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Title
Semi-supervised temperature field information fusion method based on taylor modal decomposition for spacecraft application

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Abstract
As the information technology industry continues to upgrade, the space industry has ushered in a new era of digital development, marked by a significant increase in the integration of spacecraft. The highly integrated electronic components make stringent requirements on the operating environment of spacecraft payloads. Temperature is important is an environmental factor for the safe operation of spacecraft in orbit. However, complex payload component systems do not have exactly the same operational temperature requirements, for example, semiconductor microwave devices are very sensitive to high temperature and temperature impact, and integrated circuits are subject to fatal failures such as thermal puncture and welding spot failure at high temperature and temperature impact, etc. Therefore, real-time acquisition of the overall spacecraft temperature field is an important prerequisite for effective on-orbit thermal control and the construction of a digital twin of the spacecraft in orbit. However, the mature and universal method of monitoring spacecraft temperature in orbit currently is to place temperature sensors at key nodes of the spacecraft and use a limited number of scattered temperature data to monitor the whole field of the spacecraft. But this approach does not allow for comprehensive and accurate temperature monitoring of the spacecraft. Hence, there is an urgent need for a resource-saving, operationally efficient and highly reliable method to monitor the spacecraft on-orbit temperature field. In recent years, the rapid development of artificial intelligence technology, represented by machine learning and deep learning, has opened up the possibility of this need. In this paper, we propose a semi-supervised temperature field information fusion method based on taylor modal decomposition, by which a double fidelity multi-order partial differential field dataset is obtained. The low-fidelity dataset is used as a pre-training dataset to pre-train the Fourier neural operator based fusion network. The high-fidelity dataset is then used as the fine-tuning dataset to fine-tune the fusion network, resulting in highly accurate, high-resolution temperature field data. The experimental results show that the pre-trained and fine-tuned fusion network can effectively fuse multi-source heterogeneous data and effectively improve the accuracy and resolution of temperature field data, which is of great significance to improve the temperature self-awareness of spacecraft in orbit and increase the safe on-orbit service life of spacecraft in orbit.