"The model approximates the complex prototype asymptotically. The trend of the approximation is to become identical with the prototype. In the limit, model and prototype coincide. For a typical example, the best model of a cat is another cat, or indeed, the original cat proper. In other words, if the model realizes the purpose of the prototype in all its aspects, then it is possible to explore the prototype in all detail, and no model is needed".

Norbert Wiener (26.11.1894–18.3.1964)

2

Methodology of Modeling

Modeling, as a specific form of experiment, enables one to recognize the laws of Nature. Its broad development, numerous forms and many application areas have resulted in the fact that modeling has gradually become a relatively disorganized field. It follows from this that modeling methodology is actually itself a problem.

Apart from other things, the task of methodology is to find a common point of view in sorting models, which enables their classification and explains their specific position in a broader system of experimental means. Clearly, this could be a point of view from which to look at information and similarity.

2.1. Identification, Modeling and Simulation

Modeling represents one of the most general ways of representing the outer world and studying the objective laws existing in it. It is an experimental information process where another physical or abstract object, called a model, is assigned unambiguously to the examined system (original, object or work) according to certain criteria. Dynamic system modeling, with direct or indirect feedback on the examined object, is called simulation.

With modeling, diverse forms of similarity and analogy can be connected. In this sense, similarity can be understood as unambiguous mutual assignment between different systems in terms of their structure, properties and behavior. Physical similarity refers to the similarity between systems and processes, having the same physical substances,
and involves, besides geometric similarity, the similarity of parameters and values of the system state. Mathematical similarity expresses the similarity between systems and processes having identical mathematical descriptions. It is called an analogy when it is about different systems and processes. Finally, cybernetic (functional) similarity expresses the mathematical similarity in the external behavior of systems.

In accordance with the above-mentioned three kinds of similarity, modeling can be classified as physical, mathematical and cybernetic. Cybernetic modeling makes use of black box models. This black box concept, introduced by N. Wiener, is understood to be a system which does not deliver any information on its inner structure but on its external behavior only. Opposite to a black box is a white or, better, a transparent box, which represents the inner structure of a system and a process under way in it. Similarly, a grey box concept can be used, delivering partial information about the inner structure of the system. The experiment is the general superior concept to the modeling one.

Essentially, there are two ways to generate a mathematical model (Fig. 2.1). In direct identification, one proceeds from a summary of knowledge about the behavior of the examined object which has been obtained either as a result of the object identification or as a result of the development of knowledge in a corresponding field. Often, the necessary information is obtained indirectly as a result of identification.

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**Fig. 2.1.** Procedure diagram of direct and indirect identification of an object and generation of mathematical and simulation models.