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Preface

Designing object detection and recognition systems that work in the real world is a challenging task due to various factors including the high complexity of the systems, the dynamically changing environment of the real world and factors such as occlusion, clutter, articulation, and various noise contributions that make the extraction of reliable features quite difficult. Furthermore, features useful to the detection and recognition of one kind of object or in the processing of one kind of imagery may not be effective in the detection and recognition of another kind of object or in the processing of another kind of imagery. Thus, the detection and recognition system often needs thorough overhaul when applied to other types of images different from the one for which the system was designed. This is very uneconomical and requires highly trained experts. The purpose of incorporating learning into the system design is to avoid the time consuming process of feature generation and selection and to lower the cost of building object detection and recognition systems.

Evolutionary computation is becoming increasingly important for computer vision and pattern recognition fields. It provides a systematic way of synthesis and analysis of object detection and recognition systems. With learning incorporated, the resulting recognition systems will be able to automatically generate new features on the fly and cleverly select a good subset of features according to the type of objects and images to which they are applied. The system will be flexible and can be applied to a variety of objects and images.

This book investigates evolutionary computational techniques such as genetic programming (GP), linear genetic programming (LGP), coevolutionary genetic programming (CGP) and genetic algorithms (GA) to automate the synthesis and analysis of object detection and recognition systems. The ultimate goal of the learning approaches presented in this book is to lower the cost of designing object detection and recognition systems and build more robust and flexible systems with human-competitive performance.

The book presents four important ideas.

First, this book shows the efficacy of GP and CGP in synthesizing effective composite operators and composite features from domain-independent primitive image processing operations and primitive features (both elementary and complex) for object detection and recognition. It explores the role of domain knowledge in evolutionary computational techniques for object recognition. Based on GP and CGP's ability to synthesize effective features from simple features not specifically designed for a particular kind of imagery, the cost of building object detection and recognition systems is lowered and the flexibility of the systems is increased. More importantly, a large amount of unconventional features are explored by GP and CGP and these unconventional features yield exceptionally good detection and recognition performance in some cases, overcoming the human experts' limitation of considering only a small number of conventional features.

Second, smart crossover, smart mutation and a new fitness function based on the minimum description length (MDL) principle are designed to improve the efficiency of genetic programming. Smart crossover and smart mutation are designed to identify and keep the effective components of composite operators from being disrupted and a MDL-based fitness function is proposed to address the well-known code bloat problem of GP without imposing severe restriction on the GP search. Compared to normal GP, smart GP algorithm with smart crossover, smart mutation and a MDL-based fitness function finds effective composite operators more quickly and the composite operators learned by smart GP algorithm have smaller size, greatly reducing both the computational expense during testing and the possibility of overfitting during training.

Third, a new MDL-based fitness function is proposed to improve the genetic algorithm's performance on feature selection for object detection and recognition. The MDL-based fitness function incorporates the number of features selected into the fitness evaluation process and prevents GA from selecting a large number of features to overfit the training data. The goal is to select a small set of features with good discrimination performance on both training and unseen testing data to reduce the possibility of overfitting the training data during training and the computational burden during testing.

Fourth, adaptive coevolutionary linear genetic programming (LGP) in conjunction with general image processing, computer vision and pattern recognition operators is proposed to synthesize recognition systems. The basic two-class approach is extended for scalability to multiple classes and various architectures and strategies are considered.

The book consists of eight chapters dealing with various evolutionary approaches for automatic synthesis and analysis of object detection and recognition systems. Many real world imagery examples are given in all the chapters and a comparison of the results with standard techniques is provided.

The book will be of interest to scientists, engineers and students working in computer vision, pattern recognition, object recognition, machine learning, evolutionary learning, image processing, knowledge discovery, data mining, cybernetics, robotics, automation and psychology.

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