International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

Machine Learning-Based Analysis of Echocardiography Images for Cardiac Disease Diagnosis

[1]Pankaj Negi, [2]Dr. Dany John, [3]Vrince Vimal, [4]Dr Versha Prasad

Submitted:24/03/2023 **Revised:**28/05/2023 **Accepted:**13/06/2023

Abstract: Echocardiography, often known as cardiac ultrasonography, is the imaging technique that evaluates heart function and structure that is used the most frequently and is easily accessible. Echocardiography is one of the most often used imaging tests because it does not expose the patient to the dangers associated with ionizing radiation, in addition to its portability, quick picture collection, high temporal resolution, and rapid image acquisition. Echocardiography is both essential and sufficient for the diagnosis of various cardiovascular disorders. This includes conditions ranging from heart failure to diseases that affect the heart's valves. The primary goal of this study is to build a Hyperparameter Tuned (HPT) Xception emulate using Adagrad optimizer with Class attention the layer and BiLSTM model for MV diagnosis and classification. This will be accomplished by classifying arrhythmia disease with electrocardiogram (ECG) and photoplethysmography (PPG) signals using a machine learning approach.

Keywords*: Electrocardiogram, photoplethysmography, valvular heart diseases, image acquisition*

1. Introduction

The magnificent and powerful heart delivers oxygenated and nutrient-rich blood to the body's tissues through the circulatory system. One of the leading killers worldwide is heart disease. Heart illness refers to any ailment that disrupts the heart's normal functioning. Workload, stress, smoking, lack of exercise, and other lifestyle factors all have a role. Cardiac arrhythmias, heart valve disease, congenital heart disease, heart attacks, and heart failure are all examples of heart conditions. Cardiac arrhythmia, in which the circulatory system beats abnormally (either too slowly or too fast), is the main cause of death. Heart rate irregularities are a leading cause of cardiac arrest and sudden cardiac death. For the early diagnosis of arrhythmia disorder, the establishment of the Cardiac Arrhythmia Diagnosis System is a challenging research topic. Several algorithms are used in this study to extract features from an electrocardiogram (ECG) and a photoplethysmogram (PPG) signal, to choose features using choosing features approaches, and to classify arrhythmia diseases.

[1]*Asst. Professor, Department of Mech. Engg. Graphic Era Hill University, Dehradun Uttarakhand 248002,*
pnegi@gehu.ac.in
[2]*Department of Cardiology, Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth "Deemed To Be University" Karad Malkapur, Karad (Dist. Satara), Maharashtra, India. PIN – 415539*
Email ID:- danyjohn411425@gmail.com "
[3]*Graphic Era Hill University;*
Adjunct Professor Graphic Era Deemed to be University, Dehradun, India. 248002. Vvimal@ec.iitr.ac.in"
[4]*Assistant Professor School of Health Sciences C. S. J. M. University Kanpur"*

Recently, research into medical decision support systems has focused on better methods for detecting and categorizing cardiac disease at an earlier stage. Cardiac valves open and close in response to factors such as pressure and volume of blood inside the heart. The occurrence of these cardiac sounds is due to the constriction of the heart's blood vessels and valves. When analyzing heart sounds, a physician would listen for four distinct sounds—the mitral valve, the tricuspid valve, the pulmonary valve, and the aortic valve—all of which have to do with blood flow. Heart sounds are monitored in each section and cross-verified to pinpoint the problematic areas and locate the root of the issue. Blood is pumped through the left atrium to the left ventricle through the mitral valve (MV). Mitral stenosis (MS) occurs when the aperture in the MV narrows. This abnormality may be present at birth or it may emerge at a later time. Classifying typical heart sounds, MS, and mitral regurgitation illnesses using frequency estimate is becoming an increasingly common study issue as heart sound analysis for disease detection becomes more commonplace. In contrast to cardiac auscultation, modern diagnostic tools like echocardiography, color doppler, computed tomography (CT), and magnetic resonance imaging (MRI) provide clear and reliable proof of heart illness. Due to their high cost, bulk, and operational complexity, these modalities have no place in primary care or remote areas. Furthermore, most internal medicine and cardiology training programs undervalue cardiac auscultation and do not provide younger practitioners with enough training in this area. So, good decision support systems will help doctors make more

accurate diagnoses of cardiac conditions. Several modern image processing methods, including preprocessing, segmentation, feature extraction, and classification, may be used to distinguish between normal and pathological heart valve performance. Machine learning (ML) and deep learning (DL) based categorization methods are widely used for accurate heart sound diagnostic. When compared to other ML models, DL's capacity to generate novel features from a small collection of characteristics already present in the training dataset is a big advantage. For this reason, DL models are helpful in MV diagnosis and categorization. The use of DL models is currently underexplored, despite the fact that certain MV classification models are accessible in the literature. Furthermore, improvements to MV classification performance still to be made. As a result, optimizing classification performance necessitates the creation of an efficient automated MV classification model based on ML and DL.

Echocardiogram An echocardiogram is a kind of ultrasound examination in which pictures of the heart's chambers and valves are created by the sound waves. A transducer, a portable instrument used to retrieve pictures, is held by the operator while gel is put to the chest in this examination. A transesophageal echocardiography is performed to provide high-quality pictures of the heart at this time. The procedure involves inserting an ultrasonic probe into the esophagus, the tube that transports food and drinks to the stomach, via the mouth. A local throat anesthetic and sedation are administered. When it comes to imaging methods for diagnosing and quantifying cardiac valve dysfunction, the echocardiography is still the gold standard..

Cardiac CT Scan Computerized Tomography (CT) scans are recommended by doctors for cardiac conditions. The most up-to-date X-ray model is used to create cross-sectional pictures of the heart in a cardiac CT scan. These pictures help doctors make accurate diagnoses, uncover the causes of illnesses, and keep an eye on patients' arterial health without the need for unnecessary testing. NYU Langone uses a state-of-the-art, encrypted CT scan system. With less radiation exposure, the dual-source CT scanner creates high-definition diagnostic pictures. In addition, renal patients follow a unique regimen designed to minimize the amount of contrast dye used during the procedure..

Cardiac Catheterization Blood pressure and flow to the MV may be roughly estimated with the use of a cardiac catheterization. The capacity of the valve to control blood flow through the heart may be used in this way to foretell future issues. It may also foretell when coronary arteries will become blocked. A long, thin, hollow tube called a catheter is inserted into a blood artery in the arm, neck, or groin to conduct the test. The catheter is guided toward the heart with the use of X-ray pictures. It is done under general anesthesia in a hospital setting..

Process Involved In MV Diagnosis And Classification

As shown in Figure 1, the many modules that make up image processing models include enhancement, segmentation, classification, clustering, compression, and many more. Digital pictures typically undergo four distinct processes: pre-processing, image segmentation, feature extraction, and image classification.

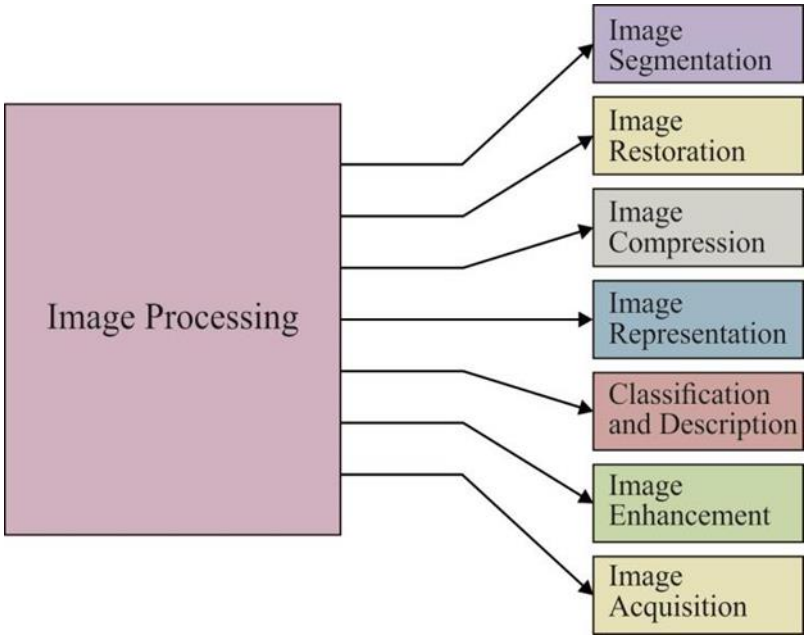


Fig. 1. Image processing techniques

2. Image pre-processing

In this update, an image's dominance over the module is strengthened. A group of photos from several sources may be grouped together under the guise of a low-quality image in certain circumstances. To improve the clarity, it adjusts the image's components. Changing the visual effect improves the photos' finer details. In addition, it is used in the image processing, feature extraction, and visual presentation processes. Its versatility and adaptability have led to widespread use. Noise reduction, histogram shifting, and contrast improvement are the enhancement models at your disposal. As can be seen in Figure.2, there are two main categories for picture enhancing techniques.

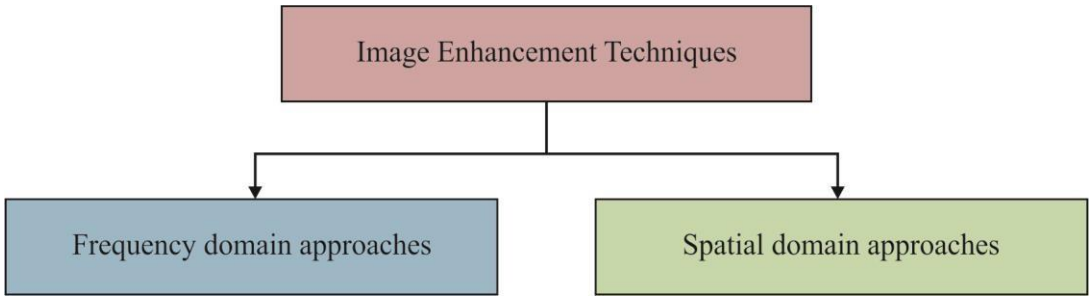


Fig. 2. Image Enhancement Models

MACHINE LEARNING (ML)

Machine learning (ML) is a methodical approach to determining which models are at play. Typically, ML uses datasets and computes them to get useful features. In addition, the ML method is a widely used model, particularly today in the AI era. Due to the abundance of data and substantial savings in processing power, ML is experiencing a significant renaissance. The various ML methods were shown in Figure 3.

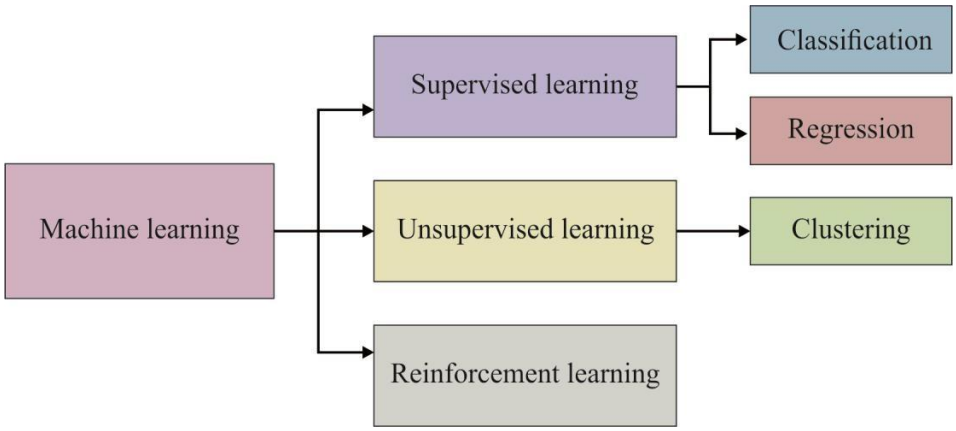


Fig 3. Types of Machine learning

Here, ML is a study of process strategies for incorporating the empirical data into the relevant one. Therefore, the ML technique evolves from traditional approaches to AI and statistical analysis. In the last several decades, ML has become an integral part of computational science, being used by large firms like Google, Microsoft, Facebook, Amazon, and many more. Additionally, a humongous quantity of data has been collected from these commercial modules.

In this research, we use a classification scheme based on learning style to ML models in order to identify a suitable one. Using a labeled dataset helps supervised learning. The process of unsupervised learning has been used on datasets with missing labeling. Unsupervised learning methods such as SOMs, K-means clustering, EM, and hierarchical clustering may be used in a variety of situations. Finally, visual analytic tools make extensive use of simulations of unsupervised frameworks. The unsupervised method verifies both the range of numbers covered by the data and the distance metric used. Finally, semi-supervised learning integrates aspects of both unsupervised and supervised methods. These methods are used in situations when there is little unlabeled data. Then, it must be inductive or transductive..

Over-fitting and under-fitting, which are problems in ML, are mislabeled as variance and bias. While

over-fitting or model variance is inevitable when building a machine learning model and training dataset, it serves no purpose when attempting to generalize fresh datasets. Creating a model with an excessive amount of error to suit the training set is known as underfitting. In most cases, this is the peak of the learning process. In this case, regularization and reducing the total number of features are used to address over-fitting concerns that have been reported. When working with a maximum feature set, regularization is the method used to reduce the magnitude of values. A machine learning diagnostic is a test-based strategy created to gain understanding of an algorithm or methods for improving its performance. The diagnostics involved in producing well trained ones are difficult. The efficacy of the ML method is verified through cross-validation.

3. Classification

In the realm of supervised learning, RF refers to a family of methods that may be used for both classification and regression. It's adaptable, and it has a forest of trees in it. The definition of robustness is that a bigger number of trees makes it so. RF creates the DT using randomly selected data samples, makes predictions using all of the trees, and then uses voting to choose the best one. It provides a useful signal for conveying the importance of certain qualities. Recommendation engines, picture categorization, and feature selection are just some of the many uses for RF. In order to determine what kind of MV it is, an RF classifier is used in this research. Essentially, it's a more in-depth version of the divide-and-conquer strategy that uses an ensemble approach. It includes a group of DTs constructed using a dataset that has been randomly split, as illustrated in Figure 4. These DT classifiers may alternatively be thought of as a "forest" of classifiers. Attribute selection indicators such as information gain, gain ratio, and the Gini index are applied to each variable to produce a set of unique DTs. Each tree is based on its own random selection. When doing a classification job, each tree will cast a vote for the class with which it is most acquainted.

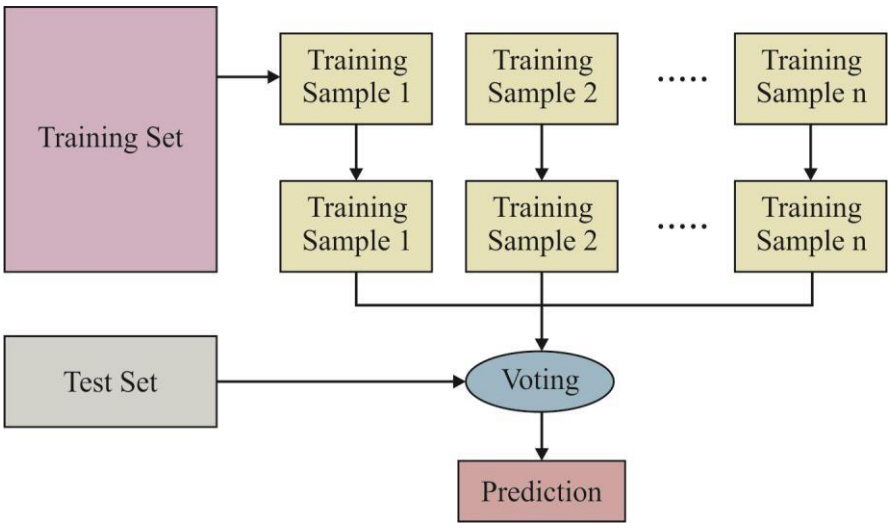


Fig. 4. RF classification process

4. Performance Validation

The results of the provided model are shown in Table 1 for a range of severity levels. The raw picture data is shown in the second column of the table. The segmented and labeled photos may be seen in the third and fourth columns, respectively. It is clear from the table that the provided model successfully places photos into their respective categories.

The assessment process of the provided WS-X model is shown in Figure 5. Class labels for all of the used test images are shown in this snapshot. The graphic also displays the confusion matrix that was calculated using the results. It is also shown that the WS-X model achieved an overall average accuracy of 98.10% across all of the used test photos.

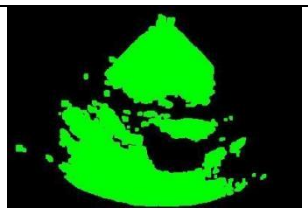
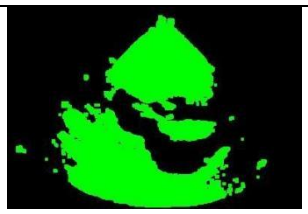
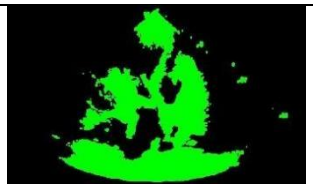
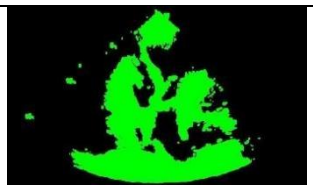
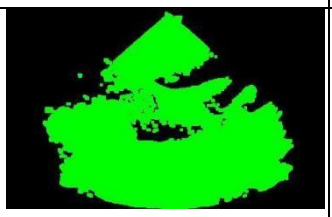
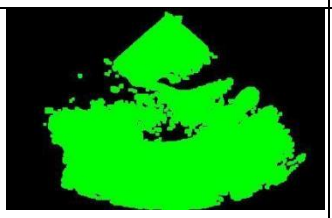
Different Levels	Original Image	Segmented Image	Classified Image
Normal			
			
Mild			
			

Table.1 Results of MV Problem

Images that were incorrectly labeled are detailed in Table 2. In the first two rows, we see that a typical picture is incorrectly labeled as moderate or severe.

Different Levels	Original Image	Segmented Image	Classified Image
Normal			
			

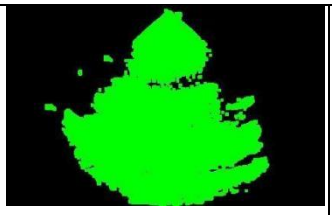
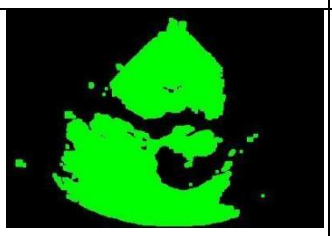
Moderate			
Severe			

Table 2 Identification of Misclassified Images

5. Conclusion

Finally, the area of cardiovascular imaging is one where machine learning has showed tremendous potential. Because of their ability to analyze cardiovascular images quickly and accurately, machine learning algorithms may one day help doctors better diagnose and treat heart disease. It was found via simulation that the HPT-Xception-MLP model achieved the highest accuracy of 99.38%, while the HPT-Xception-RF model achieved the highest accuracy of 99.84%. The suggested models are compared in depth in the next chapter.

References

[1] Abduh, Z., Nehary, E.A., Wahed, M.A. and Kadah, Y.M., 2019. Classification of heart sounds using fractional Fourier transform based mel-frequency spectral coefficients and stacked autoencoder deep neural network. Journal of Medical Imaging and Health Informatics, 9(1), pp.1-8.

[2] Ahlstrom, C., Hult, P., Rask, P., Karlsson, J.E., Nylander, E., Dahlström, U. and Ask, P., 2006. Feature extraction for systolic heart murmur classification. Annals of biomedical engineering, 34(11), pp.1666-1677.

[3] Ahmad, S.A., Chavan, C., Badhani, R., Diwan, A., Periasamy, M. and Wankhade, V., 2019. Epidemiology of frequent admitters of cardiovascular diseases in urbanizing Pune population. Australasian Medical Journal (Online), 12(7), pp.189-199.

[4] Al-Naymat, G., Al-Kasassbeh, M., Abu-Samhadanh, N. and Sakr, S., 2016. Classification Of VoIP And Non-VoIP Traffic Using Machine Learning Approaches. Journal of Theoretical & Applied Information Technology

[5] Bala, A. and Kaur, T., 2016. Local texton XOR patterns: A new feature descriptor for content-based image retrieval. Engineering Science and Technology, an International Journal, 19(1), pp.101-112.

[6] M, T. ., & K, P. . (2023). An Enhanced Expectation Maximization Text Document Clustering Algorithm for E-Content Analysis. International Journal on Recent and Innovation Trends in Computing and Communication, 11(1), 12–19. https://doi.org/10.17762/ijritcc.v11i1.5982

[7] Bozkurt, B., Germanakis, I. and Stylianou, Y., 2018. A study of timefrequency features for CNN-based automatic heart sound classification for pathology detection. Computers in biology and medicine, 100, pp.132-143

[8] Brusco, M. and Nazeran, H., 2006, January. Development of an intelligent PDA-based wearable digital phonocardiograph. In 2005 IEEE Engineering in Medicine and Biology 27th Annual Conference (pp. 3506-3509). IEEE.

[9] Chandra, V., Sarkar, P.G. and Singh, V., 2020. Mitral Valve Leaflet Tracking in Echocardiography using Custom Yolo3. Procedia Computer Science, 171, pp.820-828.

[10] Chen, L., Ren, J., Hao, Y. and Hu, X., 2018. The diagnosis for the extrasystole heart sound signals based on the deep learning. Journal of Medical Imaging and Health Informatics, 8(5),

pp.959-968

[11] Chen, T.E., Yang, S.I., Ho, L.T., Tsai, K.H., Chen, Y.H., Chang, Y.F., Lai, Y.H., Wang, S.S., Tsao, Y. and Wu, C.C., 2016. S1 and S2 heart sound recognition using deep neural networks. IEEE Transactions on Biomedical Engineering, 64(2), pp.372-380.

[12] Ms. Madhuri Zambre. (2012). Performance Analysis of Positive Lift LUO Converter . International Journal of New Practices in Management and Engineering, 1(01), 09 - 14. Retrieved from http://ijnpme.org/index.php/IJNPME/article/view/3

[13] Cheng, X., Zhan, Q., Wang, J. and Ma, R., 2019, April. A high recognition rate of feature extraction algorithm without segmentation. In 2019 IEEE 6th International Conference on Industrial Engineering and Applications (ICIEA) (pp. 923-927). IEEE.

[14] Chollet, F., 2017. Xception: Deep learning with depthwise separable convolutions. In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 1251-1258).

[15] Corinzia, L., Provost, J., Candreva, A., Tamarasso, M., Maisano, F. and Buhmann, J.M., 2019, June. Unsupervised Mitral Valve Segmentation in Echocardiography with Neural Network Matrix Factorization. In Conference on Artificial Intelligence in Medicine in Europe (pp. 410-419). Springer, Cham.

[16] Criley, S.R., Criley, D.G. and Criley, J.M., 2000, September. Beyond heart sounds: An interactive teaching and skills testing program for cardiac examination. In Computers in Cardiology 2000. Vol. 27 (Cat. 00CH37163) (pp. 591-594). IEEE

[17] DeGroff, C.G., Bhatikar, S., Hertzberg, J., Shandas, R., Valdes-Cruz, L. and Mahajan, R.L., 2001. Artificial neural network–based method of screening heart murmurs in children. Circulation, 103(22), pp.2711-2716

[18] Dominguez-Morales, J.P., Jimenez-Fernandez, A.F., Dominguez-Morales, M.J. and Jimenez-Moreno, G., 2017. Deep neural networks for the recognition and classification of heart murmurs using neuromorphic auditory sensors. IEEE transactions on biomedical circuits and systems, 12(1), pp.24-34

[19] Faturrahman, M., Wasito, I., Ghaisani, F.D. and Mufidah, R., 2017, October. A classification method using deep belief network for phonocardiogram signal classification. In 2017 International Conference on Advanced Computer Science and Information Systems (ICACSIS) (pp. 283-290). IEEE

[20] Ghosh, S.K., Ponnalagu, R.N., Tripathy, R.K. and Acharya, U.R., 2020. Automated detection of heart valve diseases using chirplet transform and multiclass composite classifier with PCG signals. Computers in Biology and Medicine, 118, p.103632