Cognitive Intelligence and Robotics

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Cognitive Intelligence refers to the natural intelligence of humans and animals, it is considered that the brain performs intelligent activities. While establishing a hard boundary that distinguishes intelligent activities from others remains controversial, most common behaviors and activities of living organisms that cannot be fully synthesized using artificial means are regarded as intelligent. Thus the acts of sensing and perception, understanding the environment, and voluntary control of muscles, which can be performed by lower-level mammals, are indeed intelligent. Besides the above, advanced mammals can perform more sophisticated cognitive tasks, including logical reasoning, learning, recognition, and complex planning and coordination, none of which can yet be realized artificially to the level of a baby, and thus are regarded as cognitively intelligent.

This book series covers two important aspects of brain science. First, it attempts to uncover the mystery behind the biological basis of cognition, with a special emphasis on the decoding of stimulated brain signals or images. Topics in this area include the neural basis of sensory perception, motor control, sensory-motor coordination, and understanding the biological basis of higher-level cognition, including memory, learning, reasoning, and complex planning. The second objective of the series is to publish consolidated research on brain-inspired models of learning, perception, memory, and coordination, including results that can be realized on robots, enabling them to mimic the cognitive activities performed by living creatures. These brain-inspired models of machine intelligence complement the behavioral counterparts studied in traditional artificial intelligence.

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Nandita Sengupta · Jaya Sil

Intrusion Detection

A Data Mining Approach

Springer

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Preface

Data mining is an integrated process of data cleaning, data integration, data selection, data transformation, data extraction, pattern evaluation, and knowledge presentation. The exponential growth of data opens up new challenges to extracting knowledge from large repositories consisting of vague, incomplete, and hidden information. Data mining research attracted many people working in different disciplines for quite a long period of time. However, the methods lack a comprehensive and systematic approach to tackle several problems in data mining techniques, which are interrelated.

The phrase *intrusion detection* refers to the detection of traffic anomaly in computer networks/systems with an aim to secure data resources from possible attacks. Several approaches to intrusion detection mechanisms are available in the literature. Most of these techniques utilize principles of machine learning/pattern recognition. Unfortunately, the existing techniques fail to incrementally learn network behavior. The book fills this void. It examines the scope of reinforcement learning and rough sets in handling the intrusion detection problem.

The book is primarily meant for graduate students of electrical, electronics, computer science and technology. It is equally useful to doctoral students pursuing their research on intrusion detection and practitioners interested in network security and administration.

The book includes five chapters. Starting from the foundations of the subject, it gradually explores more sophisticated techniques on intrusion detection, including Fuzzy Sets, Genetic Algorithm, Rough Sets, and Hierarchical Reinforcement Learning. The book serves a wide range of applications, covering general computer security to server, network and cloud security.

Chapter 1 provides an overview of intrusion detection. Two distinct types of Intrusion Detection Systems have been examined. They are referred to as misuse detection and anomaly detection systems. Next, the chapter outlines the types of possible attacks. It then emphasizes the main steps usually undertaken in an Intrusion Detection System. The steps include data preprocessing, discretization, dimensionality reduction, and classification. The data preprocessing includes data cleaning, such as missing value prediction, filtering of noisy data, and management of

inconsistent data. Subsequent major steps in data preprocessing are data integration, data transformation, and data reduction. Data reduction has been examined in two ways: attribute reduction and object reduction. The next main step in intrusion detection is discretization, i.e., the transformation of continuous data into quantized intervals. The discretization techniques covered are equal width and equal frequency discretization, bottom-up margin, ChiMerge, entropy-based, and nonparameterized supervised discretization. The rest of Chap. 1 covers the classification of network traffic data. Finally, the chapter comes to an end with a list of concluding remarks.

Chapter 2 is concerned with the well-known discretization procedure of network traffic data. The discretization begins with preprocessing of NSL-KDD data set. Two specific discretization techniques have been examined. The former one, called cut generation method, focuses at the center of a data range dividing the range into two halves. The latter one deals with machine learning techniques.

Chapter 3 introduces the principles and techniques of data reduction. Data reduction refers to either dimension reduction or instance reduction. In this chapter, dimension reduction is achieved by two ways: Rough Sets and Fuzzy–Rough Sets. Instance reduction is performed using clustering algorithms. The rest of the chapter deals with experiments and reporting of results to demonstrate the relative performance of different techniques introduced therein. The metrics used include a confusion matrix.

Chapter 4 provides a novel approach to Q-learning induced classifier to classify the traffic data. In classical Q-learning, we develop a Q-table to store the Q-values at given state space. The Q-table is indexed by states as rows and actions by columns. After the Q-learning algorithm converges, the Q-table is used for the planning application, where the optimal action at a state is determined by the highest Q-value at the state. Here, the authors employ cuts of the continuous traffic attribute to represent the states, and the attributes represent the action set.

The Q-table contains immediate reward/penalty at a given cut for selecting an action (attribute). The Q-table adaptation is undertaken by classical Q-learning. To improve the performance of the Q-learning algorithm, we used rough sets to select a fewer alternatives from a long list so as to improve the classification accuracy. Thus, the attributes used in the Q-table are minimized. This chapter also aims at improving the speed of classification of intrusion traffic data using novel hierarchical learning. Here, the hierarchy is required to determine the attributes in coarse level at the higher level of the hierarchy and at a relatively finer level at lower level in the hierarchy. Generally, the reducts (important attributes obtained by the rough set algorithm) are used to represent the row indices of the Q-table. After an attribute at a given reduct is selected by Q-learning in a top hierarchy, the sub-tasks involved in the selected attribute are determined at the next level of the hierarchy. Thus, multiple levels of hierarchy are used to determine tasks as well as sub-tasks at higher speed of completion.

Chapter 5 concludes the book and provides future research path.

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List of Publication by the Authors Relevant to the Book

List of Publication by Dr. Nandita Sengupta Relevant to the Book

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