Contents

List of Figures							
List of Tables							
Preface							
1	Inti	oduction	1				
	1.1	Biological neurons	2				
		1.1.1 Biological model	5				
	1.2	Artificial Neural Networks	9				
		1.2.1 Basics of electrical circuit	19				
		1.2.2 Additive model	20				
		1.2.3 Hopfield neural network	22				
		1.2.4 Cohen-Grossberg neural network	27				
		1.2.5 Bidirectional Associative Memory	29				
	1.3	An Overview of Mathematical Concepts	31				
		1.3.1 Delay Differential Equations	32				
		1.3.2 Impulsive Differential Equation	37				
		1.3.3 Matrix measure theory	39				
	1.4	Synchronization	42				
2	We	k, modified, and function projective synchronization of Cohen-					
	Gro	ssberg neural networks	47				
	2.1	Introduction	47				
	2.2	Model description and mathematical preliminaries	48				
	2.3	Main results	50				
	2.4	Results and discussion	63				
	2.5	Conclusion	65				
3	Pro	jective synchronization of delayed neural networks with mis-					
-	mat	ched parameters and impulsive effects	67				

	3.1	Introduction	
	3.2	Problem formulation and preliminaries	
	3.3	Main Results	
	3.4	Optimization of error bound	
		3.4.1 Optimized error bound for $-2 < \tau < 0$ except $\tau = -1$ 84	
		3.4.2 Discussion about optimal error bound for $-\infty < \tau < -2$ or	
		$\tau = 0 \dots \dots$	
	3.5	Numerical computation and discussion	
	3.6	Conclusion	
4	Exp	ponential stability of inertial BAM neural network with time-	
	var	ying impulses 93	
	4.1	Introduction	
	4.2	Model description and preliminaries	
	4.3	Global exponential stability criteria of inertial BAM neural network . 104	
	4.4	Numerical simulations and discussions	
	4.5	Conclusion	
_	Dœ	ects of infinite occurrence of hybrid impulses on quasi-synchronization	1
5	Effe	cus or minine occurrence or my or ru mipulses on quasi-synem on Zaulo	1
5	of p	parameter mismatched neural networks 119	.1
5	Effe of p 5.1	arameter mismatched neural networks 119 Introduction	.1
5	Effe of p 5.1 5.2	parameter mismatched neural networks 119 Introduction 119 Problem formulation and some preliminaries 120	.1
5	Effe of p 5.1 5.2 5.3	parameter mismatched neural networks 119 Introduction 119 Problem formulation and some preliminaries 120 Main Results 126	.1
5	Effe of p 5.1 5.2 5.3	parameter mismatched neural networks119Introduction119Problem formulation and some preliminaries120Main Results1265.3.1Quasi-synchronization criteria for $T_a < \infty$ 126	.1
5	Effe of p 5.1 5.2 5.3	parameter mismatched neural networks119Introduction119Problem formulation and some preliminaries120Main Results1265.3.1Quasi-synchronization criteria for $T_a < \infty$ 1265.3.2Quasi-synchronization criteria for $T_a = \infty$ 133	
5	Effe of p 5.1 5.2 5.3 5.4	parameter mismatched neural networks119Introduction119Problem formulation and some preliminaries120Main Results1265.3.1Quasi-synchronization criteria for $T_a < \infty$ 1265.3.2Quasi-synchronization criteria for $T_a = \infty$ 133Numerical simulation and discussions139	
5	Effe of p 5.1 5.2 5.3 5.4 5.5	parameter mismatched neural networks119Introduction119Problem formulation and some preliminaries120Main Results126 $5.3.1$ Quasi-synchronization criteria for $T_a < \infty$ 126 $5.3.2$ Quasi-synchronization criteria for $T_a = \infty$ 133Numerical simulation and discussions139Conclusion142	
5 6	Effe of p 5.1 5.2 5.3 5.4 5.5 Cor	Derivative of the information of t	.4
5 6	Effe of p 5.1 5.2 5.3 5.4 5.5 Cor	Description119Introduction119Problem formulation and some preliminaries120Main Results126 $5.3.1$ Quasi-synchronization criteria for $T_a < \infty$ 126 $5.3.2$ Quasi-synchronization criteria for $T_a = \infty$ 133Numerical simulation and discussions139Conclusion142nclusion and Future Works145	.4

Bibliography	149
List of Publications	165

List of Figures

1.1	Schematic structure of a typical neuron [1]	3
1.2	Schematic diagram of a network of neurons. Neuron N_i sends a signal pulse S_{ij} through its axon to hits the target neuron N_j with coupling	
	strength $Z_{ij}(t)$. The external inputs I_i are stimuli for the neuron model.	6
1.3	A diagram of an artificial neuron of the network	10
1.4	(a) A threshold function, (b)Piecewise linear function, and (c) Sig-	
	moid activation function for $\beta = 2, 3$, and 4	12
1.5	A feedforward network without hidden layer	14
1.6	Multilayer feedforward neural network with one hidden layer	15
1.7	A recurrent network with one hidden layer of neurons.	16
1.8	A recurrent neural network without a hidden layer and a self-feedback	
	loop	17
1.9	Partially connected neural network.	17
1.10	RC-circuit with a source of voltage.	19
1.11	Additive model of a neuron.	21
1.12	An architecture of Hopfield neural network consisting of $n = 4$ neurons.	23
1.13	Encoding-Decoding illustration between the space of fundamental	
	memories ξ_{μ} and the space of stored vectors x_{μ}	24
1.14	Bidirectional associative memory neural network.	30
2.1	Periodic attractors of neural networks without coupling terms	64
2.2	Time evolution of the error system is shown in (a) for $\ \Lambda(t)\ _1 = 2.3$.	
	and in (b) for $\ \Lambda(t)\ _1 = 0.5$.	65
2.3	Time evaluation of the error system for $\omega_i/\omega_i \approx 0.000001, i \neq j$.	65
3.1	The chaotic attractors of master system (3.53) and response system	
	(3.54).	90
3.2	(a) and (b) presents error bound for $\tau = -0.5$ and $\tau = 0.2$, when	0.0
0.0	$\gamma_i = 0$ and $\gamma_i = 20$ respectively.	90
3.3	(c) demonstrate the error curve when $\tau = 0.2$ and $\gamma_i = 0.$ (d) plot of	00
	nonuniform distribution of impulses	90

4.1	(a) and (b) demonstrate time evolution and phase portrait of states'	
	trajectories for the system (4.44), respectively	114
4.2	(a) and (b) demonstrate time evolution of $ e(t) _2$ for stabilizing and	
	destabilizing impulses with $\hat{T}_a = 0.071$, respectively	114
4.3	(a) demonstrate time evolution of $ e(t) _1$ for stabilizing with $\hat{T}_a =$	
	0.03. (b) demonstrate time evolution of $ e(t) _1$ for destabilizing im-	
	pulses with $T_a = 0.04$.	114
5.1	Phase portrait of hybrid impulses with $T_s = \infty$ for $N_c(t,s) = [\sqrt[3]{t-s}]$	
0.1	in Example 5.4.2. \ldots	140
5.2	Chaotic attractors of equations (5.2) and (5.4) are shown in (a) and	
	(b), respectively.	140
5.3	Hybrid impulsive sequence with $\mu = 1.1$ and the corresponding time	
	evolution of controlled error neural network (5.12) for $T_a < \infty$ are	
	shown in (a) and (b) , respectively. \ldots \ldots \ldots \ldots	140
5.4	Time-evolution of error neural network (5.12) with $\mu = 1.15$ and	
	$\mu = 0.35$ for $T_a = \infty$ are shown in (a) and (b), respectively.	142

List of Tables

1.1 Comparison between a human brain and an artificial neural network. 10