

Pietro Carlo Cacciabue

Modelling and Simulation of Human Behaviour in System Control

With 113 Figures



Springer

CONTENTS

Foreword	xi
Author's Preface	xv
Acknowledgements	xix

Chapter 1. A Framework for Human-Machine Interaction Simulation

1.1 Introduction	1
1.1.1 Human-Machine System	2
1.1.2 Models and Simulations	4
1.1.3 Modelling Modern Working Contexts	6
1.2 Types and Applications of HMI Simulation	8
1.2.1 Types of Cognitive Simulation and Types of Analysis	8
1.2.2 Types of Application	10
1.3 Elements of HMI Simulation	15
1.3.1 Micro-Cognition, Macro-Cognition and Simulation	15
1.3.2 Theoretical Content of HMI Simulation	18
1.3.3 Practical Implementation of HMI Simulation	27
1.4 An Architecture for HMI Simulation	33
1.4.1 Interaction Model and HMI Simulation	34
1.4.2 Interaction Model and Data Management	36

1.5	A Data Architecture	40
1.5.1	Taxonomies	40
1.5.2	Data and Parameters	42
1.5.3	Data and HMI Simulation Architectures	44
1.6	A Framework for HMI Simulation	45
1.6.1	Elements of Framework	45
1.6.2	Mechanisms of Framework	47
1.7	Summary Requirements and Specifications.....	49
1.7.1	Areas of application	50
1.7.2	Models, Simulations and Data.....	51
1.7.3	Types of Analysis.....	54
1.7.4	Tables of Requirements and Specifications.....	55
1.7.5	Conclusions	57

Chapter 2. Engineering Methods and Cognitive Task Analysis

2.1	Introduction	59
2.2	Engineering Methods for Detection, Diagnosis and Action.....	60
2.2.1	Theory of Communication	62
2.2.2	Signal Detection and Other Monitoring Theories	63
2.2.3	Control Theory	65
2.3	Engineering Methods for Planning and Decision Making.....	71
2.3.1	Fuzzy Set Theory	71
2.3.2	Qualitative-Physics Theory	76
2.3.3	Artificial Intelligence and Expert Systems	78
2.4	Cognitive Task Analysis.....	80
2.4.1	Scope of Cognitive Task Analysis.....	81
2.4.2	Structures and Forms of Cognitive Task Analysis.....	82
2.4.3	Outcomes of Cognitive Task Analysis	85

2.5 Qualitative-Physics Model for the Control of a Steam Generator	90
2.5.1 Structure of Models, Simulations and Data	90
2.5.2 Quantitative and Qualitative-Physics Models of Physical Processes	92
2.5.3 Quantitative and Qualitative-Physics Models of the Regulator	98
2.5.4 Qualitative-Physics Simulation of Human Machine Interaction....	101
2.6 Summary	104

Chapter 3. Models and Simulations of Cognition

3.1 Introduction	107
3.2 Review of Models of Cognition	108
3.2.1 SHEL Model	110
3.2.2 Model of Human Problem Solving.....	113
3.2.3 Step-Ladder, Skill-Rule-Knowledge Model	117
3.2.4 Model of “Fallible Machine”	122
3.2.5 Basic Supervisory Control Paradigm	126
3.2.6 Contextual Control Model.....	131
3.2.7 Comparison of Cognitive Models	136
3.3 Review of Simulations of Cognition.....	142
3.3.1 The Simulation AIDE.....	144
3.3.2 The Simulation CAMEO.....	147
3.3.3 The Simulation CES.....	149
3.3.4 The Simulation COSIMO.....	154
3.3.5 The Operator Function Modelling - OFM.....	156
3.3.6 The Simulation of a Group - SYBORG.....	160
3.3.7 Other Cognitive Simulations	163
3.4 Guidelines for Development of a Simulation	173
3.4.1 Definition of Problem Boundaries and Aim of Simulation	175
3.4.2 Cognitive Task Analysis and Field Study of Working Context.....	175
3.4.3 Selection of Theoretical Model	176

3.4.4	Selection of Numerical Algorithms and Implementation in Programming Language and Environment	176
3.5	An Example of Application	177
3.5.1	Definition of Problem Boundaries and Aim of Simulation - Case Study COSIMO	177
3.5.2	Cognitive Task Analysis and Field Study of Working Context - Case Study COSIMO	178
3.5.3	Selection of Theoretical Model - Case Study COSIMO.....	179
3.5.4	Selection of Numerical Algorithms and Implementation in Programming Language and Environment - Case Study COSIMO.....	187
3.5.5	Simulation of Problem Solving Situations by COSIMO	194
3.6	Summary	204

Chapter 4. Modelling Machine and Interaction

4.1	Introduction	207
4.2	Models and Simulations of Machines.....	208
4.3	Interaction Model.....	210
4.3.1	Algorithms for Interaction Models	211
4.3.2	The DYLAM Methodology.....	213
4.4	The Chemical and Volume Control System Case Study	221
4.4.1	Plant Description and Accident Scenario - Case Study CVCS.....	221
4.4.2	Machine Model and Simulation - Case Study CVCS	223
4.4.3	Human Model and Simulation - Case Study CVCS	226
4.4.4	Interaction Model - Case Study CVCS.....	238
4.4.5	Results of Case Study CVCS.....	243
4.5	The Auxiliary Feed-Water System Case Study.....	268
4.5.1	Plant Description and Accident Scenario - Case Study AFWS	268
4.5.2	Machine Model and Simulation - Case Study AFWS	276
4.5.3	Human Model and Simulation - Case Study AFWS.....	284
4.5.4	Interaction Model - Case Study AFWS	301
4.5.5	Results of Case Study AFWS.....	305

4.6 Critical Review of Case Studies CVCS and AFWS	327
4.7 Summary	330
Acronyms and Abbreviations	333
References	337
Subject Index	351
Author Index	355