Mathematical Problems in Engineering

Hindawi

Special Issue on **Mathematical Methods and Techniques in Self-Sensing Systems for Virtual Sensors**

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One of the most important issues in electronic devices and in control systems is represented by the possibility of signals sensing. Sensors are devices for information conversion from its natural form to any kind of sensors; the most crucial theoretical problem is how precise and truthful this information after such a conversion is. Traditionally, due to impossibility to estimate such information in its primary form, the estimation of such conversion quality is provided by recognized mathematical formalism, mostly statistical. The complexity of particular sensing systems usually defines the adequate or mostly matching mathematical method. In particular, virtual sensors systems represent a very challenging field in terms of mathematical aspects and techniques.

The basic concept is represented by the observability of the system. In fact, in other words a virtual sensor is an observer which is based on the intrinsic structural self-sensing physical principle and which allows to estimate quantities using the intrinsic physical coupling of these quantities. To be more specific electromagnetic systems with the duality between Lorentz's and Lentz's effect, with the well-known back electromagnetic force (bemf) and, for instance, piezo electric system with the back electro charge force (becf) or Siebeck and Peltier effect in thermal systems and many others, represent the basic self-sensing principle which helps in a virtual sensor development. In other words, self-sensing systems are the ones which use a physical and a technical duality; in this sense, actuators can be used in the meantime as sensors.

A possible favorable alternative to expensive and impractical physical measurement instruments can be represented by virtual sensors and automatic recognition systems.

Information obtained from other measurements and process parameters for calculating an estimate of the quantity under interest is used by a virtual sensing system. In other words, the most benefit of such an approach is a total substitution of hardware, with all its disadvantages, by a theoretical formalism identified as desired phenomena observer.

In general, virtual sensing techniques are classified in two major categories, analytical techniques and empirical ones. Two techniques which use observers' model based, in which an accurate mathematical and physical model should be available, belong to the first categories.

If not, an approximation of the model is used through data validation and reconciliation methods. In this context the famous Kalman filter used as an observer is well placed. In fact, the Kalman filter with its different variations represents a compromise between a deterministic and a stochastic approach. Empirical techniques are used when the physical and thus the mathematical model are not sufficiently known or they are computationally expensive to run on-line. Empirical virtual sensors are accordingly based on function approximation and regression techniques, which can be carried out by means of statistical or machine learning modeling methods.

The aim of this special issue is to collect new advanced methods and techniques in the conception of virtual sensors from academic and industrial fields, to make a contribution in terms of wide compendium on this futuristic topic.

Potential topics include, but are not limited to:

- Self-sensing in electromagnetic, piezo, thermal, and mechanical actuators as a basic principle for virtual sensors
- Observers in sensorless control as virtual sensors based on the self-sensing principle
- Kalman filter used as an observer in sensorless control
- Control aspects using sensorless control
- Industrial application using sensorless control

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