# Machine learning for Remote Sensing Data Analysis

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## Abstract

Machine learning has become a standard paradigm for the analysis of remote sensing and geoscience data at both local and global scales. In the upcoming years, with the advent of new satellite constellations, machine learning will have a fundamental role in processing large and heterogeneous data sources. Machine learning will move from mere statistical data processing to actual learning, understanding, and knowledge extraction. The ambitious goal is to provide responses to the challenging scientific questions about the Earth system.

In this tutorial, we will present the remote sensing image processing chain, and take the attendants on a tour of different strategies for feature extraction, classification, unmixing, retrieval, and pattern analysis for remote sensing data analysis. We will present powerful methodologies for remote sensing supervised remote sensing data classification: extracting knowledge from data, including interactive approaches via active learning, classifiers that encode prior knowledge and invariances, semisupervised learning that exploit the information of unlabeled data, and domain adaptation to compensate for shifts in the ever-changing data distributions. Latest advances in the field of unmixing will be reviewed, covering sparse approaches, spatial-spectral methods, and methods constrained by physical models. Finally, we will pay attention to recent advances in bio-geophysical parameter estimation that care about remote sensing data characteristics, such as spatial and temporal structures or the presence of heteroscedastic noise. Beyond theory, we will also present results of recent studies illustrating all the covered issues. Finally, we will provide MATLAB code and demos to the attendees to try the different methodologies, and provide a solid ground for their future experimentations.

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Gustau Camps-Valls (IEEE Member'04, IEEE Senior Member'07) received a B.Sc. degree in Physics (1996), in Electronics Engineering (1998), and a Ph.D. degree in Physics (2002) all from the Universitat de València. He is currently an associate professor (hab. Full professor) in the Department of Electronics Engineering. He is a research coordinator in the Image and Signal Processing (ISP) group, http://isp.uv.es. He has been Visiting Researcher at the Remote Sensing Laboratory (Univ. Trento, Italy) in 2002, the Max Planck Institute for Biological Cybernetics (Tübingen, Germany) in 2009, and was Invited Professor at the Laboratory of Geographic Information Systems of the École Polytechnique Fédérale de Lausanne (Lausanne, Switzerland) in 2013.

He is interested in the development of machine learning algorithms for geoscience and remote sensing data analysis. He is an author of 130 journal papers, more than 150 conference papers,

20 international book chapters, and editor of the books "Kernel methods in bioengineering, signal and image processing" (IGI, 2007), "Kernel methods for remote sensing data analysis" (Wiley & Sons, 2009), and "Remote Sensing Image Processing" (MC, 2011). He's a co-editor of the forthcoming book "Digital Signal Processing with Kernel Methods" (Wiley & sons, 2015). He holds a Hirsch's index h=45 (see Google Scholar page), entered the ISI list of Highly Cited Researchers in 2011, and Thomson Reuters ScienceWatch identified one of his papers on kernel-based analysis of hyperspectral images as a Fast Moving Front research. In 2015, he obtained the prestigious European Research Council (ERC) consolidator grant on Statistical learning for Earth observation data analysis. He is a referee and Program Committee member of many international journals and conferences.

Since 2007 he is member of the Data Fusion technical committee of the IEEE GRSS, and since 2009 a member of the Machine Learning for Signal Processing Technical Committee of the IEEE SPS. He was a member of the MTG-IRS Science Team (MIST) of EUMETSAT. He is Associate Editor of the IEEE Transactions on Signal Processing, IEEE Signal Processing Letters, IEEE Geoscience and Remote Sensing Letters, and invited guest editor for IEEE Journal of Selected Topics in Signal Processing (2012) and IEEE Geoscience and Remote Sensing Magazine (2015).

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