

Pattern Recognition Methods

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INTRODUCTION

Humans have developed sophisticated skills for sensing their environment and taking actions according to what they observe such as recognizing a face, understanding spoken words, reading handwriting, distinguishing fresh food from its smell. Since our early childhood, we have been observing patterns in the objects around us such as toys, flowers, pets, and faces. Most children can recognize small characters, large characters, handwritten, machine printed, or rotated by the time they are five years old. We would like to give similar capabilities to machines. Pattern recognition is the study of how machines can observe the environment, learn to distinguish patterns of interest from their background, and make sound and reasonable decisions about the categories of the patterns (Jain et al., 2000). Pattern recognition stems from the need for automated machine recognition of objects, signals or images, or the need for automated decision-making based on a given set of parameters.

Machine recognition, description, classification, and grouping of patterns are important problems in a variety of engineering and scientific disciplines such as biology, psychology, medicine, marketing, computer vision, artificial intelligence, and remote sensing. But what is a pattern? Watanabe (1985) defines a pattern "as opposite of a chaos; it is an entity, vaguely defined, that could be given a name. As seen in Figure 1, a pattern could be a fingerprint image, a handwritten word, a human face, a speech signal, a bar code, or a Web page on the Internet or DNA sequence.

Humans are the best pattern recognizers in most scenarios, yet we do not fully understand how we recognize patterns. Despite over half a century of

Figure 1. Examples of patterns: sound wave, fingerprint, trees, face, bar code, and character images (Jain et al., 2000)



productive research, pattern recognition continues to be an active area of research because of many unsolved fundamental theoretical problems as well as an increasing number of applications that can benefit from pattern recognition (Polikar, 2006). However, rapid advances in computing technology not only enable us to process huge amounts of data, but also facilitate the use of elaborate and diverse methods for data analysis and classification. Besides, demands on pattern recognition systems are rising due to the availability of large databases.

Pattern recognition is as a classification process and its goal is to extract patterns based on certain

conditions and is to separate one class from the others. It has many applications in psychology, psychiatry, ethology, cognitive science, traffic flow and computer science such problems span a wide spectrum of applications, including speech recognition (e.g., automated voice-activated customer service), speaker identification, handwritten character recognition (such as the one used by the postal system to automatically read the addresses on envelopes), topographical remote sensing, identification of a system malfunction based on sensor data or loan/credit card application decision based on an individual's credit report data, among many others (Polikar, 2006). More recently, a number of biomedical engineering related applications have been added to this list, including DNA sequence identification, automated digital mammography analysis for early detection of breast cancer, automated electrocardiogram (ECG) or electroencephalogram (EEG) analysis for cardiovascular or neurological disorder diagnosis, and biometrics (personal identification based on biological data such as iris scan, fingerprint, etc.).

This chapter gives a brief survey of methods used to recognize objects. These methods apply to the recognition of objects in images, but are applicable to any other kind of data as well. Several different approaches to the pattern recognition problem will be introduced including the statistical approach, neural network approach and the syntactical approach.

BACKGROUND

A pattern recognition system is an automatic system that aims at classifying the input pattern into

a specific class and proceeds into two successive tasks (Kpalma & Ronsin, 2007):

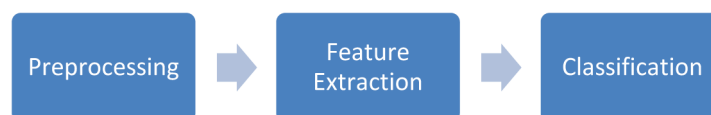
1. the description that extracts the characteristics from the pattern being studied,
2. the recognition that enables us to recognise a pattern by using some characteristics derived from the first task.

Pattern recognition is the research area of artificial intelligence that studies the operation and design of systems that recognize patterns in the data. Important application areas are image analysis, character recognition, fingerprint classification, speech analysis, DNA sequence identification, man and machine diagnostics, person identification and industrial inspection. The design of a pattern recognition system essentially involves the following four aspects (Jain & Duin, 2000):

1. **Data Acquisition and Preprocessing:** Taking a picture of an object and removing the irrelevant background,
2. **Data Representation:** Deriving relevant object properties which efficiently offer pertinent information needed for pattern recognition,
3. **Training:** Imparting pattern class definition into the system by showing a few typical examples of the pattern,
4. **Decision-Making:** Finding the pattern class or pattern description of new, unseen objects based on a training set of examples.

As seen in Figure 2, the basic components of a pattern recognition system are preprocessing, feature extraction, and classification.

Figure 2. Pattern recognition process



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