

TABLE OF CONTENTS

	Page
TABLE OF CONTENTS	i
LIST OF TABLES	ii
LIST OF FIGURES	v
INTRODUCTION	1
OBJECTIVES	6
LITERRATURE REVIEW	8
MATERIALS AND METHODS	50
Materials	50
Methods	50
RESULTS AND DISCUSSION	83
CONCLUSION AND RECOMMENDATION	138
Conclusion	138
Recommendation	142
LITERATURE CITED	145
APPENDICES	154
Appendix A the details of input information of a Pak Phanang coastal gate system	155
Appendix B the details of input information used for providing the training and testing data set for Artificial Neural Networks	215
Appendix C the configuration of CoastalGate model	243

LIST OF TABLES

Table	Page
1 The input and output data requirement for hydrodynamic model	40
2 The principal subcatchment areas of Pak Phanang River Basin	71
3 The details of telemetering stations installed Pak Phanang River Basin	72
4 The sensitivity analysis results The sensitivity analysis results of maximum number of generations and number of population.	85
5 Satisfaction function value on effects of varying F and CR values for Pak Phanang coastal gate system	86
6 The values of weighting factor and relative importance given for FOP#1	88
7 The values of weighting factor and relative importance given for FOP#2	89
8 The values of weighting factor and relative importance given for FOP#3	89
9 The desired criteria used for controlling a coastal gate system located in PPRB	90
10 Comparison of satisfaction function value for four study cases	98
11 Summary results of state variables at control points of ten controlled gates for four study cases	109
12 The sensitivity analysis results of maximum number of generations	123
13 The sensitivity analysis results of the number of population	123
14 Satisfaction function value on effects of varying F and CR values for a hypothetical coastal gate	125
15 Sample of training data set for Artificial Neural Networks	126
16 Details of input variables used for training different ANNs controller	128
17 Training and testing results of ANNs model for coastal gate operations	129
18 State variables comparison between ANNs and reference model controllers	133

LIST OF TABLES (continued)

Appendix Table	Page
A1 Node information of river network	156
A2 Branch information of river network	158
A3 Cross section and roughness coefficient of river network	161
A4 Structural information	185
A5 Transition sectional data	186
A6 Flow direction data	190
A7 Sample of gate operation data	193
A8 Node and upstream hydrograph pattern number data	194
A9 Upstream hydrograph pattern data	196
A10 Downstream boundary data	198
A11 Initial discharge data	199
A12 Initial water level data	201
A13 Node information used for salinity submodel	203
A14 Boundary condition (ppt) used for salinity submodel	204
A15 Initial condition (ppt) used for salinity submodel	205
A16 Diffusion coefficient (m^2/s) used for salinity submodel	206
A17 Node information used for BOD/DO submodel	207
A18 BOD boundary condition (mg/l) used for BOD/DO submodel	208
A19 DO boundary condition (mg/l) used for BOD/DO submodel	208
A20 Initial condition (mg/l) used for BOD/DO submodel	209
A21 Diffusion coefficient (m^2/s) used for BOD/DO submodel	210
A22 Load data of BOD/DO used for BOD/DO submodel	211
A23 BOD and DO parameters used for BOD/DO submodel	213
B1 Node information of river network	216
B2 Branch information of river network	216
B3 Cross section and roughness coefficient of river network	217
B4 Structural information	223

LIST OF TABLES (continued)

Appendix Table	Page
B5 Transition sectional data	223
B6 Flow direction data	224
B7 Sample of gate operation data	224
B8 Node and upstream hydrograph pattern number data	224
B9 Sample of upstream hydrograph pattern data	225
B10 Sample of downstream boundary data	227
B11 Sample of initial discharge data	229
B12 Sample of initial water level data	230
B13 Node information used for salinity submodel	231
B14 Boundary condition (ppt) used for salinity submodel	232
B15 Sample of initial condition (ppt) used for salinity submodel	233
B16 Diffusion coefficient (m^2/s) used for salinity submodel	233
B17 Node information used for BOD/DO submodel	233
B18 BOD boundary condition (mg/l) used for BOD/DO submodel	234
B19 DO boundary condition (mg/l) used for BOD/DO submodel	235
B20 Sample of initial condition (mg/l) used for BOD/DO submodel	236
B21 Diffusion coefficient (m^2/s) used for BOD/DO submodel	236
B22 Load data of BOD/DO used for BOD/DO submodel	237
B23 BOD and DO parameters used for BOD/DO submodel	241
B24 The values of weighting factor and relative importance used for deriving coastal gate operating rules	241
B25 The desired criteria used for deriving coastal gate operating rules	242

LIST OF FIGURES

Figure	Page
1 Illustration of the crossover process for $D = 7$ parameters	14
2 The overall processes of DE	15
3 The example of using DE for solving a simple objective function	16
4 A typical neural network structure	24
5 Flowchart of the Back Propagation Algorithm	27
6 The architecture of the generalized regression neural network	28
7 Pattern unit of the radial basis function network	29
8 Training process of supervised control	31
9 The use of trained neural network for control	31
10 Schematic standard Tank Model	43
11 Schematic diagram of ROM model: real time mode	48
12 Schematic diagram of ROM model: forecasting mode	49
13 The overall framework of coupling simulation and optimization model	57
14 Sample code fragment from routine to prevent violation of physical bounds on gate operations	58
15 Sample code fragment from routine to prevent alternate optimal solution	60
16 The input-output file management of hydrodynamic and water quality model	65
17 Flow diagram of the main processes in CoastalGate model	68
18 A satellite image showing the boundary of the Pak Phanang River Basin	70
19 Map showing the location of telemetering stations installed in PPRB	73
20 Schematic diagram showing coastal gate system of PPRB	75
21 Schematic diagram of hypothetical coastal gates system	79
22 The overall framework of NGO-ROM model	82
23 Optimal crest level setting for Uthokawiphatprasit gate	91

LIST OF FIGURES (continued)

Figure	Page
24 Optimal gate opening for Sua Hueng gate	92
25 Optimal gate opening for Pakrawa gate	92
26 Optimal gate opening for Emergency gate	93
27 Optimal gate opening for Thapraya gate	93
28 Optimal gate opening for Klong Khong gate	94
29 Optimal gate opening for Chian Yai gate	94
30 Optimal gate opening for Bang Sai gate	95
31 Optimal gate opening for Sukoom gate	95
32 Optimal gate opening for Praekmueng gate	96
33 Satisfaction function value for coastal gate system versus control horizon	98
34 The state variables versus control horizon at checkpoints of Uthokawiphatprasit gate	112
35 The state variables versus control horizon at checkpoints of Sua Hueng gate	113
36 The state variables versus control horizon at checkpoints of Pakrawa gate	114
37 The state variables versus control horizon at checkpoints of Emergency gate	115
38 The state variables versus control horizon at checkpoints of Thapraya gate	116
39 The state variables versus control horizon at checkpoints of Klong Khong gate	117
40 The state variables versus control horizon at checkpoints of Chian Yai gate	118
41 The state variables versus control horizon at checkpoints of Bang Sai gate	119

LIST OF FIGURES (continued)

Figure	Page
42 The state variables versus control horizon at checkpoints of Sukoom gate	120
43 The state variables versus control horizon at checkpoints of Praekmueng gate	121
44 Comparison of input patterns and ANN types in terms of AAE	131
45 Comparison of input patterns and ANN types in terms of R^2	131
46 Comparison of upstream water levels under the control of ANNs and CoastalGate model	134
47 Comparison of downstream water levels under the control of ANNs and CoastalGate model	134
48 Comparison of upstream salinity concentrations under the control of ANNs and CoastalGate model	135
49 Comparison of downstream salinity concentrations under the control of ANNs and CoastalGate model	135
50 Comparison of upstream DO concentration under the control of ANNs and CoastalGate model	136
51 Comparison of downstream DO concentration under the control of ANNs and CoastalGate model	136
52 Comparison of gate openings under the control of ANNs and CoastalGate model	137

Appendix Figure

C1 DE's parameters and configuration input window	244
C2 Observation points input window	245
C3 Constraints input window	246
C4 Upper boundary input window	247
C5 Lower boundary input window	248

LIST OF FIGURES (continued)

Appendix Figure	Page
C6 Point source input window	249
C7 File management input window	249
C8 Criteria input window	250
C9 Weighting factor input window	251
C10 Node data input window	252
C11 Branch data input window	252
C12 Node section data input window	253
C13 Floodplain data input window	253
C14 Structural data input window	254
C15 Flow direction data input window	254
C16 Gate operation data input window	255
C17 Upper boundary and lateral discharge data input window	255
C18 Lower boundary data input window	256
C19 Initial condition data input window	256
C20 Time data input window	257
C21 Node and time step data input window for salinity model	258
C22 Boundary condition data input window for salinity model	258
C23 Initial condition data input window for salinity model	259
C24 Diffusion coefficient data input window for salinity model	259
C25 Node and time step data input window for BOD/DO model	260
C26 Boundary condition data input window for BOD/DO model	260
C27 Initial condition data input window for BOD/DO model	261
C28 Diffusion coefficient data input window for BOD/DO model	261
C29 Waste load data input window for BOD/DO model	262
C30 Water quality's parameters data input window for BOD/DO model	262

LIST OF ABBREVIATIONS

a_i	=	the amplitude of the i^{th} constituents
a_0	=	displacement from the reference datum to the mean level
A	=	cross section of river (m^2)
AAE	=	average absolute error
ANNs	=	Artificial Neural Networks
AR	=	auto regressive & updating procedure model
ARMA	=	Autoregressive Moving Average Model
β	=	correction factor
BOD	=	biological oxygen demand
c	=	mass concentration (kg/m^3)
C	=	constant coefficient
CR	=	crossover constant
δ_i	=	phase of the i^{th} constituents
D	=	diffusion coefficient (m^2/s)
DE	=	Differential Evolution
DEMO	=	Differential Evolution for Multiobjective
DO	=	dissolved oxygen
DOS	=	dissolved oxygen saturation
ϕ_i	=	model parameter
F	=	weighting factor
FAS	=	fuzzy adaptive systems
FP	=	flood plain model
g	=	gravitational acceleration (m/s^2)
ga	=	the matrix of gate setting
$\bar{g}$ and $\underline{g}$	=	the upper and lower bounds for gate setting, respectively
G	=	the generation to which the population belongs
GA	=	Genetic Algorithm
GOP	=	gate operation model
H	=	water level (m)
HA	=	harmonic analysis model
i	=	index of the population
HD	=	hydrodynamic model
$K1$	=	decay rate
$K2$	=	reaeration rate
$K3$	=	settling removal rate
n	=	Manning's roughness coefficient
$\eta(\tau)$	=	the resultant tidal variation at a particular locality

LIST OF ABBREVIATIONS (continued)

N	=	the number of harmonic constituent
N_d	=	number of data
NB	=	node-branch model
NGO	=	NeuroGenetic Optimizer
NP	=	population size
P	=	population
PDE	=	Pareto Differential Evolution algorithm
q	=	lateral discharge (m^3/s)
Q	=	discharge (m^3/s)
$\hat{Q}_{t+1}$	=	measured discharge at previous time (t+1)
$Q_{sim,t+1}$	=	discharge simulated by Tank model at time t+1
R	=	hydraulic radius (m)
R^2	=	correlation coefficient
$R_{di,j}$	=	relative importance of interesting parameter j in water subsystem i within a particular area
$rand_j[0,1]$	=	uniformly distributed random value within range [0.0,1.0]
$Randb(j)$	=	the j^{th} evaluation of a uniform random number generator with outcome $\hat{I} [0,1]$
$Rnbr(i)$	=	a randomly chosen index $\in 1,2,3,...,D$
RC	=	rating curve model
RID	=	Royal Irrigation Department
ROM	=	River Operation model
RTC	=	real-time control
S	=	source/sink term ($kg/m/s$)
$S_{i,j}(\bar{x}, \bar{u})$	=	satisfaction function j for water subsystem i
SOD	=	sediment oxygen demand
SOM	=	Self Organizing Map
STR	=	structural model
t	=	time (s)
T_i	=	period of the i^{th} constituents
u	=	flow velocity (m/s)
$\bar{u}$	=	time-dependent control variables
$U_{i,G+1}$	=	the trial vector
$V_{i,G+1}$	=	the mutant vectors
VEDE	=	Vector Evaluated Differential Evolution
w	=	the weight vector

LIST OF ABBREVIATIONS (continued)

W_{ai}	=	weighting factor for an area in the objective function
WD	=	water demand model
WQ	=	water quality model
wq	=	water quality parameters
x	=	distance (m)
$\bar{x}$	=	time-dependent state variables
$x^{(L)}$ and $x^{(U)}$	=	lower and upper boundary constraints, respectively
$X_{i,G}$	=	the target vector
$X_{r1,G}$, $X_{r2,G}$ and $X_{r3,G}$	=	three random individuals chosen in the current generation
$x_{calculated}$	=	state variables obtained from calculation of simulation model
$x_{desired}$	=	desired state variables
$\bar{x}$	=	state variables
x_u	=	upper limits on state variables
x_l	=	lower limits on state variables
$Y_{desired}$	=	desired output
$Y_{predicted}$	=	predicted output
$\hat{Z}$	=	objective function
Z_{t+1}	=	model error at time t+1
$\{Z_t\}$	=	sequence of observed model error