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FAKULTÄT FÜR MATHEMATIK
Dekan Univ.-Prof. Dr. Christian Krattenthaler

Einladung zur öffentlichen Defensio von

Anna Breger

Thema der Dissertation:

Dimension Reduction with Orthogonal Projections and Applications in Medical Imaging using Learning Frameworks

Abstract:
Orthogonal projections are important linear methods for dimension reduction, compressing and combining high-dimensional data. Thereby the dimension reduction itself is just based on a matrix multiplication, allowing fast computation on large data sets. We derive new results on point sequences that sample the space of orthogonal projections, called the Grassmannian. In particular, we prove that a specific class of sequences covers the space in an asymptotically optimal manner. Our numerical experiments illustrate the theoretical results, validating further analyses and experiments in applications with such point sequences.

To measure the adequacy of a dimension reduction method, the preservation of diverse aspects of information must be considered. The orthogonal projection arising from the well known principal component analysis (PCA) maximizes the total variance within the projected data. Especially tasks that work with noisy data benefit from this method. On the other hand, random projections ensure with high probability the preservation of all pairwise distances within a data set. This property is especially important for tasks that rely on small changes within the data. Whether one or the other kind of information is of main importance depends on further objectives and the condition of the given data. We provide a mathematical proof to show that these two objectives strongly correlate and usually cannot be achieved at the same time. Numerical experiments are designed to illustrate these results.

Dimension reduction and orthogonal projections are useful in plenty diverse imaging problems. In the applied part of my PhD project I worked with clinical optical coherence tomography (OCT) and magnetic resonance imaging (MRI) data. This research emerged from collaborations with the Vienna Reading Center (VRC), Department of Ophthalmology, Medical University of Vienna as well as the Laboratory of Mathematics in Imaging (LMI), Brigham and Women's Hospital, Harvard Medical School, Boston, MA. Based on annotated data we develop analyses and image segmentation methods using (deep) learning algorithms that include dimension reduction and orthogonal projections.

Prüfungssenat:

Univ.-Prof. Dr. Josef Hofbauer(Vorsitz)
(Universität Wien)

Assoz. Prof. Dr. Martin Ehler, Privatdoz.
(Universität Wien)

Dr. rer. nat. habil. Gerlind Plonka-Hoch
(Universität Göttingen)

Prof. Dr. Wojciech Czaja
(University of Maryland)

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