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## From the Main Author

As a main author of Mechatronic Servo System Control (in Japanese), I would like to express my thanks to Dr. Zhang Tao who translated our book into English. The authors, myself, Dr. Goto and Prof. Kyura published the original book which mainly consisted of the authors' original research achievement of mechatronic servo systems control during last over ten years. The original book was fortunately awarded as the best book from the Society of Instrument and Control Engineering (SICE in Japan) in 2001. Moreover, the book was already translated into Korea language by a Korean publisher. As the authors believe that our book is effective for students and engineers who are involved in the field of Mechatronic Control and Robotics, we have been intended the translation of it in English. The authors themselves made the Japanese-English dictionary for the terminologies in the book, and ask to Dr. Zhang Tao for the translation of the book by use of the dictionary. Dr. Zhang Tao has completed the translation by use of his every night times during last several months. I would like to show my great gratitude for his effort for the translation. I also express my great thanks to Prof. Jeffrey Johnson and Dr. Mike Richards (Open University in UK) who helped the final check of the translation.

November 2002

Main author Masatoshi NAKAMURA



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## From the Translator

Since the term "Mechatronics" was first introduced by a Yaskawa Electric engineer in 1969, and its rigorous definition was given by a technical committee, i.e., The International Federation for the Theory of Machines and Mechanism (IFToMM), as "*Mechatronics is the synergistic combination of precision mechanical engineering, electronic control, and systems thinking in design of products and manufacturing processes*", the development of mechatronic techniques has led to widespread adoption of electronics in machinery. At the same time, as one of the key techniques of mechatronics, servo control system has been well defined for various kinds of mechanical system. At present, mechatronic techniques are essential for advanced mechanical engineering. Furthermore, the introduction of servo control system design to engineers engaged in mechanical engineering is thought to be indispensable.

As a researcher on mechatronic technique, when I firstly read the Japanese version of this book "Mechatronic Servo System Control", written by Prof. Nakamura, Dr. Goto and Prof. Kyura, I was attracted by its meticulous study on the issues of mechatronic servo control system arising from mechanical engineering as well as the significance of application. Additionally, I aroused a strong desire to transfer its valuable achievements to whole researchers and engineers who are engaging in the mechatronic techniques or willing to obtain knowledge related with mechatronic techniques. After I heard that this book was awarded the 2001 Works Reward of The Society of Instrument and Control Engineers (SICE), and Prof. Nakamura also had the same desire to translate it into other languages for readers, I expressed my strong wish to be responsible for translating this book into English. With deep trust and great encouragement from Prof. Nakamura, I started this challenging project from one year ago.

Through the great efforts, the English version of "Mechatronic Servo Control System" was finished recently. As I read the English version of this book once again, I have also obtained great enlightenment from it, particularly for my further research on mechatronic techniques. From the contents of this book, I believe all readers will share the same feeling. The profit of this book

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will be reflected not only in the research or teaching on mechatronic techniques, but also for engineers working on mechanical engineering.

Finally, I also want to express my great gratitude to Prof. Nakamura, Dr. Goto and Prof. Kyura to distribute such a great valuable book on their achievements within several decades of years to whole readers. For the kindly help from Dr. D. Kushida during the period of my translation, especially the valuable review of this book from Prof. Jeffrey Johnson and Dr. Mike Richards, Open University, UK, I transfer my deep appreciate to them.

Because of my insufficiency of knowledge on translation between Japanese and English, there might have some mistakes in this book. It will be very kind if you can indicate them to me and I will make my best efforts continuously to improve them.

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Tao ZHANG

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## Preface

The editor and composer is engaging in the study on systems control and their applications in university. As one of his research fields, with a plenty of opportunities of discussion with Kyura, who is long-term working on the servo controller design and its application in mechatronic industry, on the control of mechatronic machine during the past ten years, the cooperative research has been made greatly progress. These discussion meetings were held several times once a year. Achievements on the items of these discussion meetings were compiled into reports, each of which has between 50~100 pages. Then, many valuable commends were obtained from Kyura in terms of these achievements. Moreover, new research directions were found. The distributions of co-authors are that,

Kyura illustrated the issues on the control in the servo parts of an industrial robot adopted in industry, numerical control working machine, three-dimensional measurement machine, a mechatronic machine called a chip mounter, etc.;

Nakamura explained these issues in systems control theory and formulized the obtained crucial points of problem solution;

Goto made computer simulations for the solution of these problems as well as verified the appropriation of these distinct theoretical results by using mechatronics-related experimental devices in the laboratory. In addition, among the undergraduate students, master students, doctor students who have interests in the control of mechatronic servo system, some items were allocated to them and the relevant achievements were obtained by research supervision. So far, about 60 conference presentations as well as 20 reviewed papers on the mechatronic control have been completed.

Based on the above research story, the motivation of writing this book was written down. Through the question answering in the conference for presenting the obtained research achievement or dealing with the paper reviewers or the conversation in the visiting the universities or research institutes which are doing research on robot manipulator, we felt strongly that a lot of researchers

or engineers have many misunderstanding on the already solved problems in industry.

In fact, according to the words of coauthor Kyura, the strategies for the encountered problems in the servo controller design in industry depending on the experience with trial errors of designers and engineers are just responding to the demand of the world. These technologies have not become distinct in the so-called know-how world. Since they are not logical strategies, even successfully performing them, there are still many cases that the understandable explanation can not be obtained. In industry, even the clarification of the undesired points was conducted concretely, the contents are not announced. It is still in the present condition that why the good pursuit is hardly realized.

Through the collaboration, the essence of problems encountered in industry was analyzed and formulized logically and mathematically. According to the solution of derived equations and the verification of justifiability of these results, many useful items were obtained. At the present time, these items are summarized systematically. The opaque technologies under the name of know-how until now are explained distinctly. Therefore, many researchers or engineers can know them widely and effectively use them. These are the motivation of writing this book.

The problems discussed in this book are based on the common needs of industries rather than the pending problem areas of one research engineer in industry. The results for them, which were being caught empirically until now, are clarified logically. Therefore, the results are adapted for a real machine, and various performances or control methods of controller design previously determined with the experience of an expert can now be decided logically based on the adopted results. Moreover, a know-how only suitable for special situations until now, is changed into a more complicated and more ingenious universal technology. This book is unique in handling these problems.

The organization of this book is that, the design of the servo controller of mechatronic servo system is with respect to the fields of modeling, analysis and controller design control. It is from the introduction to the following chapters till 7.

In the introduction, the outline of mechatronic servo system and its main points of the problem in industry are given.

In chapter 2, these problems are solved reasonably, which are the achievements of cooperative research of co-authors. In each chapter, main points are attached.

The present conditions and problems in industry, main results, significant of results as well as the explanation of the main points of applications about each item are conducted at the commencement of each chapter.

It is acceptable even if the reader reads this book from the beginning. For the reader who wants to learn with the purpose of understanding, it is also good to learn each section of one chapter for dealing with the problems which are combined from the problems personally held and described in introduction. In each section of each chapter, main points are inserted at the beginning of

each section for recommending the text reading thoroughly. The contents of each section are based on one of authors' papers which is specified with the quotation article number in the place of the bibliography list. Finally, the book contains an index, a glossary of terms, a collection of symbols and a description of the experimental devices used in our experiments.

During preparation, the book was read with distribution of sections of this book by seven master students of department of advanced systems control and engineering, graduate school of science and engineering, Saga university (Mr. Shigeto Aoki, Mr. Tatsuro Katafuchi, Mr. Daisuke Kushida, Mr. Kenta Shiramasa, Mr. Shojiro Yamagami, Mr. Masashi Tamura, Mr. Minoru Nishizawa). Referring to their impressions of the book, the book was revised to improve readability. The significance of the problems took up in this book and the efforts are in making the essence of a problem to the formula appropriately. The keys to solution of many formulas are the easily adopted basis of classical control (Laplace transformation) or modern control (differential equation) learnt with the university bachelor degree, and the most fundamental knowledge in the control theory explained in appendix. Therefore, not only the enterprise directly related with system control or postgraduate students of university or researchers, but also the undergraduate students with the purpose to make the theory learnt in university into practice can be expected to read it widely. We expect that the knowledge obtained from this book can be adopted widely in mechatronic industries, and expect simultaneously that the research planted the root in this kind of ground will be expanded at the research institute etc. of an enterprise and, especially and university.

At the end of the preface, since the materials of this book are all obtained from the cooperative research, the conditions of cooperative research, thoughts and feelings aroused from the cooperative research, are written as below, though it may be redundant.

1. The cooperative researcher should be proficient in each field.
2. Keep frequent discussion for a long time among cooperative researchers.
3. Respect the views of the partner mutually.
4. Fine mutual human relations.

Concerning the writing of this book, Mr. Kojiro Kobayashi, Department of production of the Morikita press, and Mr. Shoji Ishida, Department of compilation of the Morikita press, took care of it very much. All my great gratitude are here expressed.