Emotion-aware Music Information Retrieval Based on Physiological Signals and User Profile

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Emotion-aware Music Information Retrieval

- To explore the possibility of using **physiological signals** to detect users' **emotional responses** to music
- To explore whether individual differences (in personality, music preferences, etc.) can affect music mood perception.
- A user experiment to collect
(1) users' interactions with a novel MIR system (Moody 3.0)
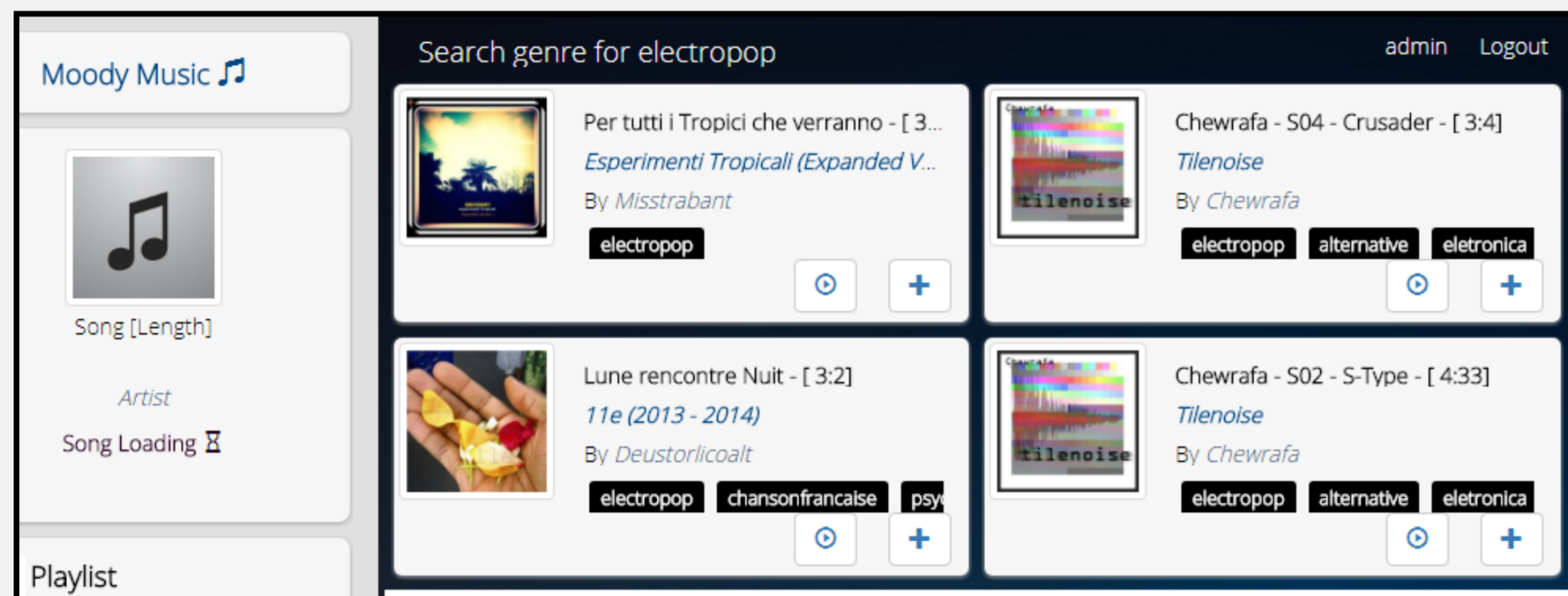
(2) users' **physiological signals** using a wearable device (wristband)
- Data analysis:
Machine learning + **physiological feature extraction** methods

Method • Experimental Design

Participants	• **50** participants (24 M, 26 F) • Different majors in a comprehensive university in HK • With **various music knowledge background** and relatively **high frequency of music listening**

Procedure

| Mood identification	During MIR task: for each music piece listened for > 30s → answer 2 **mood-related questions:** Q1: **Arousal** (High … Low, on a continuum) Q2: **Mood** (discrete)

Physiological Signals During Music Listening

Empatica E4 wristband
- Developed by the Massachusetts Institute of Technology (MIT)
- Designed for research and clinical purposes
- Unobtrusive
- Real-time data visualization (with mobile app)
- Raw data encrypted and stored on secure cloud platform for convenient retrieval
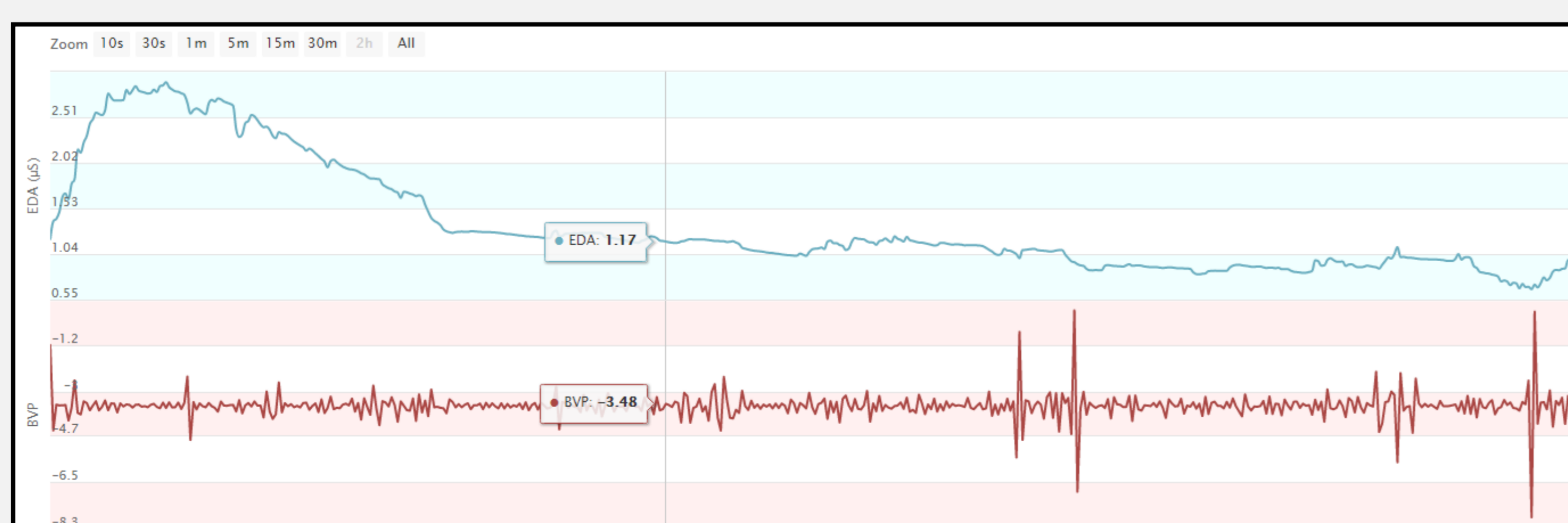
Method • Data Analysis

❖ Physiological Signals

EDA	BVP	IBI	HR	TEMP

Data normalization	• Normalized by z-score formula
Feature set	• **Statistical features:** Means, SD, Median, Range • **Time-related feature:** Variation in 60s • **Time series features:** Means of the absolute values of the 1st / 2nd differences of the raw / normalized signals • **Frequent domain features:** HF, LF, LF/HF • **Physiological signal specific features:** skin conductance response (SCR), heart rate variability (HRV)
Classifier	• k-NN, decision tree, logistic regression, naïve Bayes, logistical regression

❖ User Profile

Personality	Music preference	Learning style

Data collection	• Personality, music preference, and learning style • Collected in the pre-experiment questionnaire
Analysis	• To explore their **moderation effect** on relationships between physiological signals and emotional responses to music

Preliminary Results

- Arousal and Mood values → each with 3 categories: **+ve, -ve, neutral**
- Significant results of ANOVA comparison (at $p < 0.1$)

Across 3 arousal categories		Across 3 mood categories	
BVP_median	0.032	**BVP_median**	0.005
BVP_range	0.09	**HR_mean**	0.07
HR_SD	0.025	**HR_SD**	0.046
HR_range	0.011	**HR_median**	0.074
		HR_range	0.036
		IBI_mean	0.001
		IBI_median	0.002

- Significant t-test results* on variables between +ve and –ve categories

Arousal	BVP_median	BVP_range	HR_SD	HR_range	IBI_mean	IBI_median	
	0.012	0.081	0.007	0.003	0.055	0.056	

Mood	BVP_mean	HR_mean	HR_SD	HR_median	HR_range	IBI_mean	IBI_median
	0.037	0.073	0.015	0.074	0.011	0.011	0.013

Classification results (kappa):
- 10-fold cross-validation, stratified sampling; measure: kappa
- Using Mean, Median, SD and range of **BVP, HR, IBI**

Classifier	Arousal: +ve (N=436) vs. –ve (N=176)	Mood: +ve (N=387) vs. –ve (N=142)
Naïve Bayesian	0.068	0.01
Decision Tree	-0.021	0.016
Random Forest	-0.003	0.02
Logistic Regression	-0.012	0.005
kNN	0.019	-0.03

- For individuals, with **all features except for TEMP**

User	Arousal		Mood	
User_A	+ve (N=25) -ve (N=19)	0.128	+ve (N=29) -ve (N=22)	0.12
User_B	+ve (N=21) -ve (N=11)	0.17	+ve (N=20) -ve (N=8)	0.125