Dealing with Complexity in Supervision Systems

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Keywords

- Complexity
- Supervision systems

- Nonlinear models
- Dimensional reduction techniques
- Computational intelligence
- Optimization

Presentation Layout

- Introduction
- Complex Systems
- Supervision Systems
- Methodology to Deal with Complexity in Dynamic Systems
- Conclusions

Introduction

- **Supervision systems** play an important role in industry mainly due to the increasing demand for product quality and high efficiency, and to the growing integration of automatic control systems in technical processes
- The **supervision of technical processes** shows the present state, indicating undesired or not permitted working regions, and taking appropriate actions to avoid damage or accidents. The main idea is to *guarantee that faults do not cause drastic failures*
- A supervision system has a great number of components and interconnections, and it is difficult to describe and understand its behaviour, so it can be classified as a **complex system**
- **Systemic approaches** to deal with complexity in supervision systems are proposed in this paper

Complex Systems

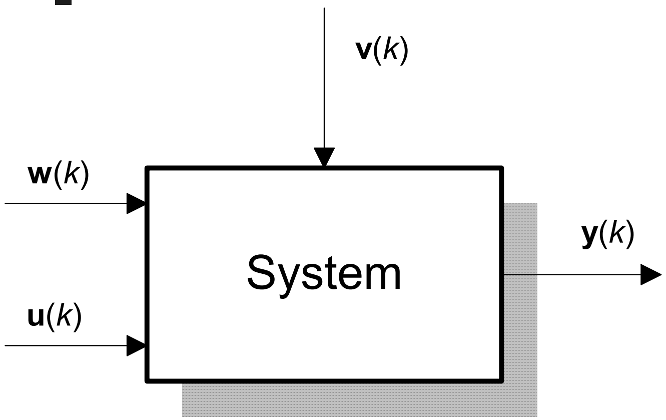

Fig.1: Dynamic system.

Systems and signals are broad concepts, and it is not surprising that they play an important role in modern science

A **Signal** is a function of one or more independent variables, and typically contains information about the behaviour or nature of some phenomenon

A **System** responds to particular input signals by producing other output signals. Another definition is: a group of interacting, interrelated or interdependent elements forming a complex whole. In loose terms, a system is an object in which variables of different physical nature interact and produce observable signals.

One possible definition for a complex system is proposed here: a dynamic system, with various components and interconnections, that is difficult to describe, understand its behaviour, model and predict, design, control, and supervise.

Complex Systems

- The **human being** is one of the most complex systems existing in our world. Within our body, the **human mind** is certainly a high complex system. According to Ackoff, the content of the human mind can be classified into five categories: *data, information, knowledge, understanding and wisdom*.

- In our world, there exist a great number of other systems that can be classified as complex systems. Societies are complex dynamic systems where synergy and emergence play a crucial role. Other complex systems are biological systems, ant colonies, economy, climate, nervous systems, modern energy or telecommunication infrastructures, etc.

Fig: Power plant.

Supervision Systems

The **supervision systems** in industrial plants, implemented in SCADA software, must undertake, at least, the following three main tasks: *monitoring, control and fault tolerance*.

Fig: Power plant.

Monitoring generally means to be aware of the state of a system. This task involves acquiring and evaluating the behaviour of input and output signals, and possibly the estimation of certain process parameters.

Control focuses on the modelling of systems, on analyzing their dynamic behaviour, and using control theory to design a controller to guarantee that the systems have a desired dynamic behaviour in closed loop.

Fault tolerance implies compensation of fault effects in such a way that they do not provoke the system's failure. To reach this goal it is necessary to implement redundancy (in hardware or software). The main task to be tackled in achieving fault tolerance is the design of a controller with suitable structure to guarantee stability and satisfactory performance, in the case of faults on process components, sensors or actuators. The fault tolerant control system must possess integrity in the control loops.

Faults and Failures

- A **Fault** is a non permitted deviation of at least one characteristic property or parameter of the system from the acceptable/usual/standard condition

- A **Failure** can be defined as a permanent interruption of a system's ability to perform a required function under specified operating conditions

Supervision (complex) systems try to guarantee that faults do not cause drastic failures …

Fault Detection and Diagnosis

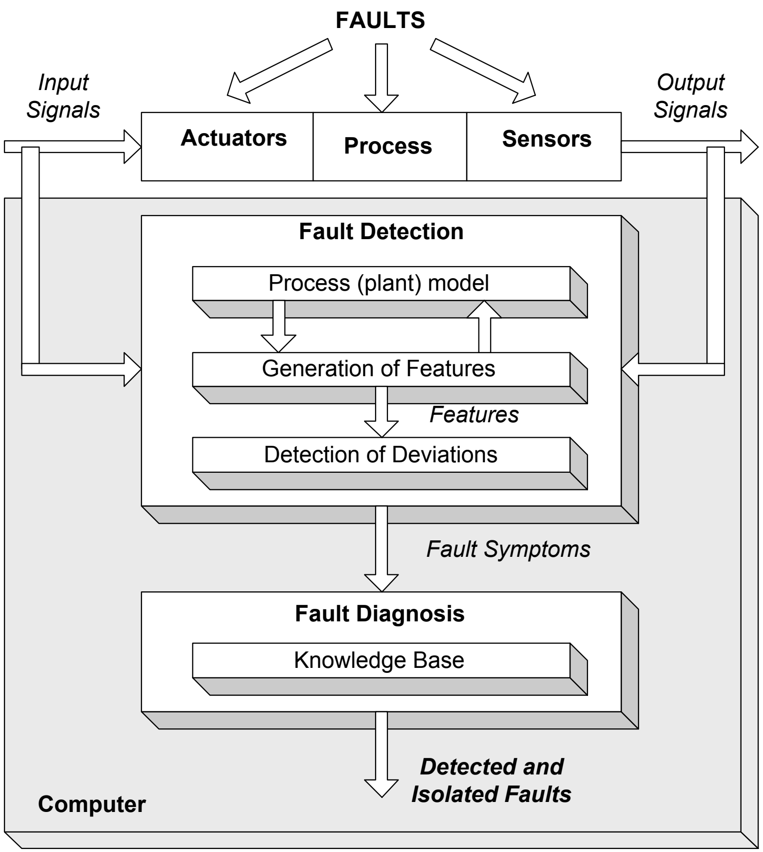

Fig. 2: Typical model-based fault detection and diagnosis architecture.

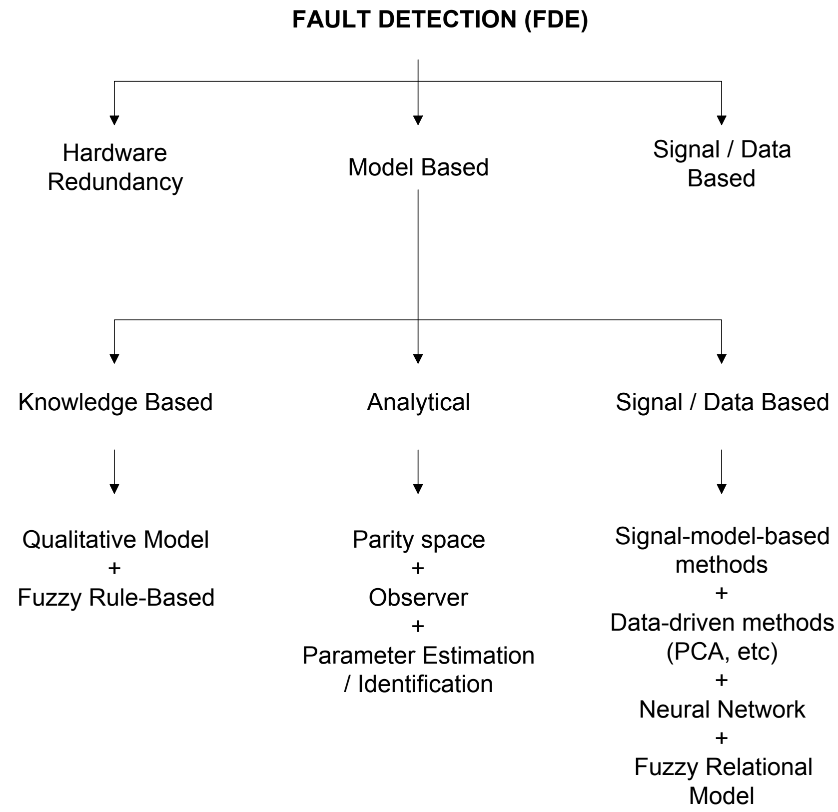

Fig. 3: Scheme of features (residuals, parameter deviations, etc) generation approaches.

Fault Tolerance

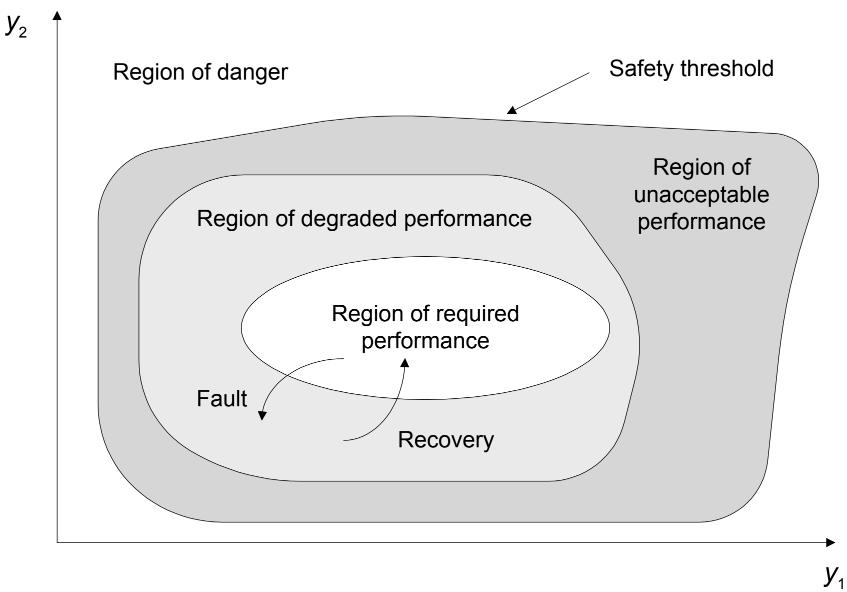

Fig. 4: Performance regions.

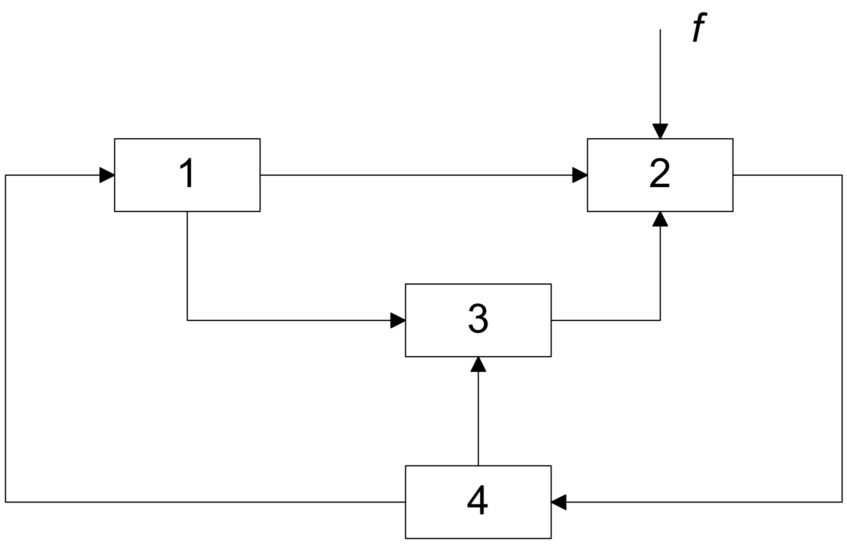

Figure 5: Fault propagation in interconnected systems.

Fault Tolerant Control

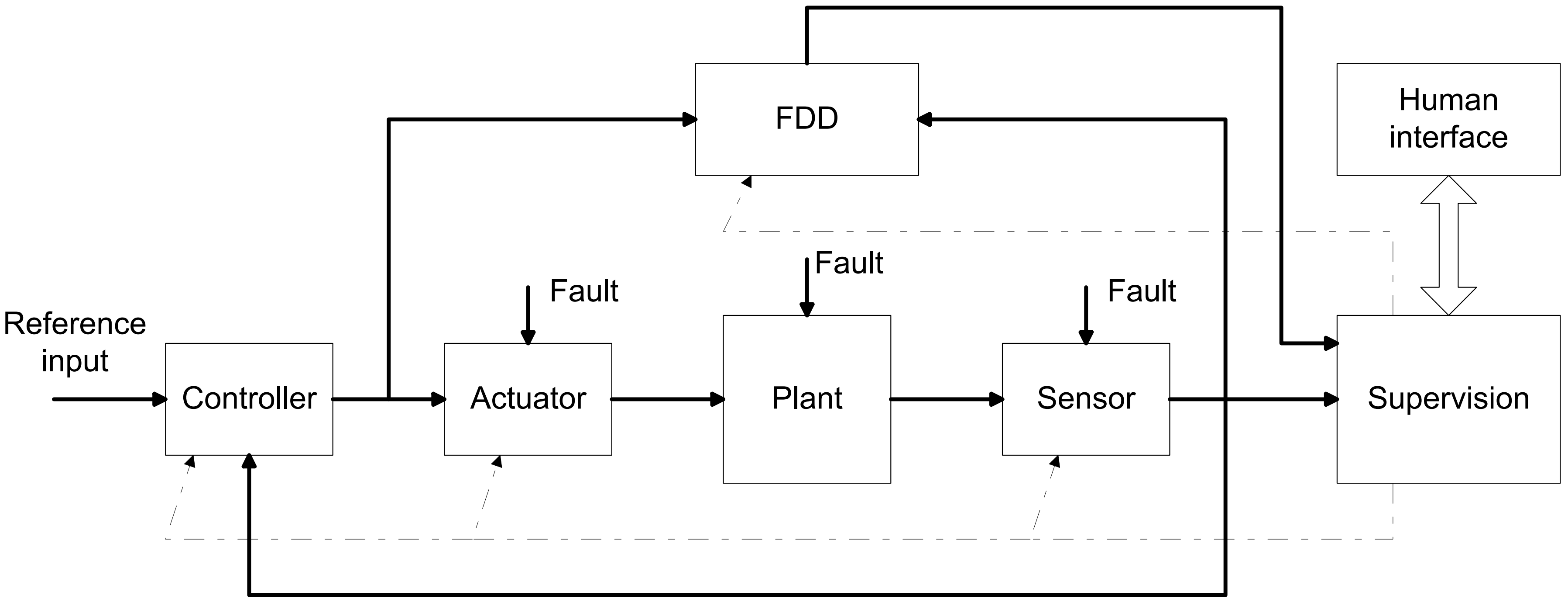

Figure 6: Fault tolerant control architecture.

In most critical situations, the final *decisions* are taken by the **humans**.

Methodology to Deal with Complexity in Dynamic Systems

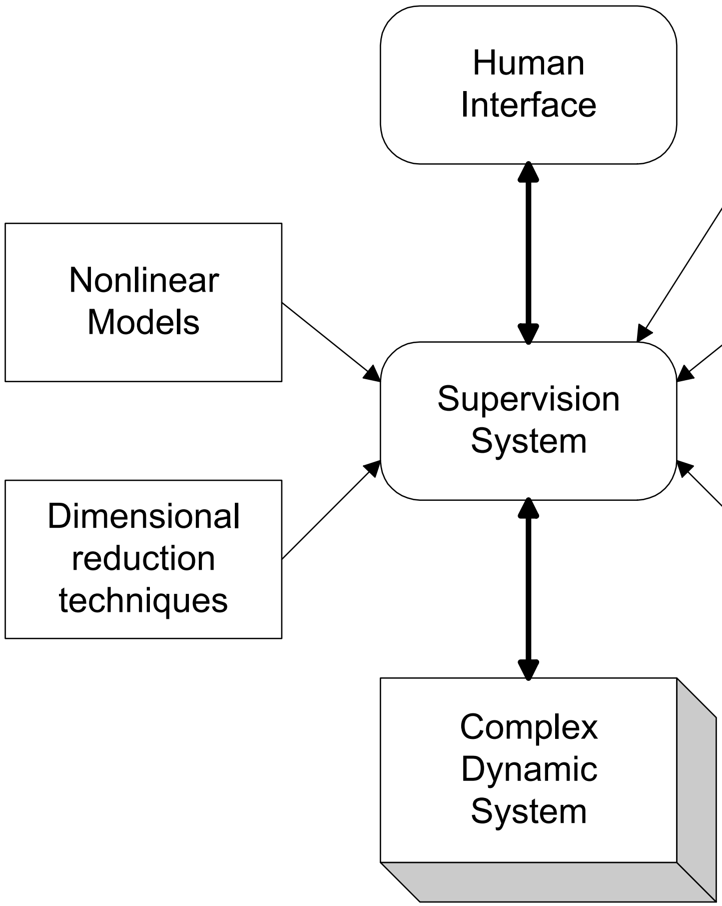

Fig. 7: Systemic architecture to deal with complex dynamic systems.

Conclusions

- **This paper presents a systemic approach to deal with complex systems**. This approach incorporates a supervision system, to supervise the complex system that is build up by integrating nonlinear models, dimensional reduction techniques, computational intelligence, optimization and other techniques.

- **Systemics is the science of systems**. To *understand our world* we need to think that almost everything can be regarded as a system, where signals must be monitored, controlled and ultimately supervised. The supervision of systems should by nature try to guarantee the observability, the controllability and, most important, the system stability.

- The architectures and key concepts presented can be applied to any complex system like a social system, an economic system, a biological system, etc. This extrapolation is a pointer for future research.

Supervision (complex) systems try to guarantee that faults do not cause drastic failures …

Thanks for your attention.