Recruitment Learning

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Recruitment Learning

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Preface

This monograph provides an overview of recruitment learning approaches from a computational perspective. Recruitment learning is a unique machine learning technique that: (1) explains the physical or functional acquisition of new neurons in sparsely connected networks as a biologically plausible neural network method; (2) facilitates the acquisition of new knowledge to build and extend knowledge bases and ontologies as an artificial intelligence technique; (3) allows learning by use of background knowledge and a limited number of observations, consistent with psychological theory.

Connectionist learning is almost synonymous with "learning by examples", i.e. induction on the basis of the repeated presentation of a large number of training examples. In contrast, symbolic artificial intelligence developed "learning by instruction" or explanation-based learning methods. In this context, recruitment offers an important advantage: "one-shot learning" or learning with a limited number of examples. Recruitment learning also offers other advantages in areas that are not sufficiently covered by neural network techniques and that are essential for human learning (Levelt, 1990, p.501): (1) learning new knowledge *without impairing existing knowledge*, e.g. children learn to multiply after they have learned to add and the ability to multiply does not negatively affect the skill to add numbers. (2) learning by instruction - as explained by Levelt: If a person is being told that a dialing code is extended by the number 2, *then this rule can be applied immediately* without re-learning all existing or known telephone numbers.

The idea of learning as the result of a single presentation of a stimulus is by no means new and neither artificial intelligence nor cognitive psychology introduced the concept. Guthrie (1959) assumed already that a single co-occurrence of stimulus and response is sufficient for forming an association. Gestalt theorists such as Koehler (1917) and psychologists such as Yerkes (1927) examined "learning by problem solving" or "learning by insight" at the beginning of the last century. This uniquely human learning capability is not adequately represented by statistical neural network learning systems.

As a machine learning system, recruitment learning typically operates in sparsely connected neural networks, utilizes Hebbian and competitive learning mechanisms such as "release of inhibition", and hence claims a high degree of biological plausibility. The current research on adult neurogenesis is particularly

exciting, supporting the core concepts of recruitment learning, which is, after all, *the* neural network learning technique based on the physical and functional acquisition of new neurons.

This volume provides an overview of the field and introduces a number of different approaches for concept learning. The idea of recruitment learning is traced from early cognitive psychology to current connectionist systems. In addition, successful algorithms, techniques and applications are presented and future research opportunities are discussed.

The book is a reference for researchers and graduate students, and since the first chapter provides an introduction to the topic and others outline the foundations, the book should be an asset in the classroom as well. Due to the interdisciplinary nature of recruitment learning, this volume aims to be a resource for scholars in computer science and electrical engineering, biology, psychology and the social sciences.

Professor Jerome Feldman, Dr. Thomas Wennekers and Dr. Christian Huyck provided feedback on early versions of the book and the authors are grateful for their comments.

The authors would like to thank Professor Janusz Kacprzyk for including this volume in Springer Verlag's "Studies on Computational Intelligence" series. Dr. Thomas Dillinger and Heather King provided advice and support during the writing and editing process of this book and the authors appreciate their contributions. Ms. Belinda Lee assisted in the preparation of the final manuscript.

Joachim Diederich would like to thank Dr. Dale Anderson, Professor Tim Roberts, Dr. Denise Dillon and the friends and colleagues at James Cook University Australia, Singapore Campus, for their commitment to a research culture that encourages the writing of books and acknowledges their value. The first author is grateful to Professor Paul Bailes from the School of Information Technology and Electrical Engineering at the University of Queensland, Australia, for his ongoing support and the use of the excellent facilities of the University. Joachim Diederich's interest in recruitment learning developed during several visits to the International Computer Science Institute in Berkeley, California and his collaboration with Professor Jerome Feldman. Finally, Joachim Diederich would like to thank the most successful academic book author he knows, Professor Susan K. Wright, for her encouragement and tolerance.

Cengiz Günay would like to thank his parents and his partner Anca Doloc-Mihu for their support during the preparation of this monograph. He is also appreciative of his postdoctoral supervisor Astrid A. Prinz for letting him proceed with this volume. He acknowledges that his Ph.D. supervisor Anthony S. Maida contributed to most of the work included in this volume and Dr. Günay expresses his gratitude to him for giving permission to publish them within this volume.

James M. Hogan would like to thank his family – Tertia and Adrian - for their support during the preparation of this volume, particularly for their tolerance of interruptions during a number of holiday periods. A number of researchers have contributed greatly to the development of his understanding of recruitment learning and its relationship to the computational and cognitive neurosciences. While

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March 2010

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