Preface

Since the middle of the twentieth century, and accelerating sharply around the 1980s, computer science developed an area in which it is tried to equip computers with the capability to exhibit intelligent behavior, and thus to mimic the ability of humans and other intelligent animals to deal with uncertainty and vagueness, to learn from experience, and to adapt to changing environments. This area has aptly been named "Computational Intelligence" and nowadays belongs to the most actively researched areas not only in computer science, but even in the whole of science, technology and engineering.

Rudolf Kruse, to whom this book is dedicated on the occasion of his retirement from his post as a Professor at the Otto-von-Guericke-University of Magdeburg, Germany, helped substantially in shaping this area, not only with his own significant contributions, which are manifold, but also, and possibly even more, by promoting this area, by encouraging many others to enter it, and by supporting them to advance its state of the art.

This book collects several contributions that honor the achievements of Rudolf Kruse either directly or indirectly, by referring explicitly to his work or by showing the state of the art in specific areas of Computational Intelligence on which he had an influence. The main focus of these contributions lies on treating vague data as well as uncertain and imprecise information with automated procedures, which use techniques from statistics, control theory, clustering, neural networks, etc., to extract useful and employable knowledge.

The contribution by Enric Trillas and Rudolf Seising considers a problem that has been discussed in a sometimes heated fashion since fuzzy sets entered the stage of science, namely the interpretation and proper mathematical modeling of fuzzy sets. They remind us that despite a multitude of concepts with different names there are not many different types of fuzzy sets, but rather merely different formalizations of the linguistic phenomena of vagueness that one tries to model with fuzzy sets.

The contribution by Maria Ángeles Gil compares two definitions of fuzzy random variables, one of which originated from a book Rudolf Kruse wrote together with Klaus-Dieter Meyer ("Statistics with Vague Data"), which is contrasted to the one by Puri and Ralescu. Again, we find an interpretation problem at the heart

of the distinction: Are fuzzy phenomena aspects of the real world or are they merely aspects of our observation of it? Depending on the answer, slightly different results and procedures are obtained.

The contribution by Inés Couso and Eyke Hüllermeier considers the case of statistically estimating ranking information from an incomplete observation of a ranking. This setting can be modeled along the general lines of handling set-valued information, similar to how set-valued information is treated in Dempster–Shafer theory or possibility theory, the latter of which was developed out of fuzzy theory as an alternative calculus to model uncertainty, orthogonal to probability theory and with a different emphasis.

The contribution by Thomas Runkler et al. takes a look at the area of fuzzy control, which has certainly been the most successful outcome of fuzzy theory w.r.t. actual applications. Again, the connection to Rudolf Kruse is very direct, as he played a decisive part in several applications of fuzzy control at Volkswagen (idle speed control, automatic gear shift, etc.). Thomas Runkler et al. study how a type-2 fuzzy set can be defuzzified, which is the necessary last step in the processing of a fuzzy controller based on type-2 fuzzy sets.

The contribution by Frank Klawonn enters the area of clustering, and especially fuzzy clustering in its various forms, on which Rudolf Kruse coauthored an influential book ("Fuzzy Cluster Analysis") with Frank Höppner, Frank Klawonn, and Thomas Runkler. Frank Klawonn considers dynamic data assigning assessment clustering, which was developed out of noise clustering, a fuzzy clustering approach to better deal with noise and outliers, to detect single clusters in an iterative fashion, and applies this approach to improve cluster detection in time-resolved data from the life sciences.

The contribution by Sara Mahallati et al. is also located in the area of clustering and considers the task of interpreting the structure of a clustering result, especially with the help of the well-known Dunn index, but also with visual assessment based on properly reordered distance matrices. The authors explore the close connection of both approaches to the time-tested single linkage hierarchical clustering method and apply their theory to the specific task of clustering waveform data, which, due to the time-dependent nature of the data, is closely connected to the preceding contribution.

The contribution by Malte Oeljeklaus et al. deals with one of the currently hottest topics in Computational Intelligence, namely deep learning neural networks for image analysis. With the discovery that the reach of the universal approximation theorem for neural networks is limited by the potentially needed huge size of a single hidden layer and the development of new activation functions and new training methods that allow, supported by advances in hardware, for efficient training of neural networks with many hidden layers ("deep" neural networks), the area of neural networks has seen unprecedented successes and consequently a surge of interest in recent years. This contribution deals with an application of such deep learning neural networks to traffic scene segmentation and recognition, which is a decisive step toward enabling autonomously driving vehicles ("self-driving cars").

The contribution by Christer Carlsson looks at the wider context and application potential of fuzzy methods and, more generally, soft computing technology in the area of management science and operations research or, as it is more often referred to today, business analytics. Here, fuzzy ontologies may be used for capturing domain-specific semantics for information retrieval by using fuzzy concepts, relations, and instances, and by defining and processing degrees of inclusion and coverage between concepts, which are then processed by a typical fuzzy min-max approach. However, since using software tools built with such sophisticated methodology requires high expertise of the operators, digital coaches are needed to help domain experts to fully exploit the benefits of such systems, which Carlsson also considers and advocates.

We are very grateful to all authors who accepted our invitation to contribute a chapter to this volume and to all reviewers who helped to improve the contributions. Furthermore, we express our gratitude to Janusz Kacprzyk, who made it possible to publish this book in the Springer series "Studies in Computational Intelligence." Last, but not least, we thank Springer-Verlag for the excellent collaboration that helped a lot to publish this book in time.

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June 2017



http://www.springer.com/978-3-319-67788-0

Frontiers in Computational Intelligence
Mostaghim, S.; Nürnberger, A.; Borgelt, C. (Eds.)
2018, IX, 143 p. 43 illus., 32 illus. in color., Hardcover
ISBN: 978-3-319-67788-0