Contributions to the control configuration selection

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With the ever increasing complexity of the process plants and manufacturing processes, the objectives of process control strategies cannot be attained unless a suitable control configuration is selected. To select an appropriate control configuration, it is important to determine which variables should be measured and how the process should be actuated. Therefore, the first step is to determine the optimal locations for the sensors and actuators. This makes providing the accurate and reliable process measurements and suitable actuations possible for the control purposes. For the multivariable processes, this step is followed by choosing the appropriate input and output pairs for the design of SISO (or block) controllers. This is due to the popularity of the distributed and decentralized control in industrial control systems. The reason for this popularity is that the centralized control of large-scale complex systems are expensive and difficult, due to the computational complexity, the problems related to reliability and the limitations in communications. On the other hand, decentralized controllers are easy to understand for operators, easy to implement and to re-tune [1]-[2].
In this paper both key issues in control configuration selection are addressed. These two key issues have been studied extensively for deterministic systems. For the placement of the sensors and the actuators, several techniques have been proposed over the last few decades. These techniques take into account different performance criteria [3]-[9]. One of the most reliable criterions for determining sensor and actuator locations is the improvement of state controllability and observability of the process [3]. In these methods, the problem of determining the sensor locations is viewed as the problem of maximizing the output energy generated by a given state. The problem for the actuator locations is viewed as the problem of minimizing the input energy required to reach a given state. In [4]-[6], several gramian-based methods from this category for optimal placement of the sensors and the actuators have been proposed. These methods have been improved and have been extended to unstable systems in [9] and further to nonlinear systems in [8]-[7].

The second key issue of control configuration selection which is input-output pairing has also been studied extensively for multivariable deterministic systems. The results in this context are based on different interaction measures. Interaction measures make it possible to study input-output interactions and to partition a process into subsystems in order to reduce the coupling, to facilitate the control and to achieve a satisfactory performance. There are two broad categories of interaction measures in the literature. The first category is the relative gain array (RGA) and its related indices [10]-[16] and the second category is the family of the gramian-based interaction measures [17]-[26].

In recent years, gramians become popular in the process of control configuration selection. The gramians are matrices with the embedded controllability and observability information. The controllability and observability gramians were first introduced in [27] and [28] and more recently in [29]. It is well-known that the controllability gramian shows the level of controllability. Similarly, the observability gramian contains information of the level of observability for a system. Gramians have been also been extended, improved and have been used in different applications such as model reduction [27]-[39].

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