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Robust Coupled Tensor Decomposition and Feature Extraction for Multimodal Medical Data

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High-dimensional data to describe various aspects of a patient's clinical condition have become increasingly abundant in the medical field across a variety of domains. For example, in neuroimaging applications, electroencephalography (EEG) and functional magnetic resonance imaging (fMRI) can be collected simultaneously (i.e., EEG-fMRI) to provide high spatial and temporal resolution of a patient's brain function. Additionally, in telemonitoring applications, a smartphone can be used to record various aspects of a patient's condition using its built-in microphone, accelerometer, touch screen, etc. Coupled canonical polyadic (CCP) tensor decomposition is a powerful approach to simultaneously extract common structures and features from multiple tensors and can be applied to these high-dimensional, multi-modal data. However, the existing CCP decomposition models are inadequate to handle outliers, which are highly present in both applications. For EEG-fMRI, outliers are common due to fluctuations in the electromagnetic field resulting from interference between the EEG electrodes and the fMRI machine. For telemonitoring, outliers can result from patients not properly following instructions while performing smartphone-guided exercises at home. This motivates us to propose a robust CCP decomposition (RCCPD) method for robust feature extraction. The proposed method utilizes the Alternating Direction Method of Multipliers (ADMM) to minimize an objective function that simultaneously decomposes a pair of coupled tensors and isolates outliers. We compare the proposed RCCPD with the classical CP decomposition and the coupled matrix-tensor/tensor-tensor factorization (CMTF/CTTF). Experiments on both synthetic and real-world data demonstrate that the proposed RCCPD effectively handles outliers and outperforms the benchmarks in terms of accuracy.

Keywords

Multimodal Data, Robust Tensor Analysis, Data Fusion

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