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Matrix Completion with Sparse Measurement Errors

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Matrix completion generally refers to the problem of finding a matrix based on the knowledge of a small fraction of it's elements, under the assumption that the target matrix has a low rank. Certain approaches, like SVP algorithm [1], have been developed for this problem, notably, with geometric convergence bounds under the incoherence hypothesis, and work has been done on the complexity reduction of the said SVP algorithm [2].

In this work, the problem of completion of matrices of small ranks is considered in a special setting, where each element of the matrix may be erroneous with probability $\rho_e = \mathcal{O}\left(\frac{1}{n}\right)$.

Although such a perturbation is extremely sparse on a given mask of known elements, it is not incoherent and algorithms such as SVP method most likely will not work. A new iterative method is proposed that is insensitive to rare observation errors. The method provides the low rank matrix and defines a set containing the erroneous matrix elements. The cardinality of the erroneous set is only a finite number of times greater than the cardinality of a true set of errors.

The method maintains a geometric convergence rate, which is supported by numerical experiments on artificial data. The approach is also applicable to the problem of approximating a given matrix by the sum of a sparse matrix and a matrix of low rank.

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References

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[2] O.S. Lebedeva, A.I. Osinsky, S.V. Petrov. Low-Rank Approximation Algorithms for Matrix Completion with Random Sampling. Computational Mathematics and Mathematical Physics (2021), 61(5), pp. 799-815.