

克里斯托夫·罗伊特, 伊莎贝拉·切泽迪克-艾森伯格, 崔晓星

Happy Life comes with P5

Vienna Signal Analysis Tools for
audio-synced motion, expression and emotion acquisition

P5带来快乐生活

用于采集音频同步动作、表情和情绪的维也纳信号分析工具



Happy Life comes with P5

1 What's up? Modern JavaScript Libraries

- 1.1 P5, P5.sound and ML5
- 1.2 Plotly.js
- 1.3 Meyda

2 What's it good for? Applications with P5, Plotly, Meyda and others

- 2.1 Signal Analysis Tool
- 2.2 Valence Arousal Model incl. EDA measurement
- 2.3 Video Pose-Tracking
- 2.4 Emotion or Expression Analysis
- 2.5 Video Hand Tracking
- 2.6 EEG Data Logging with 4 Channel Muse S EEG Headband
- 2.7 Work in Progress

3 What's next? Summary and Outlook

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1 什么事？现代 JavaScript 库

- 1.1 P5, P5.sound 和 ML5
- 1.2 Plotly.js
- 1.3 Meyda

2 它有什么用？使用 P5、Plotly、Meyda 等软件的应用

- 2.1 信号分析工具
- 2.2 价觉唤醒模型, 包括 EDA 测量
- 2.3 视频姿势跟踪
- 2.4 情绪或表情分析
- 2.5 视频手部跟踪
- 2.6 使用 4 通道 Muse S EEG 头带记录 EEG 数据
- 2.7 进展中的工作

3 下一步行动？总结与展望

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1.1 P5, P5.sound and ML5

P5: JavaScript library to solve complex programming tasks quickly and easily (Lauren McCarthy, Casey Reas und Ben Fry, seit 2014) based on **Processing** (Reas, Fry 2001).

1.1 P5, P5.sound 和 ML5

```
<html>
<head>
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<body bgcolor="#FFFFFF" text="#000000">

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sound.amp(0.5); // evtl. grundlegende Einstellung für Verstärkung des Klangs
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function draw(){
background(255, 255, 255);
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Typical structure of a P5 script / P5 脚本的典型结构:

Embed the libraries in the header / 在页眉中嵌入程序库

Preload big media files / 预载大型媒体文件: preload(){...}

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P5: 快速轻松解决复杂编程任务的 JavaScript 库 (Lauren McCarthy, Casey Reas 和 Ben Fry, 2014 年至今), 基于 **Processing** (Reas, Fry, 2001 年).

Happy Life comes with P5 P5带来快乐生活

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P5.sound:

Fast calculation of **FFTs** in various representations, filtering, convolutions, sound synthesis, etc.

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P5.sound:

快速计算各种表示形式的 **FFT**, 滤波, 卷积, 声音合成等.

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1.1 P5, P5.sound and ML5

P5: JavaScript library to solve complex programming tasks quickly and easily (Lauren McCarthy, Casey Reas und Ben Fry, seit 2014) based on Processing (Reas, Fry 2001).

P5.sound:

Fast calculation of FFTs in various representations, filtering, convolutions, sound synthesis, etc.

ML5:

(since 2018) Machine learning library, based on TensorFlow.js, to integrate pre-trained models for recognizing or tracking people, movements, objects, faces, hands, pitches, and much more.

1.1 P5, P5.sound 和 ML5

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P5.sound:

快速计算各种表示形式的 FFT, 滤波, 卷积, 声音合成等.

ML5:

(自2018年以来) 基于 TensorFlow.js 的机器学习库, 可集成预训练模型, 用于识别或跟踪人, 动作, 物体, 脸, 手, 音调等.

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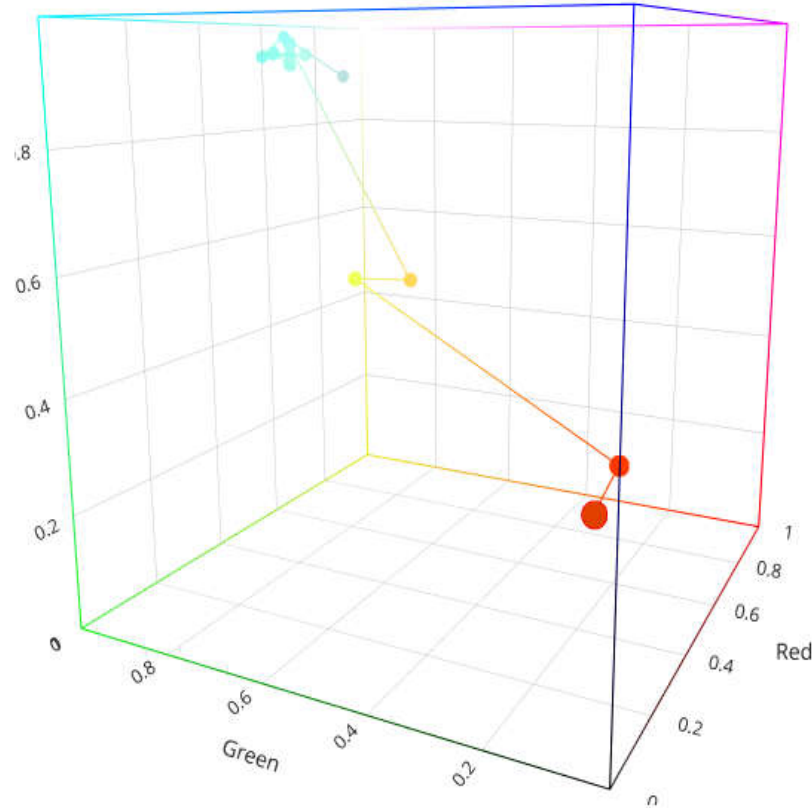
1.2 Plotly.js

Plotly.js: JavaScript library for interactive data visualization
(Alex Johnson, Jack Parmer, Chris Parmer, Matthew Sundquist, seit 2015)

More than 40 visualization types in 2D and 3D.

Connecting data plots with associated audio or video files.

1.2 Plotly.js



Plotly.js: 用于交互式数据可视化的 JavaScript 库
(Alex Johnson, Jack Parmer, Chris Parmer, Matthew Sundquist, 2015 年至今)

40 多种二维和三维可视化类型。

连接带有相关音频或视频文件的数据图。

Plotly output for timbre-color synesthesia:

change in color perception of synesthetes as soon as one removes one partial after the other from a sound.

音色联觉的图解输出: 只要从声音中去掉一个又一个部分, 联觉者的颜色感知就会发生变化。

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1.2 Plotly.js

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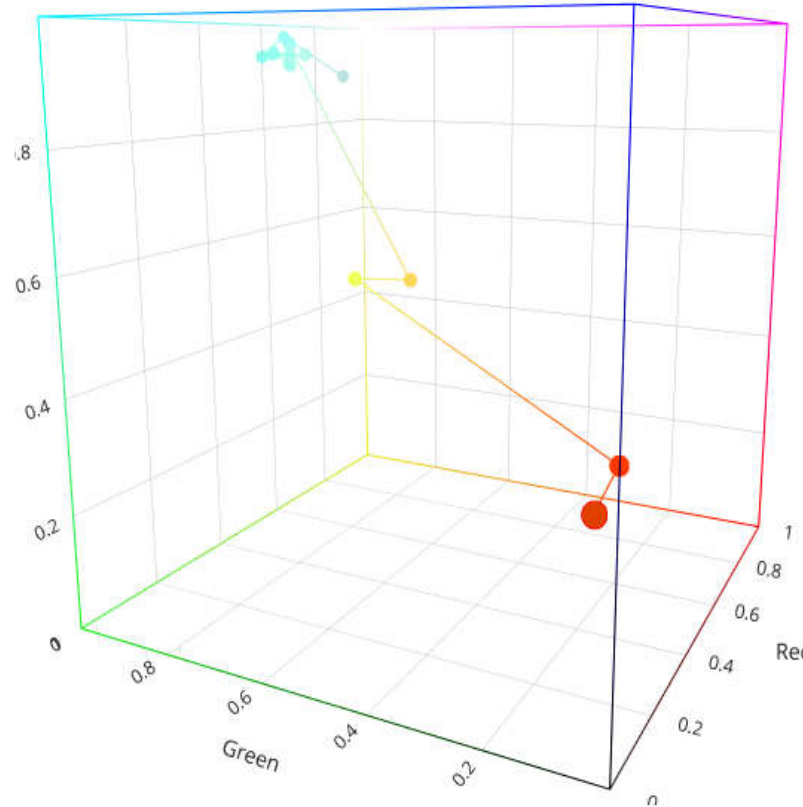
More than 40 visualization types in 2D and 3D.

Connecting data plots with associated audio or video files.

Similar **canvas principle** as in P5:

- Inclusion of the libraries in the **header**
- Define the **environment** of the display
- Determination of the **data** to be displayed
- **Layout** of the data to be displayed

1.2 Plotly.js



Plotly output for timbre-color synesthesia:

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40 多种二维和三维可视化类型.

连接带有相关音频或视频文件的数据图.

与 P5 类似的**画布原理**:

- 在**代码头**中包含库
- 定义显示**环境**
- 确定要显示的**数据**
- 显示数据的**布局**

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1.3 Meyda: JavaScript-Library for Audio Signal Analysis
(Hugh Rawlinson, Nevo Segal, Jakub Fiala, seit 2015)

C: 0.386
Cis: 0.328
D: 0.223
Dis: 0.264
E: 0.248
F: 0.31
Fis: 0.295
G: 0.317
Gis: 0.654
A: 1
Ais: 0.737
H: 0.309

Real time audio feature analysis:

RMS-Amplitude
Spectral Centroid
Zero Crossing Rate
Spectral Flatness
Spectral Slope
Spectral Rolloff
Spectral Spread
Spectral Skewness
Spectral Kurtosis
Perceptual Spread
Perceptual Sharpness
Perceptual Loudness (inkl. Bark bands)
Chroma
MFCC



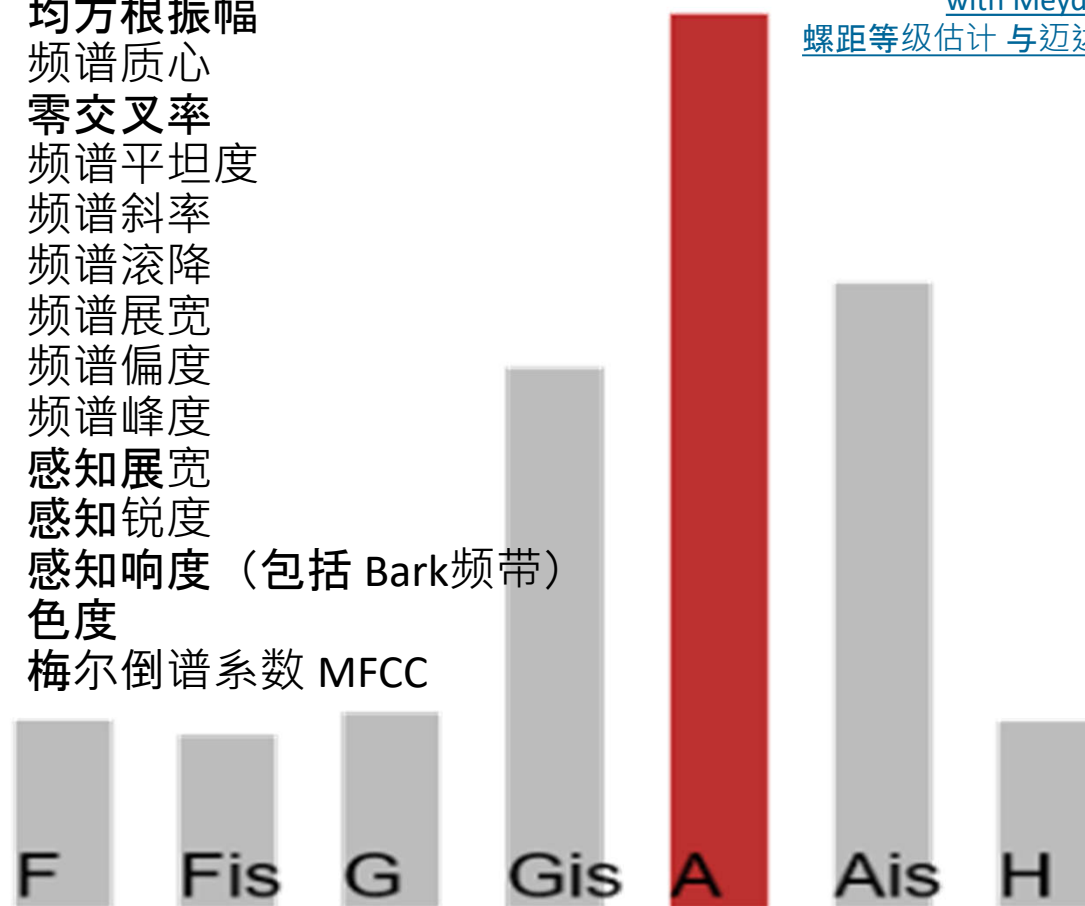
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1.3 Meyda: 用于音频信号分析的 JavaScript 库
(Hugh Rawlinson, Nevo Segal, Jakub Fiala, 自 2015 年起)

实时音频特征分析:

均方根振幅
频谱质心
零交叉率
频谱平坦度
频谱斜率
频谱滚降
频谱展宽
频谱偏度
频谱峰度
感知展宽
感知锐度
感知响度 (包括 Bark 频带)
色度
梅尔倒谱系数 MFCC

[Pitch class estimation with Meyda](#)
[螺距等级估计与迈达](#)



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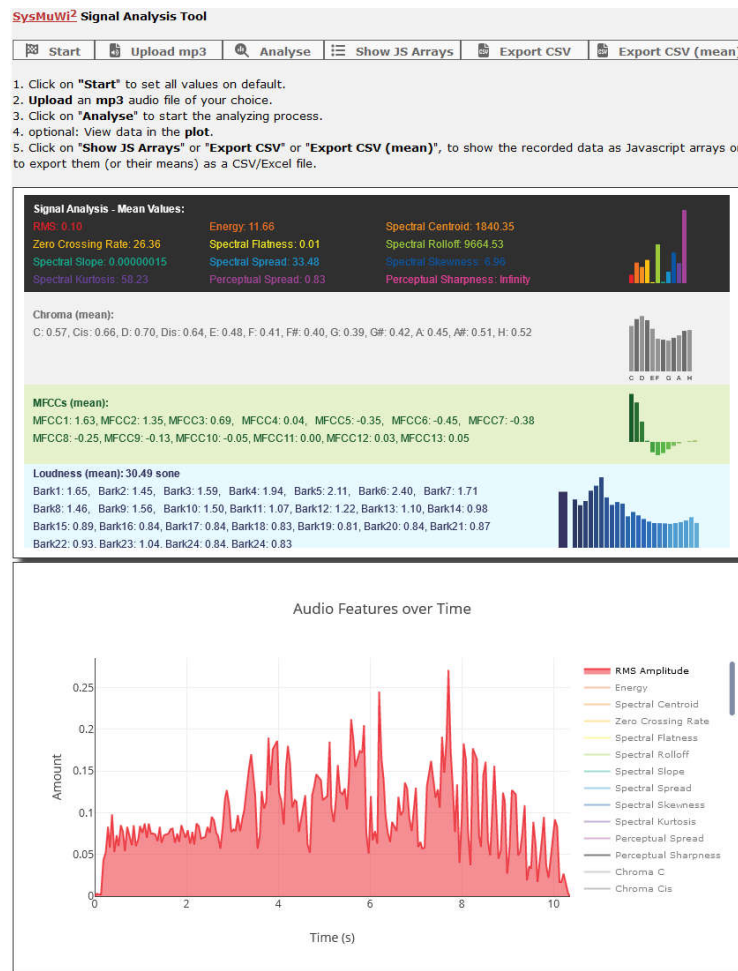
2.1 Signal Analysis Tool

Signal Analysis Tool, created with P5, Plotly.js and Meyda:

Features:

- Audio file upload (wav, mp3)
- all Meyda audio feature analysis
- Output as interactive plots and JavaScript arrays
- CSV export (all values and means) for further processing in Excel, Matlab or similar.
- Accuracy of the time synchronous output: 50 ± 1 ms (20fps)

2.1 信号分析工具



Signal Analysis Tool / 信号分析工具

信号分析工具, 使用 P5、Plotly.js 和 Meyda 创建:

功能:

- 音频文件上传 (wav, mp3)
- 所有 Meyda 音频特征分析
- 输出为交互式图表和 JavaScript 数组
- CSV 导出 (所有值和均值), 以便在 Excel, Matlab 或类似软件中进一步处理.
- 时间同步输出的精度: 50 ± 1 毫秒 (20fps)

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2.2 Valence Arousal Model

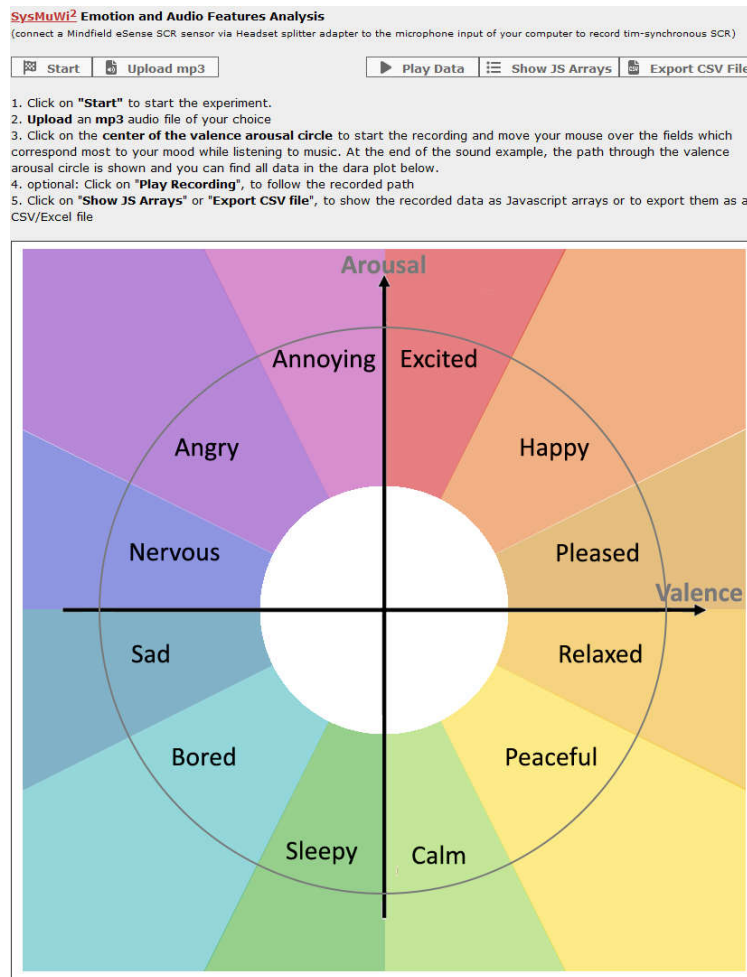
Emotion and Audio Feature Analysis, created with P5, Plotly.js and Meyda:

Features:

- Audio file upload (wav, mp3)
- all Meyda audio feature analysis
- Recording of emotional self-disclosure while listening to a piece of music
(corresponding to: „EmuJoy“, Nagel et al. 2007)

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2.2 价值唤醒模式



Emotion and Audio Feature Analysis / 情感和音频特征分析

情感和音频特征分析，使用 P5、Plotly.js 和 Meyda 创建：

功能:

- 音频文件上传 (wav, mp3)
- 所有 Meyda 音频特征分析
- 记录聆听音乐时的情感自我表露
(对应: „EmuJoy“, Nagel 等人, 2007 年)

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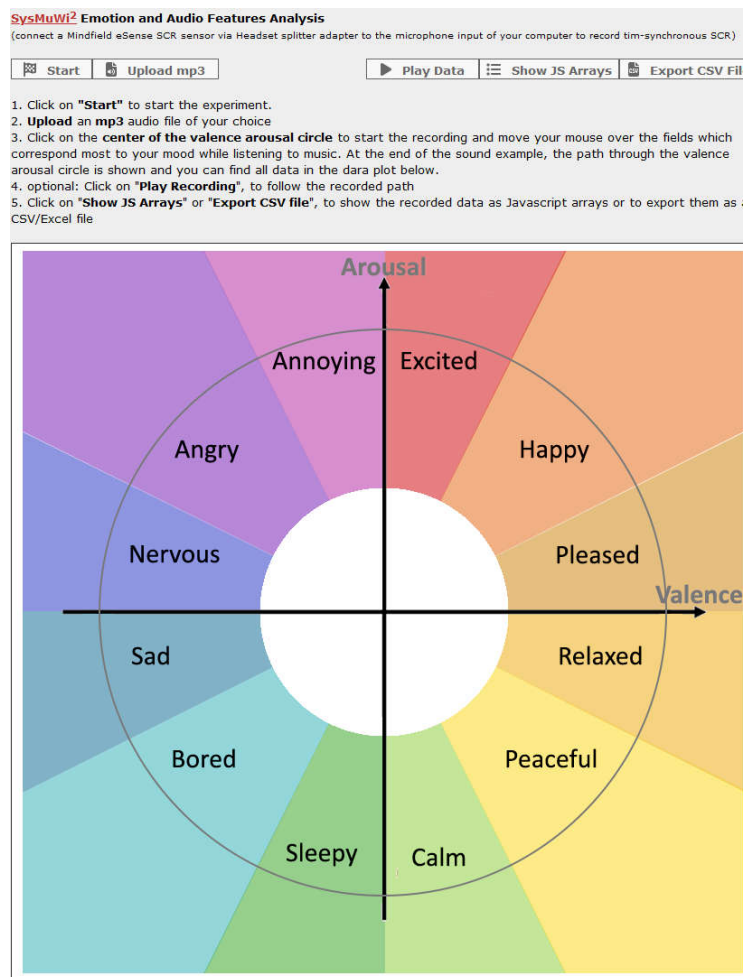
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2.2 价值唤醒模式

Emotion and Audio Feature Analysis, created with P5, Plotly.js and Meyda:

Features:

- Audio file upload (wav, mp3)
- all Meyda audio feature analysis
- Recording of emotional self-disclosure while listening to a piece of music (corresponding to: „EmuJoy“, Nagel et al. 2007)
- Time synchronous **skin conductance measurement**
- Output as **interactive plots** and JavaScript arrays
- **CSV export** for further processing in Excel, Matlab or similar.
- **Accuracy** of the time synchronous output: **50 ±1 ms (20fps)**



Emotion and Audio Feature Analysis / 情感和音频特征分析

情感和音频特征分析，使用 P5、Plotly.js 和 Meyda 创建：

功能：

- 音频文件上传 (wav, mp3)
- 所有 Meyda 音频特征分析
- 记录聆听音乐时的情感自我表露 (对应: „EmuJoy“, Nagel 等人, 2007 年)
- 时间同步皮肤电导测量
- 输出为 **交互式图表** 和 JavaScript 数组
- **CSV 导出** (所有值和均值), 以便在 Excel, Matlab 或类似软件中进一步处理.
- 时间同步输出的**精度**: **50 ±1 毫秒 (20fps)**

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2.2 Valence Arousal Model

2.2 价值唤醒模式

Emotion and Audio Feature Analysis, with video support

情感和音频特征分析, 支持视频

to capture the emotional engagement while watching videos.

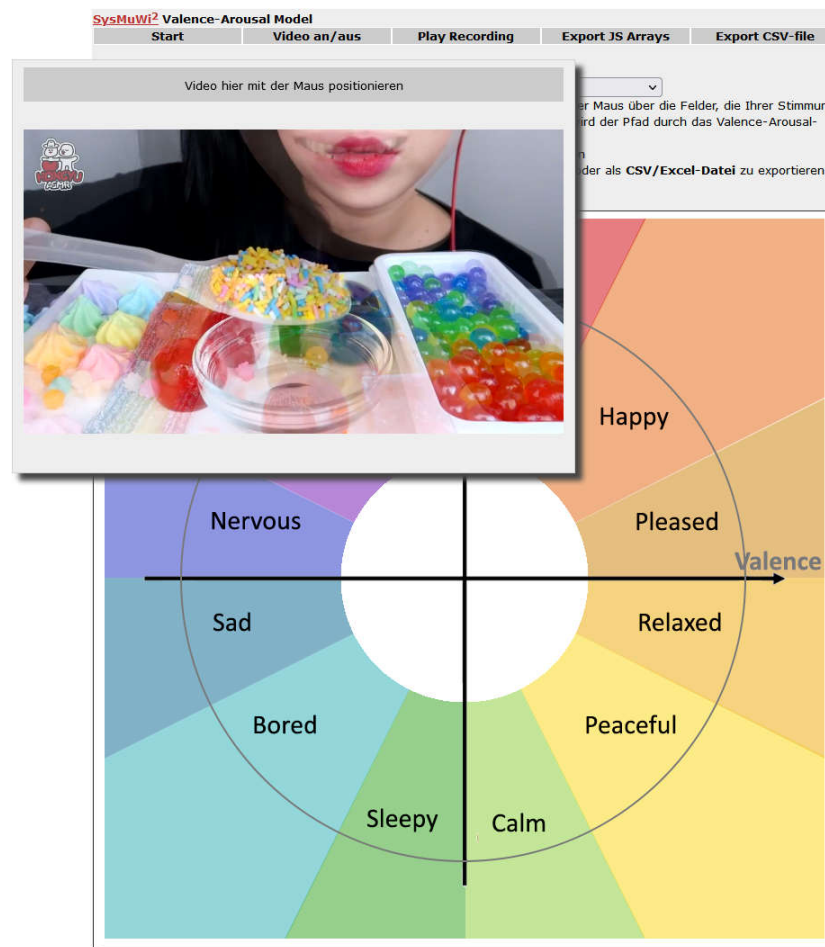
以捕捉观看视频时的情感投入.

E.g: to what extent the emotional and physiological impact of ASMR videos depends on the video image (compared to the audio track alone)

例如: ASMR 视频的情感和生理影响在多大程度上取决于视频图像 (与单独的音轨相比)

(Stickler, Greil, Domnanich, Yamada, Reuter, 2023)

(Stickler, Greil, Domnanich, Yamada, Reuter, 2023 年)



Emotion and Audio Feature Analysis with video support
支持视频的情感和音频特征分析

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2.2 Valence Arousal Model

Emotion and Audio Feature Analysis, with arbitrary axis designations

to capture arbitrary two-dimensional self-disclosures in their temporal variation

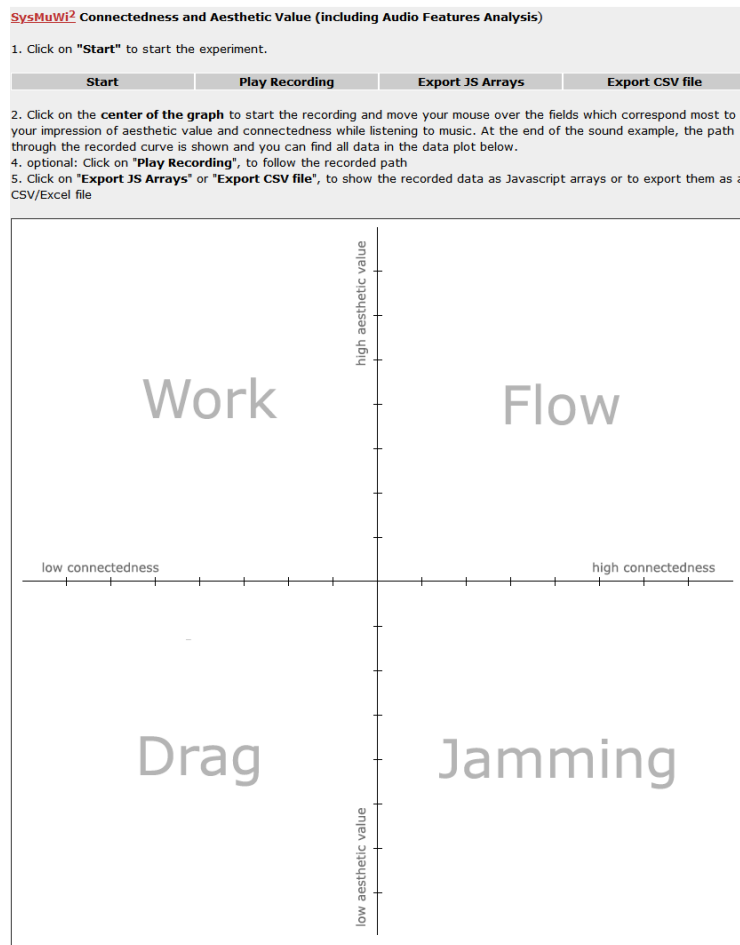
E.g.: To evaluate the ensemble play of two improvising musicians:

to what extent are they connected in time/musically and how valuable is their musical output.

(Scheer, Bergamin, Reuter, Cui, 2023)

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2.2 价值唤醒模式



Connectedness and aesthetic value estimation
关联性和审美价值评估

情感和音频特征分析，可任意指定坐标轴

捕捉时间变化中的任意二维自我表露

例如 评估两位即兴音乐家的合奏：他们在时间/音乐上的联系程度，以及他们的音乐产出的价值 (Scheer, Bergamin, Reuter, Cui, 2023 年)

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2.3 Video Pose Tracking

Motion and Audio Feature Analysis, created with P5/ML5, Plotly.js and Meyda:

Features:

- Video file upload (mp4)
- all Meyda audio feature analysis
- Pose Tracking of single individuals in videos
- Output as interactive plots and JavaScript arrays
- CSV export for further processing in Excel, Matlab or similar.
- Accuracy of the time synchronous output: 100 ± 2 ms (10fps)

2.3 视频姿势跟踪

运动和音频特征分析, 使用 P5/ML5, Plotly.js 和 Meyda 创建:

功能

- 视频文件上传 (mp4)
- 所有 Meyda 音频特征分析
- 视频中单个个体的姿态跟踪
- 输出为交互式图表和 JavaScript 数组
- CSV 导出 (所有值和均值), 以便在 Excel, Matlab 或类似软件中进一步处理.
- 时间同步输出的精度: 100 ± 2 毫秒 (10fps)



Motion and Audio Feature Analysis
运动和音频特征分析

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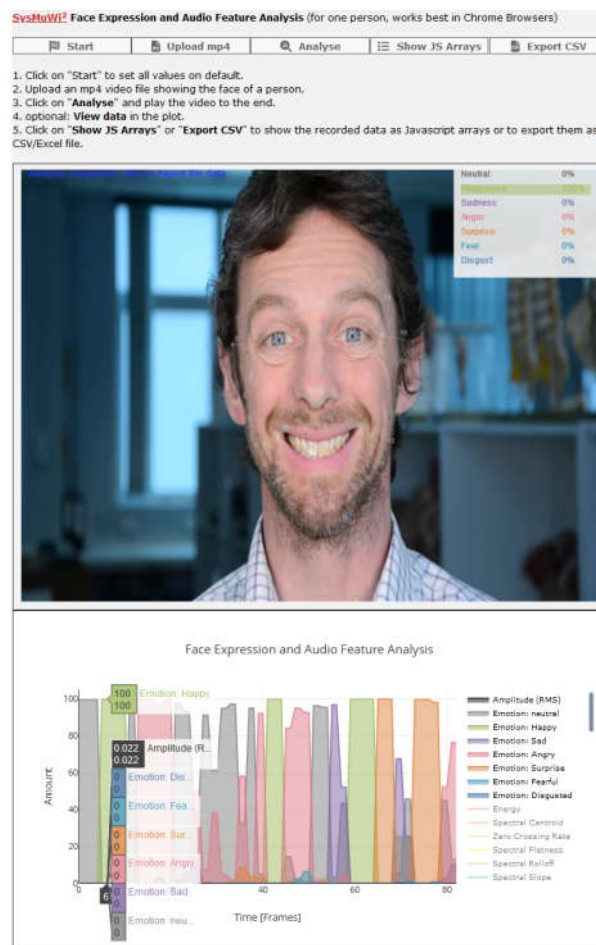
2.4 Emotion or Expression Analysis

2.4 情绪或表情分析

Face Expression and Audio Feature Analysis, created with P5/ML5, Plotly.js and Meyda:

Features:

- Video file upload (mp4)
- all Meyda audio feature analysis
- Capture facial expressions of single individuals in videos.
- Output as interactive plots and JavaScript arrays
- CSV export for further processing in Excel, Matlab or similar.
- Accuracy of the time synchronous output: 100 ± 2 ms (10fps)



Face Expression and Audio Feature Analysis
情绪或表情分析

面部表情和音频特征分析, 使用 P5/ML5, Plotly.js 和 Meyda 创建:

功能

- 视频文件上传 (mp4)
- 所有 Meyda 音频特征分析
- 捕捉视频中单个人的面部表情
- 输出为交互式图表和 JavaScript 数组
- CSV 导出 (所有值和均值), 以便在 Excel, Matlab 或类似软件中进一步处理.
- 时间同步输出的精度: 100 ± 2 毫秒 (10fps)

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2.5 Video Hand Tracking

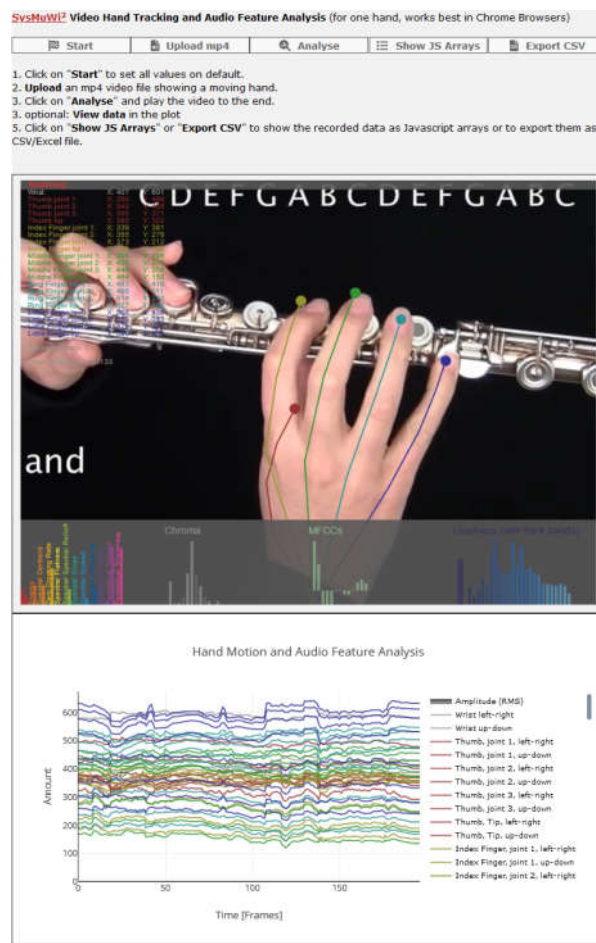
Hand Tracking and Audio Feature Analysis, created with P5/ML5, Plotly.js and Meyda:

Features:

- Video file upload (mp4)
- all Meyda audio feature analysis
- Pose tracking of single individual hands in videos
- Output as interactive plots and JavaScript arrays
- CSV export for further processing in Excel, Matlab or similar.
- Accuracy of the time synchronous output: 100 ± 2 ms (10fps)

2.5 视频手部跟踪

手部跟踪和音频特征分析, 使用 P5/ML5, Plotly.js 和 Meyda 创建:



[Hand Tracking and Audio Feature Analysis](#)
手部跟踪和音频特征分析

功能

- 视频文件上传 (mp4)
- 所有 Meyda 音频特征分析
- 视频中单个手的姿势跟踪
- 输出为交互式图表和 JavaScript 数组
- CSV 导出 (所有值和均值), 以便在 Excel, Matlab 或类似软件中进一步处理.
- 时间同步输出的精度:
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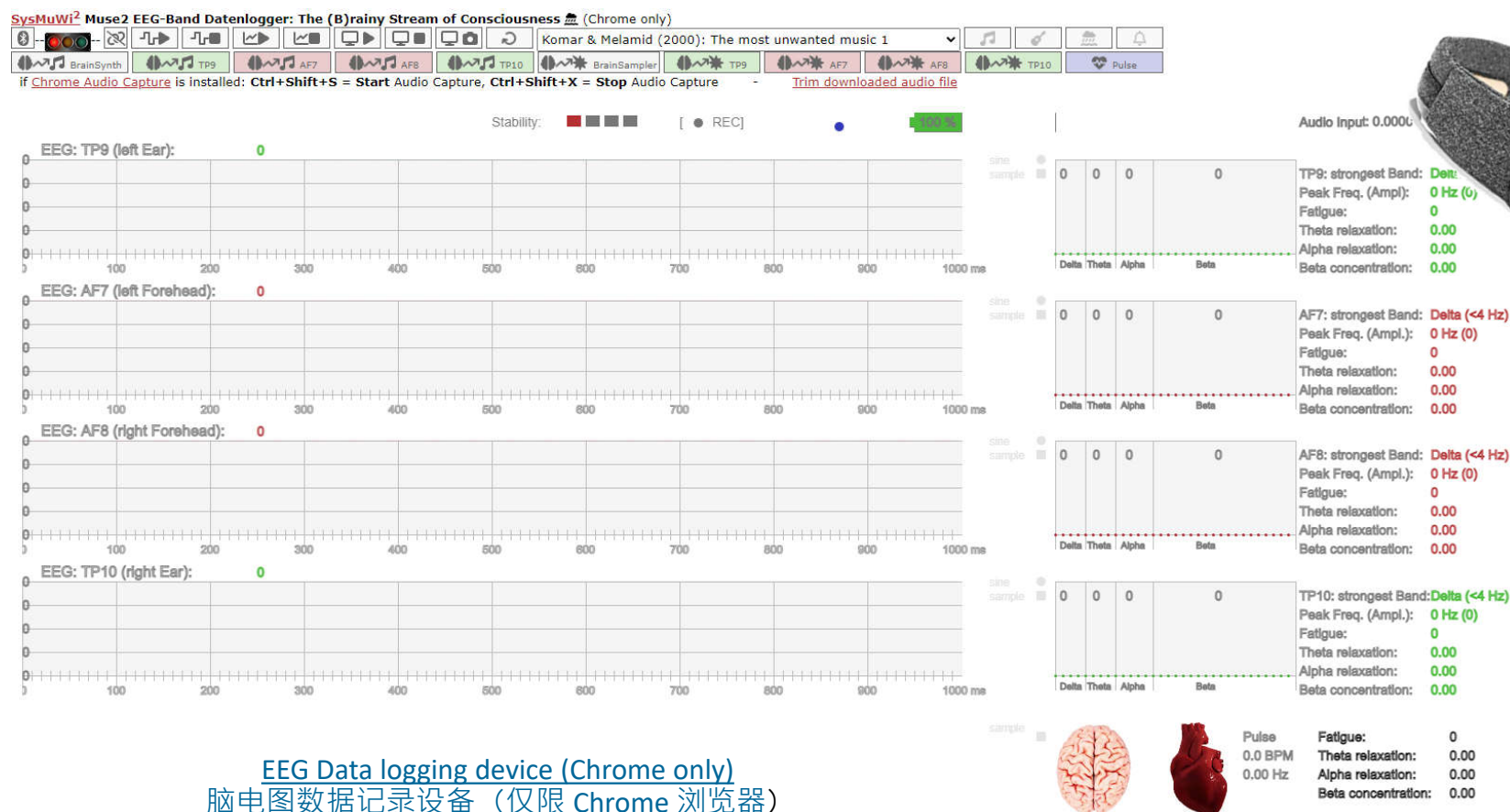
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2.6 EEG Data Logging with 4 Channel Muse S EEG Headband, created with P5 and Plotly

2.6 使用 4 通道 Muse S 脑电图头带进行脑电图数据记录, 使用 P5 和 Plotly 创建

Accuracy: 4ms (256fps), CSV-Export

精度: 4 毫秒 (256 帧/秒), CSV 导出



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2.6 EEG Data Logging with 4 Channel Muse S EEG Headband, created with P5 and Plotly

2.6 使用 4 通道 Muse S 脑电图头带进行脑电图数据记录, 使用 P5 和 Plotly 创建

.....还可以用[Cellobellum](#)演奏一些音乐

... its also possible to make some music with the [Cellobellum](#)

TP9, strongest Frequency: 14
AF7, strongest Frequency: 14
AF8, strongest Frequency: 14
TP10, strongest Frequency: 14

TP9, strongest Frequency Band: 3
AF7, strongest Frequency Band: 2
AF8, strongest Frequency Band: 3
TP10, strongest Frequency Band: 3

Fatigue: 0.62
Theta Relaxation: 0.74
Alpha Relaxation: 1.40
Beta Concentration: 1.65

TP9, instantaneous value: -3031
AF7, instantaneous value: -346
AF8, instantaneous value: -800
TP10, instantaneous value: -884

Pulse (BPM): 8.0
Beat Sequence: 6
Part: Moll
Gyroscope Z: -2.737

Time (in ms): 344335.5 ms
Battery: 100 %
Stability: 4
Audio Input: 0.0926

Ctrl+Shift+S = Start Audio Capture
Ctrl+Shift+X = Stop Audio Capture

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P5带来快乐生活

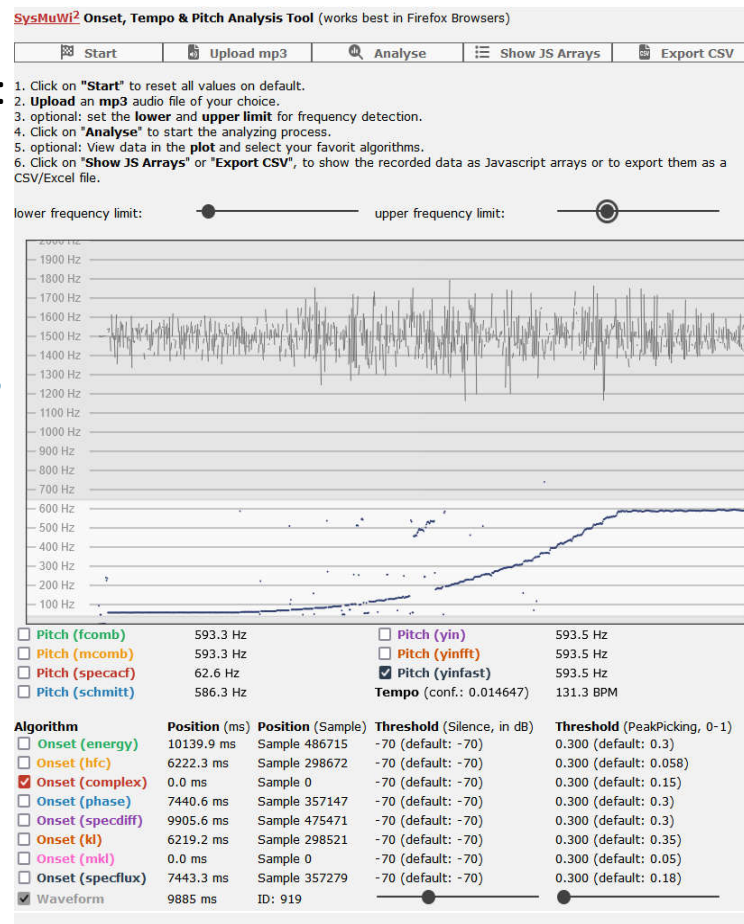
2.7 Current Work in Progress

2.7 目前正在进行的工作

Onset, Tempo & Pitch Analysis Tool, created with P5 and Aubio.js:
(Quixiang, 2021)

Features:

- Audio file upload (wav, mp3)
- all Aubio audio feature analysis
- Detection of pitch and piece sections according to different popular algorithms
- Output as interactive plots and JavaScript arrays
- CSV export for further processing in Excel, Matlab or similar.
- Accuracy of the time synchronous output: 11 ± 1 ms (91 fps)



起音,节奏和音高分析工具,
使用 P5 和 Aubio.js 创建:
(Quixiang, 2021 年)

功能

- 音频文件上传 (wav, mp3)
- 所有 Aubio 音频特征分析
- 根据不同的流行算法检测音高和乐
- 输出为交互式图表和 JavaScript 数组
- CSV 导出 (所有值和均值), 以便在 Excel, Matlab 或类似软件中进一步处理.
- 时间同步输出的精度:
 11 ± 1 毫秒 (91 fps)

[Onset, Tempo & Pitch Analysis Tool](#)
起音,节奏和音高分析工具

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P5带来快乐生活

2.7 Current Work in Progress

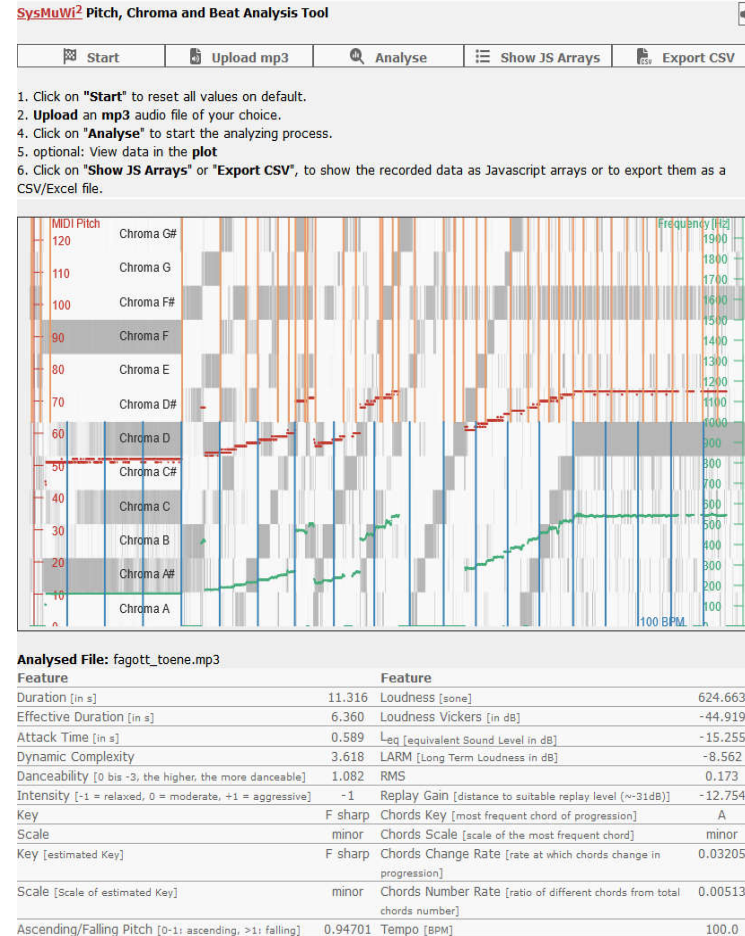
2.7 目前正在进行的工作

Pitch, Chroma & Beat Analysis Tool, created with P5 and Essentia.js:

(Correya, Marcos-Fernandez, Joglar-Ongay, Alonso-Jimenez, Serra, Bogdanov, 2021)

Features:

- Audio file upload (wav, mp3)
- Pitch, chroma and tempo related audio feature analysis with Essentia.
- Output as interactive plots and JavaScript arrays
- CSV export for further processing in Excel, Matlab or similar.
- Accuracy of the time synchronous output: 3 ms (333 fps)



[Pitch, Chroma & Beat Analysis Tool](#)
[音高、色度和节拍分析工具](#)

音高, 色度和节拍分析工具, 使用 P5 和 Essentia.js 创建: (Correya, Marcos-Fernandez, Joglar-Ongay, Alonso-Jimenez, Serra, Bogdanov, 2021 年)

功能

- 音频文件上传 (wav, mp3)
- 利用 Essentia 分析与音高、色度和节奏相关的音频特征。
- 输出为交互式图表和 JavaScript 数组
- CSV 导出 (所有值和均值), 以便在 Excel, Matlab 或类似软件中进一步处理。
- 时间同步输出的精度: 11 ±1 毫秒 (91 fps)

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P5带来快乐生活

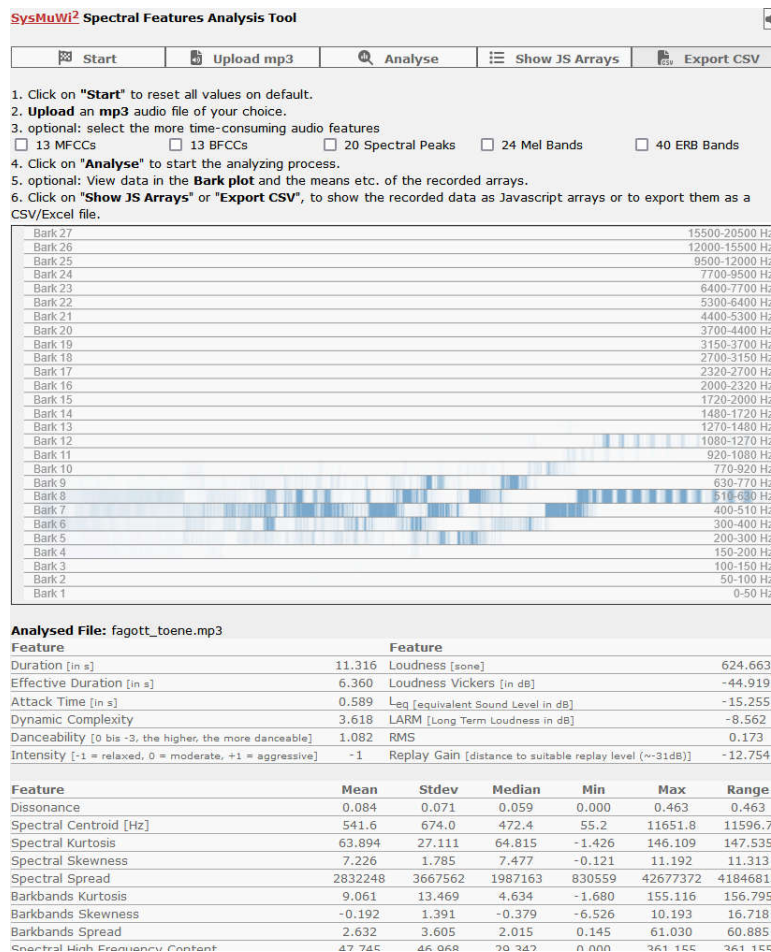
2.7 Current Work in Progress

2.7 目前正在进行的工作

Spectral Features Analysis Tool,
created with P5 and Essentia.js:
(Correya, Marcos-Fernandez, Joglar-Ongay,
Alonso-Jimenez, Serra, Bogdanov, 2021)

Features:

- Audio file upload (wav, mp3)
- Timbre related audio feature analysis with Essentia.
- Acquisition of spectral features including MFCCs, ERB, Bark Bands, Mel Bands, etc.
- Output as interactive plots and JavaScript arrays
- CSV export for further processing in Excel, Matlab or similar.
- Accuracy of the time synchronous output: 3 ms (333 fps)



频谱特征分析工具,
使用 P5 和 Essentia.js 创建:
(Correya, Marcos-Fernandez, Joglar-Ongay, Alonso-Jimenez, Serra, Bogdanov, 2021 年)

功能

- 音频文件上传 (wav, mp3)
- 利用 Essentia 进行与音调相关的音频特征分析.
- 获取频谱特征, 包括 MFCC, ERB, Bark Bands, Mel Bands 等.
- 输出为交互式图表和 JavaScript 数组
- CSV 导出 (所有值和均值), 以便在 Excel, Matlab 或类似软件中进一步处理.
- 时间同步输出的精度: 11 ±1 毫秒 (91 fps)

[Spectral Features Analysis Tool](#)
频谱特征分析工具

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P5带来快乐生活

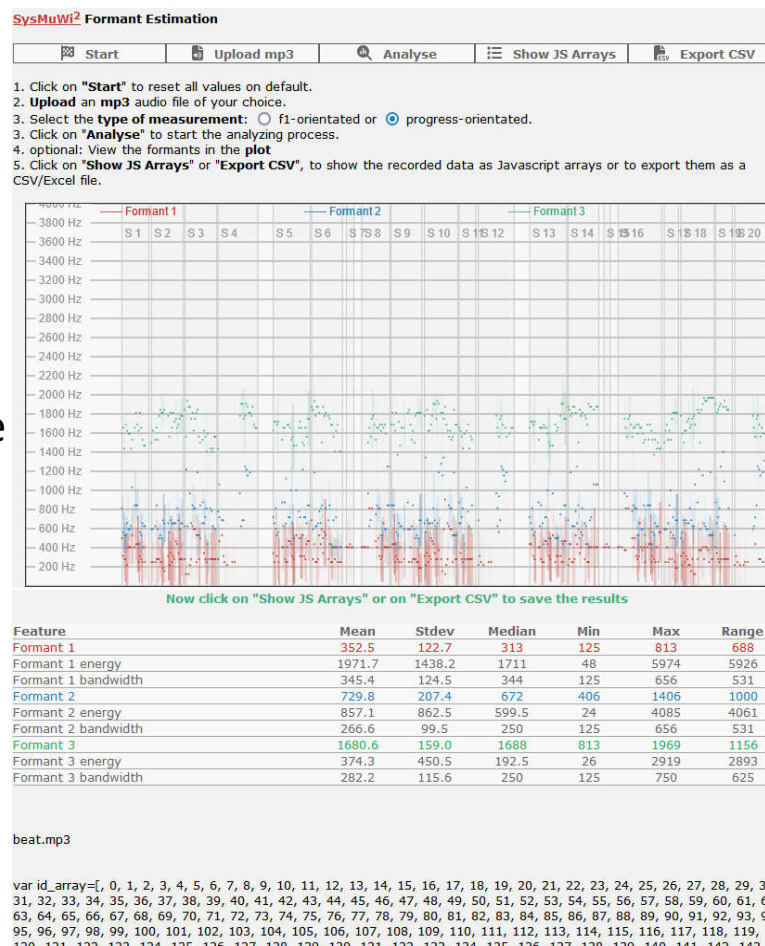
2.7 Current Work in Progress

2.7 目前正在进行的工作

Formant Estimation Tool,
created with P5 and
formantalyzer.js:
(Rehman, Liu, Xu, 2021)

Features:

- **Audio file upload** (wav, mp3)
- Identification of the first three **formants** incl. **formant energy** and **bandwidth**
- Output as segmented **interactive plots** and JavaScript arrays
- **CSV export** for further processing in Excel, Matlab or similar.
- **Accuracy** of the time synchronous output: **15 ms** (67 fps)



Formant Estimation Tool
方音估算工具

方音估算工具,
使用 P5 和 formantalyzer.js 创建:
(Rehman, Liu, Xu, 2021)

功能

- **音频文件上传** (wav, mp3)
- 识别前三个共振峰, 包括共振峰**能量和带宽**
- 输出为分段**交互式绘图**和 JavaScript 数组
- **CSV 导出** (所有值和均值), 以便在 Excel, Matlab 或类似软件中进一步处理.
- 时间同步输出的**精度**:
15 毫秒 (67 fps)

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3 Summary and Outlook

P5, Plotly.js, Meyda, Aubio, Essentia:

- Ideal for the creation of online applications in **research** and **teaching**
- Ideal starting point for students in programming, it is **easy** and **quick** to learn
- Enables **new approaches** and new forms of **presentation**
- Allows **time-synchronous** integration of **audio signal analysis**, **face expression** and **position tracking data**, **(neuro-)physiological data** and much more.
- Flexible **extensibility**
- **Sustainable, future-proof** because of:
 - **JavaScript** = proven, non-proprietary format
 - Interface to **machine learning models** via ML5
 - Strong, long-standing **communities** for P5, Plotly, and Essentia

P5带来快乐生活

3 总结与展望

P5, Plotly.js, Meyda, Aubio, Essentia:

- 在**研究**和**教学**中创建在线应用程序的理想之选
- 学生编程的理想起点, **简单易学**, **快速上手**
- 支持新的**方法**和新的**展示形式**
- 允许对**音频信号分析**, **面部表情**和**位置跟踪数据**, **(神经) 生理数据**等进行**时间同步整合**.
- **灵活的可扩展性**
- **可持续, 面向未来**, 因为
 - **JavaScript** = **久经考验**的非专有格式
 - **通过 ML5 连接机器学习模型**
 - 为 P5, Plotly 和 Essentia 提供强大, 长期的**社区支持**

Happy Life comes with P5

3 Summary and Outlook

Outlook: Next Steps:

- Integration of **Motion Amplification** (e.g. [Heart beat estimation via WebCam](#))
- Integration of further **AI Models** (e.g. [optimized Pitch Tracking](#))

Curious?

The applications and more are available at <https://sines.univie.ac.at/sinestools/>

P5带来快乐生活

3 总结与展望

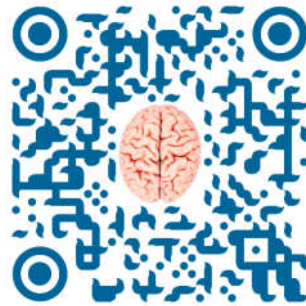
展望: 下一步:

- 集成**运动放大功能** (例如[通过网络摄像头进行心跳估算](#))
- 整合更多**人工智能模型** (如[优化的音高跟踪](#))

好奇吗?

更多应用信息, 请访问

<https://sines.univie.ac.at/sinestools/>



谢谢