Chapter 1 Introduction

1.1 Background

The study of complex systems has become increasingly important in modern scientific research. Many phenomena in nature and society exhibit intricate patterns that cannot be adequately described by simple models. This chapter provides the foundation for understanding such systems by introducing the mathematical tools and conceptual frameworks that will be used throughout the book.

1.2 Scope and Organization

This book is organized into twelve chapters. Chapter 2 reviews the mathematical prerequisites. Chapter 3 introduces the basic theory of dynamical systems. Chapter 4 discusses bifurcations and chaos. Chapter 5 covers fractals and self-similarity. Chapter 6 presents the theory of cellular automata. Chapter 7 examines complex networks. Chapter 8 discusses self-organization and emergence. Chapter 9 covers agent-based modeling. Chapter 10 presents applications in biology. Chapter 11 presents applications in economics and social systems. Chapter 12 discusses open problems and future directions.

1.3 Notation

Throughout the book, we use the following notation. Vectors are denoted by bold lowercase letters, $\mathbf{x}$. Matrices are denoted by bold uppercase letters, $\mathbf{A}$. The set of real numbers is denoted $\mathbb{R}$, the set of integers is denoted $\mathbb{Z}$, and the set of natural numbers is denoted $\mathbb{N}$. The norm of a vector is denoted $\|\mathbf{x}\|$. The derivative of a function $f(x)$ is denoted $f'(x)$ or $\frac{dx}{dt}$.