Fast algorithms for SSS matrix problems and their application to wind farm control

Y. Qiu[†] J. W. van Wingerden[†] M. B. van Gijzen[‡] M. Verhaegen[†]

[†]Delft Center for System and Control, TU Delft, [‡]Delft Institute of Applied Mathematics, TU Delft,

Introduction

The biggest challenge in distributed control of spatially interconnected systems is the computational complexity of the control algorithms. Conventional solution algorithms will require $O(n^3N^3)$ floating point operations (flops), in which N is the number of subsystems and n is the number of state variables per subsystem. This makes traditional controller synthesis expensive for fine discretizations or a large number of distributed subsystems. Sequentially Semi-Separable(SSS) matrices [1][2] provide an effective approach for controller synthesis of 1-D interconnected system that requires $O(n^3N)$ flops, which is a linear computational complexity with respect to number of subsystems. This nice property can be shown by the example of Extended Kalman Filter (EKF) for identification of heat conduction coefficients of the heated rebar described by figure 1.

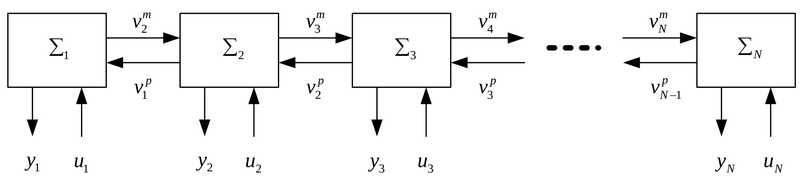

Figure 1: 1-D interconnected subsystem for heated rebar

The computation times for the SSS-matrix approach and the full-matrix approach are illustrated by figure 2.

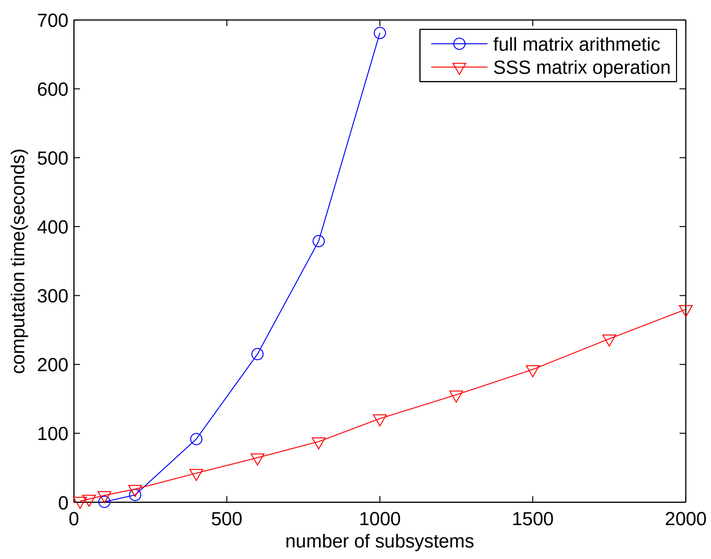

Figure 2: Computation time for identification of heat conduction coefficients of heat rebar

Objective

The wind farm at Nashville, shown in figure 3, can be described by the 2-D interconnected subsystems displayed in figure 4, because of the interconnections between wind turbines. The matrices of the state-space models that represent the 2-D interconnected subsystems have the structure of multi-level SSS matrices, which means that generators of multi-level SSS matrices are SSS matrices.

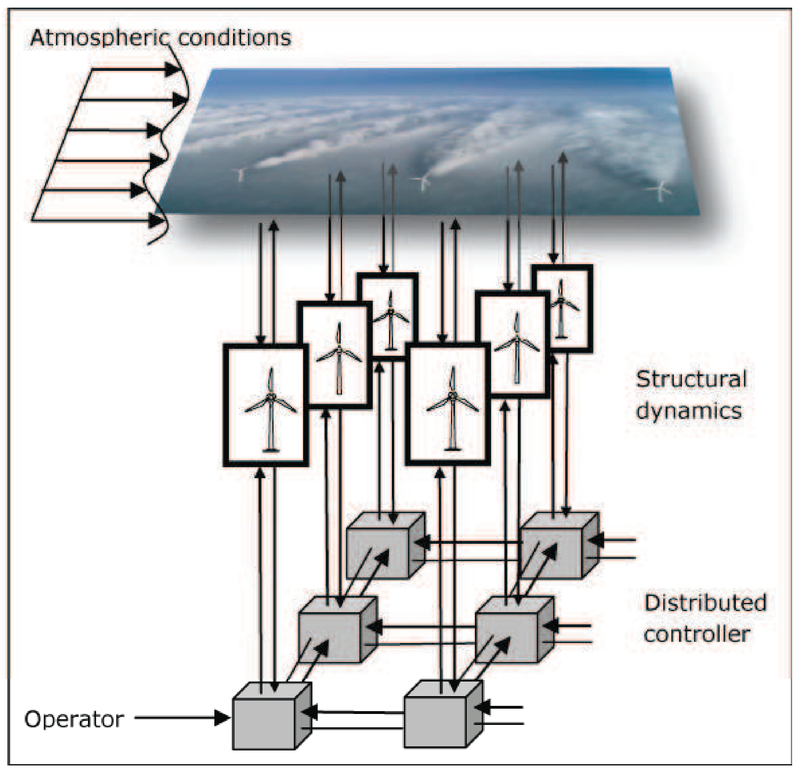

Figure 3: Wind farm at Nashville

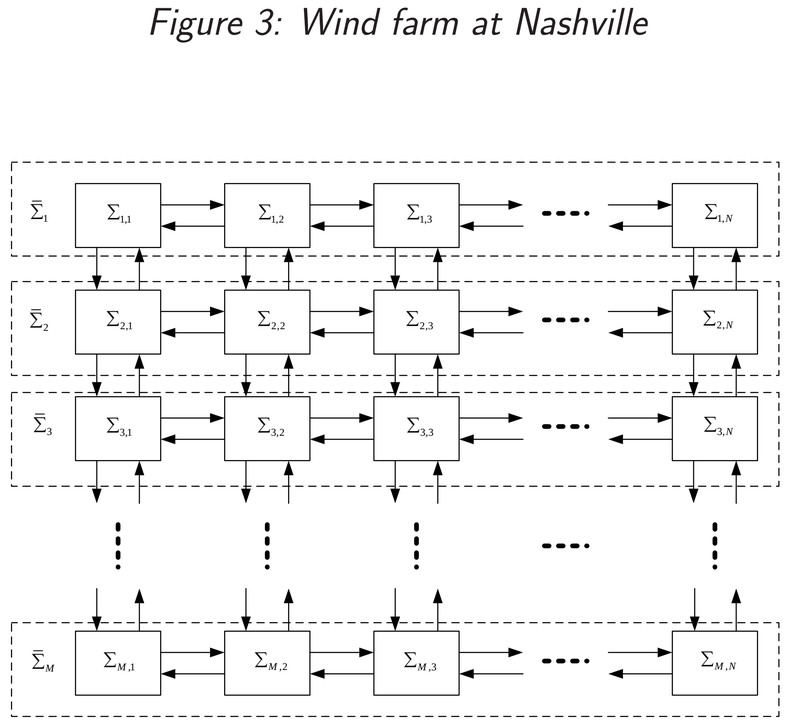

Figure 4: 2-D interconnected subsystem

The goal of this research is to develop a fast solver for multi-level SSS matrices that has linear computational complexity. This fast solver can be used to identify aerodynamical and environmental interconnections of wind farms.

References

[1] J. K. Rice. *Efficient Algorithms for Distributed Control: A Structured Matrix Approach*. PhD thesis, Delft University of Technology, 2010.

[2] S. Chandrasekaran, P. Dewilde, M. Gu, T. Pals, X. Sun, A. J. van der Veen, and D. White. Some fast algorithms for sequentially semiseparable representations. *Siam Journal on Matrix Analysis and Applications*, 27(2):341–364, 2005.

TU Delft Delft University of Technology