

This paper considers the problem of robustly estimating a structured covariance matrix with an elliptical underlying distribution with a known mean. In applications where the covariance matrix naturally possesses a certain structure, taking the prior structure information into account in the estimation procedure is beneficial to improving the estimation accuracy. We propose incorporating the prior structure information into Tyler's M-estimator and formulating the problem as minimizing the cost function of Tyler's estimator under the prior structural constraint. First, the estimation under a general convex structural constraint is introduced with an efficient algorithm for finding the estimator derived based on the majorization-minimization (MM) algorithm framework. Then, the algorithm is tailored to several special structures that enjoy a wide range of applications in signal processing related fields, namely, sum of rank-one matrices, Toeplitz, and banded Toeplitz structure. In addition, two types of non-convex structures, i.e., the Kronecker structure and the spiked covariance structure, are also discussed, where it is shown that simple algorithms can be derived under the guidelines of MM. The algorithms are guaranteed to converge to a stationary point of the problems. Furthermore, if the constraint set is geodesically convex, such as the Kronecker structure set, then the algorithm converges to a global minimum. Numerical results show that the proposed estimator achieves a smaller estimation error than the benchmark estimators at a lower computational cost.