to promote the performance and to classify the liver images using two CNN algorithms and to compare with its results accuracy.

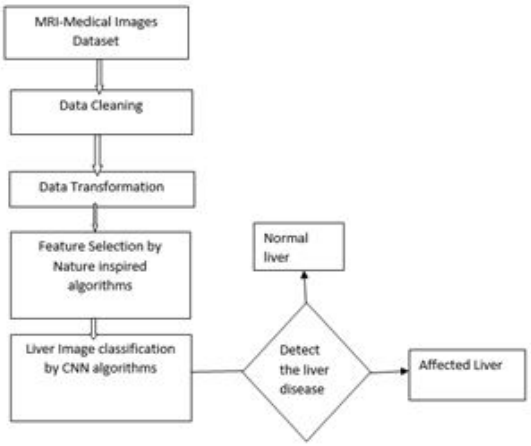


Figure: Methodology

Conclusion

Liver acting an important role in the digestive system of the human body. In this paper, we have studied, understand, and collected the information for the last five years of researcher's contribution in the field of liver illness prediction and analysis. In that, we found few limitation and merit. To overcome the difficulties as well the challenges and the limitations will be addressed by our proposed methodology and algorithm.

Future work

To implement the proposed methodology and the hybrid algorithm with recent big dataset of MRI images of patients records to make much clear accuracy in the earliest prediction of the liver diseases and also for the further treatment guidelines to the physician and radiologist to the help the human society from the deadly liver diseases in the modern world.

References

1. Zhou et al. "Artificial intelligence in medical imaging of the liver." World journal of gastroenterology 25.6 (2019): 672.
2. Ghosh, Mounita, et al. "A Comparative Analysis of Machine Learning Algorithms to Predict Liver Disease." INTELLIGENT AUTOMATION AND SOFT COMPUTING 30.3 (2021): 917-928.
3.Ji, Weidong, et al. "A Machine Learning Based Framework to Identify and Classify Non-alcoholic Fatty Liver Disease in a Large-Scale Population." Frontiers in Public Health 10 (2022).
4. Panayides, Andreas S., et al. "AI in medical imaging informatics: current challenges and future directions." IEEE journal of biomedical and health informatics 24.7 (2020): 1837-1857.
5. Musunuri, Balaji, et al. "Acute-on-chronic liver failure mortality prediction using an artificial neural network." Engineered Science 15 (2021): 187-196.
6.Wu, Chieh-Chen, et al. "Prediction of fatty liver disease using machine learning algorithms." Computer methods and programs in biomedicine, Elsevier, 170 (2019): 23-29.[https://www.sciencedirect.com/science/article/abs/pii/S0169260718315724]
7.Rashid J, et al. "An augmented artificial intelligence approach for chronic diseases prediction." Frontiers in Public Health 10 (2022).
8. Sivakumar, D., et al. "Chronic liver disease prediction analysis based on the impact of life quality attributes." International Journal of Recent Technology and Engineering (IJRTE) 7.6S5 (2019).
9. Wei, Runmin, et al. "Clinical prediction of HBV and HCV related hepatic fibrosis using machine learning." EBioMedicine 35 (2018): 124-132.
10.Nahar, Nazmun, et al. "A comparative analysis of the ensemble method for liver disease prediction." 2019 2nd International Conference on Innovation in Engineering and Technology (ICIET). IEEE, 2019.

11. Joloudari, Javad Hassannataj, et al. "Computer-aided decision-making for predicting liver disease using PSO-based optimized SVM with feature selection." Informatics in medicine unlocked 17 (2019): 100255.
12. Nisa, Mehrun, et al. "Deep Convolutional Neural Network Based Analysis of Liver Tissues Using Computed Tomography Images." Symmetry 14.2 (2022): 383.
13. Wadhwa, Mudit, and Shallu Juneja. "Comparing Classification Models for Predicting Liver Diseases." International Journal of Computer Science and Mobile Computing 7.4 (2018): 135-140.
14. Uddin, Shahadat, et al. "Comparing different supervised machine learning algorithms for disease prediction." BMC medical informatics and decision making 19.1 (2019): 1-16.
15.Zhu, Ziquan, et al. "Deep Learning in the Classification of Stage of Liver Fibrosis in Chronic Hepatitis B with Magnetic Resonance ADC Images." Contrast Media & Molecular Imaging 2021 (2021).
16. Jacob, Joel, et al. "Diagnosis of liver disease using machine learning techniques." International research journal of engineering and technology 5.04 (2018): 4011-4014.
17. Murty, S. V., and R. K. Kumar. "Enhanced classifier accuracy in liver disease diagnosis using a novel multi layer feed forward deep neural network." Int. J. Recent Technol. Eng 8 (2019): 1392-1400.
18. Pasyar, Pezhman, et al. "Hybrid classification of diffuse liver diseases in ultrasound images using deep convolutional neural networks." Informatics in Medicine Unlocked 22 (2021): 100496.
19.Zamanian, H., et al. "Implementation of combinational deep learning algorithm for non-alcoholic fatty liver classification in ultrasound images." Journal of Biomedical Physics & Engineering 11.1 (2021): 73.
20. Rahman, AKM Sazzadur, et al. "A comparative study on liver disease prediction using supervised machine learning algorithms." International Journal of Scientific & Technology Research 8.11 (2019): 419-422.
21. Singh, Jagdeep, Sachin Bagga, and Ranjodh Kaur. "Software-based prediction of liver disease with feature selection and classification techniques." Procedia Computer Science 167 (2020): 1970-1980.
22. Mostafa, Fahad, et al. "Statistical Machine Learning Approaches to Liver Disease Prediction." Livers 1.4 (2021): 294-312.
23. Assegie, Tsehay Admassu. "Random forest and support vector machine based hybrid liver disease detection." Bulletin of Electrical Engineering and Informatics 11.3 (2022)