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Automatic detection of magnetopause and bow shock crossing signatures in MESSENGER magnetometer data using Convolutional Neural Networks.

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During its 2011-2015 lifetime the MESSENGER spacecraft completed more than 4000 orbits around Mercury, producing vast amounts of information regarding the planetary magnetic field and magnetospheric processes. During each orbit the spacecraft left and re-entered the Hermean magnetosphere, giving us information about more than 8000 crossings of the bow shock and the magnetopause of Mercury's magnetosphere. The information obtained from the magnetometer data offers the possibility to study in depth the structures of the bow shock and magnetopause current sheets and their shapes. In this work, we take a step in this direction by automatically detecting the crossings of bow-shock and magnetopause. To this end, we propose a five-class problem and train a Convolutional Neural Network based classifier using the magnetometer data. Our key experimental results indicate that an average precision and recall of at least 87% and 96% can be achieved on the bow hock and magnetopause crossings by using only a small subset of the data. We also model the average three-dimensional shape of these boundaries depending on the external interplanetary magnetic field . Furthermore, we attempt to clarify the dependence of the two boundary locations on the heliocentric distance of Mercury and on the solar activity cycle phase. This work may be of particular interest for future Mercury research related to the BepiColombo spacecraft mission, which will enter Mercury’s orbit around December 2025.