Foreword

Most people are familiar with the "mad scientist," usually a brilliant, sometimes comical figure found in books and movies. Years ago I developed the motif of the "MAD control engineer" as a way to inspire a bit of passion and even brilliance in the students taking my feedback control classes. As such, I am pleased to see the new edition of this book, *Modelling, Analysis and Design of Control Systems in MATLAB and Simulink*, by Professors Xue and Chen, which follows the same motif.

"MAD" is an acronym that stands for Modeling, Analysis, and Design. My particular perspective is that these are the three essential activities required to design a control system. Specifically, given a physical system that we want to control, along with a desired behavior or performance for the controlled system, we determine a control law that will cause the closed-loop system to exhibit the desired behavior by:

1. **Modeling** (mathematically) the system, based on measurement of essential system characteristics.

2. **Analysis** of the model to determine the properties of the system.

3. **Design** of the controller which, when coupled with the model of the system, produces the desired closed-loop behavior. This will involve development of

   (a) Control law algorithms.

   (b) Measurement and testing techniques for the specific physical system.

   (c) Signal processing and Signal conditioning algorithms necessary for interfacing the sensor and controller to the physical system and to each other.

   (d) Simulation studies of the individual components of the control system as well as simulation of the closed-loop system in which all the components are interconnected. Simulation studies are an essential part of the design and development process and are highly dependent on the models obtained from the measurement process.

Wrapped around these three activities are two other key parts of the controller development process:

1. **Development of performance specifications** that define the objective of the control design.

2. **Implementation of the controller** through software and hardware realizations of the control law, including complete specification of the sensor, signal processing, and control elements, and final assembly, testing and validation, delivery, and operation of the control system.

The five activities described above are summarized in Figure 1, which shows an overall conceptual flowchart of the control system design process. As shown in the figure, starting with the original system we wish to control (defined as including the plant, sensors, and actuators), we proceed with two tasks in parallel: defining the required performance specifications and developing a model of the process. The modeling activity will often include some form of measurement to determine key system properties. Note that mathematical modeling is a particularly important part of the process of control system development. By having a framework for describing the system in a precise way, it is possible to develop rigorous techniques for analyzing and designing systems. Once a math model is available and we have decided the goal of the design, it is possible to proceed with the analysis of the model and design of the control law. Finally, once the control law is finalized the implemented controller is combined with the physical system to collectively act as a new system - one that meets the desired performance.

Central to the process shown in Figure 1 is the iteration of simulation, modeling, and design. Indeed, in today's world simulation cannot be separated from analysis and design. Further, the process of arrive at a math model of the controller is itself a feedback process. Once a controller model is defined it is necessary to evaluate its effectiveness in combination with the math model of the process (via simulation of the complete control system) before proceeding to implementation. We also note that today the process of going from a completed math model of the controller to its implementation is typically highly coupled to the same software environment used for simulation, using a hardware-in-the-loop approach to rapid prototyping. One such environment is the MATLAB/Simulink package.

This discussion then brings me back to the present book by Professors Xue and Chen. My pleasure in the new edition comes from seeing how first they have developed an exposition that embodies the perspective of the MAD Control Engineering and second they have integrated the real-world practices of simulation as part of analysis and design process together with controller implementation using rapid prototyping tools, using MATLAB/Simulink. I believe students who study and follow this text will be well-equipped to "hit the ground running!"

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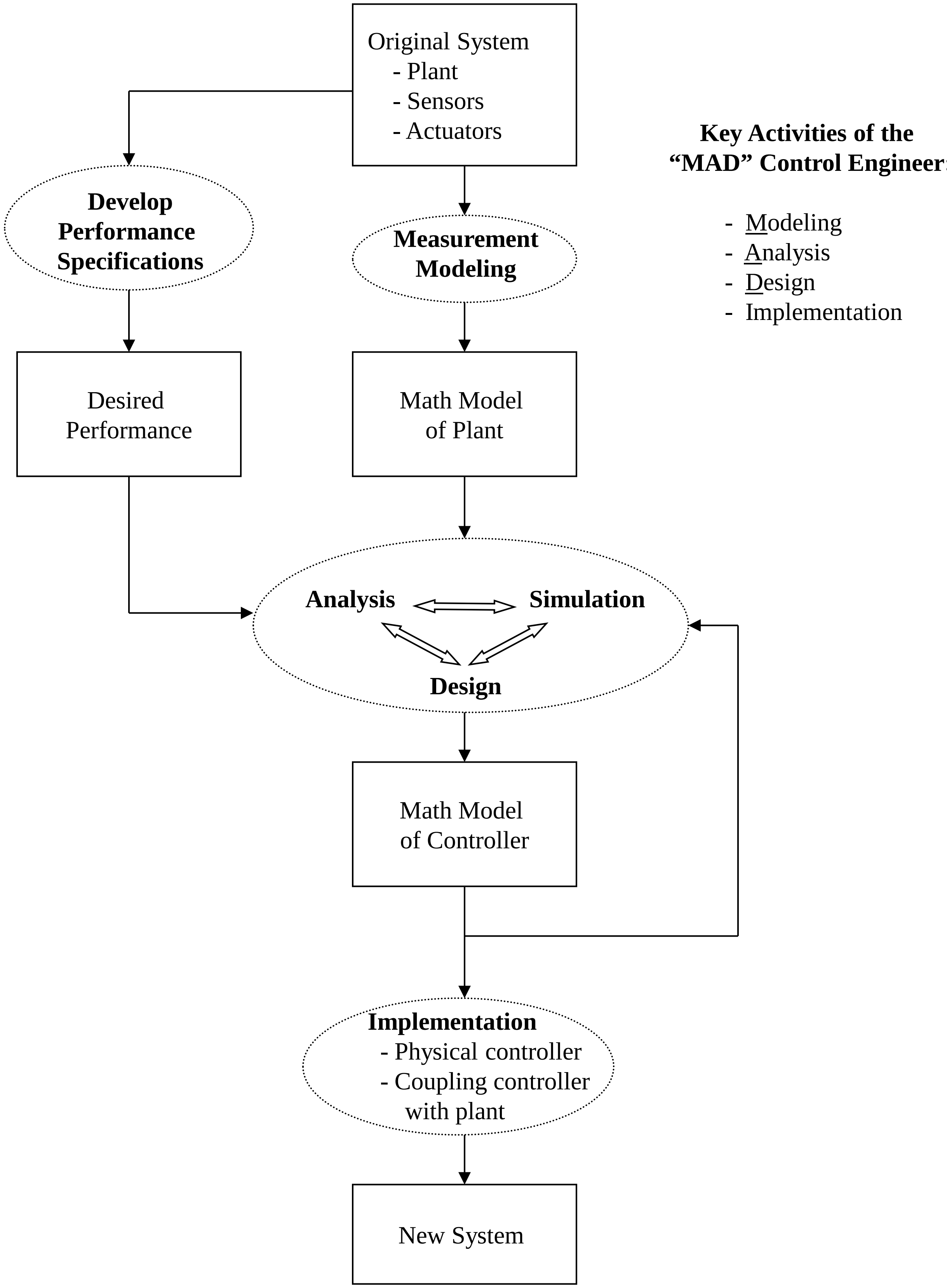

Figure 1: Flowchart of the control system design process.