Identification and distributed control of large scale systems: an application to wind farm

Yue Qiu[†] , Jan-Willem van Wingerden[†], Martin van Gijzen [‡] and Michel Verhaegen [†]
[†] Delft Center for System and Control, Delft University of Technology
Mekelweg 2, 2628 CD, Delft, the Netherlands
[‡]Delft Institute of Applied Mathematics, Delft University of Technology
Mekelweg 4, 2628 CD, Delft, the Netherlands
Email: Y.Qiu@tudelft.nl

Keywords: system identification, distributed control, aerodynamic interconnection, wind farm

INTRODUCTION

With the increasing capacity of wind farms, distributed control and optimization is of great importance to make wind farm operate in an economical state. However, interconnections between wind turbines caused by aerodynamics are very complicated and difficult to model and modify by first principle. Therefore, algorithms for identifying aerodynamic interconnections between wind turbines are necessarily required. The biggest challenge of distributed control and identification of spatially interconnected systems is the complexity of the control algorithms. The system matrix that describes the input-state-output behavior of N interconnected subsystems, with subsystems of order n, will be of size $nN \times nN$ matrix. Therefore most conventional solution algorithms will require $O(n^3N^3)$ floating point operations (flops), which makes traditional controller synthesis expensive for fine discretization of PDEs or large number of distributed subsystems.

METHODOLOGY

Sequentially Semi-Separable (SSS) matrices [1] provide an effective approach, which has linear computational complexity. State space model of 1-dimensional spatially interconnected system which is shown by figure 1 has SSS matrix structure. The extension of the 1D system to a 2-dimensional spatially interconnected system (2D) is shown in figure 2. The latter structure can be used to describe a wind farm and leads to a higher-level SSS structure, called multi-level SSS matrix structure. Our research focuses on developing a fast solver for multi-level SSS matrices of linear computational complexity for 2D system, which can be applied for identification of aerodynamics and distributed control of wind farms.

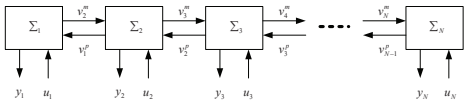

Figure 1: 1-dimensional spatially interconnected system

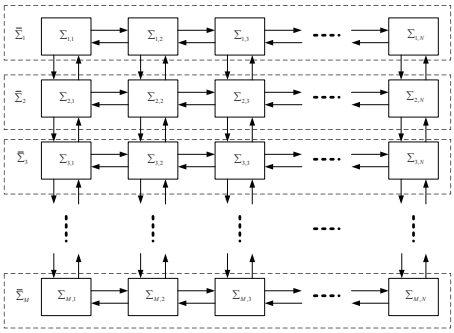

Figure 2: 2-dimensional spatially interconnected system

CONCLUSIONS

Our work consists of three steps, the first step is to implement the algorithms based on SSS matrices to do fast identification of a 2D system. The second step is to exploit the multi-level structure of the 2D system model to accelerate the computation speed via structure preserving model reduction for multi-level SSS matrix. The third step is to apply the previous mentioned algorithms to identify aerodynamic interconnections between wind turbines. Our ongoing research shows that algorithms based on SSS matrix structure for 2D system have linear computational complexity, which is very efficient for wind farm control and identification.

REFERENCES

[1] J.K. Rice and M. Verhaegen. Efficient system identification of heterogeneous distributed systems via a structure exploiting extended kalman filter. *Automatic Control, IEEE Transactions on*, 56(7):1713–1718, 2011.