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Fuzzy Image Processing: A Tutorial

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Motivation for the Tutorial

During the processing of gray-level images, we encounter different types of imperfection (uncertainties, ambiguities and vagueness). These imperfections can involve the gray-level intensities, the geometrical characteristics and relations among image objects, and the expert knowledge itself used to overcome these problems. If one tries to catch these imperfections by crisp formulations of the processing steps, one may lose valuable information, which could possibly facilitate the next phases of processing. Fuzzy sets in general, and fuzzy image processing in particular can assist us in overcoming imperfections in designing image-processing algorithms.

What is Fuzzy Image Processing (FIP)?

Under Fuzzy Image Processing (FIP) we understand the collection of all methodologies in digital image processing, with which the images, their segments or features, which represent these images or their segments, are understood, represented and processed as fuzzy sets. In which manner this takes place, depends on the problem definition and on the respective fuzzy method. This definition refers naturally to other methodologies and not to image processing as a separate branch of science. Thus the misunderstanding has to be avoided that fuzzy image processing may replace the classical image processing.

Applications of FIP

Fuzzy algorithms can be used in different ways. If we consider the three different stages of any computer vision system, namely low-, intermediate- and high-level image processing, then we can recognize the applications of different fuzzy concepts for different tasks:

	low level	**intermediate level**	**high level**
Fuzzy Geometry	✓	✓	-
Measures of Fuzziness	✓	✓	-
Fuzzy Inference	✓	✓	✓
Fuzzy Clustering	-	✓	✓
Fuzzy Morphology	✓	✓	-
Fuzzy Measures/Integrals	-	✓	✓
Fuzzy Grammars	-	-	✓
Fuzzy-Neural approaches	-	✓	✓
Fuzzy-Genetic approaches	-	✓	✓

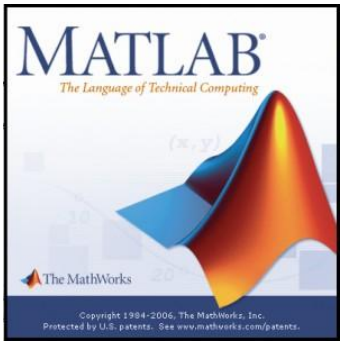
Structure of The Tutorial

The tutorial runs in 2 hours:

1. Short review of the history
2. Introduction into basics of fuzzy systems
3. Introduction into basic definitions fro FIP
4. Theory of FIP
5. Applications of IP
6. Matlab Hands-on Code development

Hands-On Tutorial Part II: Medical Image Analysis

Medical images analysis has become a crucial component in modern medicine. Clinicians employ different image modalities, such as CT, MR and ultrasound images, for diagnostic, treatment planning and post-treatment monitoring of many diseases. The analysis of medical images involves many tasks such as enhancement, filtering, segmentation and registration of digital images. Due to the complexity of human anatomy, the limitations of imaging devices and other reasons, analyzing medical images is always accompanied with uncertainty and vagueness. Fuzzy image processing is a knowledge-based approach to image processing.



In the second part of the tutorial, we will design a complete processing chain for medical image analysis. abdominal CT and pelvis MR images, we will, step by step, develop a complete processing chain to extract the prostate and bladder from these images. In each step we will demonstrate the benefit if using fuzzy image processing in managing uncertainty and vagueness.

Matlab Code of the developed fuzzy methods will be distributed during/after tutorial.

Readings

- Fuzzy Models and Algorithms for Pattern Recognition and Image Processing, Bezdek et al., Springer 2005, ISBN-10: 0387245154
- Fuzzy Filters for Image Processing (Studies in Fuzziness and Soft Computing) Nachtegael et al., Sprinmger 2003, ISBN-10: 3540004653
- Fuzzy Image Processing and Applications with MATLAB, Chaira et al., CRC Press, 2009, ISBN-10: 1439807086
- Fuzzy Techniques in Image Processing (Studies in Fuzziness and Soft Computing) Kerre et al., Physica Verlag, 2010, ISBN-10: 3790824755
- Fuzzy Algorithms: With Applications to Image Processing and Pattern Recognition, Chi et al., World Scientific, 1996, ISBN-10: 9810226977
- Fuzzy Bild-Verarbeitung, Tizhoosh, Springer, 1997, ISBN-10: 3540631372

Speaker's Short Bio

Dr. Hamid Tizhoosh received the MSc degree in electrical engineering with a major in computer science from University of Technology, Aachen, Germany, in1995. From 1993 to 1996, he worked at Management of Intelligent Technologies Ltd., Aachen, Germany in the field of industrial image processing. Dr. Tizhoosh received his Ph.D. degree from University of Magdeburg, Germany, in2000 with the subject of fuzzy processing of medical images. Dr. Tizhoosh was active as the scientist in the engineering department of IPS (Image Processing Systems Inc., now Photon Dynamics), Markham, Canada, until 2001. For six months, he visited the Knowledge/Intelligence Systems Laboratory, University of Toronto, Canada.

Since September 2001, Dr. Tizhoosh is a faculty member at the department of Systems Design Engineering, University of Waterloo, Canada.

At the same time, he has been the Chief Technology Officer and Chief Executive Officer of Segasist Technologies, a software company (Toronto, Canada) developing innovative software for medical image analysis. His research encompasses machine intelligence and computer vision. Dr. Tizhoosh has extensive experience in medical imaging including portal (megavoltage) imaging, x-rays, MRI and ultrasound. He has been a member of the European Union Projects INFOCUS and ARROW for radiation therapy to improve the integration of online images within the treatment planning of cancer patients. Dr. Tizhoosh has extensively published on fuzzy techniques in image processing. He is the author of two books, 14 book chapters, and more than 100 journal/conference papers.

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