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Introduction

1.8 STRUCTURE OF THIS COURSE

Despite a wide range of possibilities and complexities, most identification procedures refer to a single class of models: lumped, linear, discrete, SISO or MISO constant models.

The use of lumped models is a common practice also outside the identification field because models of this kind combine, when their order is suitable, the possibility of giving accurate descriptions also for distributed processes and an easy use. The choice of linear models relies, on one side, on the necessity to describe most real systems, usually nonlinear, only in the neighborhood of specific working conditions where the behavior is essentially linear and, on the other side, on the powerful tools available for linear systems. When several working conditions are possible, a set of linear models can be preferred to a single nonlinear model. Discrete models are imposed by the general availability of sampled measures also for continuous systems and by the widespread use of digital controllers. With the exception of limited classes of time–dependent systems (e.g. periodic systems), constant models are often used also for time–dependent systems, adopting, in these cases, on–line identification schemes which tune the model on system variations.

This course also adopts previous choices and, because of its scope, limits its content to equation error models i.e. to the sector that still constitutes the mainstream approach to system identification. Its structure allows to follow three paths defined as:

- BASIC
- STANDARD
- ADVANCED (short)
- ADVANCED (extended)

The basic level concerns a complete treatment of the simplest class of MISO equation error models (ARX and AR) that can be identified by means of simple and easily implementable batch and on–line algorithms. The contents of the basic course, that

can be used at Diploma levels, correspond to approximately 30 hours of lectures.

The standard level covers all classes of MISO equation error models and requires the introduction of more complex algorithms leading to more sophisticated implementations. This learning path corresponds to traditional identification courses (Master level) with approximately 60 hours of traditional lectures.

The third level (advanced short) develops vertically the contents of the basic course introducing notions on the internal structure of multivariable systems and on their identification that are not usually covered in standard courses and, in part, not even in the literature. This path corresponds to approximately 50 hours of lectures.

The fourth and last level (advanced extended) develops vertically the whole content of the standard course in the same fashion as previous level and corresponds approximately to 90 hours of standard lectures. Both advanced levels can be used for courses at a Doctorate level.

To properly evaluate the importance of identifying true multivariable models it is sufficient to recall that a collection of MISO models can be reduced to a MIMO model with the lowest possible complexity, i.e. without redundancies, only when the single MISO models are known *exactly*. In all other cases it is impossible to recognize the duplicated dynamics and insert them only once into the model; the reduction of a collection of uncertain MISO models to a single reduced–order MIMO model involves approximations and the introduction of specific criteria (many available) that can alter in a substantial way the optimality of the final model. The internal structure of MIMO systems is, however, substantially richer than that of MISO systems and, as a consequence, the use of MIMO models in identification requires a clear understanding of their properties.

The course is designed for a distribution through a Web server and relies on the same channel to establish links with remote tutors. Every section contains questions and problems whose solution must be submitted to the tutor; some of these problems concern the identification of models using data concerning real processes that can be downloaded from the server. These experiences in identifying real processes can be entirely performed using the Java Interactive Identification Laboratory that has been specifically developed for this course and that can be used on every hardware platform and under any operating system.

The whole exposition follows a *model–oriented* instead than the more frequent *algorithm–oriented* approach; specific algorithms and their properties are introduced only when necessary to develop identification procedures for the models under study. This choice, which derives from many years of experience in teaching this subject, integrates in a natural way with the multilevel modular structure of the course.

The eleven sections constituting the course are structured into modules concerning base and advanced levels and have the following contents:

Other auxiliary sections linked to previous ones are the following:

The German physician and erudite Georg Bauer, best known as Georgius Agricola, stated, in the introduction of his monumental work *De Re Metallica*, that remained an unsurpassed textbook and guide for miners and metallurgists for 180 years “Io non ho scritto cosa niuna la quale non abbia veduta, o letta o con accuratissima diligenza esaminata, quando che da altrui mi sia stata raccontata” (I have not written anything about what I have not seen personally or very carefully examined when reported by others). Any comparison between this course and the magnificent *De Re Metallica*, whose 290 carvings alone make it an exceptional artwork, would be out of place. I can however state that no parts of it concern schemes, algorithms and procedures not directly tested and applied to data obtained from simulated and real processes.