Abstract

This thesis consists of the main scientific achievements of the candidate since 2009, when he presented his PhD thesis entitled "Novel image processing methods based on fuzzy logic" at Budapest University of Technology and Economics. All contributions and achievements reported here as new results represent the output of postdoctoral research activity performed at Sapientia University of Tîrgu Mureş (August 2010 - August 2012, research grant PD667, 28/05.08.2010, funded by UEFISCDI Romania), Budapest University of Technology and Economics (October 2012 - December 2015, research grant OTKA PD103921, funded by OTKA Hungary), and the University of Canterbury, Christchurch, New Zealand (March 2015 - June 2015, research grant IRSES 318943, funded by FP7 Marie Curie Actions).

Contributions reported in this thesis are structured in three main chapters (Chapters 2 to 4).

The first introductory chapter of this thesis presents the most important background works and previous results standing at the foundation of the thesis.

Chapter 2 entitled "The Fuzzy-Possibilistic Product Partition" introduces a novel, qualitatively different way of combining probabilistic and possibilistic partitions within the fuzzy c-means clustering model, intended to efficiently suppress the effect of outlier data while preserving or even improving the fine partition quality provided by previous solutions. The most important achievements are:

- The introduction of the notion of fuzzy-possibilistic product partition, which is composed of two multiplicative factors: a probabilistic and a possibilistic one. It is designed to efficiently suppress outlier data in clustering problems.
- The introduction of the fuzzy-possibilistic product partition c-means clustering algorithm, which proved more robust and accurate than previous hybrid c-means algorithms.
- The introduction of the fuzzy-possibilistic product partition c-spherical shells clustering algorithm, to accurately detect clusters of spheroidal shape. It outperformed previous solutions in terms of accuracy, especially in the presence of noise.
- The introduction of fuzzy-possibilistic product partition c-elliptic shells clustering algorithm, to accurately detect clusters of ellipsoidal shape. It proved to be more accurate than previous algorithms, especially in the presence of noise.

Chapter 3 entitled "Generalizations of the suppressed fuzzy c-means clustering algorithm" extends the theory of the so-called suppressed fuzzy c-means clustering algorithm (Fan *et al* , 2003) via introducing the usage of context dependent suppression rates and various suppression rules. Further on, this chapter reveals the close relation between all suppressed FCM clustering models and the fuzzy c-means algorithm with (generalized) improved partition (Höppner & Klawonn, 2003; Zhu *et al* , 2009), giving also an evidence of the optimality of suppressed FCM algorithms. The most important contributions are:

- The introduction of the concept of context sensitiveness in the theory of suppressed fuzzy c-means algorithm.

- The introduction of two generalization ways and several generalization rules for the suppressed fuzzy c-means algorithm, resulting in new context sensitive clustering algorithms.
- The beneficial effects of various suppression rules are evaluated through several applications, leading to recommendations concerning the choice of parameter values.
- The introduction of a framework that unifies the theories of FCM algorithms with suppressed and improved partitions.
- Presentation of evidence of the optimality of suppressed FCM algorithms.

Chapter 4 entitled "Applications of c-Means Clustering Models", as its title suggests, gives five detailed examples of application fields, all of them having important achievements:

- The introduction of an efficient, fuzzy c-means clustering based algorithm that compensates the intensity inhomogeneity of magnetic resonance images and performs accurate segmentation of the human brain.
- Development of a cascade fuzzy c-means clustering algorithm for the accurate segmentation of brain tumors in multispectral volumetric magnetic resonance image data. Alternately, the development of a random forest technique based procedure for the accurate detection and segmentation of brain tumors in multispectral volumetric magnetic resonance image data.
- The introduction of an efficient, c-means clustering based color quantization algorithm, and the evaluation of several suppressed FCM algorithms within this application.
- A detailed analysis of the so-called Fuzzy Local Information c-Means (FLICM) clustering algorithm, which has a major impact within the field of image segmentation applications.
- The development of a digital imaging based system for the education of correct hand hygiene techniques in hospitals, involving image segmentation performed via semi-supervised fuzzy c-means clustering.

The last chapter of this thesis is dedicated to the presentation of future research and professional carrier development plans of the candidate.