Abstract—Prediction of epileptic seizures may improve the Quality of Life of patients. In this study, we developed a seizure prediction machine learning model using R-R interval (RRI) data of epileptic patients, and a Self-attentive Autoencoder (SA-AE) was used to efficiently train the model and predict seizures. The constructed model achieved the sensitivity of 71% and FP rate of 0.90 times/h. We will further improve the model performance and explore the causes of patients with poor seizure prediction performance.

Clinical relevance—Seizure prediction in epilepsy can ease a patient’s anxiety about seizures. In addition, RRI is easy to measure by wearable devices, which can realize an epileptic seizure prediction system that can be used in daily life.

I. INTRODUCTION

Epilepsy is a neurological disorder which causes recurrent seizures and affects about 1% of the global population. Epileptic seizures may affect the autonomic nerve system (ANS) from 15-20 minutes before seizure onsets. The alternation in ANS affects R-R intervals (RRI) on electrocardiogram (ECG). This study aims to develop a machine learning model for predicting focal epileptic seizures by using the RRI data.

II. METHODS

The proposed seizure prediction algorithm utilizes an anomaly detection framework based on a Self-attentive Autoencoder (SA-AE), which is expected to take account of time-dependency structures of the data suitably. The input values of SA-AE are the original RRI data, and the output values are the reconstructed RRI data by SA-AE.

The reconstruction error (RE) is defined as the error between the original RRI data and the reconstructed RRI data by SA-AE. A seizure warning is given when RE continuously exceeds its control limit for more than a time threshold.

We collected clinical RRI data from 66 patients with focal epilepsy, which consists of training and validation data including 131 interictal episodes for a total of 77.4 hours, and 264 interictal and 85 preictal episodes for a total of 195 hours, respectively. The collection and analysis of the clinical data was approved by the Ethics Committee of Tokyo Medical and Dental University and the Ethics Committee of each institution.

III. RESULT

The control limit of RE was determined by the 99.5% confidence limit, the time threshold was set to eight seconds. After a seizure alarm ended, seizure prediction stopped for 30 minutes to restore ANS to its normal state. These were set by trial and error.

The overall results showed that the sensitivity of 71%, the precision of 0.34, False Positive (FP) rate of 0.90 times/h, and Area Under the Curve (AUC) is 0.99. Figure 1 shows an example of seizure prediction result of patient A (male, 41 y.o., right temporal lobe epilepsy), indicating that seizure prediction by the proposed algorithm functioned well for this patient.

IV. DISCUSSION&CONCLUSION

There were three patients whose epileptic seizures were not predicted; their FP rate is more than 2.5 times/h. It indicates that it is necessary to individually tune hyperparameters of the algorithm and to investigate causes of FPs.

In this study, we proposed the anomaly detection algorithm for epileptic seizure prediction using SA-AE. The results of applying the proposed algorithm to the clinical data demonstrated that this algorithm functioned well; however, it suggested that more improvement is needed for clinical use. In the future, we will optimize the algorithm for further seizure prediction performance improvement.

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Fig. 1. Seizure prediction results of patient A for preictal data (upper) and interictal period data (lower)