Bielefeld University

Graduate Program
Task-Oriented
Communication

Sonification of Multi-Channel Image Data

Thomas Hermann[1], Tim Nattkemper[1], Walter Schubert[2], Helge Ritter[1]

[1] Neuroinformatics Group, Bielefeld University, email:thermann@techfak.uni-bielefeld.de
[2] Institude of Medical Neurobiology, MELTEC Ltd., University of Magdeburg

Motivation

In many scientific applications the analysis of topographical ordered multi-channel data by an human expert is required. Some examples are

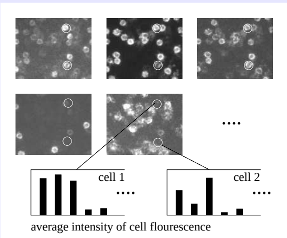
- Multi-Parameter Fluorescence Microscopy Data
- Multi-Spectral Tomography Data
- Geographic Maps
- Self-Organizing Maps (SOM) for high-dimensional data sets

The usual visualizations are limited in different ways (see below). The aim of this work is to provide a new method to inspect the data through the image stack. This is achieved by extending the visualizations with (audible) *sonifications*, which are sound images rendered from the data.

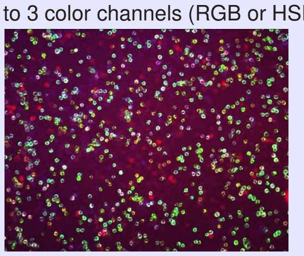
Visualization Techniques

There are some standard ways to inspect these kind of data:

- plot all images aligned to a grid - the expert has only sequential access to the images.



- visualize up to 3 grey images using different color channels - this is usually limited to 3 color channels (RGB or HSI).



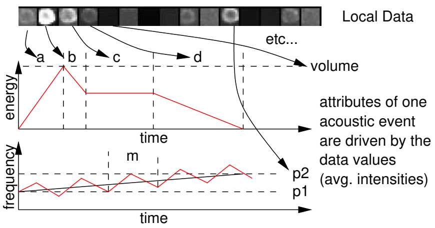
Auditory Maps

Auditory Maps are a way to overcome the limitation of the color-coded visualization by allowing the expert to probe certain locations on the map and rendering a sound which encodes the information through the image stack.

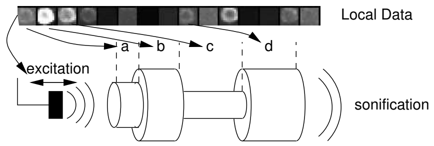
- Interaction: Mouse Pointer probes image elements.
- Adjust Size of **Aura** (Acoustic Fovea).
- Probing: Mouse-Click → Spot Sonification is rendered and played.
- Summary: Region-Select → Summary about image area is played.

Sonification Strategies

Parameter Mapping

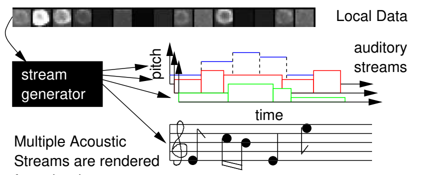


Model-Based Sonification



Data parametrizes "Virtual Resonator" and provides Model Excitation (here: Tube-Model).
- implicit coding of data into sound
- Physical Model for Sonification-Rendering

Auditory Scene Generation



Multiple Acoustic Streams are rendered from the data.
- like different instruments in an orchestra
- simulate complex sound environments.

Application

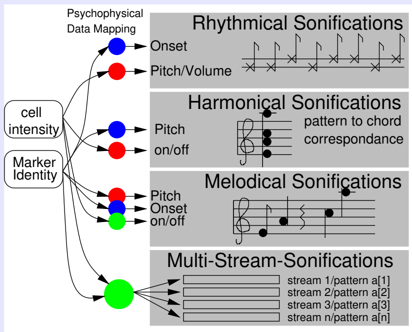
The method was applied to analyze image data from Multi-Parameter Fluorescence Microscopy

- Data: MPF images ($n \approx 5 \ldots 20$ per data set) of immunofluorescently labeled lymphocytes (example: images in left column)
- fluorescent cells in image n indicate existence of marker proteins $m(n)$ on the cell surface.
- due to method: constant cell coordinates through the image stack.

Task Specification:

- Comparison of Cell's Fluorescence Patterns (check for Identity, Similarity of patterns)
- Perceive frequency of fluorescence patterns.
- Extensibility (allow addition of further markers)
- Fast Image Browsing - provide information in "a short time" (some secs).

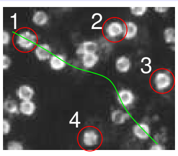
Sonification Design



- Using Auditory Scene Generation with one/two streams.
- Restriction to musical pitches and using Melodical Sonifications increases the learning effect.

Sound Examples

The different sonifications have been optimized and tested with synthetically generated images. The following sound examples are generated for real-world data. (see http://www.techfak.uni-bielefeld.de/~thermann/projects/index.html)



- blood sample
- 6 markers

A - identical patterns (1/2)
- similar patterns (1/3)
- very different patterns (2/4)

B - Sonification along a path

C - Summary of the image area

Summary

- Data Sonification allows the Perception of high-dimensional patterns.
- Multi-Channel Image Data can be inspected without disrupting the view onto the visually presented image.
- According to our experiences, melodical motives can easily be memorized and thus the comparison and identification of patterns is facilitated.
- The sonifications are extensible in different ways (addition of new markers and information types)
- Sonification offers a useful extension to visualizations.