A Study on Unsupervised HMM Based Anomalous Signal Detection from Waveform Images of ELF Magnetic Signals

Motoaki Mouri (Aichi University, Japan) *mouri@aichi-u.ac.jp*
Akitoshi Itai (Chubu University)
Takumi Ichi (Nagoya Institute of Technology, Japan)
Hiroshi Yasukawa (Aichi Prefectural University, Japan)

1 Waveform Images of ELF Magnetic Signals

Our research group has been measuring extremely low frequency (ELF) band magnetic fields across Japan since 1985. The observation devices record the average absolute value of the EM field every 6-second periods, and they send it to data server. We visually browse the ELF data which have been converted to waveform image files with down-sampling (576 samples per day). Then, if human can find anomalous signals using visually evaluation, it is said that these waveform images include enough information to judge.

2 Unsupervised HMM Based Anomalous Signal Detection

The Hidden Markov Model (HMM) is a statistical model which is often used in pattern recognition. In unsupervised approach, the HMM can be trained using many sets of sequential symbols which are obtained from the data in the same class. We can calculate acceptance probability (AP) by applying the symbols of a target data to the trained HMM. When the AP was small, it suggest that the target data was not blong to the class of the HMM.

The symbols in our proposed method are made by counting red pixels, the line color of the observed signal, in each horizontal direction of a waveform image. The flow of anomalous signal detection is follow. 1) Training a HMM using 40 sets of symbols of usual data. 2) Calculating AP using HMM and the symbols of target data. 3) Detecting anomalous part whose AP was small.

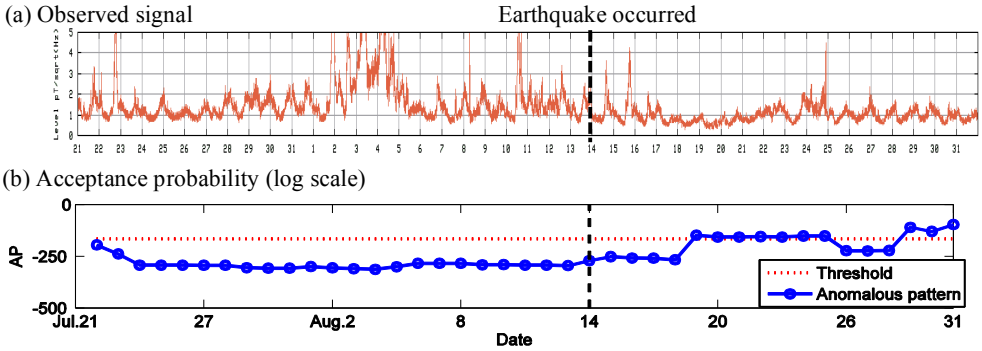

Fig. 1. Observed signal and acceptance probability (at Miyagi, from Jul. 21 to Aug. 31 in 2002)

Figure 1(a) shows an observed signal including an earthquake occurrence. In visually evaluation by human, the anomalous signal is recorded on Jul. 22th, from the Jul. 28th to Aug. 16th and from the Aug. 24th to 25th. The APs are shown in Fig. 1(b). The threshold was the smallest AP in training data. The AP seems it has correspondence with visually evaluation. The characteristic fact is that the AP became large, i.e. judged as a usual, after the earthquake has occurred. However, the small-AP term before the earthquake occurrence might be too long. We need more research about validity of our method.

3 Conclusion

We proposed a method of unsupervised HMM based anomalous signal detection from waveform images. The example of the application seems it has correspondence with human evaluation. In future work, we need more validation and consideration about this approach.

Reference:
S. Urata, H. Yasukawa, A. Itai, I. Takumi, “A Study on Clustering for Anomalous Signal Detections From Electromagnetic Wave Data”, Proc. IEEE International Geoscience and Remote Sensing Symposium, pp.6083 -6086, 2012.