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A review of “Principles of Robot Modelling and Simulation” by S. M. Megahed

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Principles of Robot Modelling and Simulation. By S. M. MEGAHED (Wiley) [Pp. xviii +312.]
Price £39.95.

Principles of Robot Modelling and Simulation is primarily concerned with the mathematical and computational issues in the modelling and simulation of industrial robots. The interest in modelling these mechanisms stems from a desire to design robotic workplaces, work tasks and the mechanical and control elements of robot devices themselves. There is also considerable interest in off-line programming of robots as a means of reducing robot downtime and minimising hazards to human operators.

This particular book is clearly a direct result of the author's research work in the field. This has several benefits in that the material is presented in the well-structured way that is a natural consequence of thorough first-hand research of the literature, is detailed and precise rather than general and descriptive and evaluates the alternative approaches to particular problems - not just the author's favoured solution. The only drawback, which could be seen as an advantage by some, is the detailing of the author's use of symbolic programming techniques. Most of this is consigned to appendices, but as these follow each major chapter it does interrupt the reader's progress through the book.

The first chapter provides a very brief summary of some aspects of robot technology and passes through the familiar territory of defining robots, identifying application areas and describing industrial robots in terms of their mechanical, drive, transmission, sensory and control systems.

The main body of the book is contained in chapters 2-6 which address the issues of geometric modelling, transformations, direct kinematics, inverse kinematics and dynamic modelling. In common with most work in this field, it is assumed that robots have a basic structure of three joints to which is appended a three degree of freedom wrist. The geometric modelling chapter is mainly concerned with developing analytical solutions capable of predicting reach envelopes for different basic structures or revolute and prismatic joints. Chapter three gives a very thorough description of orientation description methods (rotation matrix, quaternions, rotation vectors and Euler parameters), the use of homogeneous transformation matrices and the important Denavit-Hartenberg notation.

Direct kinematic modelling refers to the process of determining the location and velocity of the endpoint of the robot arm from a knowledge of individual joint locations and velocities. This relatively straightforward analytic problem which is also sometimes known as forward kinematics is discussed in chapter 4. One of the difficulties is that each type of robot configuration requires a different set of analytic equations and the author's method of symbolic programming as an aid in overcoming this problem whilst improving computational efficiency is described in some detail.

The fifth chapter tackles the more complex problem of inverse kinematics where the objective is to predict the location and velocity of individual joints from a knowledge of the motion of the robot endpoint. Again there is the dependency on the kinematic structure of the robot, but this time there is the added potential difficulty of there being no single analytic solution. Analytic and numeric methods are described in some detail, again in relation to symbolic programming methods.

Chapter six investigates the dynamics of robots in both the direct form where the objective is to determine the forces required to generate known joint velocities and accelerations, and the inverse form where the forces are known and the joint accelerations are to be determined. The well-known Newton-Euler and Lagrange Equations of Motion methods are described together with some useful computational procedures from the author's own work.

In the final two chapters the content starts to tail off dramatically. Some useful work on identification (determining the parameters required by the various simulation equations) is followed by a brief survey of commercially available modellers, a superficial look at robot languages, some statistics on usage of robots in various countries and an appendix listing the characteristics of eight commercial robots.

This is a book for the serious student of robotics and, as its title implies, its primary objective is to provide a comprehensive treatise on the mathematical aspects of modelling for the purpose of computer simulation. It succeeds well in this objective and the extensive references and bibliography for each chapter will be useful to those seeking even deeper knowledge. The book deserves to take its place alongside one or two earlier publications of similar stature where it can become a most useful addition to the knowledge available to those researching, teaching and learning about robotics.

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