An Outlier-Robust PCA Method with Applications to Computer Vision

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Abstract. Robust subspace recovery (RSR), or outlier-robust PCA, aims to identify a lowdimensional subspace in datasets corrupted by outliers—an essential task for fundamental matrix estimation in computer vision. Despite numerous approaches, RSR faces two main challenges: heuristic methods like RANSAC often outperform mathematically rigorous approaches, and as outlier fractions grow, the problem becomes computationally intractable, with limited theoretical guarantees. We introduce the subspace-constrained Tyler's estimator (STE), which fuses Tyler's M-estimator with the fast median subspace method. Our analysis establishes that STE, when properly initialized, achieves effective subspace recovery even in challenging regimes previously lacking theoretical guarantees. We further demonstrate STE's competitive performance in fundamental matrix estimation and relate it to broader structurefrom-motion (SfM) challenges.