Detection of spread-F echoes in ionograms using machine learning

*Hiroyuki Nakata[1], Yuta Goto[2], Hiroyo Ohya[1], Toshiaki Takano[1]

1. Graduate School of Engineering, Chiba University, 2. Department of Electrical and Electronics Engineering

Ionospheric irregularities referred to as equatorial spread-F is very important phenomena in terms of radio wave propagation because their spatial scales are from centimeters to tens of kilometer and they affects wide-band radio waves. Therefore, they influence the reliability of satellite-ground communications, navigation systems and so on. The ionogram is one of the important observation system of spread-F. Because the detection of spread-F in the ionogram is done manually, detection of spread-F could be replaced with automatic detection by developing an excellent machine learning system. In this study, therefore, we have developed a method to detect spread-F in the ionogram automatically using machine learning.

In this detection process, we have arranged two classifiers for typical frequency-type and mixed (frequency-type and range-type) spread-F echoes in the ionograms. A number of correct images must be prepared for these classifiers to learn the feature values of spread-F. To do so, ten thousands of correct images were generated by create_samples utility provided by OpenCV library. Using these classifiers, we have detected the both types of spread-F echos in the ionograms observed at 4 observatories (Wakkanai, Kokubunji, Yamagawa, Ogimi) utilized by National Institute of Information and Communications Technology. The detection rates of both types of spread-F echos are from 50% to 73% and both classifier detected both types of spread-F echos similarly. Namely, the classifier for the frequency-type spread-F echo detected both of the frequency-type and mixed-type echos, and vice versa. In case where the two types of spread-F echos are not distinguished, on the other hand, both of classifiers detect 80% of total spread-F echos. In addition, the classifiers also picked up some other phenomenon , such as overlapped traces of O-mode and X-mode, multi-hop trace.

As for the future plan, there might be several way to improve the detection rate; to use more classifiers, to make the classifiers be precisely with more training data, and so on. However, a number of correct images are inevitable in machine learning. In order to prepare such a number of images, it may be effective to generate training data using deep generative model.

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