CHAPTER 1

Introduction to Computational Intelligence

1.1 WELCOME TO COMPUTATIONAL INTELLIGENCE

Welcome to the world of computational intelligence (CI), which takes inspiration from nature to develop intelligent computer-based systems. Broadly, the field of CI encompasses three main branches of research and application: (1) neural networks, which model aspects of how brains function, (2) fuzzy systems, which model aspects of how people describe the world around them, and (3) evolutionary computation, which models aspects of variation and natural selection in the biosphere. These three approaches are often synergistic, working together to supplement each other and provide superior solutions to vexing problems.

1.2 WHAT MAKES THIS BOOK SPECIAL

A unique feature of this textbook is that each of us has been an editor-in-chief for an IEEE Transactions sponsored by the IEEE Computational Intelligence Society (CIS), the main technical society supporting research in CI around the world. This book offers the only systematic treatment of the entire field of CI from the perspectives of three experts who have guided peer-reviewed seminal research published in the top-tier journals in the area of CI.

The publications we've edited include the *IEEE Transactions on Neural Networks* (Derong Liu), the *IEEE Transactions on Fuzzy Systems* (James Keller), and the *IEEE Transactions on Evolutionary Computation* (David Fogel). These publications consistently present the most recent theoretical developments and practical implementations in the field of CI.

As you read through the book, you'll notice that each central area of CI is offered in its own style. That's because each of us has taken the primary lead on the material in our own area of expertise. We've made efforts to be consistent, but you'll certainly

Fundamentals of Computational Intelligence: Neural Networks, Fuzzy Systems, and Evolutionary Computation, First Edition. James M. Keller, Derong Liu, and David B. Fogel.

notice three distinct ways of conveying what we know. We believe that this is one of the advantages of our partnership—you get the whole story, but not from the standpoint of a single author. We made a deal to allow each of us to tell our story in our own way.

You may relate more to one of our styles over the others, but the content is solid and your efforts at studying this material will be rewarding. The theories and techniques described will allow you to create solutions to problems in pattern recognition, control, automated decision making, optimization, statistical modeling, and many other areas.

1.3 WHAT THIS BOOK COVERS

This introduction to CI covers basic and advanced material in neural networks, fuzzy systems, and evolutionary computation. Does it cover all of the possible topics within the field of computational intelligence? Certainly not!

Our goal is to provide fundamental material in the diverse and fast growing area of CI and give you a strong fundamental understanding of its basic concepts. We also provide some chapters with more advanced material. Each chapter offers exercises to test your knowledge and explore interesting research problems. When you master these chapters, you will be ready to dig deeper into the literature and create your own contributions to it.

1.4 HOW TO USE THIS BOOK

The best way for you to use this book is to study all of the chapters. (You knew we would say that, right?) We think that the development from neural networks to fuzzy systems to evolutionary computation provides a logical flow within the framework of a semester-long course. You'll find that each of the three main topics is described with basic chapters upfront, which cover theory, framework, and algorithms. These are followed by more advanced chapters covering more specific issues, fine points, and extensions of the basic constructions.

For instructors, presuming a typical 16-week U.S. university semester, you can easily construct three 4-week modules from the basic material with plenty of time remaining for in-class exercises, homework discussions, and computer projects. There's even some time available to pursue more advanced research in your own favorite area. (This is how the "Introduction to CI" class at the University of Missouri (MU) is organized.)

Alternatively, if you want to focus more on one area of CI, you can certainly use this book to do so. For example, if you wanted a course mainly on fuzzy systems, you could use all four of the chapters on fuzzy systems, and then sample from neural networks (to demonstrate the basis for neuro–fuzzy systems) and evolutionary computation (to develop optimization approaches in the design of fuzzy inference

systems). By analogy, you could focus on neural networks or evolutionary computation, and then supplement those materials with the other chapters in the book.

1.5 FINAL THOUGHTS BEFORE YOU GET STARTED

An introductory course on computational intelligence has been taught at the University of Missouri (Jim's place) since 2005. Various texts have been used, including most recently draft chapters from this book. The class is colisted in the Electrical and Computer Engineering Department and the Computer Science Department and is available to both seniors and beginning graduate students.

In at least one semester, students were given a first-day assignment to provide a list of things that computers can't do as well as humans. The following are some of the items from the combined list:

Qualitative classification
Going from specific to general, or vice versa
Consciousness and emotion
Driving a car
Writing a poem
Chatting
Shopping
Handling inaccuracies in problems
Ethics
Natural language in conversation, with idioms
Face recognition
Aesthetics
Adaptivity
Learning (like humans do)

This was from a group of students with little or no background in intelligent systems. Depending on what you read and/or do, you might say that progress (significant in some cases) has been made on creating systems with attributes from that list, and you'd be right. Amazing things are happening. This book will provide you with the background and tools to join in the fun.

As editors-in-chief of the three main IEEE publications in the area of CI, we've had the good fortune to see novel advancements in our fields of interest even before they've been peer-reviewed and published. We've also had the joy of participating in making some of those advancements ourselves.

In fact, we've devoted our lives to advancing the theory and practice of the methods that you'll read about in this textbook. We've done that because we've often found these techniques to offer practical advantages as well as mental challenges. But in the end, we've pursued these lines of research primarily because they're a lot of fun.

We hope that you'll find not only a mathematically and practically challenging set of material in this book, but also that the material ultimately brings you as much enjoyment as it has brought for us, or even more!

Enjoy!

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