Curriculum Vitae: Dr. Monika Dörfler

Born on December 24, 1972 in Vienna, Austria, residence in Vienna.
Married, two children (born 2003 and 2005).

Current Position

Hertha Firnberg Fellow at the Faculty of Mathematics, University of Vienna
Homepage: `http://homepage.univie.ac.at/monika.doerfler`

Education

- Ph.D. in Mathematics, University of Vienna, 2002.
- M.S in in Mathematics, University of Vienna, 1996.
- Bachelor in classical piano (1997) and Jazz piano and composition (2001), University of Music, Vienna

Funded Projects

- 2010-2012: Audio-Miner, Interdisciplinary project with OFAI, WWTF
- 2009-2012: Individual Hertha Firnberg FWF-grant P21247 "Local Aspects of Time-Frequency Analysis"
- Scholarship for scientific work abroad, of the Center for Studies abroad, University of Vienna (1995)

Former Employment and Work Experience

- March 2008 - February 2009 Research assistant at the Acoustic Research Institute, Austrian Academy of Science, Vienna
- October 2006 - February 2008 Lecturer at the University of applied sciences, St.Pölten, Austria
- September 2006 Hassip Fellow at Université de Provence, Marseille, France
- January - June 2005: Hassip Fellow at Université de Provence, Marseille, France
- September 2004 to January 2005: Research assistant with NuHAG, University of Vienna

- 2003/2004: Teaching and research assistant at the department of mathematics, University of Vienna
- 2003 Co-Organisation of Sampta'03 conference, Strobl, Austria
- 1999 - 2003: Research assistant with NuHAG, University of Vienna (Supported by the science fonds of the Austrian National Bank and the Austrian science foundation FWF)
- 1999: Co-Organisation of the Diderot conference *Mathematics and Music* in Vienna
- 1998 Piano teacher at Musikschule Krems/Niedersterreich
- 1996-1998 Research assistant at the Institute for Econometrics and system theory, Technical University of Vienna

Publications

1. Articles in journals (the five most important being commented):

   (a) M. Dörfler and K. Gröchenig. **Time-Frequency partitions and characterizations of modulations spaces with localization operators.** *J. Funct. Anal.*, 260(7):1903–1924, 2011.
   This article generalizes a result on characterization of modulations spaces by means of families of lattice-shifted localization operators proved in 1.(*e*) *for lattices with integer-oversampling to general lattices. The given characterization justifies a local interpretation of time-frequency coefficients obtained via the short-time Fourier transform. As a by-product, we obtain a new proof for the existence of multi-window Gabor frames and extend the structure theory of Gabor frames to multi-window frames.*

   (b) M. Dörfler and B. Torrésani. Representation of operators by sampling in the time-frequency domain. *Sampl. Theory Signal Image Process.*, 10(1-2): 172–190, 2011.

   (c) M. Dörfler. **Quilted frames - a new concept for adaptive representation.** *Advances in Applied Mathematics*, to appear Doi: 10.1016/j.aam.2011.02.007, 2011.
   In this article, the concept of quilted Gabor frames is introduced. This new model for adaptive signal representation is motivated by the desire to achieve flexibility in time-frequency representations in the sense of windows and sampling sets that adapt to the properties of signals under analysis. For many natural signals, such as music or speech signals, these signal properties change locally in time and *frequency. This paper presents a mathematically sound definition and an investigation of the conditions on windows and sampling sets, under which the frame property can be fulfilled.*

(d) M. Dörfler and B. Torrésani. **Representation of operators in the time-frequency domain and generalized Gabor multipliers.** *J. Fourier Anal. Appl.*, 16(2):261–293, 2010.
Starting from a general operator representation in the time-frequency domain, this paper addresses the problem of approximating linear operators by operators that are diagonal or band-diagonal with respect to Gabor frames. A characterization of operators that can be realized as Gabor multipliers is given and necessary conditions for the existence of (Hilbert-Schmidt) optimal Gabor multiplier approximations are discussed and an efficient method for the calculation of an operators best approximation by a Gabor multiplier is derived. The spreading function of Gabor multipliers yields new error estimates for these approximations. Generalizations (multiple Gabor multipliers) are introduced for better approximation of overspread operators. The Riesz property of the projection operators involved in generalized Gabor multipliers is characterized, and a method for obtaining an operators best approximation by a multiple Gabor multiplier is suggested.

(e) M. Dörfler, H. G. Feichtinger, and K. Gröchenig. Time-frequency partitions for the Gelfand triple $(S_0, L^2, {S_0}')$. *Math. Scand.*, 98(1):81–96, 2006.

(f) M. Dörfler, H. G. Feichtinger, and K. Gröchenig. **Compactness criteria in function spaces.** *Colloq. Math.*, 94(1):37–50, 2002.
In this article, a classical criterion for compactness in Banach spaces of functions is reformulated into a simple tightness condition in the time-frequency domain. This description preserves more explicitly the symmetry between time and frequency than the classical conditions. The result is first stated and proved for $L^2(\mathbb{R}^d)$, and then generalized to coorbit spaces. As special cases, we obtain new characterizations of compactness in Besov-Triebel-Lizorkin spaces, modulation spaces and Bargmann-Fock spaces.

(g) M. Dörfler. **Time-frequency Analysis for Music Signals. A Mathematical Approach.** *Journal of New Music Research*, 30(1):3–12, 2001.
This paper establishes a link between certain problems that arise when digital audio signals are processed, and the theory of Gabor frames. Indeed, various widely used spectral domain methods, in particular, so-called FFT-based overlap-add methods, correspond to the use of particular Gabor frames. The interpretation of this situation from the point of view of Gabor analysis makes the calculation of dual windows computationally efficient and post-processing by a weighting function unnecessary, thus leading directly to perfect reconstruction.

2. Refereed conference contributions

(a) G. Velasco, M. Dörfler, and N. Holighaus. Constructing an Invertible Constant-Q Transform with Non-stationary Gabor Frames. Proceedings of DAFX11, Paris, 2011.

(b) K. Siedenburg and M. Dörfler. Structured sparsity for audio signals. Proceedings of DAFX11, Paris, 2011.

(c) P. Majdak, P. Balazs, W. Kreuzer, and M. Dörfler. Increasing the Signal-to-Noise Ratio in system Identification with Exponential Sweeps by Thresholding in the Time-Frequency Domain. *IEEE Proceddings of ICASSP 2011, Prag*, May 2011.

(d) M. Dörfler, A. Flexer, G. Velasco, and V. Klien. Sparse Regression in Time-Frequency Representations of Complex Audio. In *Proceedings of SMC 2010*, Barcelona, Spain, July 2010.

(e) M. Dörfler and B. Torrésani. Representation of operators by sampling in the time-frequency domain. In *Proceedings of SAMPTA09*. 2009.

(f) F. Jaillet, P. Balazs, M. Dörfler, and N. Engelputzeder. Nonstationary Gabor Frames. In *SAMPTA'09, Marseille, May 18-22*. 2009.

(g) M. Dörfler and B. Torrésani. Spreading function representation of operators and Gabor multiplier approximation. In *Proceedings of SAMPTA07*, Thessaloniki, June 2007.

(h) M. Dörfler and H. G. Feichtinger. Orthogonal projections derived from localization operators. In *Proc. Conf. EUSIPCO (Sept. 2004, TU Vienna)*, pages 1195—1198, 2004.

(i) M. Dörfler, S. J. Godsill, and P. J. Wolfe. Multi-Gabor dictionaries for audio time-frequency analysis. In *Proceedings of the IEEE Workshop on Applications of Signal Processing to Audio and Acoustics*, pages 43–46, Mohonk, NY, Oct. 2001.

(j) M. Dörfler and M. Deistler. A Structure Theory for Identification of Recurrent Neural Nets, Part 1. In H. Huijberts, H. Nijmeijer, A. Van der Schaft, and J. Scherpen, editors, *IFAC, NoLCos*, pages 459–464, Enschede, The Netherlands, July 1998.

3. Miscellaneous (submitted articles or unrefereed conference proceedings)

(a) P. Balazs, M. Dörfler, F. Jaillet, N. Holighaus, and G. A. Velasco. Theory, implementation and applications of nonstationary Gabor Frames. Submitted, 2011.

(b) F. Jaillet, P. Balazs, and M. Dörfler. On the structure of the phase around the Zeros of the STFT transform. DAGA, March 2009.

(c) M. Dörfler, P. Balazs, and F. Jaillet. Removing Components from a Time-Frequency Representation. DAGA, March 2009.

4. Book chapter

M. Dörfler. What time-frequency analysis can do to Music Signals. In M. Emmer, editor, *Matematica e Cultura 2003*. Springer Italia., 2003.

Teaching experience

Linear algebra and Analysis (”Exercise courses, Übungen”), Faculty of Mathematics, University of Vienna.
University of Applied Sciences, St. Pölten: Lectures in Analysis, Lineare Algebra, Statistics, Mathematical Signal Processing.
In WS 2011/12 I will teach the course *Angewandte Mathematik für Lehramtskanditaten* at the Faculty of Mathematics, University of Vienna.
Presently, I co-superwise two PhD-thesis and a masters thesis (due to owing ”Habilitation” formally in cooperation with Prof.Feichtinger). Habilitation is scheduled for 2012.

Talks and presentations, 2008 - 2011

Invited Talks (Selection):
- Mathematics as a reading glass for music, Conference ”From Abstract to Computational Harmonic Analysis”, Strobl, Austria, June 2011
– Time-frequency partitions in continuous and discrete settings. Akademia Grniczo-Hutnicza, Krakau, Poland. June 2011
- Timbre in time-frequency domain, Vienna Talk 2010, September 2010
- Time-frequency localization in phase-space, nthca Bremen, June 2010
- Aliasing in the TF-representation of operators - observations and possible remedies, Mulac10, Marseille, France, April 2010
- Mathematical Signal Analysis and MIR, Queen Mary College London, January 2010
- Quilted Gabor frames - progress and challenges, International Conference on Time-Frequency, Strobl, June 2009
- Representation of operators by sampling in the time-frequency domain, SAMPTA09, Marseille, France, May 2009
- Mathematik, Signale und moderne Kommunikation, Symposium Natur ab 4, PH Baden, April 2009
- Removing Components from a Time-Frequency Representation, DAGA09, Rotterdam, March 2009
- Generalizing (Gabor)Frame Multipliers, Dagstuhl, December 2008
- Frauen in der Mathematik, Wissenschafterinnen im Film, Wien, November 2008

Research

My field of research is *time-frequency analysis*, which is part of abstract, applied and numerical analysis. Motivated by concrete applications, in particular from audio signal processing, I study representations which allow for localization in both time and frequency. Harmonic analysis traditionally requires the interaction of various mathematical fields, mainly functional analysis, complex analysis, linear algebra, representations theory and numerical analysis. Time-frequency analysis aims at providing simultaneous information on a signal's time- and frequency content. In order to clarify this idea, time-frequency representations are often compared to a music-score, which, in fact, very efficiently convey the information which frequency, or rather pitch, should sound at which instant. For the mathematical understanding, however, this comparison may be misleading, as the uncertainty principle, due to Heisenberg, does not permit an exact separation of signal components in the time-frequency domain. In the analysis of signals with *Gabor frames*, this fact leads to a trade-off between good time- and good frequency resolution.

An important part of my research deals with the introduction and investigation of adaptive representations which provide flexible resolution of analyzed signals. This strand of research is reflected in both of my current projects, LOCATIF, which deals with the theoretical aspects, and Audio-Miner, which investigates concrete applications from music information retrieval (MIR) in the light of adaptive time-frequency analysis.

I introduced a new class of frames, denoted by "Quilted Gabor Frames (QGF)", (see Paper 1.(c)). By their construction, QGF allow for the adaptation of both the analysis window and the time- and frequency shift parameters to the properties of a signal or class of signals under consideration. One typical example would be given by the analysis of music signals, which often requires wide windows, implying good frequency resolution, in low frequency bands. On the other hand, in areas of the time-frequency domain, where the signal is dominated by rather percussive elements, which determine the rhythmical structure, short windows and dense time-sampling will lead to optimal results. By allowing for different Gabor frames locally in the time-frequency sense, QGF allow for analysis methods adapted to this kind of situation. As the structure of the Heisenberg group may no more be used in a global sense, completely new methods are necessary in order to achieve results on the systems' properties and for their efficient numerical implementation. An important theoretical landmark was given by the theory of characterization of function spaces with time-frequency localization operators over time-frequency partitions, see Papers 1.(a) and 1.(e). Ongoing work focuses on the construction of quilted frames from known frames. Two approaches have been envisaged so far: first, the usage of families of known global Gabor frames generated from single windows with various properties. The varying properties of the windows (and sampling lattices) allow the adaptation to signal properties, which leads to sparser signal-representations. Second, locally adaptive frames can be achieved by replacing known local generators in multi-window Gabor frames. In this context, we investigate, in particular, the spectral properties of time-frequency localization operators, which are well-known in some specific situations, in particular, for concentric localization domains, but have not been studies for more general settings.

Gabor-Multipliers are the discrete, i.e. sampled versions of the above-mentioned time-frequency localization operators. They are related to various applications in communications engineering, e.g. channel estimation for wireless communication, and signal-processing, e.g. time-varying filtering. These operators and, in particular, their generalizations to the case of multiple synthesis windows, were investigated in my papers 1.(b)&(d). Open research questions concern the estimation of the essential support of a given operator's spreading function, which will be accomplished by means of methods involving sparsity-criteria. Since time-frequency representations are based on the (non-commutative) Heisenberg group, it turns out that the approximation of the spreading function is related to results from non-commutative geometry. This connection will be the topic of my research in the near future and might evolve into a new research project.

The application of Gabor-Multipliers and adaptive representations is in fact at the core of my ongoing interdisciplinary project Audio-Miner, conducted in cooperation with the Austrian Institute of Artificial Intelligence, see `http://www.ofai.at/research/impml/projects/audiominer.html`. In the framework of this project, I am heading a small group of about 7 colleagues, who deal with problems at the intersection of applied mathematics and MIR. One important task, namely the development and implementation of an analysis method with non-linear, flexible frequency resolution, which is still perfectly invertible and efficiently implemented, has recently been accomplished, see `http://www.univie.ac.at/nonstatgab/`. Other challenges, such as the identification and extraction of certain *sound objects* from audio signals are the topic of our ongoing work.

Due to the vivid interest in particular of young colleagues (Phd and master students), this strand of research, truly on the cutting edge due to numerous Internet applications of MIR, promises many new and interesting results in the near future.

Other

Languages: German (native), English, French (fluent) , Polish, Spanish (basics)
Software: MATLAB, Latex, MSOffice, HTML