

Preface

This state-of-the-art book describes important advances in type-2 fuzzy systems that have been made in the past decade for real-world pattern recognition problems, such as speech recognition, handwriting recognition, and topic modeling. The success of type-2 fuzzy sets has been largely attributed to their three-dimensional membership functions to handle both randomness and fuzziness uncertainties in real-world problems. In pattern recognition, both features and models have uncertainties, such as nonstationary babble noise in speech signals, large variations of handwritten Chinese character shapes, uncertain meaning of words in topic modeling, and uncertain parameters of models because of insufficient and noisy training data. All these uncertainties motivate us to integrate type-2 fuzzy sets with probabilistic graphical models to achieve better overall performance in terms of robustness, generalization ability, or recognition accuracy. For example, we integrate type-2 fuzzy sets with graphical models such as Gaussian mixture models, hidden Markov models, Markov random fields, and latent Dirichlet allocation-based topic models for pattern recognition. The type-2 fuzzy Gaussian mixture models can describe uncertain densities of observations. The type-2 fuzzy hidden Markov models incorporate the first-order Markov chain into the type-2 fuzzy Gaussian mixture models, which is suitable for modeling uncertain speech signals under babble noise. The type-2 fuzzy Markov random fields combine type-2 fuzzy sets with Markov random fields, which is able to handle large variations in structural patterns such as handwritten Chinese characters. The type-2 fuzzy topic models focus on uncertain mixed membership of words to different topical clusters, which is effective to partition the observed (visual) words into semantically meaningful topical themes. In conclusion, these real-world pattern recognition applications demonstrate the effectiveness of type-2 fuzzy graphical models for handling uncertainties.

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Jia Zeng
Zhi-Qiang Liu

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Zeng, J.; Liu, Z.-Q.

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