German Pattern Recognition Award 2011

Laudatio for Prof. Dr. **Matthias Hein**

The German Pattern Recognition Award 2011 is awarded to Matthias Hein in recognition of his innovative work in the field of machine learning. He has made outstanding contributions to machine learning, particularly to graph-based learning methods both on a theoretical and algorithmic level. Matthias Hein is a (tenured) professor for computer science in the area of machine learning at the Saarland University.

Matthias Hein has analyzed geometrical aspects of statistical learning in his PhD thesis which was performed at the Max-Planck-Institute for Biological Cybernetics under the supervision of Bernhard Schölkopf. In particular, he was one of the pioneers of a rigorous theoretical foundation of manifold learning. In manifold learning one makes use of the fact that due to strong correlations of the features, high-dimensional data is often concentrated on a low-dimensional manifold. Hein studied the approximation of quantities like the weighted Laplace-Beltrami operator which characterize the unknown manifold. The learning problem arises when the manifold properties are estimated from samples based on neighborhood graphs. In particular, he showed the convergence of the graph Laplacian towards the continuous weighted Laplace-Beltrami operator of the data manifold which provides a link between continuous diffusion processes and "label-propagation" algorithms in semi-supervised learning. Moreover, he provided consistent estimators of the intrinsic dimension and the density on the data manifold. The areas of semi-supervised learning and clustering have also benefited from his ideas to analyse the effect of the choice of the neighborhood graph on the employed graph-based algorithm. The surprising result that different neighborhood graphs lead to different results in spectral clustering has been awarded the Outstanding Student Paper Award at NIPS 2008.

A fascinating new direction of his research investigates nonlinear eigenproblems, which also lead to a new algorithmic approach for the old problem of finding balanced graph cuts. Hein could show that the combinatorial problem of the normalized cut used in spectral clustering can be formulated equivalently as a continuous nonlinear eigenproblem. His generalization of the inverse power method to nonlinear eigenproblems yields graph cuts which are guaranteed to outperform standard spectral clustering based on the relaxation into a linear eigenproblem while having similar runtime performance.

Beyond graph-based methods, he has made contributions to kernel methods by proposing an extension of the SVM which allows to apply the maximum margin principle for arbitrary metric spaces and by studying kernels on probability measures as they are frequently used in the bag-of-words representation. Moreover, he has worked on learning with manifold-valued output by proposing a generalization of thin-plate splines and by proving consistency of a family of Nadaraya-Watson type estimators with manifold-valued output.

As recognized by the German Pattern Recognition Award 2011, Matthias Hein has made innovative and significant contributions to machine learning. We are looking forward to his future work.