Universitat Pompeu Fabra Barcelona

MTG Music Technology Group

ICASSP2020 Barcelona

Signal Processing and Machine Learning Challenges in Sound and Music Computing

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Disclaimer

Biased towards
our research !!!

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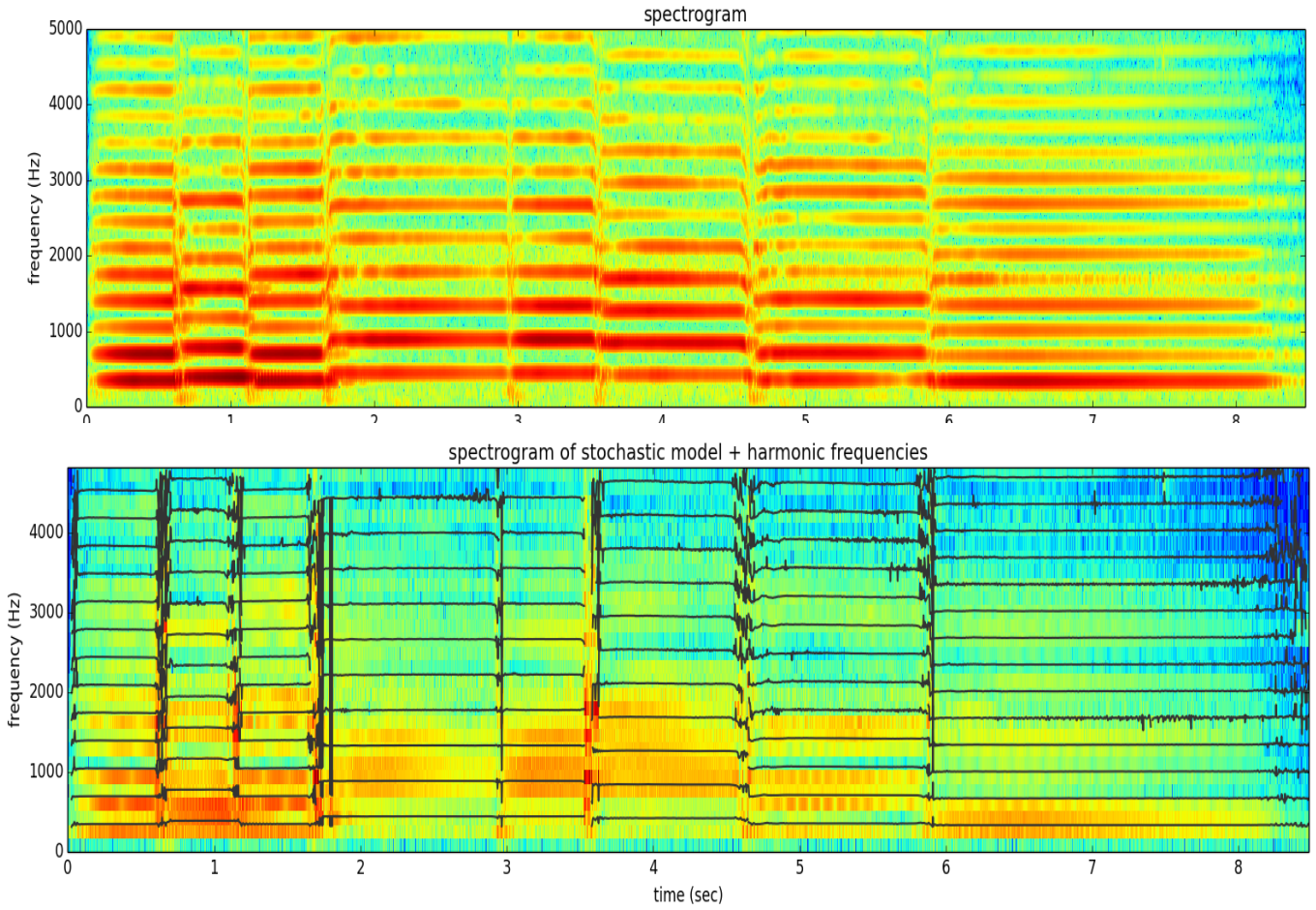
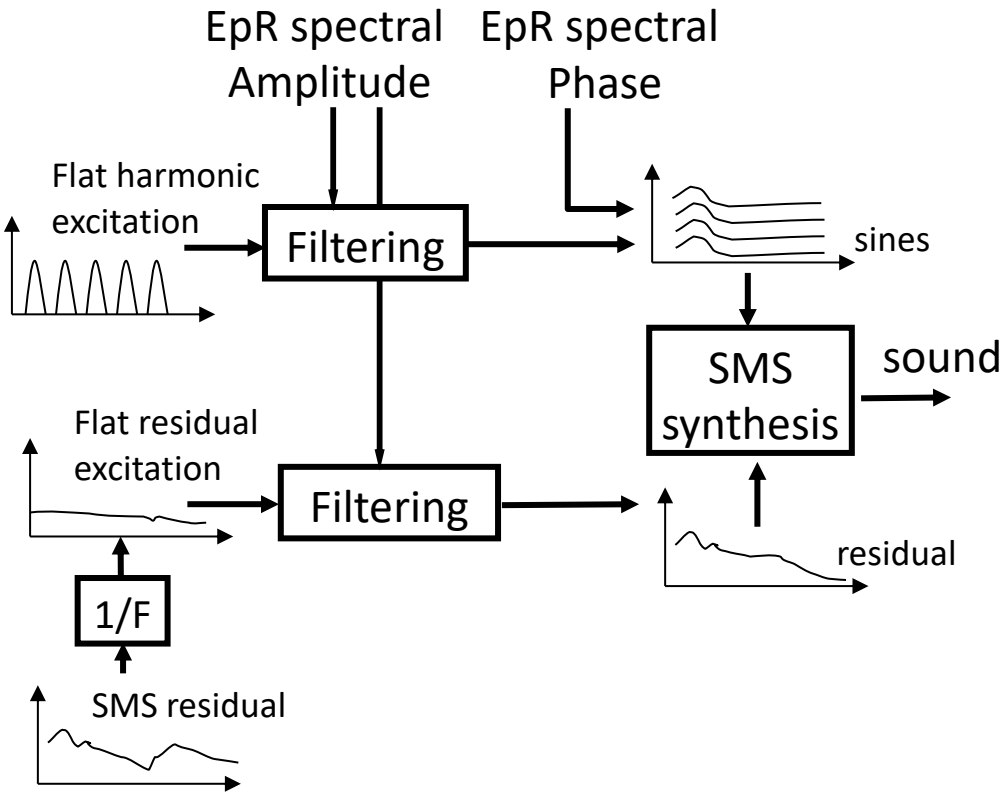
- Personal research highlights
- The field of Sound and Music Computing
- Current research challenges
- Conclusions

Personal research trajectory (1 of 4)



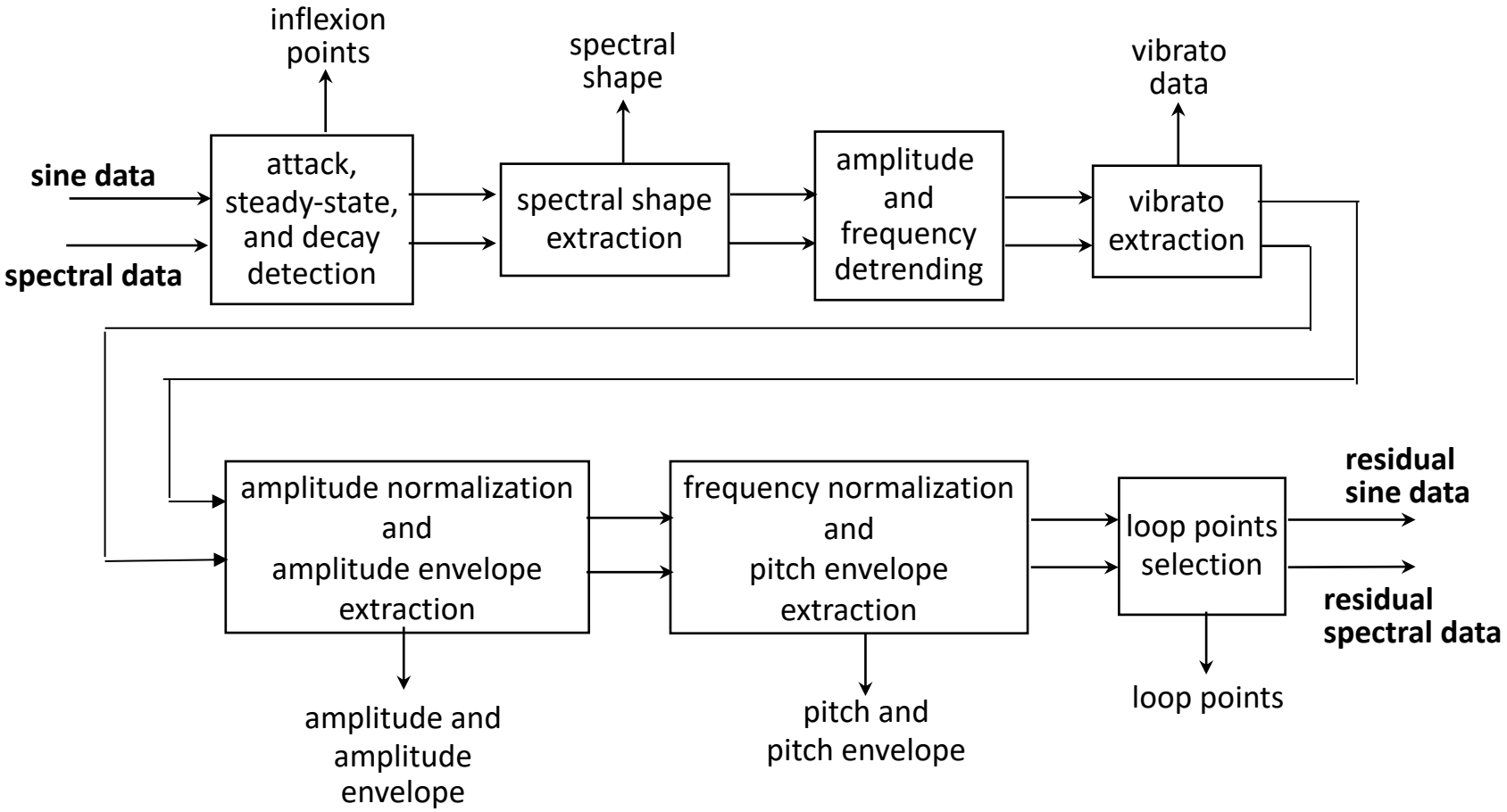
X. Serra. 1989. *A System for Sound Analysis/Transformation/Synthesis based on a Deterministic plus Stochastic Decomposition.* PhD Thesis.

Personal research trajectory (2 of 4)



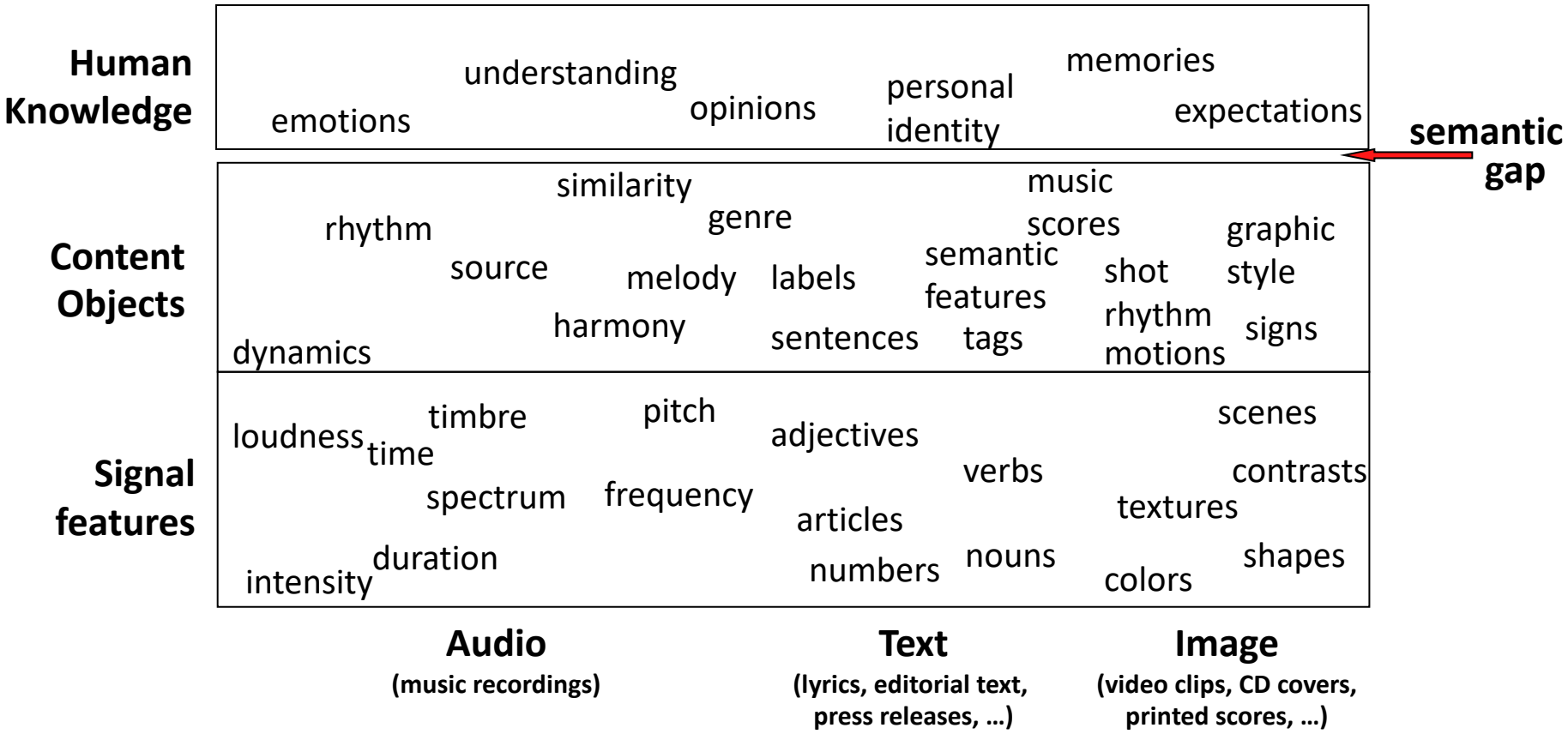
J. Bonada, O. Celma, A. Loscos, J. Ortolà, X. Serra. 2001. "Singing Voice Synthesis Combining Excitation plus Resonance and Sinusoidal plus Residual Models." *ICMC*.

Personal research trajectory (3 of 4)



P. Herrera, X. Serra, G. Peeters. 1999. "Audio Descriptors and Descriptor Schemes in the Context of MPEG-7." *ICMC*.

Personal research trajectory (4 of 4)



P. Cano, M. Koppenberger, N. Wack, J. G. Mahedero, T. Aussenac, R. Marxer, J. Masip, O. Celma, D. Garcia, E. Gómez, F. Gouyon, E. Guaus, P. Herrera, J. Massaguer, B. Ong, M. Ramírez, S. Streich, X. Serra. 2005. "Content-based Music Audio Recommendation." *ACM Multimedia*.

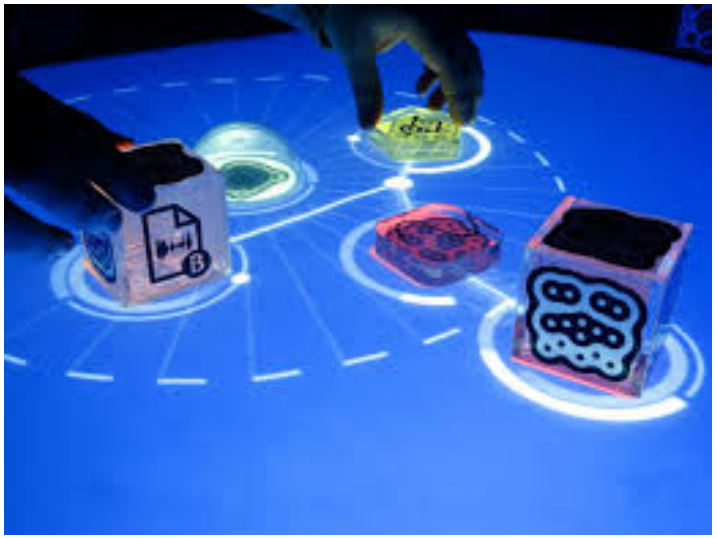
The field of Sound and Music Computing (1 of 2)

"By combining scientific, technological and artistic methodologies it aims at **understanding**, **modelling** and **generating** sound and music through computational approaches."

X. Serra, G. Widmer, M. Leman. 2007. *A Roadmap for Sound and Music Computing*. S2S Consortium.

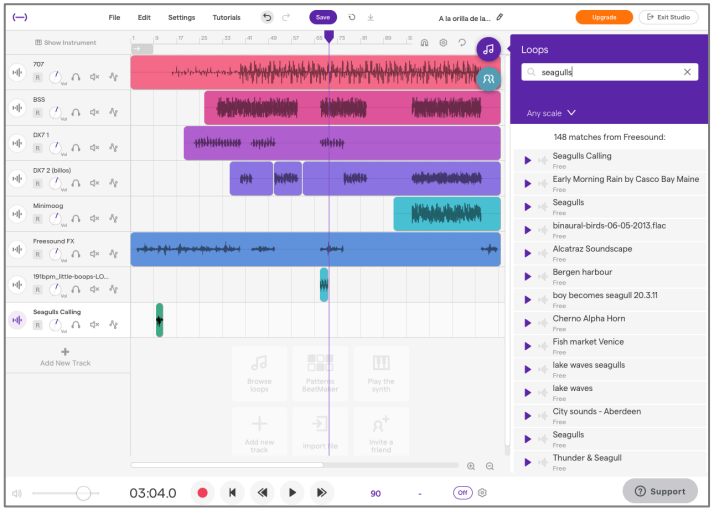
The field of Sound and Music Computing (2 of 2)

- **Digital music instruments**



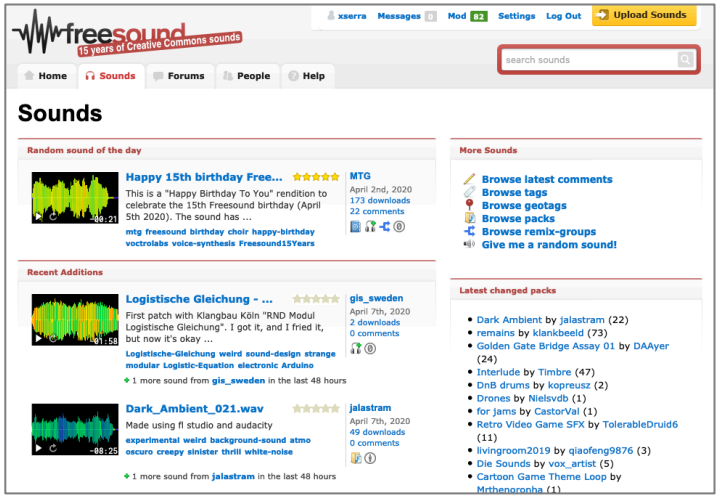
The field of Sound and Music Computing (2 of 2)

- Digital music instruments
- **Sound and music production**



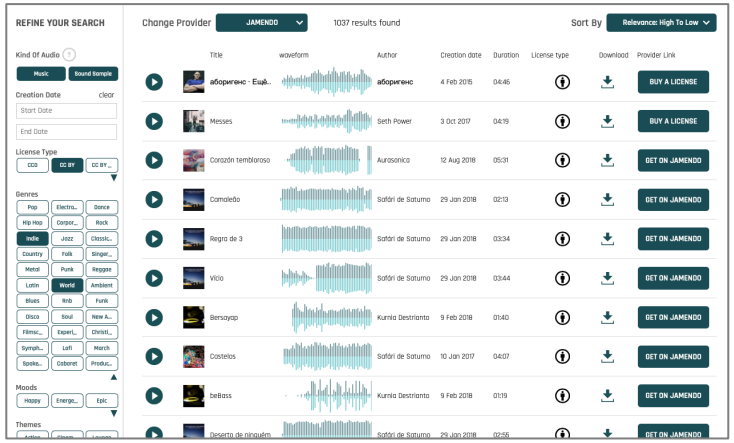
The field of Sound and Music Computing (2 of 2)

- Digital music instruments
- Sound and music production
- **Sound and music archiving**



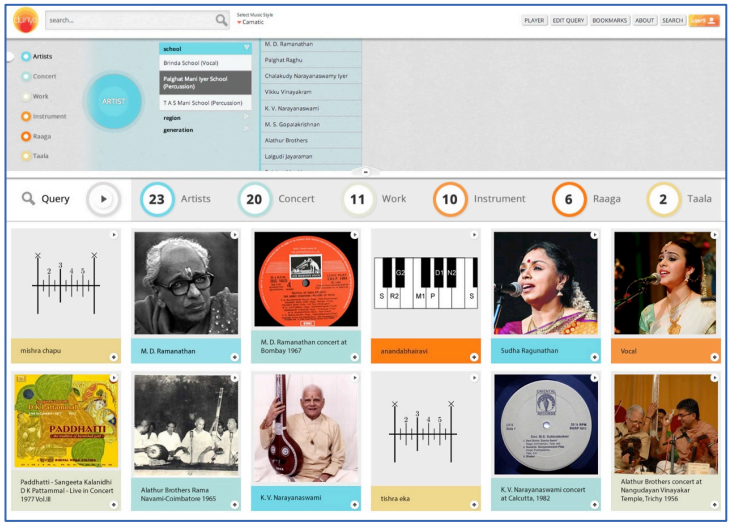
The field of Sound and Music Computing (2 of 2)

- Digital music instruments
- Sound and music production
- Sound and music archiving
- **Sound and music retrieval**



The field of Sound and Music Computing (2 of 2)

- Digital music instruments
- Sound and music production
- Sound and music archiving
- Sound and music retrieval
- **Computational musicology**



The field of Sound and Music Computing (2 of 2)

- Digital music instruments
- Sound and music production
- Sound and music archiving
- Sound and music retrieval
- Computational musicology
- …

Current research challenges

- Corpora and datasets
- Musical understanding
- Neural Networks for musical tasks
- Musical sound synthesis
- Separation of musical audio sources
- Sound and music classification
- Applications
- …

Current research challenges

- **Corpora and datasets**
- Musical understanding
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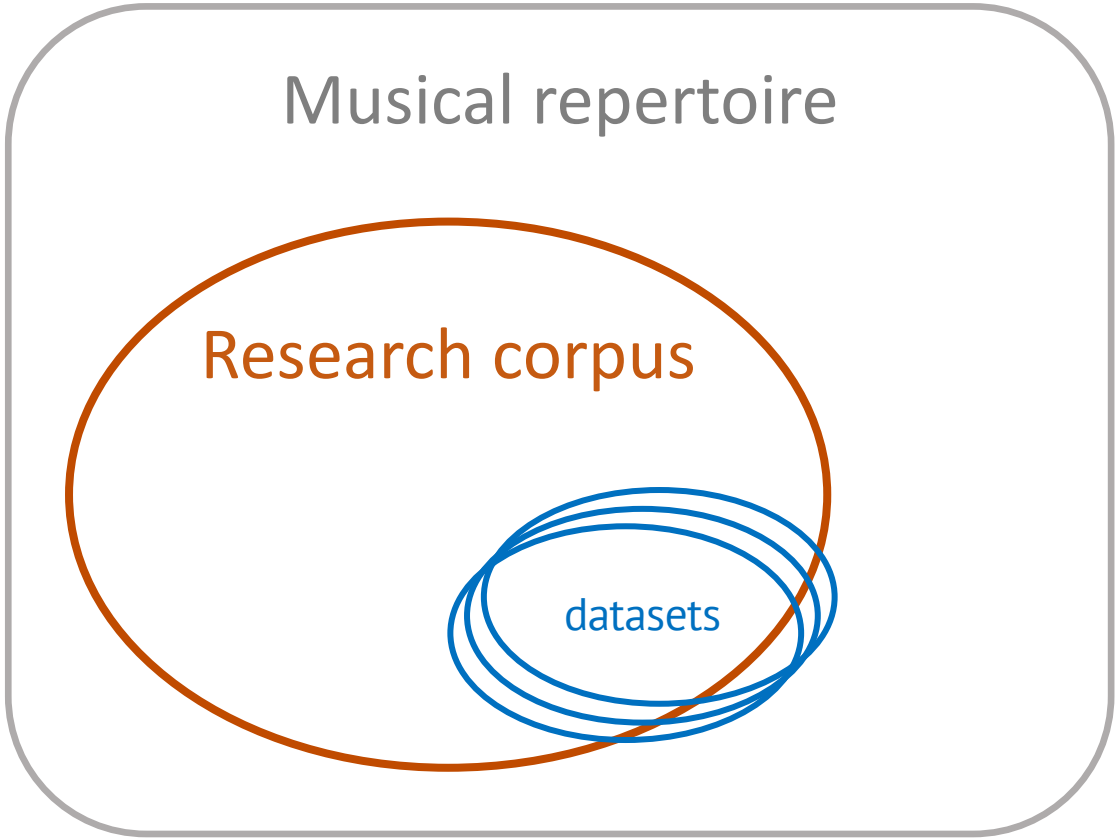
- …

Challenge: Corpora and Datasets (1 of 2)

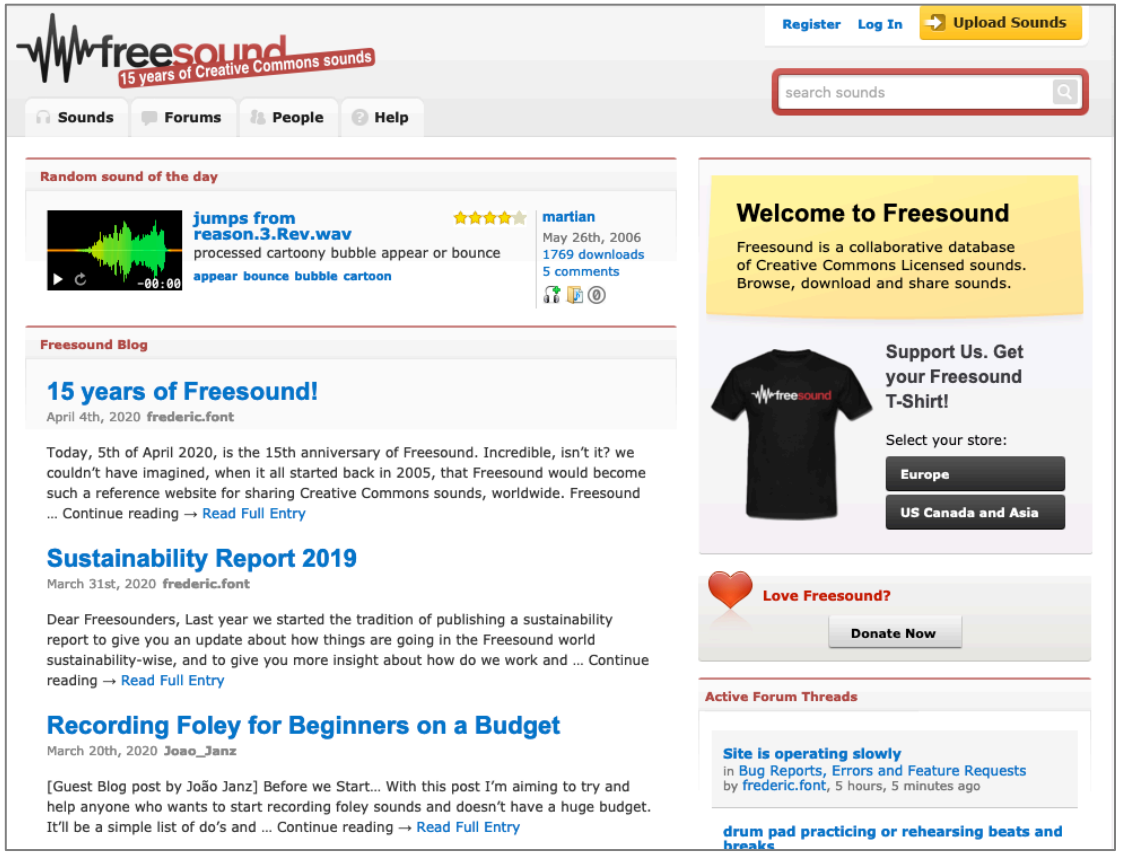


- Purpose
- Coverage
- Completeness
- Quality
- Reusability

X. Serra. 2014. "Creating Research Corpora for the Computational Study of Music: the case of the CompMusic Project." *AES*.

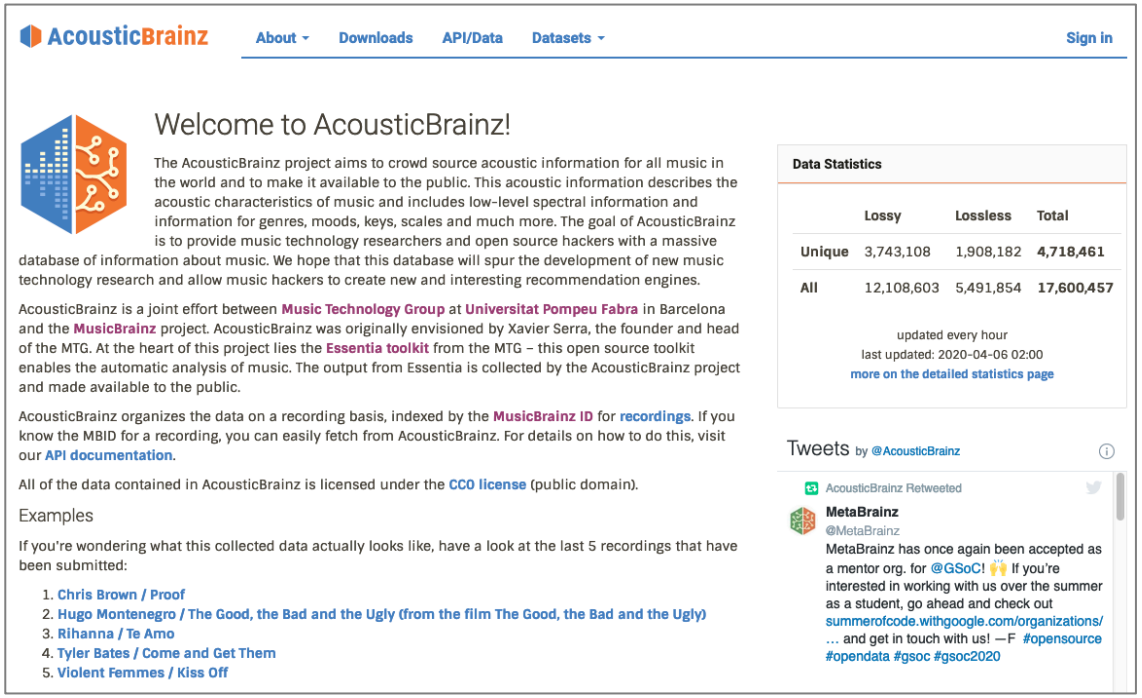
Challenge: Corpora and Datasets (2 of 2)

- **freesound.org**



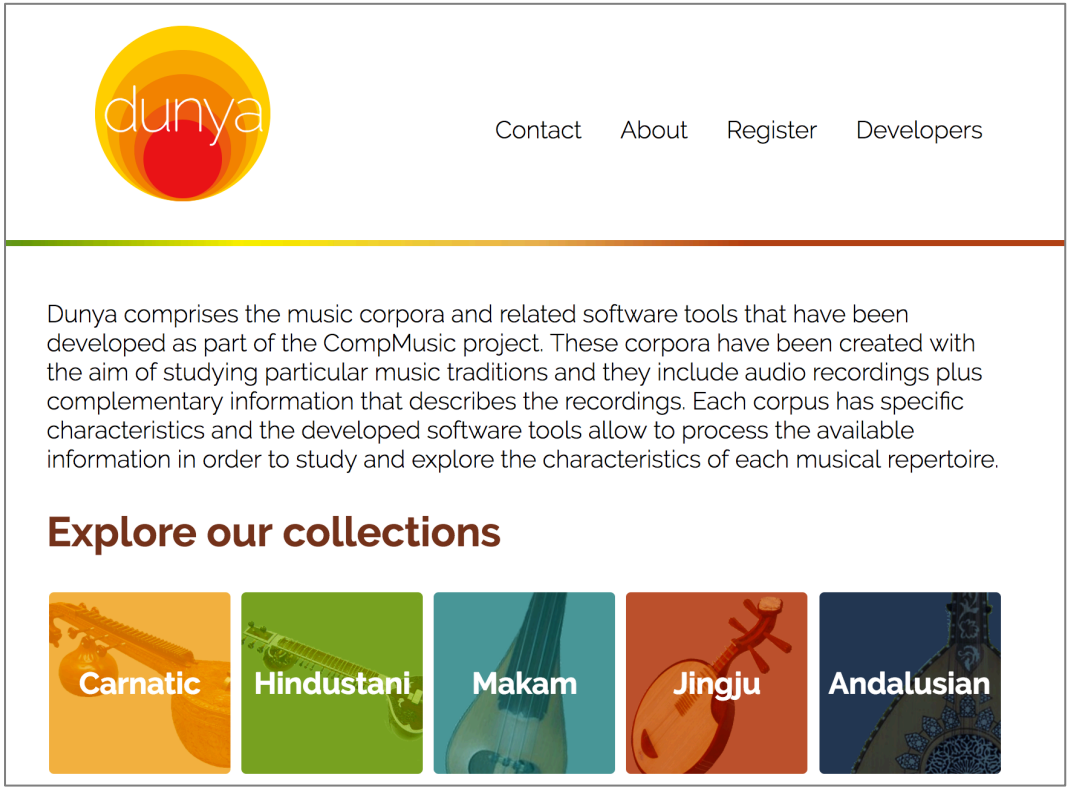
Challenge: Corpora and Datasets (2 of 2)

- freesound.org
- **acousticbrainz.org**



Challenge: Corpora and Datasets (2 of 2)

- freesound.org
- acousticbrainz.org
- **dunya.upf.edu**



Challenge: Corpora and Datasets (2 of 2)

- freesound.org
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- dunya.upf.edu
- …

Current research challenges

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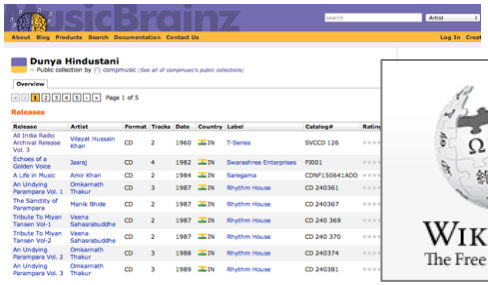
Challenge: Musical understanding (1 of 2)



Signal processing

Machine learning

Semantic analysis

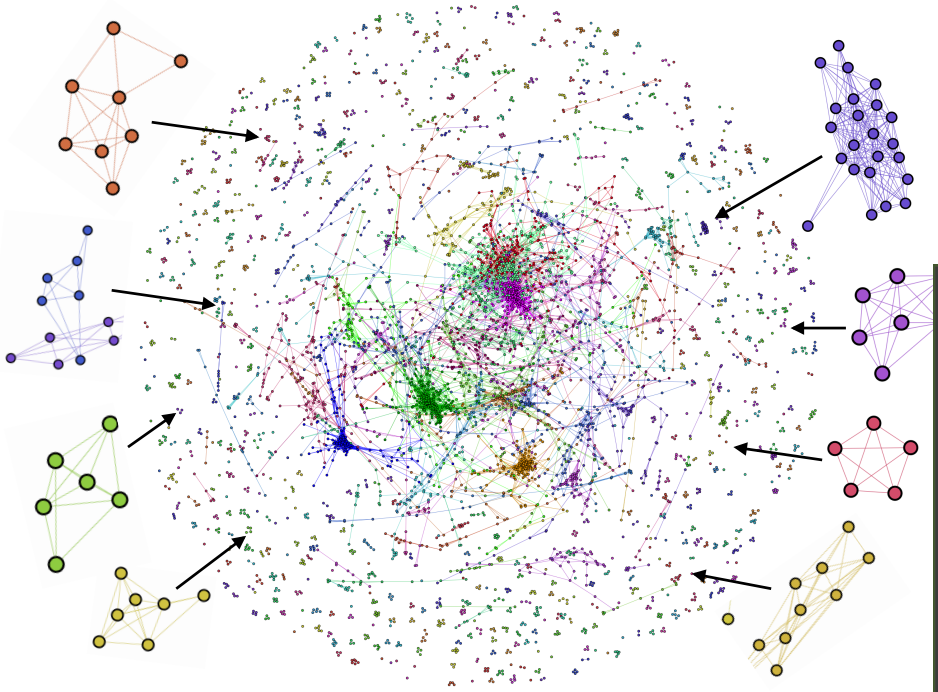
Melodic patterns

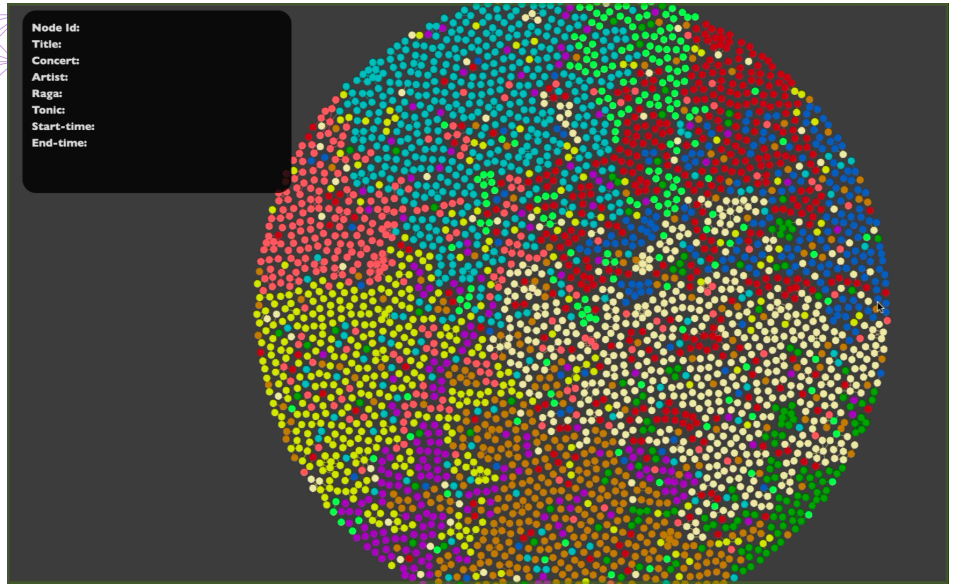
Rhythmic patterns

Semantic relationships

X. Serra. 2017. "The computational study of a musical culture through its digital traces." *Acta Musicologica*.

Challenge: Musical understanding (2 of 2)





S. Gulati. 2016. *Computational Approaches for Melodic Description in Indian Art Music Corpora*. PhD thesis.

Current research challenges

- Corpora and datasets
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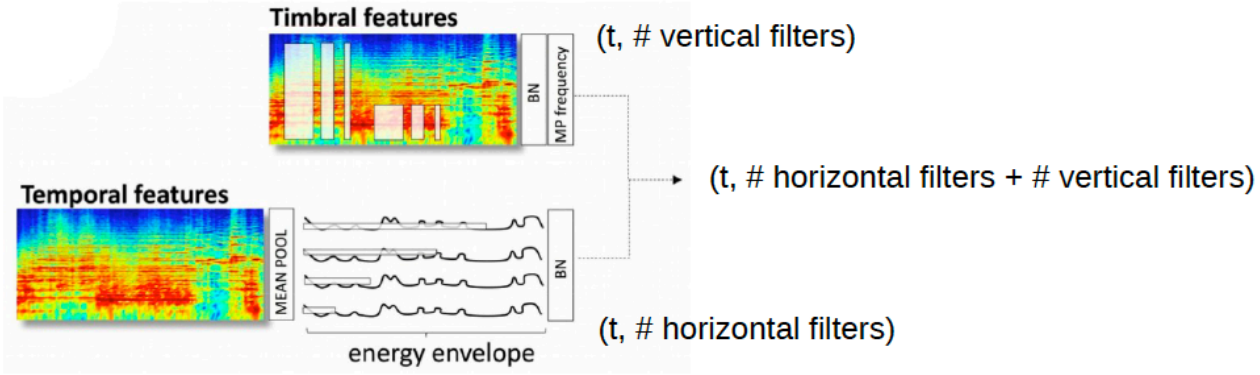
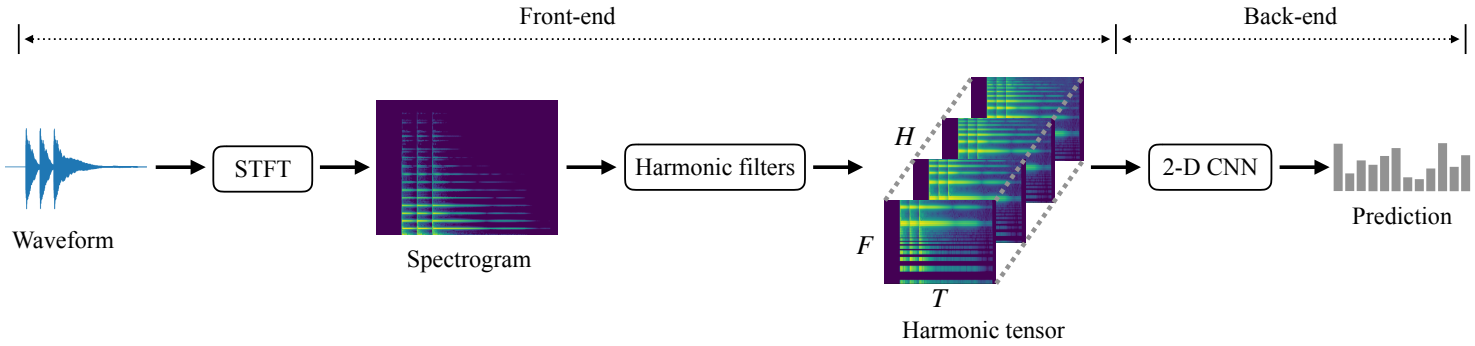
Challenge: Neural Networks for musical tasks (1 of 3)

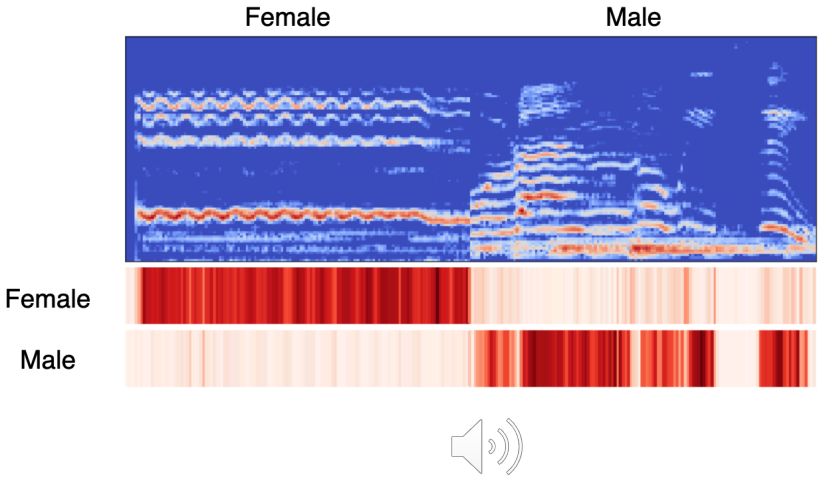


J. Pons. 2019. *Deep neural Networks for Music and Audio Tagging.* PhD Thesis.

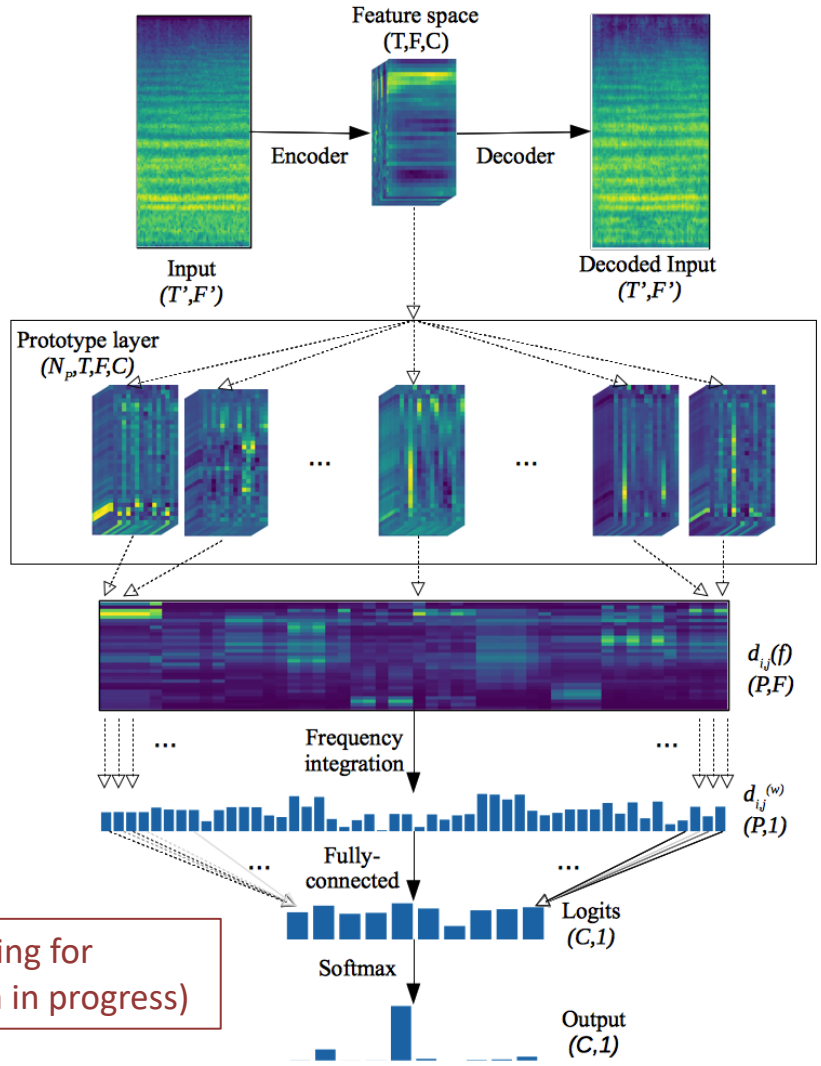


M. Won, S. Chun, O. Nieto, X. Serra. 2020. *"Data-driven Harmonic Filters for Audio Representation Learning."* **ICASSP2020**.

Challenge: Neural Networks for musical tasks (2 of 3)

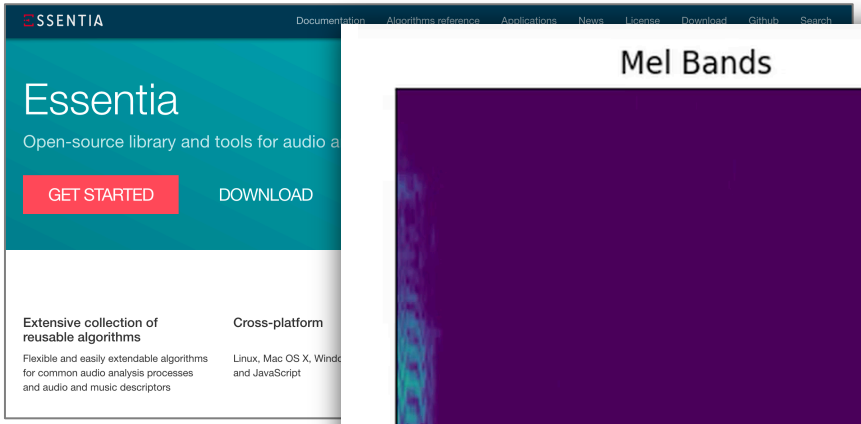


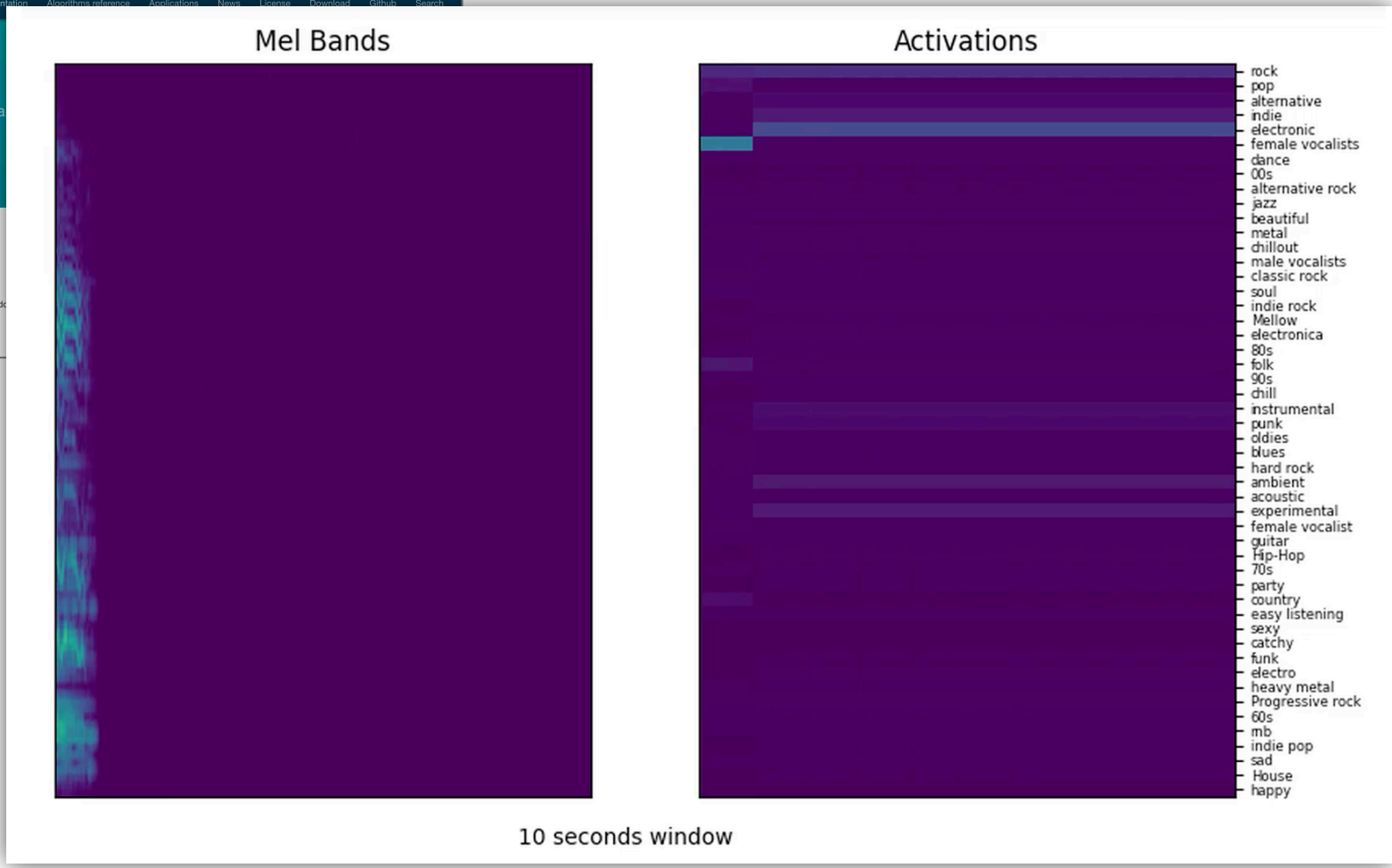
M. Won, S. Chun, X. Serra. 2019. "Toward Interpretable Music Tagging with Self-Attention." *arXiv*.



P. Zinemanas. "Explainable Deep Learning for Environmental Sound Classification." (research in progress)

Challenge: Neural Networks for musical tasks (3 of 3)





P. Alonso-Jiménez, **D. Bogdanov**, J. Pons, X. Serra. 2020. "Tensorflow Audio Models in Essentia." ***ICASSP2020***.

Current research challenges

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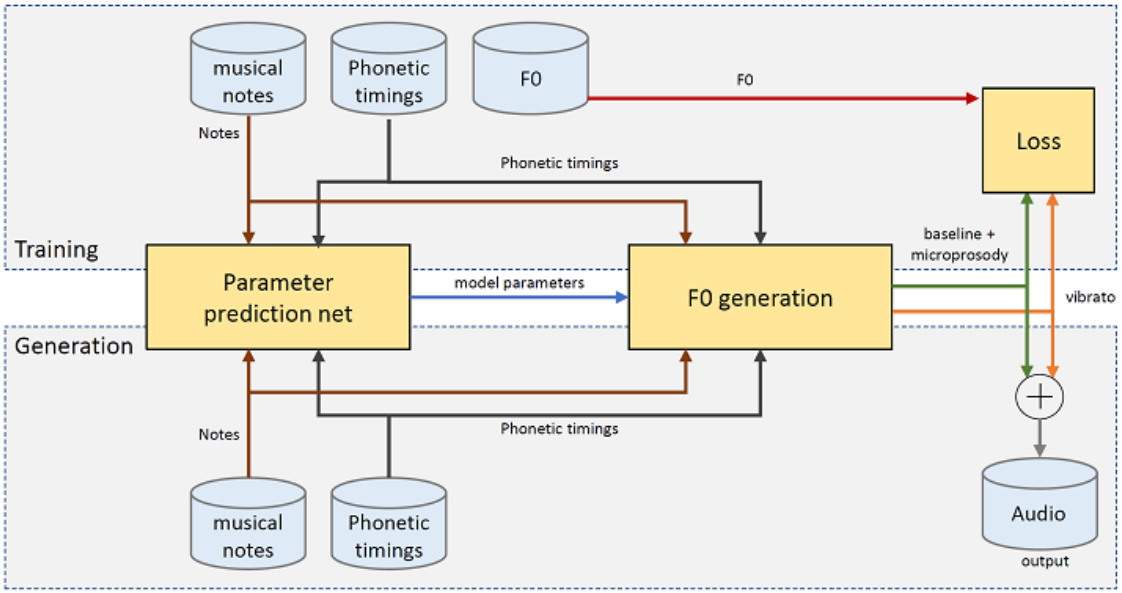
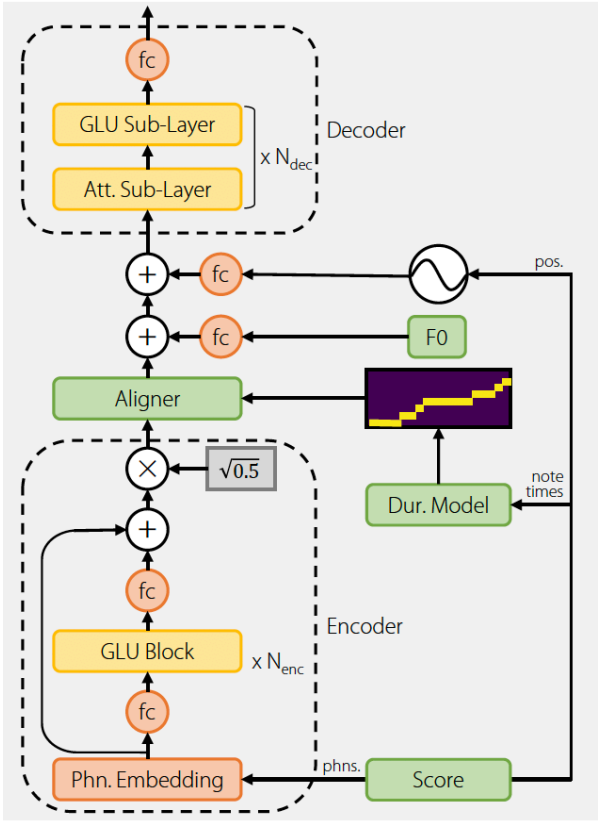
Challenge: Musical sound synthesis





J. Bonada, M. Blaauw. 2020. "Hybrid Neural-Parametric F0 Model for Singing Synthesis." **ICASSP2020**.

M. Blaauw, J. Bonada. 2020. "Sequence-to-sequence Singing Synthesis Using the Feed-forward Transformer." **ICASSP2020**.

Current research challenges

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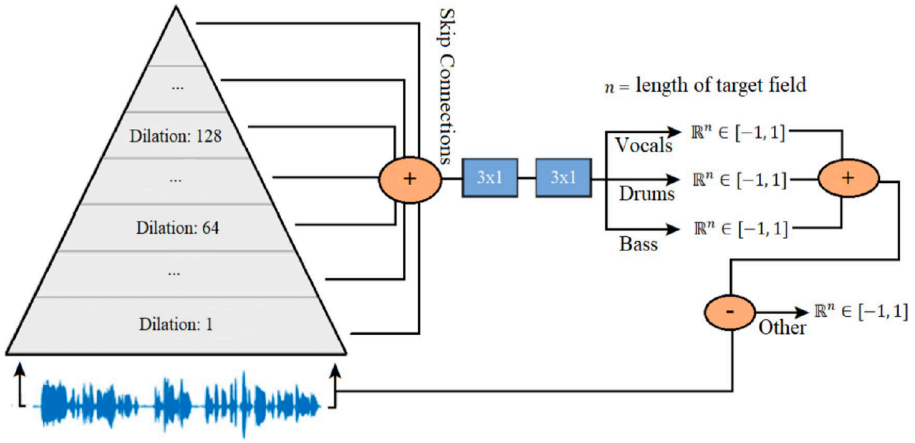
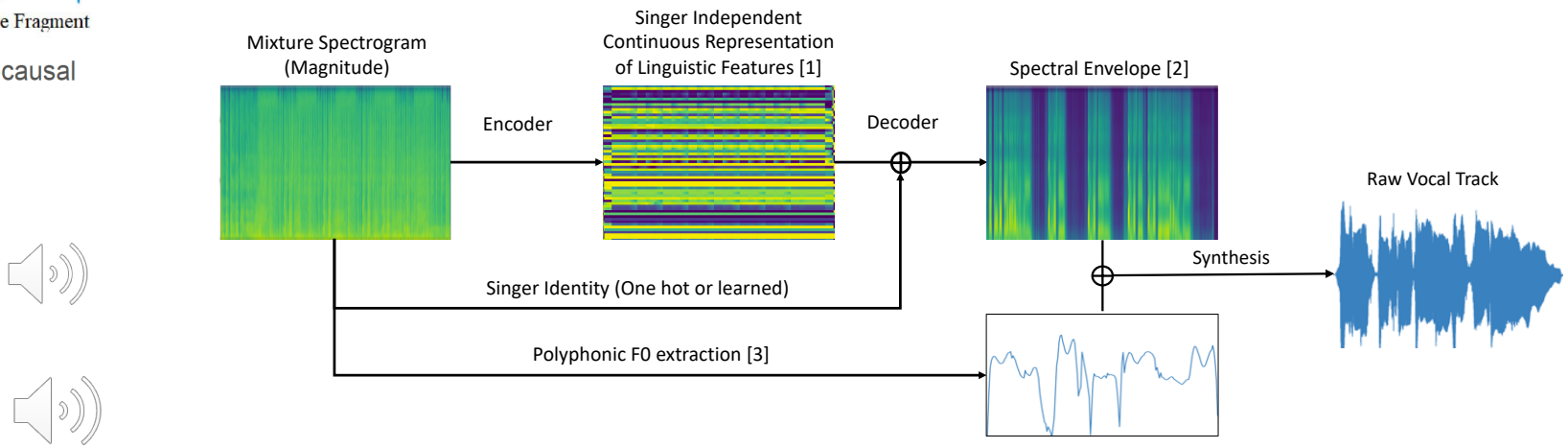
Challenge: Separation of musical audio sources



F. Lluís, J. Pons, X. Serra. 2019. "End-to-End Music Source Separation: Is it Possible in the Waveform Domain?." *Interspeech.*



P. Chandna, M. Blaauw, J. Bonada, E. Gomez. 2020. "Content Based Singing Voice Extraction From a Musical Mixture." **ICASSP2020**.

Current research challenges

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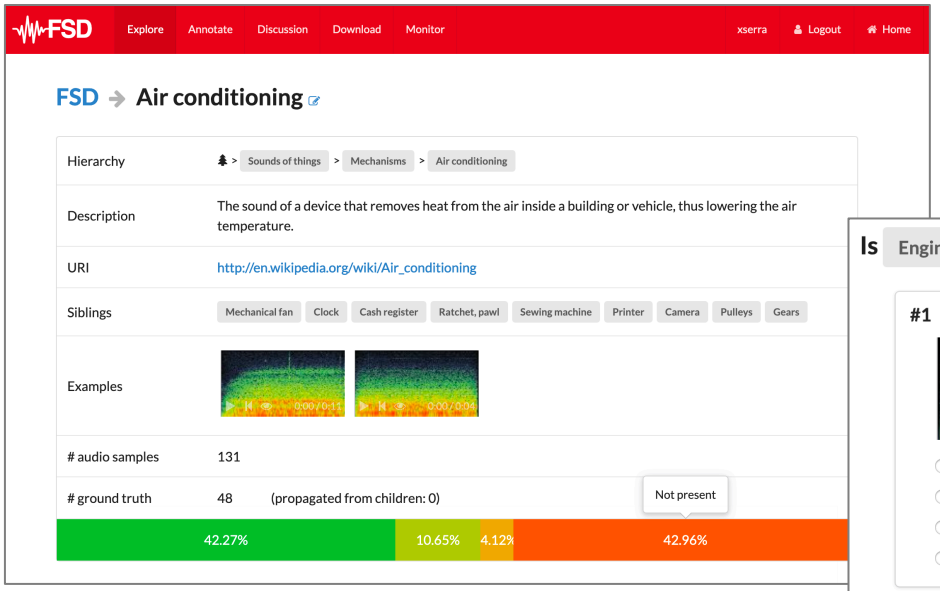
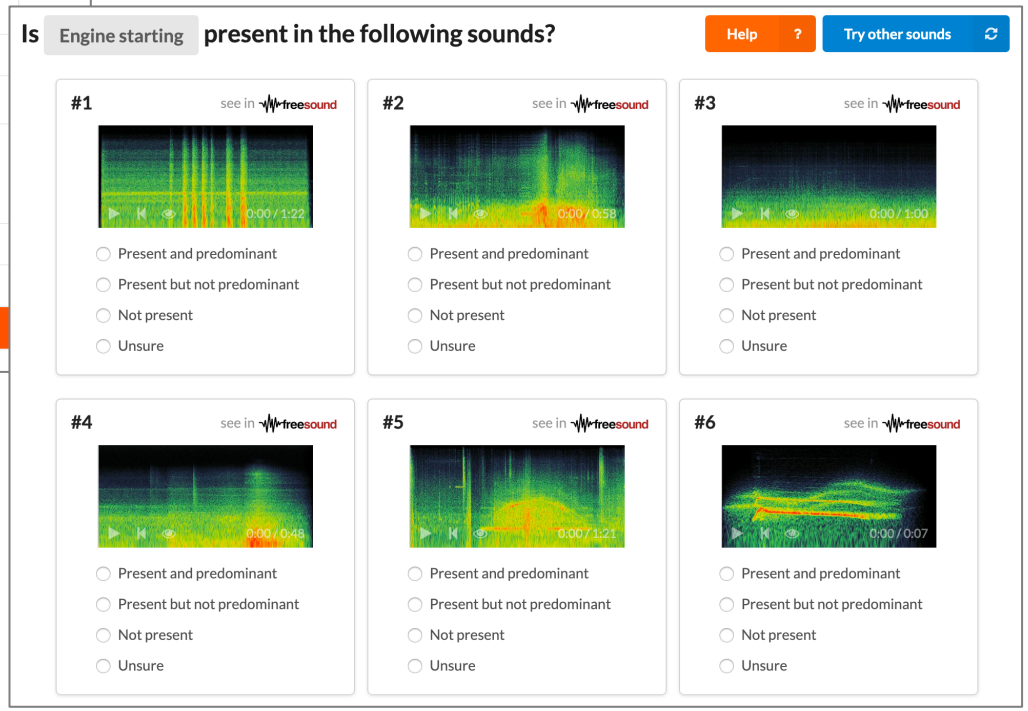
Challenge: Sound and music classification (1 of 3)

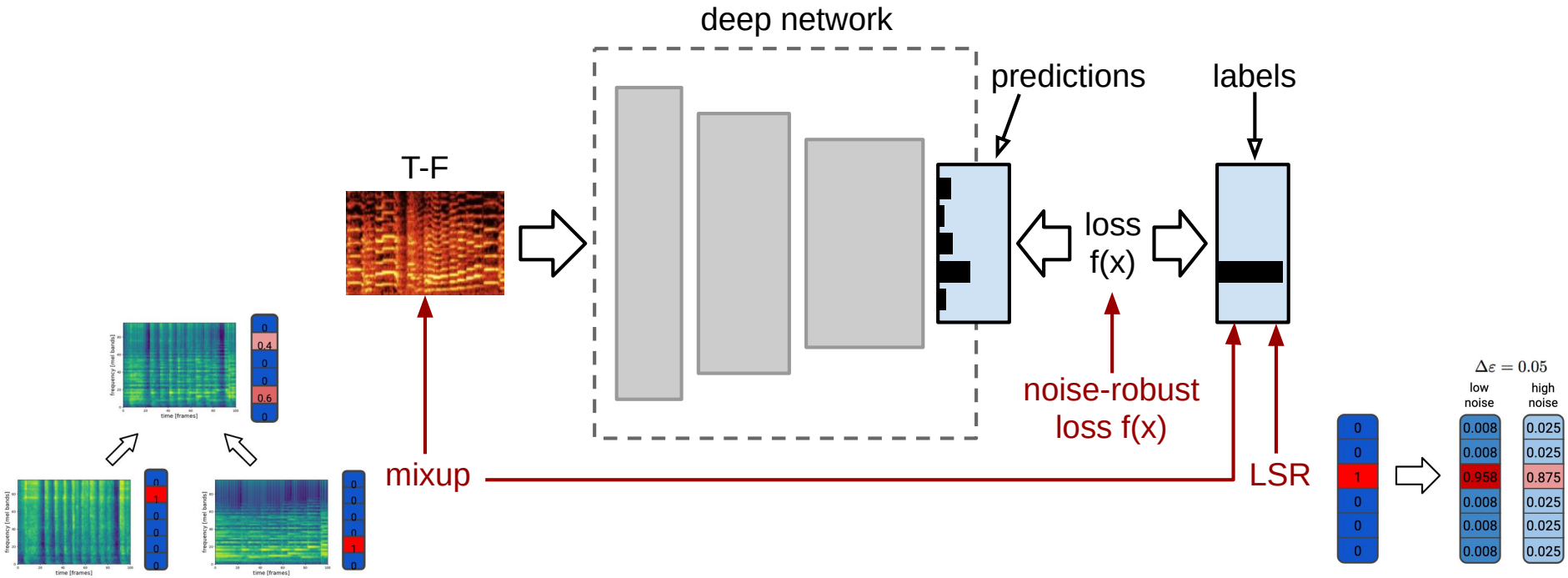




# categories	# audio samples	# ground truth annotations	# candidate annotations	# votes
632	297144	245692	685384	371690

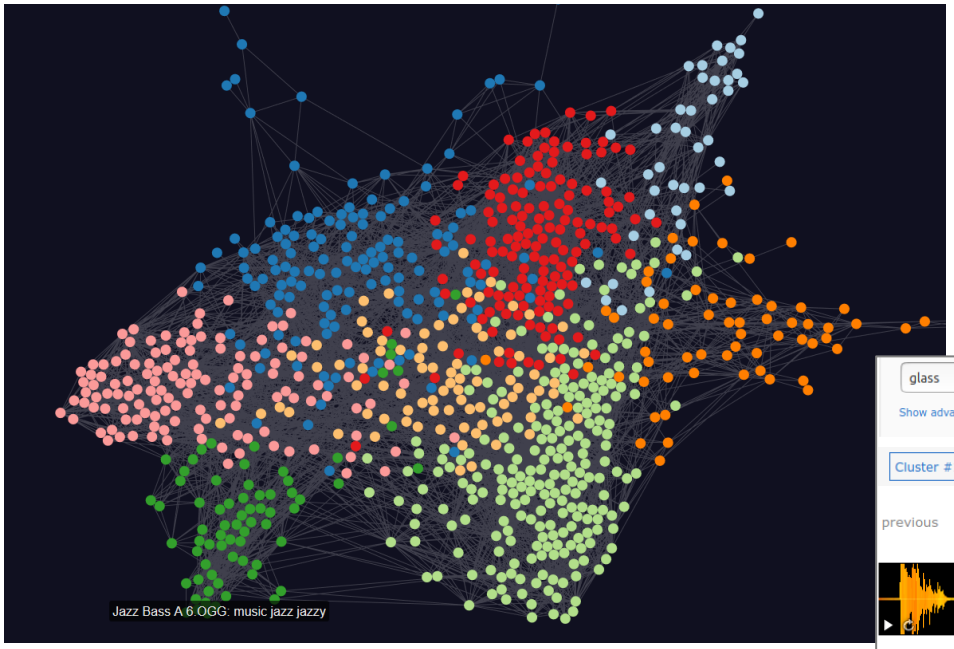
E. Fonseca, J. Pons, X. Favory, F. Font, D. Bogdanov, A. Ferraro, S. Oramas, A. Porter, X. Serra. 2017. "Freesound Datasets: A Platform for the Creation of Open Audio Datasets." *ISMIR*.

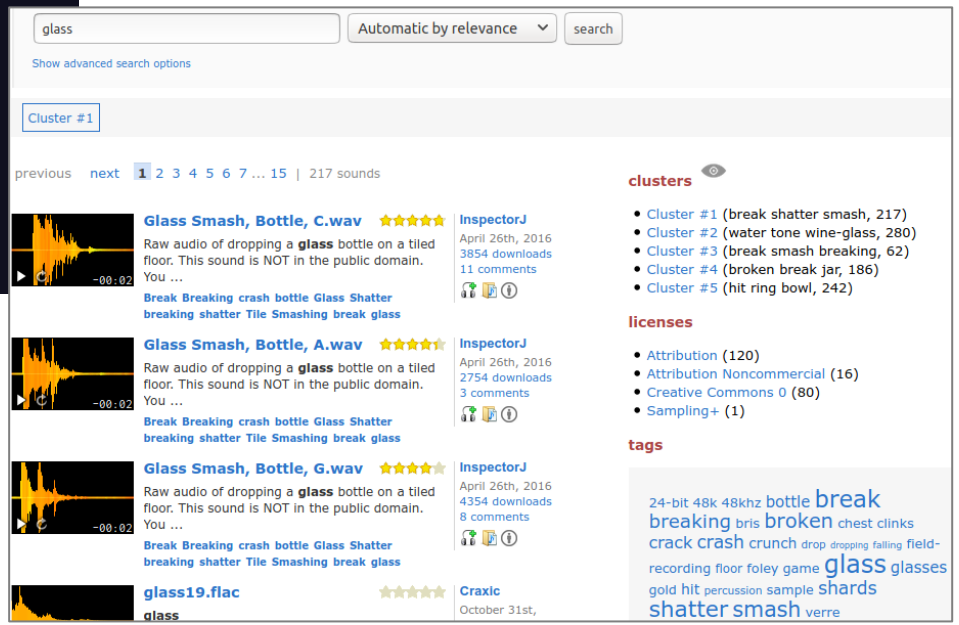
Challenge: Sound and music classification (2 of 3)



E. Fonseca, F. Font, X. Serra. 2019. "Model-agnostic Approaches to Handling Noisy Labels When Training Sound Event Classifiers." *WASPAA*.

Challenge: Sound and music classification (3 of 3)





X. Favory, F. Font, X. Serra. 2020. "Search Result Clustering in Collaborative Sound Collections." ICMR.

Current research challenges

- Corpora and datasets
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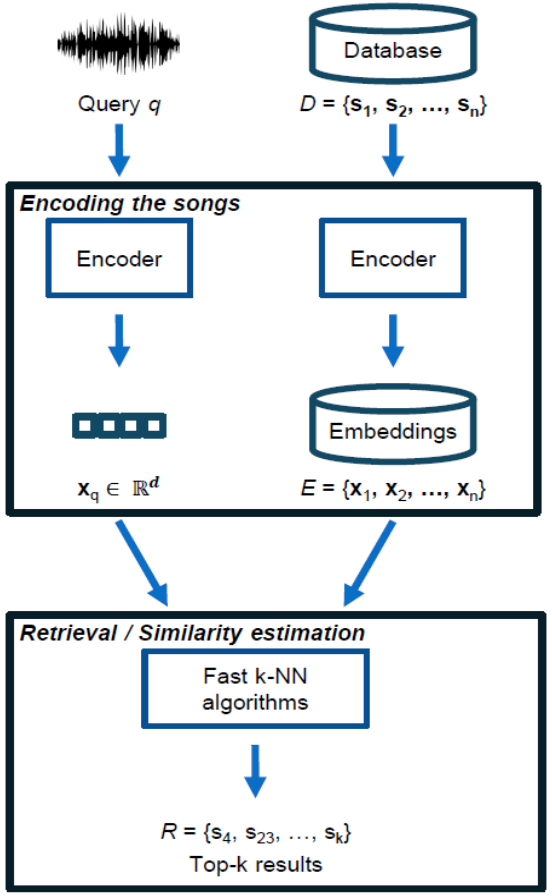
- **Applications**
- …

Challenge: Applications

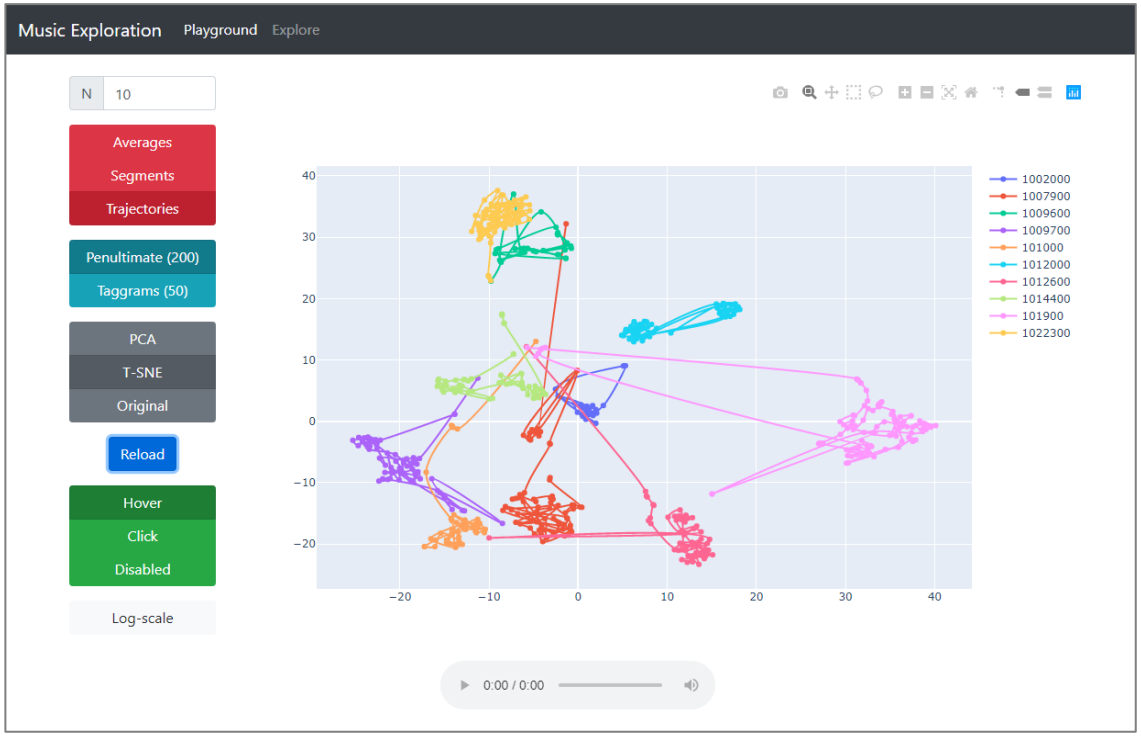
- **Music identification**



F. Yesiler, J. Serrà, E. Gómez. 2020. "Accurate and Scalable Version Identification Using Musically-Motivated Embeddings." **ICASSP2020**.

Challenge: Applications

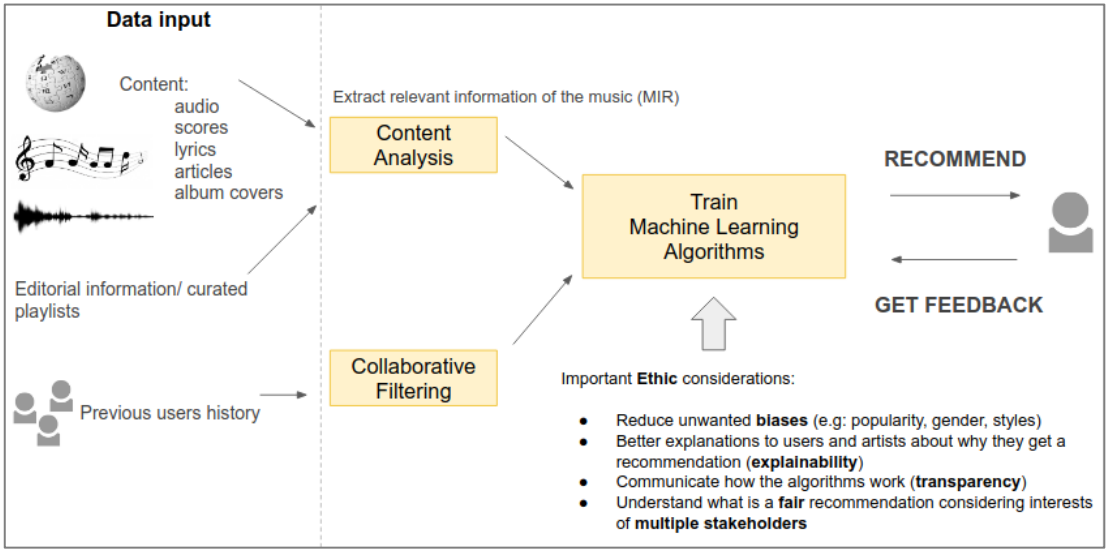
- Music identification
- **Music exploration**



P. Tovstogan. "Facilitating Interactive Music Exploration." (research in progress)

Challenge: Applications

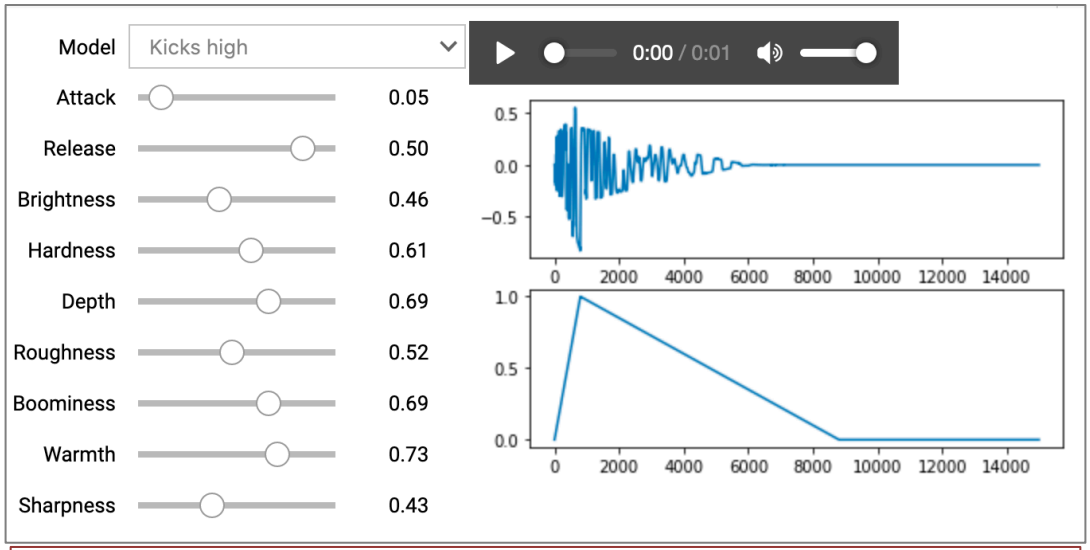
- Music identification
- Music exploration
- **Music recommendation**



A. Ferraro, D. Bogdanov, X. Serra, J. Yoon. 2019. "Artists and Style Exposure Bias in Collaborative Filtering Based Music Recommendation." wsHCMIR.

Challenge: Applications

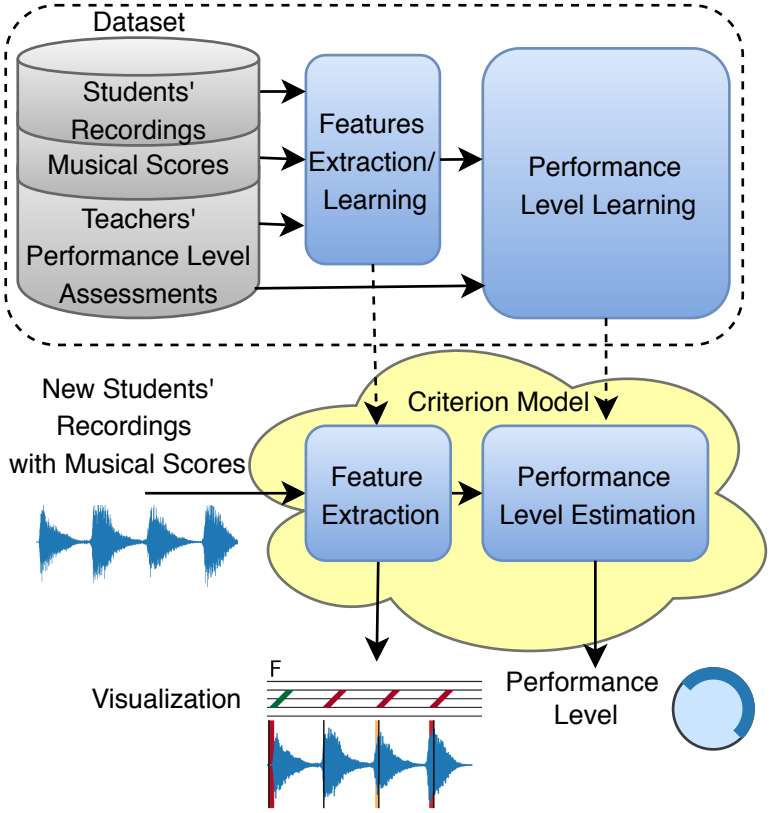
- Music identification
- Music exploration
- Music recommendation
- **Music creation**



A. Ramires, P. Chandna, X. Favory, E. Gómez, X. Serra. 2020. "Neural Percussive Synthesis Parameterised by High-Level Timbral Features." **ICASSP2020**.

Challenge: Applications

- Music identification
- Music exploration
- Music recommendation
- Music creation
- **Music education**



V. Eremenko, A. Morsi, J. Narang, X. Serra. 2020. "Performance Assessment Technologies for the Support of Musical Instrument Learning." *CSME.*

Challenge: Applications

- Music identification
- Music exploration
- Music recommendation
- Music creation
- Music education
- …

Conclusions

- Many things left out
- Specificity of sound and music research and applications
- Multidisciplinarity
- Publications:
  - https://www.upf.edu/web/mtg/research/publications
- Software & Datasets:
  - https://www.upf.edu/web/mtg/software-datasets

Thanks !!

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