On Perceived Emotion in Expressive Piano Performance: Further Experimental Evidence for the Relevance of Mid-level Perceptual Features

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INTRODUCTION

Perceived emotion of in music can be affected by several musical qualities. Music Emotion Recognition (MER) models have typically used features derived from audio content or midi/score to learn and predict emotion. Recent methods have used end-to-end audio to emotion neural networks.

Can we do better by using mid-level perceptual features [1]?

Research Questions:

Evaluate and compare feature sets on their predictive capacity for Arousal and Valence (A/V).

1. A/V fitting using each feature set
2. Importance of individual features in each set
3. Modeling variation of A/V between pieces
4. Modeling variation of A/V between different performances of the same piece

Feature Sets:

1. Low-level features
2. Score-level features
3. DEAMResNet features (end-to-end audio to emotion model)
4. Mid-level Features

Data:

- Recordings of Bach's Well-Tempered Clavier Book 1 (48 pieces) by six famous pianists: Gould, Gulda, Hewitt, Richter, Schiff, Tureck.
- A/V annotations gathered from participants in a listening experiment and averaged for each recording.
- Each recording annotated by 29 participants.
- Audio stimuli limited to first 8 measures of each piece.

References

[1] Chowdhury et al. "Towards Explainable Music Emotion Recognition: The Route via Mid-level Features" (ISMIR 2019)

[2] Koutini et al. "Emotion and theme recognition in music with Frequency-Aware RF-Regularized CNNs" (arXiv:2007.13503)

[3] Chowdhury & Widmer "Towards Explaining Expressive Qualities in Piano Recordings: Transfer of Explanatory Features via Acoustic Domain Adaptation" (ICASSP 2021)

[4] Aljanaki & Soleymani "A data-driven approach to mid-level perceptual musical feature modeling" (ISMIR 2018)

[5] Aljanaki et al. "Developing a benchmark for emotional analysis of music" (PloS one 12 (3), e0173392)

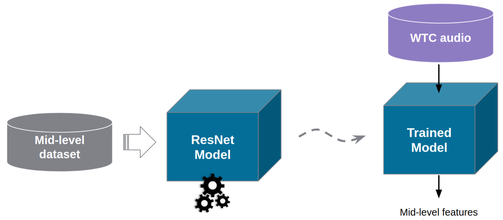
FEATURE EXTRACTION USING NEURAL NETWORK MODELS

Mid-level Features

Model: receptive-field regularised ResNet [2].

Trained using audio and annotations from Midlevel Dataset [4].

Adapted for piano music using unsupervised domain adaptation [3]



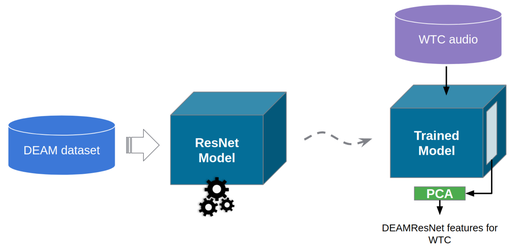
DEAMResNet Features

Features from end-to-end audio to emotion model

Model: receptive-field regularised ResNet [2].

Trained on DEAM Dataset [5].

Adapted for piano music using unsupervised domain adaptation [3]



A/V FITTING USING EACH FEATURE SET

	Piece-wise		Pianist-wise		LOO	
Feature Set	A	V	A	V	A	V
Mid-level	**0.68**	0.63	**0.68**	0.64	**0.69**	0.65
DEAMResNet	0.67	0.37	0.61	0.41	0.68	0.43
Low-level	0.54	0.20	−0.11	−0.05	0.57	0.30
Score	0.08	**0.67**	0.39	**0.75**	0.37	**0.74**

Adjusted R2 score
for different cross-validation splits. A: Arousal, V: Valence, LOO: Leave-One-Out

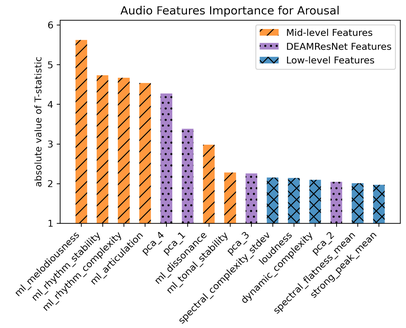
PERFORMANCE-WISE VARIATION*

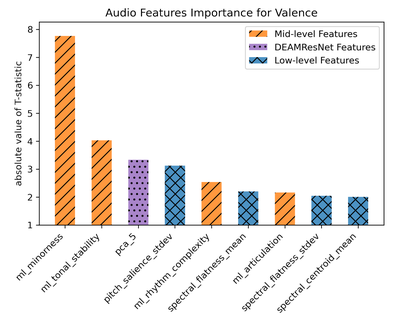
	Arousal		Valence	
Feature Set	FVU	Corr (p<0.1)	FVU	Corr (p<0.1)
Mid-level	**0.31**	**0.58** (47.9%)	**0.36**	0.42 (27.0%)
DEAMResNet	0.32	0.54 (43.8%)	0.61	**0.47** (37.5%)
Low-level	0.43	0.56 (54.2%)	0.75	0.38 (22.9%)

Evaluation metrics for performance-wise variation.
FVU: Fraction of Variance Unexplained. Corr: Pearson's correlation coefficient.

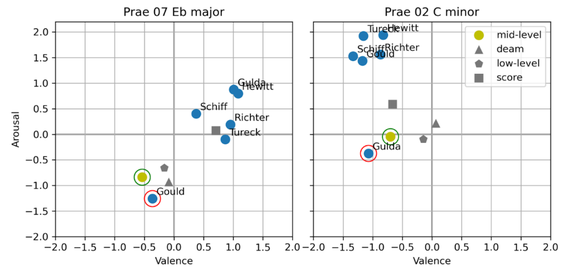
* See paper for piece-wise variation results (omitted here for brevity)

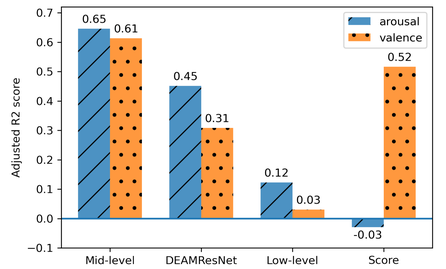
FEATURE IMPORTANCE





GENERALIZING TO OUTLIER PERFORMANCES





(Top) Emotions for two pieces with the outlier performance marked in red; Predictions using different feature sets are also plotted.
(Bottom) Adjusted R2 score for predicting emotion on a test set with 48 outlier performances

TAKEAWAYS

- Mid-level features are useful for modeling emotion in general, and differences in emotion between performances in particular.
- Mid-level features have good generalizing capacity.
- Valence is hard to model using audio content derived features. Score features generally perform better more consistently for valence.

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