Exploiting Low-rank Structures for the Solution of PDEs

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Abstract

Exploiting low-rank structures for the solution of partial differential equations (PDEs) has emerged as a powerful technique in the field of numerical simulation and scientific computing. Many real-world systems exhibit inherent low-dimensional patterns among solution variables, allowing for more efficient computation. By efficiently approximating complex PDE solutions with fewer degrees of freedom, low-rank methods facilitate scalable algorithms and offer enhanced interpretability, making them invaluable tools for tackling high-dimensional problems in various scientific and engineering domains.

In this talk we are going to focus on the solution of evolutionary PDEs. In particular, we will show how the space-time formulation of the discrete problem can be cast in terms of a single Sylvester matrix equation, in place of a sequence of shifted linear systems as costumary in time-marching schemes. This reformulation allows to design ad-hoc numerical strategies tackling the space and time components of the algebraic equation separately. In particular, a novel solution strategy that combines projection techniques – for the space component – with the full exploitation of the entry-wise structure of the discrete time operator is proposed. The resulting scheme is able to efficiently solve problems with a tremendous number of degrees of freedom while maintaining a low storage demand as illustrated by several numerical results.

References

[1] D. Palitta, *Matrix Equation Techniques for Certain Evolutionary Partial Differential Equations*, J Sci Comput 87, 99 (2021)