# Chapter 7
# Electrocardiogram Beat Classification Using BAT-Optimized Fuzzy KNN Classifier

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## ABSTRACT

*In this chapter, the BAT-optimized fuzzy k-nearest neighbor (FKNN-BAT) algorithm is proposed for discrimination of the electrocardiogram (ECG) beats. The five types of beats (i.e., normal [N], right bundle block branch [RBBB], left bundle block branch [LBBB], atrial premature contraction [APC], and premature ventricular contraction [PVC]) are taken from MIT-BIH arrhythmia database for the experimentation. Thereafter, the features are extracted from five type of beats and fed to the proposed BAT-tuned fuzzy KNN classifier. The proposed classifier achieves the overall accuracy of 99.88%.*

## INTRODUCTION

Electrocardiogram (ECG) provides detailed information of cardiac heart activities and important procedure to diagnose conduction dysfunction and cardiac arrhythmias. The feature extraction and classification steps are crucial in such diagnosis. The arrhythmic ECG signal contains different arrhythmic beats which can classify using the classification system. In the classification system, the segmented ECG beats are denoised, then features are extracted and finally classify them in the different classes. There are various methods for the classification of the ECG beats (Lagerholm et al. 2000; Prasad and Sahambi 2003; Osowski et al. 2004; Rodriguez et al. 2005; Alickovic and Subasi 2016). Many techniques are developed in the literature for the extraction of the ECG features (Prasad and Sahambi 2003; Alickovic

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and Subasi 2016). However, the selection of the more robust and efficient classifier for the ECG beats discrimination is a still pending work. So, various classification techniques existing in the literature are concentrated on the classifier performance. The work by (Lagerholm et al. 2000) which uses the self-organizing neural networks with the hermite function encoding and the dynamic interval information as an extracted feature. The sixteen beats of arrhythmia taken from MIT-BIH are obtained an overall accuracy of 98.49%. In (Prasad and Sahambi 2003), the dynamic interval features with the wavelet transform are used as a input feature and fed to the neural network classifier. The experimentation is done on the thirteen MIT-BIH beats and achieves the overall accuracy of 96.77%. In (Osowski et al. 2004), the cumulants of the second, third, and fourth orders with the hermite function encoding are used a feature vector and fed the Support Vector Machine (SVM) classifier achieves an overall accuracy of 98.18%. In (Rodriguez et al. 2005), morphological features are fed to the decision tree for the characterization of the fourteen ECG beats and attain an overall accuracy of 96.13%. In (Alickovic and Subasi 2016), the statistical features for each wavelet coefficients are evaluated and combined with the ratio of the absolute mean values of adjacent sub-bands to fed on the random forest classifier for the characterization of Normal (N), Right Bundle Block Branch (RBBB), Left Bundle Block Branch (LBBB) Atrial Premature Contraction (APC), and Premature Ventricular Contraction (PVC) beats. The average accuracy is achieved as 99.30%. In (Melgani et al. 2008), the authors fed the combined morphological and temporal features to the particle swarm optimization (PSO) tuned SVM classifier for the ECG beat characterization. The kernel parameter $\gamma$, and regularization parameter $C$ of the SVM classifier are tuned in such a manner to obtain the maximal discrimination of the beats. The experimentation is done on the six beat types, i.e., N, APC, PVC, RBBB, LBBB, paced beat and obtained an overall accuracy of 89.72%. In (Korurek and Dogan 2010), the authors fed the morphological features to the PSO tuned radial basis function (RBF) neural network for beats classification. The parameters of the RBFNN, i.e., bandwidth $\sigma$, center $c$ of the neurons are tuned in such a manner that achieves the maximal discrimination of the heartbeats. The six beats such as N, APC, PVC, RBBB, Fusion of Ventricular and Normal beat, Fusion of Paced and normal beat are used for the experimentation and obtained an average sensitivity of 95.46%. In (Khazaee and Ebrahimzadeh 2010), the authors fed the power spectral, and timing features to the genetic algorithm (GA) tuned SVM classifier. The SVM parameters such as $C$, $\gamma$ are optimized by the GA optimization algorithm to attain the maximum discrimination of the beats and obtained an overall accuracy of 96.00% when experimented on N, LBBB, RBBB, APC, and PVC beats.

The limitations of the above methods are that, these methods not effectively classify the beats due to which the classification performance measure not obtain optimal value and the designed methods are not optimal one which gives better characterization results. To overcome the limitation of the existing methods, a new beat classification method is proposed. The objective of the paper is to design a classification approach which utilizes the BAT tuned fuzzy $k$-nearest neighbor (FKNN) classifier for ECG arrhythmia characterization. In this work, the four RR interval features are extracted from the segmented heartbeats and then, obtained feature vector is fed to the designed FKNN-BAT classifier for the discrimination of the ECG heartbeats. In the designed FKNN-BAT classifier, the overall classification accuracy is depending on the two FKNN tuning parameters which are the number of nearest neighbor ($k$), and constant parameter ($m$). To achieve beat characterization of the ECG beats, the two FKNN parameters are optimized using the BAT optimization algorithm.

The rest of the chapter is organized as: Section 2 describes the mathematical background behind the designing of the proposed classification system. The analysis and comparison of the proposed method