Preface

Outline of Content

This book is organised into three sections, Part I introduces modelling techniques and models used to represent application used later to evaluate solution processes and procedures.

Part I: Introduction to Modelling and Model Evaluation.

This part introduces modelling methodologies and models to be used as starting points to enable the derivation of efficient and effective solution techniques.

Part II: Case Studies.

This part presents a series of case studies to demonstrate how heuristic and analytical approaches may be used to solve large complex problems.

A series of case studies are presented where models are constructed and then analysed and evaluated to derive efficient and effective ways to produce good solutions.

Within Part I:

Chapter 1: Model Building. This chapter introduces the modelling methodologies:

Activity life cycles and problem analysis using activity life cycles.
Constructing models from "Big Data".
Blackboard modelling.

Chapter 2: Introduction to Cellular Automata in Simulation. This chapter aims to show how both these approaches can be used as modelling tools.

Introduction to cellular automata.
Cellular automata are introduced by way of Conway's Game of Life and applying agents.

Simulating the spread of an infection through a population.
Traffic modelling, investigating traffic flows.

Chapter 3: Introduction to Mathematical Programming. The aim in this chapter is to demonstrate how a mathematical programming model can be used to describe and explain the complexity of a planning problem and hence lead towards an efficient solution technique or methodology.

Whether (these) problems have easy solutions or because of the inherent complexity of the form of the required solution, they are better approached using heuristic techniques (generally accepting good rather than best solutions).

To achieve this objective, the following problems are presented:

Diet problems, the very obvious formulations (Stigler and Dantzig), lead to an undesirable solution (only one meal!), and a more heuristic approach is needed to add incorporate multi-objectives that typically minimise cost while maximising variety/taste.
Knapsack problems, showing how many problems are reducible to knapsack problems and are therefore appropriate for the use of heuristic solution techniques.
Network flow problems, again many planning problems can be modelled as network flow problems and hence can be solved easily.

Chapter 4: Heuristic Techniques in Optimisation. This part introduces approaches that can be used to obtain good solutions to hard or large problems comparing and contrasting the effectiveness and efficiency of heuristic approaches to problem-solving.

To achieve this objective, the following approaches are presented:

Genetic algorithms implementations illustrated through its application in producing solutions to knapsack problems, travelling salesman problems, scheduling problems, and quadratic assignment problems.
Tabu search implementations illustrated through its application in producing solutions to financial planning and travelling salesman problems.

Chapter 5: Introduction to the Use of Queueing Theory and Simulation. This chapter shows how queueing theory and simulation techniques can be applied to design efficient and effective service systems.

The major sections are concerned with the following:

Queueing theory leading to “quick” modelling, how queueing theory can be employed to carry out an evaluation of a manufacturing system.
Simulation modelling, introducing an alternative approach to modelling complex planning problems.

Part II: Case Studies

This part presents a series of case studies to demonstrate how heuristic and analytical approaches may be used to solve large complex problems.

A series of case studies are presented where models are constructed and then analysed and evaluated to derive efficient and effective ways to produce good solutions.

May be solved typical suggested applications, presenting alternative approaches to problem solving

Chapter 6 describes an investigation into the appropriateness of heuristic methodologies in the solution of

Travelling salesman problem.
Garbage collection problem, a multiple travelling salesman (type) problem.
Production planning and control problems, where a seemingly hard problem can be shown to be solvable using a simple heuristic approach reducing the need for cost data.

Chapter 7 describes how an efficient heuristic approach can be derived from an initial complex model using the following:

Flow shop scheduling, showing how a hard problem can be approached using heuristic methods.
Transport planning, deriving approaches to evaluate the benefits to be gained from the installation of an active traffic control system and the paradoxes resulting from changes to transport planning.

Chapter 8 describes an investigation into the production of an efficient and effective means of scheduling air traffic controllers, where the method used has to have the ability to respond (create a new schedule) rapidly to staff availabilities.

Chapter 9 describes how a multiple objective optimisation problem can be solved by the incorporation of techniques from genetic algorithms and fuzzy logic into a mathematical programming methodology.

This approach is illustrated by its application into the provision of solutions to a diet problem with the extended objectives:

Minimise cost.
Produce a healthy diet.
Produce a large variety of good diets.

Chapter 10 describes an investigation into the application of fuzzy logic showing how it can be used to derive a dynamic method of scheduling operations in a workshop.

This approach is applied to a workshop where there are multiple objectives:

Importance of customer and delivery due dates, using fuzzy logic to derive work schedules.

Chapter 11 describes how an approach based on tabu search methodologies can be employed to derive optimal control settings.

This approach is illustrated through its application to a Surround Sound 5 speaker system determining settings so that the system could produce "perfect" directional sound.

Chapter 12 describes how system dynamics modelling can be employed to describe the output from complex decision making processes.

Models are constructed to describe

the changes in the Dow Jones index, from growth to decline, and
the changes in the dominant mode of transport (with time) and the effect of these changes on the prior dominant modes.

Chapter 13 describes the use of queueing theory in the evaluation of traffic control systems (traffic lights) showing how the system could be improved through the use of "available forward road capacity" that is passing information between traffic lights.

Chapter 14 describes case study investigations into the use of cellular automata and agent-based simulations.

The case studies are based on message passing, by mobile devices, within a closed environment (a shopping centre for example) and
The spread of a fire and the improved positioning of the fire exits in a closed environment.

Chapter 15 discusses the use of "Big Data" to derive models.
Three case studies are provided.

Criminology,
Depression evaluation, and
University admissions.

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