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Introductory Chapter: Pattern Recognition as Cognitive Process

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1. Introduction

The development of science and rapid advances in technology have created many new problems that mankind is currently encountering. The solution to the majority of these problems is based on information processing. We can easily say that without information processing, our civilization, in the form we know, could not exist, and information is a key element of the decision-making process. Decision-making is inextricably linked to the automation of various processes. Currently, the trend is automated by performing operations with the characteristics of intelligence, which until now were performed only by people. An example here can be systems that have speech recognition capabilities, images recognition (reading hand-writing letters and signature recognition), people recognition (biometric systems), text translations, chess games, proofs of claims, and many others. The basis for solving these tasks is methods for pattern recognition.

The concept of pattern recognition is difficult to define unequivocally. The laconic definition will be too short to reflect the nature and essence of the concept. In turn, a too long definition causes the blurring of the essence of the problem. Pattern recognition is a scientific issue that has its roots among others in information theory, mathematical analysis and statistics, signal and image processing, machine learning, artificial intelligence, and many others. The possibilities of implementing algorithms from this area as well as the application potential of the developed solutions mean that this field of knowledge is most often identified with automation and robotics, mechatronics, and computer science. The methods, algorithms, and tools used in other scientific areas, e.g., artificial neural networks, optimization methods, genetic and evolutionary algorithms, fuzzy logic, etc., are often used to create and implement practical solutions in the field of pattern recognition. The pattern recognition process itself can be treated as an action consisting in retrieving raw data and taking further actions depending on the category to which these data belong.

It is most commonly assumed that the main areas of application of pattern recognition in the field of technical sciences are signal and image analysis systems. However, it should be noted that pattern recognition can be successfully used in medical sciences, e.g., in the identification of diseases or in social sciences, e.g., when recognizing the behavior of each individual or a group.

Recognition of patterns aims at classifying objects based on statistical data collected for the purpose of extracting features of objects based on a priori information or using self-learning. Classified objects are usually groups of measurement or observation results defining the location of corresponding points in the multidimensional space of features. In other words, pattern recognition is a procedure in which individual items are placed into groups based on quantitative information on one or more characteristics inherent in the items (referred to as traits, variables, characters, etc.) and based on a training set of previously labeled items.

In general, the pattern recognition system consists of several elements. The first element is a sensor that provides information from observations of a certain physical phenomenon that will be subject to classification or description. Information from the sensor is most often transformed into a digital form, which can be processed using a microprocessor system. The next elements are usually programmatic or data structures and may or may not be as needed. In their composition, one can distinguish the block responsible for filtration, quality improvement, or pre-processing of information to the desired form. The next block is associated with the mechanism of extracting features that best characterize and separate the class to which the observational data belongs. An indispensable element of the entire system is the decision-making scheme that implements the correct part of the classification or description of the observation process based on the acquired features of the object. This process can be carried out in two ways. In the approach in which the so-called supervised learning is used during the creation of the system, a priori knowledge is required, on the basis of which decisions about classification are made. In the approach in which the so-called supervised learning is used during the creation of the system, a priori knowledge is required, on the basis of which decisions about classification are made. This knowledge is usually collected and stored in a kind of database, which can be supplied with information from outside or by the system itself. In the approach where it is assumed that the system will self-organize and/or self-learn, it is not required to have initial knowledge about the observed object. The number and variety of elements included in the recognition system give a picture of how many issues should be considered to obtain efficiently operating pattern recognition systems.

The beginnings of recognizing patterns and in particular the possibilities of automating the classification process fall on the 1950s and are associated with the slow spreading of digital machines as information processing means. At that time, work in this area focused on the development of methods and algorithms, implementation of signal processing programs including images and automatic decision-making, and the creation of research equipment necessary to obtain information about the object. At that time, among others, a Dreyfus-Graf phonetograph was developed, i.e., a phone recording machine and AUDREY—a Bell machine that recognized numbers. At the end of the 1950s, F. Rosenblatt presented a system called a perceptron that had a significant impact on the development of learning systems. The algorithm describing the operation of the perceptron was one of the first models of brain activity in the field of information storage and processing. During this period, pattern recognition mainly used theories of static decisions and threshold logic. In subsequent years, research in the field of pattern recognition has accelerated with the launch of the digital machines, thereby increasing their performance computing. From the 1960s, we can call a Shoebox machine demonstrated by IBM which recognized 16 words of English, including 10 digits or a reader of reports sent to the Social Security Administration in the US that can read printed letters regardless of the thickness of characters or print quality. In subsequent years, methods, algorithms, and software for recognizing images and sounds were developed. In addition to technical sciences, other types of sciences have become interested in pattern recognition, such as medicine, sociology, psychology, archeology, and many others. Currently, these methods are very common; we use them almost every day, often without such awareness, even during unlocking smartphones with a fingerprint or showing face.

The main objective of this book is to present the latest achievements in the field of pattern recognition and a better understanding of the involved key issues. Moreover, the presented practical solutions of problems allow the same to become familiar with the technical and non-technical aspects of various applications as

well as the latest developments in this area. For this reason, scientists from research institutions and universities of various countries of the world present their achievements in the field of pattern recognition. According to the information presented in this book, the impact of pattern recognition systems on the improvement of human life is invaluable in particular due to the wide field of application. It must be noticed that many of the ideas, methods, and algorithms presented in this book can be applied in other applications. I hope that this book will bring some of the problems associated with pattern recognition and will be an inspiration for further research. I also hope that this publication will be received by the scientific community with great interest.

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