FWF Der Wissenschaftsfonds

FWF START Project
Optimisation Principles, Models & Algorithms for Dictionary Learning

University of Innsbruck
Department of Mathematics
Applied Mathematics Group

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Postdoctoral position (junior)

Dear Colleague,

I am looking for a creative mind to fill a postdoctoral position (up to 6 years) within the FWF-START-project 'Optimisation Principles, Models & Algorithms for Dictionary Learning' at the Department of Mathematics of the University of Innsbruck.

Research
Our research is located at the intersection of mathematics, signal processing and machine learning. In particular we are interested in the learning of representation systems (dictionaries) providing compact (sparse) descriptions for high dimensional data classes from a theoretical and algorithmic point of view and in applying these dictionaries to data processing and analysis tasks. Our main tools come from sparse approximation, geometric functional analysis (measure concentration), harmonic analysis and optimisation. More information can be found here and a short summary of the project is included below.

Environment
The project is embedded into the Applied Mathematics Group at the Department of Mathematics of the University of Innsbruck, which performs research into inverse problems, computed tomography, photoacoustic imaging, learning theory and compressed sensing and is involved in the interdisciplinary doctoral school on high performance computing. On an international level the project is well integrated into the dictionary learning, sparse approximation, harmonic analysis and compressed sensing communities and will be cooperating with groups in Rennes (FR), Paris (FR), Edinburgh (UK), Haifa (IL), Vienna (AT), etc. Working language is English but (readiness to acquire) some German skills will be useful for every day life in Innsbruck.

Offer
To the successful candidate will be offered a research position of up to 6 years, salary about 48.000€/year gross[1] on a 40h/week basis, rising to 53.000€/year in the 4th year, part-time employment on request. The candidate is further supported with an autonomous travel budget of about 5.000,00€/year and the University of Innsbruck is offering a variety of additional employee benefits. Teaching is not required but possible. We provide both individual guidance and independent career development. The project started June 1, 2015, and the starting date for the position is at earliest convenience.

Qualifications
Interested candidates with a mathematics related PhD and strong mathematical skills in one or more of the following fields - *geometric functional analysis (measure concentration, probability theory), machine learning (dictionary learning), sparsity, approximation theory, optimisation, harmonic analysis, compressed sensing* - are invited to apply, by electronically submitting, **in pdf format: a short motivation letter, a cv including list of publications and 2 to 3 recommendation letters** to karin.schnass@uibk.ac.at. Preferably the reference letters should be sent directly by the referees. Processing of applications is on the fly and all **complete** applications will be fully considered[2] until the position is filled.

Any questions concerning the position as well as the application material should be mailed to karin.schnass@uibk.ac.at.

Best regards,

Karin Schnass

[1] gross/net salary calculator (in German)

[2] In particular this means that incomplete applications will not be considered and additional material will not be appreciated.

Summary of the project 'Optimisation Principles, Models & Algorithms for Dictionary Learning'

Be it the 300 million photos uploaded to Facebook per day, the 800GB the large Hadron collider records per second or the 320.000GB per second it cannot record, it is clear that we have reached the age of big data. Indeed, last year the amount of data existing worldwide is estimated to have reached 2.8 ZB = 2.800 billion GB and while 23% of these data are expected to be useful if analysed only 1% actually are. So how do we deal with this big data challenge? On the side of data processing some of the most promising strategies are based on the key concept of sparsity, i.e., the low complexity of even high-dimensional data when represented in a suitable frame/dictionary. This project addresses the fundamental question how to automatically learn a dictionary, providing sparse representations for a given data class, known as dictionary learning or sparse coding. It aims to provide a deeper theoretical understanding of dictionary learning and based on that to develop stable and efficient learning algorithms for high-dimensional data. To reach this goal in particular the following topics will be addressed.

- Optimisation Principles: The most promising strategies for dictionary learning so far have been based on optimisation principles. We will investigate the local and global dictionary identification properties of several classical and new principles, given suitable sparse generating models for the signals.
- Models: We will go beyond the currently used isotropic sparse coefficient models and develop realistic sparse generating models, that allow us to model also structured sparse data sets. Further, we will design and analyse learning principles that allow identification of the dictionary together with (independent of) the underlying sparse structures.
- (Randomised) Algorithms: A fundamental challenge in dictionary learning is the high dimensionality of the learning problem itself. Hence, we will explore how to reduce the computational complexity of the learning task via Johnson - Lindenstrauss embeddings and divide& conquer schemes.
- Analysis Dictionary Learning: Analysis (co)-sparsity has been recently introduced as promising alternative to synthesis sparsity. We are going to study the analysis dictionary learning problem through an approach parallel to synthesis dictionary learning, i.e., the formulation of optimisation principles, investigation of identifiability given random co-sparse signal models and development of efficient (randomised) algorithms.
- Applications - In close cooperation with our (inter)national scientific partners we will apply the developed schemes to high-dimensional problems which cannot be tackled by currently available dictionary learning schemes, e.g. microscopy imaging, sound tracing, audio inpainting, magnetic resonance imaging or acoustic perception.