Modelling Suddenly Emerging Phenomena

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Suddenly Emerging Phenomena is a branch of Signal Analysis ; it concerns mostly the quick variations of a current. Such phenomena cannot be treated, for industrial purposes, by the same means as slowly varying phenomena, for which the usual tools of control and command are applied.

The two main questions about Suddenly Emerging Phenomena are : how to detect them and how to treat them ?

As an example of an industrial situation, we see the rotation of an electrical motor, which is affected by sudden changes of the load. If we want to keep the rotation speed constant with some accuracy, we need to detect and compensate any change in the load.

A similar situation is represented in automotive applications by variations of the electronic current of transducers due to sudden variations (disturbances) in the environment (wind direction, road condition, for example). If the driver wants to keep a constant direction, such changes should be compensated within a short time.

Another type of application is represented by a Phase-Locked Loop in AC generators or data transmission based on modulation of a carrier wave, where a local oscillator should be synchronized with a remote oscillator (both should have the same phase and frequency). This requires an accurate estimation for the trend of the angular frequency and the phase difference, in an environment where important alternating components are present (and need to be filtered).

Our Group has a research project, consisting in the design of electronic devices with robust filtering properties, in order to process the electronic signal transmitted by transducers, based upon an oscillating second order system. We use electronic devices, able to estimate the derivative of the received signal (the output of transducers), with a greater accuracy (using

oscillating second order devices or spline functions). This way, the variations of load, which usually appear as variations of the derivative for the output signal, are quickly estimated and the adequate command is quickly transmitted to the equipment.

Our Group has co-organized the technical workshop "Specific Aspects of Computational Physics for Modeling Suddenly Emerging Phenomena" during the International Conference on Computational Science and Its Applications – ICCSA, between 2005 and 2010, with submitted papers from Italy, Russia, China etc. The accepted papers were published in the series "Lecture Notes in Computer Science".

Our activity in 2008 also led to a publication in the journal "Special Issues at Mathematical Problems in Engineering" (an ISI indexed journal) ; this publication was called "Special Issue on Short Range Phenomena" (Modeling, Computational aspects and applications) with Guest Editors: Carlo Cattani, Cristian Toma, Ming Li. It also led to another Special Issue (on Nonlinear Time Series) with Guest Editors: Ming Li, Massimo Scalia, Cristian Toma, to appear in August 2010.

Our Group also participates in improvements in educational methods for students at technical universities. These improvements are based upon unexpected set of questions connected with the choice of certain mathematical methods or technical solutions given to the students, in order to increase their abilities to give quick solutions in an unpredictable environment (for instance a reaction to a fast variation of a load). This should improve the capacity of graduate engineers to react correctly in the case of risk or failure of industrial equipments.

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