VRG12-009 - Computational harmonic analysis of high-dimensional biomedical data

Abstract

This project advanced computational harmonic analysis, a field of mathematics concerned with developing methods for representing and analyzing data and functions, often in high dimensions. Modern datasets, whether in medicine, acoustics, or data science, are often too large and complex to be addressed with classical techniques. The project therefore combined new theoretical developments with application-driven research, carried out in close collaboration with the Vienna Reading Center and the Acoustics Research Institute. We developed new approaches to dimension reduction, image segmentation, and signal reconstruction, improving the extraction of clinically and scientifically relevant features from complex data. In parallel, the project contributed to numerical integration, approximation on manifolds, and modern time-frequency analysis, thus linking mathematical foundations with practical challenges. A central application concerned ophthalmology, where retinal images are essential for diagnosing widespread eye diseases. Our methods support the automatic and early detection of retinal fluid and other decisive markers for disease progression. This enables more reliable patient monitoring and treatment planning, with clear benefits for clinical practice. In acoustics, the project introduced techniques for analyzing and reconstructing speech and music signals. These advances enhance understanding of the structure of sound and open possibilities for applications in hearing aids and speech-assistant technologies. Taken together, the biomedical and acoustic outcomes highlight the versatility of computational harmonic analysis and its capacity to address problems across domains. Beyond the scientific results, the project provided interdisciplinary training for young researchers and fostered collaboration between mathematics and applied sciences. By combining theoretical innovation with concrete applications, it demonstrated how advances in computational harmonic analysis can deepen mathematical knowledge while delivering practical impact in healthcare, technology, and data science.

Keywords:
applied harmonic analysis, time-frequency analysis, frames, sparsity,dimension reduction, wavelets, shearlets

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Further links to the persons involved and to the project can be found under https://www.gmbh.wwtf.at/funding/programmes/vrg/VRG12-009/