Confidence in Medical Decision Making: Application in Temporal Lobe Epilepsy Data Mining
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Abstract
Prior to neurosurgical resection of abnormal brain tissues in mTLE patients, focal points of the seizure should be identified via a set of examinations. Once decisive evidence is not present in noninvasive clinical profile of mTLE patients, extraprocedural Electroencephalography (EEG) is required which is the practice of using electrodes placed directly on the exposed surface of the brain. Through classification techniques on a dataset of mTLE patients we have studied the possibility of reduction of such requirement and shown significant results. Furthermore, we have shown that critical domains such as medicine use of AUC does not provide sufficient information about the confidence of the classification and further measures are needed.

Introduction

- Epilepsy is a disorder of the brain characterized by an enduring predisposition to generate epileptic seizures and by the neurobiological, cognitive, psychological and social consequences of this condition.
- Neurosurgical resection of the abnormal brain tissues in patients suffering from Mesial temporal lobe epilepsy (mTLE) is a way of eliminating and reducing the occurrence of epileptic seizure onset.
- Prior to such operation, focal points of the seizures should be identified via a set of examinations.

- Data mining techniques have been applied in this study to provide decision assistance in localizing focal epileptogenicity.
- The goal of this paper is to reduce the need for EEG via data mining techniques and finding the best classifier for this purpose.
- Since decision making is highly critical in medical domains, classifiers that result in higher decision confidence are preferred.
- To be able to evaluate such confidence in different classifiers, we propose a new measure and compare it with well known area under receiver operating characteristic (ROC) curve (AUC) measure.

HBIDS
To integrate several clinical attributes of TLE patients from various sources and subsystems, human brain image database system (HBIDS), which is a clinical and imaging database of TLE patients, is developed at the radiology research department of Henry Ford Health System in Detroit Michigan:

1. Imaging features were generated using the hippocampi outlines. A domain expert outlined all hippocampal contours on coronal slices of T1-weighted images using in-house software and a previously established protocol. These were then verified by another expert.

2. Manual segmentation of the hippocampi in a representative coronal T1-weighted MR image (A) and its map on the FLAIR MRI (B), interictal SPECT (C), and ictal SPECT (D).

3. Dataset includes descriptive noninvasive electrographic features. Ictal onset locations and three most predominant interictal localities of sharp and slow waveforms are provided. Ictal onset locations were integrated into one feature indicating the probability of focal epileptogenesis in the right temporal lobe. Figure 5B demonstrates the surface electrode configuration of the EEG recordings. The abundance percentage of the two most dominant interictal sharp wave activities in each location for all patients in the dataset are shown in the figure below.

4. Wada test which is also known as the “intraarterial sodium amobarbital procedure” (ISAP), is used to establish lateralized language and motor representation of each hemisphere. Laterality of language dominance in cerebral hemispheres, and the number of correctly recalled items after left and right carotid injections, is also stored in the database.

Patient Cohort
In this study, 79 patients are selected (31 males, 48 females) with 197 medical features. The patients have an average age of 39y (S.D. 12.2), Temporal lobe epileptogenesis is found to be on the left side in 43 patients and the right side in 36 patients. In 46 patients, instrument based evaluation lateralize the TLE sufficiently well to perform resection of the site of epileptogenicity directly, whereas, 33 patients require ECoG (Phase B(41.7%)).

- The dataset contains missing values in different features due to various reasons such as inability to perform all medical tests for each patient. Missing values are identified for EEG features in 21% of cases, for Wada studies in 31%, for SPECT imaging features in 25%, and for FLAIR and volumetric imaging in less than 10% of cases. The missing values of the remaining features are found in about 20% of cases on average.

- The a and β limit are the upper bounds for the classifier performance in this fashion and could indicate the classifier’s potential in such classification. We refer to this measure as confidence prediction rate (CPR):

Confidence Evaluation

- Using six classifiers, we showed the possibility of using data mining techniques to build a decision support system that could potentially lateralize 54.8% of the patients with high confidence without the need for extraoperative Electroencephalography (ECoG). Lacking such system, only 58.2% of patients were lateralized by domain experts using noninvasive methods.

Discussion and Conclusion

- We also demonstrated that AUC does not provide sufficient information about the confidence of the classification and other measures such as our proposed “confident prediction rate” (CPR) are needed in domains such a medicine.

- Using the experiments, we also demonstrated that classifiers that generate high AUCs might not be sufficiently confident for domains that require reliable predictions.

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- Using this method, it is potentially possible to lateralized 78.8% of the phase II patients, while only 8.7% of the phase I patients will be undecided.

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Performance evaluation of different classifiers on different feature sub-sets.

- With 79 patients and 197 attributes, the need for feature selection is apparent. we have applied a heterogeneous ensemble of single variable classifiers to rank the medical features based on their individual predictive performance.

- Side of abnormality in patients is shown with “R” and “L” letters, respectively. Phase II patients are outlined.