Tackling Space Weather Forecasting Through Industry–Academia Collaboration and Information Science Technologies

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Human activity is no longer confined to the near-Earth space environment but is rapidly expanding into the cislunar space, including the lunar vicinity. At the same time, many assets that underpin modern society—such as positioning, communications, broadcasting, and Earth observation—are deployed in outer space, and we have entered an era in which variations in the space environment exert direct impacts on social and economic activities. Against this background, space weather, which encompasses phenomena such as high-energy particles and electromagnetic disturbances originating from solar activity, has been increasingly recognized as a “civilization-dependent disaster” that becomes more prominent as society advances.

On the other hand, the prediction of space weather phenomena involves inherent challenges. Observation points in space are limited both spatially and temporally, and the available data are sparse and noisy. Consequently, approaches based solely on empirical rules or a single physical model are insufficient to ensure adequate lead time or practically useful predictive accuracy.

In recent years, space weather prediction frameworks that integrate artificial intelligence technologies with numerical simulations grounded in physical laws have attracted growing international attention as a new approach to addressing these challenges. Artificial intelligence has the capability to flexibly capture complex nonlinear relationships from sparse observational data, and when combined with physical models and prior knowledge, it is expected to enable a more advanced understanding of phenomena that could not be fully captured by conventional methods.

In this presentation, we review recent research trends in the field of space weather prediction and introduce Fujitsu’s efforts in applying artificial intelligence technologies to space weather forecasting. In particular, we discuss attempts to derive prediction information that supports decision-making by leveraging machine learning methods incorporating physical knowledge and explainable artificial intelligence techniques, even under conditions of sparse space data.

Keywords: space weather, Machine Learning, Explainable AI, Physics-Informed Machine Learning

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