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Prof. Janusz Kacprzyk
Systems Research Institute
Polish Academy of Sciences
ul. Newelska 6
01-447 Warsaw
Poland
E-mail: kacprzyk@ibspan.waw.pl

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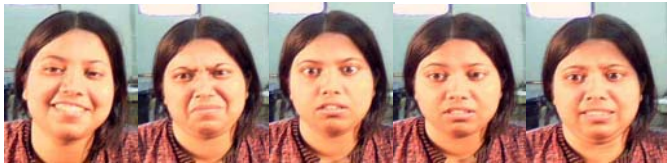
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Aruna Chakraborty and Amit Konar

Emotional Intelligence

A Cybernetic Approach



 Springer

Dr. Aruna Chakraborty

Associate Professor,

St. Thomas' College of Engineering and Technology,

4 Diamond Harbour Road, Calcutta- 700 023.

Visiting Faculty for the M.Tech. Course on Intelligent Automation and Robotics,

Department of Electronics and Tele-Communication Engineering,

Jadavpur University, Calcutta- 700 032

India

E-mail: aruna_stcet@rediffmail.com

Dr. Amit Konar

Professor,

Artificial Intelligence Research Lab.

Department of Electronics and Tele-Communication Engineering,

Jadavpur University, Calcutta- 700 032

India

E-mail: konaramit@yahoo.co.in

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Preface

Emotional Intelligence is a new discipline of knowledge, dealing with modeling, recognition and control of human emotions. The book *Emotional Intelligence: A Cybernetic Approach*, to the best of the authors' knowledge is a first comprehensive text of its kind that provides a clear introduction to the subject in a precise and insightful writing style. It begins with a philosophical introduction to Emotional Intelligence, and gradually explores the mathematical models for emotional dynamics to study the artificial control of emotion using music and videos, and also to determine the interactions between emotion and logic from the points of view of reasoning. The later part of the book covers the chaotic behavior of co-existing emotions under certain conditions of emotional dynamics. Finally, the book attempts to cluster emotions using electroencephalogram signals, and demonstrates the scope of application of emotional intelligence in several engineering systems, such as human-machine interfaces, psychotherapy, user assistance systems, and many others.

The book includes ten chapters. Chapter 1 provides an introduction to the subject from a philosophical and psychological standpoint. It outlines the fundamental causes of emotion arousal, and typical characteristics of the phenomenon of an emotive experience. The relation between emotion and rationality of thoughts is also introduced here. Principles of natural regulation of emotions are discussed in brief, and the biological basis of emotion arousal using an affective neuroscientific model is introduced next. Scope of mathematical modeling to study the dynamics of emotion is also discussed. Principles of controlling emotion by artificial means, and the effect of emotion modeling on human-machine interactions are also outlined.

Chapter 2 overviews the mathematical foundations required to understand the rest of the book. It introduces the principles of modeling of a static and dynamic system, and compares the classical first order logic with a static system, and a temporal logic with a dynamic system. General method of stability analysis of dynamical systems using Lyapunov functions is introduced next. The chapter also explores the stability analysis of fuzzy systems, and introduces the principles of Lyapunov exponents to study the existence of chaos in a neuro-dynamic system. Finally, the chapter presents the methodology of modeling emotional dynamics,

and reviews the scope of both stability analysis and Lyapunov exponents, to study the stable and chaotic behavior of the dynamics.

Chapter 3 on Image Processing is introduced as a prerequisite to the rest of the book. It begins with frequency domain transforms, such as Fourier and Cosine transforms, and then outlines the techniques for pre-processing and noise filtering from images using neighborhood averaging, median filtering and thresholding. It then explores image segmentation algorithm, including boundary detection, region detection, and fuzzy clustering algorithm. Principles of boundary description algorithm are then outlined with emphasis on chain codes, Fourier descriptors, and regional descriptors. An introduction to object recognition technique is reviewed through unsupervised clustering, supervised classification and intelligent matching algorithm. The chapter ends with a brief discussion on scene interpretation.

Chapter 4 outlines brain imaging and psycho-pathological studies on self-regulation of emotion. It begins with the mechanism of emotion processing by the human brain, and provides the latest research outcome on the role of the amygdala, the Orbitofrontal Cortex, the Insula, and the Anterior Cingulated Cortex on emotion arousal and its self-regulation. Experimental research undertaken on both humans and animals are given in brief. Principles of voluntary self-regulation of emotion are overviewed through f-MRI studies and neural models. The EEG conditioning and analysis for depression and pre-menstrual dysphoric disorder are also presented. Studies with both clinical and non-clinical samples for emotion dysregulation in childhood and adulthood are discussed in a nutshell.

Chapter 5 is an original contribution by the authors on human emotion recognition from facial expressions, and its control by audio-visual means using fuzzy logic. The chapter begins with segmentation and localization of important facial components, such as the mouth region, the eye region, and the eyebrow region. Next a scheme for determining facial attributes, such as mouth-opening, eye-opening, and the length of eyebrow-constriction is briefly outlined. Principles of fuzzy relational system have been employed for the detection of emotion from the facial attributes. Finally, the chapter introduces a novel dynamics for emotion transition, and provides an architecture for the proposed emotional dynamics to control the emotion of subjects using the logic of fuzzy sets.

Stabilization of the human mind, and its emotion-logic encounter remained an unsolved problem until this date. Chapter 6 provides a novel scheme to handle this problem by representing formalisms for emotional dynamics and logical reasoning, when both of them share common information resources of the subject. Stability analysis of the emotional dynamics and the temporal logic are then undertaken in order to activate the control of emotion over logic and vice-versa under stabilized condition of the mental system.

Chapter 7 deals with multiple emotions and chaos. A model of competitive/cooperative emotional dynamics is proposed, and the variations of different parameters on the temporal response of the dynamics are studied through computer simulations. A Lyapunov-based stability analysis of the emotional dynamics is undertaken to determine the parametric condition for stability. A system identification

approach is then overviewed to determine the suitable parameters of the dynamics to minimize an objective function, indicating error between sampled response of the amygdala and that of the model. This error function is minimized by three alternative algorithms, namely genetic algorithm, particle swarm optimization algorithm, and differential evolution algorithm. A stabilization scheme for mixed emotional dynamics is then studied through a closed loop feedback system, where the control signal attempts to improve the damping level of the dynamics in order to stabilize its behavior.

Chapter 8 provides an overview of EEG signal processing for detection and prediction of emotion. It begins with LMS, NLMS, RLS and Kalman filter algorithms, and demonstrates their scope in EEG signal prediction. Next, it employs wavelet techniques for prediction of EEG signal. The later part of the chapter proposes a scheme for emotion clustering from bio-potential signals using neural networks.

Chapter 9 is the concluding chapter of the book. It outlines possible application of the proposed scheme for emotion modeling, detection and control in human-machine interactive systems, multi-agent robotics, psycho-therapy, digital movie making, matrimonial counseling, and also in personality building of artificial creatures. Future research directions on voice and multi-modal emotion recognition are also indicated.

Chapter 10 outlines open-ended research problems in Emotional Intelligence, and also cites a number of important references to pursue research in this young discipline of knowledge.

June 2009

Aruna Chakraborty
Amit Konar

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The second author wishes to thank all his family members, and particularly his son Dipanjan for sharing his emotions during the period of writing this book.

June 2009

Aruna Chakraborty
Amit Konar

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