Deep learning for diagnosing heart problems from ECG signals

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1 Introduction

With rapid increase in computational power and AI methods, machine solutions successfully deal with more and more tasks based on real-life signals. In medicine, the adaptation of computer systems is oriented towards direct sound, pictures, EEG and ECG input.

Most current state of the art methods for ECG analysis put great effort into finding the QRS complexes first. The reason is that once QRS complexes are known, numerous problems associated with speed and regularity of heart-beat, such as Premature Atrial Complex or Ventricular Fibrillation, can easily be calculated.

2 Deep learning

In this abstract we present a deep learning method that analyses ECG signals and accurately recognizes QRS complexes, and additionally recognizes three common heart problems: Left Bundle Branch Block (LBBB), Right Bundle Branch Block (RBBB) and Premature Ventricular Contraction (PVC).

Convolutional neural networks (CNN) were chosen as the target method firstly because, they require minimal data preprocessing and are exceptionally good at signal recognition, often close to or even better than humans. The second reason for CNN application is the task itself: majority of heart problems today are diagnosed by doctors who look directly at the ECG for visual clues, therefore the task is based on detection of abnormalities in input data. Third, symbol processing, the basis of classical machine learning paradigm, is not best suited for ECG recognition tasks since the shape differences are hard to symbolically represent and are quite sensible to noise.

CNN can avoid the problems mentioned above since it learns multiple feature maps (filters) in each layer of the network and abstracts the whole image into a meaningful conclusion. An example would be the first layer that can recognize one peak shape in the signal with succeeding layers of the network a peak and two valleys from the QRS. This way, noise and other obstacles can be successfully eliminated in detecting complex forms, e.g. QRS complexes and the three common heart problems.

3 Experiments

Performance of CNN was tested on extensive MIT-BIH Arrhythmia database [Moody and Mark, 2001]. The database consists of 48 half-hour records, recorded by 47 patients. Class distribution are following: 320,268 empty windows (signal between two complexes), 75,048 normal sinus rhythm, 8,075 LBBB, 7,259 RBBB and 7,130 PVC. Window size 59 was chosen, because it represents around 2.5 times QRS complex width in the signal.

For evaluation, leave-one-patient-out technique was used. Several parameters were tested including comparison with other machine learning methods and multiple sizes of networks. Tests in general showed that the deeper the network, the better the result. For practical reasons, the network with 5 layers yielded the best results in moderate time. Larger networks are faced with diminishing gradient problems and their learning time was also significantly longer.

We have achieved average accuracy of *99.95%*. This means that out of 190,000 classified windows, only 95 were classified incorrectly. After manual inspection of the misclassified examples it became evident that some of them were wrongly labelled, but hand-correcting them is a delicate matter since the errors usually go both ways.

The method was also tested on finding LBBB, RBBB, PVC and normal sinus rhythm. The average classification accuracies for 5 classes' classification are following: LBBB (98.2%), RBBB (97.8%), PVC (97%) and normal sinus rhythm (99.97%).

4 Conclusion

We have shown that deep neural networks, in particular CNN, can successfully detect heart problems using ECG signal with 99.95% accuracy. Additionally, the proposed method successfully detected LBBB, RBBB, PVC and normal sinus rhythm with accuracy above 98%.

References

[Moody and Mark, 2001] George B Moody and Roger G Mark. The impact of the mit-bih arrhythmia database. *Engineering in Medicine and Biology Magazine, IEEE*, 20(3):45–50, 2001.