

Nikolay Avgoustinov

Modelling in Mechanical Engineering and Mechatronics

Towards Autonomous Intelligent
Software Models

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To Tania

Preface

Specificities of Modern Manufacturing

Nowadays, rapid and fundamental changes take place in government, business, technology and society. More than ever before, manufacturing is confronted with environment-related requirements. Globalization and eCommerce have led to the establishment of a demanding consumer market, where at least four general requirements for any single product concern manufacturers more than ever. These are high quality, low price, quick delivery, and last but not least – high customization, leading to an explosively increasing number of variants to be produced and to complexity of the products and their production. In these conditions of increasing competition, the trends to specialization and consolidation of small and medium-sized enterprises are a legitimate consequence.

One of the most challenging tasks related to the product and process modelling (as in many other areas) is the management of expert knowledge. This means that modelling is used in order to accelerate knowledge acquisition, to formalize knowledge representation and to enable knowledge transfer and reuse.

A key to achieving these goals is the proper application of modelling.

About the Book

History

Although I obtained a degree in mechanical engineering, my passion was actually automation and especially the use of computers for supporting it. The success of my first IT-project – my diploma work – was probably the cause for a shift in my professional career towards the interdisciplinary and new at that time field of application of computers for industrial automation. I have worked on many topics from very different areas – some of the more important are data exchange and

conversion, integration of different applications or subsystems, virtual and mixed reality applications, architecture of software systems, 3D-visualization and simulation and even simulation and visualization for medical purposes. At some point in time, I noticed that all these topics have got much more in common than one usually supposes. In short, I have noticed that the efficiency of any solution in any particular field depends primarily on the quality of the models used at the beginning of each process chain. On the other hand, I have also noticed that some problem solving methodologies and tools specific to the separate topics influence the modelling too much. So much so that in extreme cases the experts begin to think in tool-related concepts or notions, and sometimes even forget that they are using models – with all the related consequences. Actually, something similar has happened to me. During the preparation of my PhD thesis about the exchange of product model data among a large number of CAX-systems I was really concentrated on these systems, on the respective standards for exchange and as it seemed to me – on the problems of exchange. It was not until I finished the thesis that I realized: the data exchange – even if it was perfect – is not what is needed! It just helps us to compensate the imperfectness of the CAX-systems and the workflow of product models. It took some time before I realized that what was really needed was *integration*, not data exchange. Starting an investigation of integration and its problems took a long time, and has involved a lot of modelling to overcome the complexity of the matter and to enable the search for a really generic solution.

Ever since I realized the importance of modelling I have tried to learn more about it to obtain more benefits from any area where it has to be applied. As it turned out that modelling itself is not extremely well studied, I decided to investigate it myself. This book is an attempt to systematize and make public all knowledge about modelling and its application in the field of engineering that I have acquired, together with my vision and as many ideas and small discoveries in the area as possible. I believe that once described, each good idea will sooner or later be understood, no matter how bad its description is. And if the idea finds the right public, it starts rolling and growing like a snowball down the hill.

Since I am neither mellifluous (most engineers are not), nor an English native speaker, it was clear to me from the beginning that this book cannot be – at least from a literary point of view – a masterpiece. But even knowing this, I thought that “seeding” ideas is much more important than achieving a high literary quality. I hope that many readers will not only understand and use the presented material, but will be able to explain, respectively describe it much better than me. Perhaps You will be one of those readers? Finally, as Francis Darwin supposedly said, “*in science the credit goes to the man who convinces the world, not to the man to whom the idea first occurs*”.

In short, I hope that some of the ideas described in this book will either be useful to other people or lead to the birth of other novel ideas and thus contribute to the domain knowledge.

Topics/Keywords

Modelling, simulation, integration, reuse, lifespan, lifecycle, autonomy, intelligence, learning, complexity, efficiency can be mentioned as just a few of the more important topics.

Approach

I believe that the terms are tightly connected to the problems and their solutions (cf. Figure 0.1). In particular, the use of proper terms is very important not only to achieve the right understanding of the material, but also to avoid the emergence of pseudo-problems, misleading causes and side effects or improper solutions. Therefore, a great effort has been invested to define all terms used and to make the definitions as clear, precise and non-contradictory as possible. As such a goal is very difficult to achieve, some definitions can be unexpected or at least specific to this study.

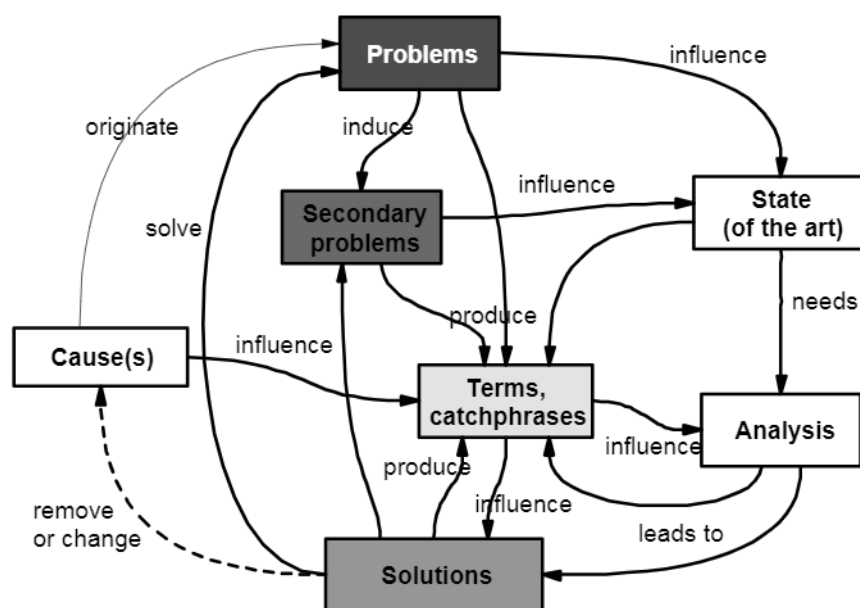


Figure 0.1. Interrelations between terminology and problem solving

A large number of earlier publications by the author are re-thought, improved and integrated in this text.

Ideas or concepts are sometimes presented on the principle of a “nasty commercial” – for some reason, unpleasant or annoying presentations can be memorized better and even against our will.

Some concepts, principles and approaches are used again and again in the reasoning, even when not apparent. This repetitive use happens not because of some particular preferences of the author (although preferences have definitely played a role), but due to their particular suitability for the task at hand. Two of them are the *set theory* and the *Pareto's principle*¹ (also known as the 80:20 rule), although their use cannot always be recognized at first glance.

¹ cf., e.g., Brockhaus, F. A. (Ed.) (1989) Brockhaus Lexikon, Mannheim, Deutscher Taschen Verlag

Audience

The issues discussed in this monograph are of interest to lecturers, researchers and students in the field of mechanical engineering, mechatronics or computer science, but the material could also be useful for programmers and other people interested in or practicing modelling of products or processes. I hope that the book can be of use also for people, involved in creating CAX-systems or dealing with them in any way – system architects, analysts, decision makers, *etc.* Finally, scientists dealing with either models or modelling in other scientific areas could find (parts of) the material useful.

Text Organization

The main text is organized in five chapters.

Chapter “Introduction” starts with the motivation for the writing of this monograph, discussed on the background of the actual problem area.

Chapter “Modelling Basics” defines basic terms in modelling, presents its objectives, and gives some possible modelling classifications based on different criteria.

Chapter “Conventional Product and Process Modelling” discusses in detail the problems of conventional product and process modelling, as well as some general problems related to the use of computer aided systems in different areas of mechanical engineering. Complexity, its consequences and the ways to master it, as well as the integration-related issues are just few of the viewed important topics.

Chapter “Towards Better Product and Process Modelling” starts with a preview of some of the known recent approaches in this area, which are trying to avoid the problems of the conventional approach. From the analysis of these approaches and from the modelling issues, reviewed in the previous chapter, is derived a set of requirements for an idealized “perfect” modelling approach. Later on, a novel approach to product and process modelling is presented, which exhibits potential for achieving better results with regard to reusability, integrability of heterogeneous models, flexibility, maintainability, *etc.*

The “Conclusion” and “Perspectives” present a final discussion, a general overview of future prospects as well as some plans for future work.

An index and a list of the used in the text abbreviations are included at the end of the monograph.

Disclaimer

As almost every other technical book, this one also does not contain only new material – in many places other people's views or opinions are presented, discussed or extended. The author did his best with referencing and giving credit always when possible. Should there be any occasion where this is not the case, it is not intentional. All trademarks and registered trademarks, mentioned in the text, belong to their respective owners.

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