PREFACE

This book presents the systemic model and coordination technology of hierarchical systems for conceptual design of mechatronic and other engineering objects. The conceptual model creation of the mechatronic system (MS) being designed is the actual task which is performed in the frames of automation and robotics, mechatronics, engineering design, computer integrated manufacturing (CIM), computer aided design (CAD) and other related subject fields. Conceptual model of the designed object is usually created before generating concrete mathematical models necessary for design tasks performing at the detailed design phase of the object life cycle [1].

Among the widespread models and methods which are usually used at the conceptual and detailed design phases are the following ones. *Models of classical mathematics* – discrete and continuous – successfully used to model the dynamics or structure of the object being designed, but do not solve the basic problem of design: do not link the structure of the object and its function. *Models of artificial intelligence* are most commonly used when describing the structure of the designed object and design knowledge representation. Solving some specific design problems, these models remain one-level at its core and do not take into account the dynamics of the object being designed and therefore do not perform the general design task in one common theoretical basis. For the case of *logical-dynamical system*s, the dynamical elements of these systems are connected by logical systems in a higher-level structure, thus forming a higher-level system. Such systems are most useful in the design, but they take into account two levels of the designed objects only. *Hybrid systems* use the models of classic mathematics or artificial intelligence in that cases when they work most sufficiently, i.e. use the models of classic mathematics for description of systems dynamics or models of artificial intelligence for structure description of the object being designed. But it is impossible to represent both models of classic mathematics and artificial intelligence in the common formal basis. It complicates the performance of the general design tasks. Other methods and models are described in Chapter 1.

In the book presented, the conceptual formal model of mechatronic systems is created using construction and technology of hierarchical systems (HS) [2] with

their standard element *aed* by S.Novikava and K.Miatluk [3-8], dynamic systems by M. Mesarovic and Y.Takahara [9, 10], numeric positional systems and hierarchical geometry [7, 11, 52]. This conceptual model allows the connected formal descriptions of a mechatronic system structure, its aggregated dynamic representation as a unit in its environment, the system environment, its process and system-environment interactions; the system coordinator and its coordination, i.e. design and control, processes. Besides, the conceptual model takes into account the connected descriptions of mechatronic subsystems of different nature, i.e. mechanical, electronic, electromechanical, and computer. Availability of HS coordinator allows the realization of inter-level connections of mechatronic system being designed.

In this manuscript, the objects under consideration are designed and controlled mecharonic systems described in the theoretical basis of hierarchical systems (HS). The design and control process of mecharonic system is realized by HS coordinator. Mechatronic system (3.1) can be presented according to HS model in forms of mechatronic object (3.2) and process (3.3) being coordinated, i.e. designed and controlled (see Section 3.1). Therefore, *mechatronic system* (MS) in this book can be also called a *mechatronic object* (MO) or *mechatronic process* (MP) depending on the way of its consideration.

At the beginning, an overview of modern approaches and methods of conceptual design and engineering design methods are presented in this book in Introduction – Chapter 1. An overview of wide-spread geometric models which are used in CAD systems is given in Chapter 2. The formal basis of the conceptual model developed with the help of hierarchical systems, dynamic systems, and numeric positional systems is presented in Chapters 3. First, the standard block of hierarchical systems – *aed* (ancient Greek word) – a formal analogue of a two-level system [3,4] is described in Chapter 3. Formal modes of mechatronic object being designed, its environment and their processes are described using dynamic systems [9,10]. The main element – coordinator – which performs design and control tasks on its strata is formally presented using its canonic model. Metrical characteristics of hierarchical mechatronic systems including numeric positional system are given after that. Chapter 4 presents the description of the proposed design method and hierarchical geometric representations of mechatronic objects being designed. The exemplary tasks of the conceptual design of methatronic objects are presented in Chapters 5-9. Among the tasks there are biomechatronic surgical robot system (SRS) design, conceptual design of dinosaur Bioloid robot, human motion design, design and testing of electronic printed circuit boards (PCB), technological manhole cutting machine (MCM) design and control. Conclusive remarks are finally presented in the book.