Spatio-temporal analysis of flash aurora using Convolutional Neural Network

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High energy electrons in the magnetosphere travel along geomagnetic field lines and precipitate into the Earth's atmosphere, then auroras are shown on the ground. We can investigate indirectly the behavior of precipitating electrons in the magnetosphere by deducing auroras on the ground. We focus on flash auroras, which illuminate suddenly at less than 1 s. It is difficult to detect a lot of flash aurora events by visually looking because the duration of flash aurora is very short. In this study, we developed an automatic detection of flash auroral position using Convolutional Neural Network (CNN) and performed statistical analysis of the spatio-temporal variations of flash aurora taken by an EMCCD camera (100 Hz sampling, 256 * 256 pixels) at Gakona (Alaska).

The learning data was obtained by dividing the keogram images (2400 * 720 pixels, 1-minute period) along the north-south direction of all-sky EMCCD data into square blocks (30 * 30 pixels, 750-ms period), then the learning data was visually classified to four classes. Four classes are, "pulsating aurora", "flash aurora", "noise", and "no aurora or noise". We classified the test data using the CNN, its accuracy was 91.2%.

The flash aurora data (about 100 events) are collected by CNN and we extracted flash auroral region using Otsu's method, which is a basic method of contour extraction. We performed statistical analysis about luminous duration, luminous point, spatial size, and spatial extent of flash aurora. The averaged luminescence duration was 0.21±0.08 seconds, and did not depend on magnetic longitudes and latitudes in the field-of-view of camera. We confirmed that most events (about 70%) expand earthward with an average spatial extent of 0.027 Re. We think that the earthward extension can be caused by wave propagation effects of whistler mode waves and the nonuniformity of spatial distribution of loss cones in the magnetosphere.
In this presentation, we will report on our automatic detection method and statistical results of spatio-temporal analysis of flash aurora in detail.

Keywords: Convolutional Neural Network, pulsating aurora, flash aurora

