

## 1 Introduction

### Problem:

- Multitrack domain: dependencies between tracks may influence decisions.
- There are no universal rules for reverberation.
- Previous intelligent mixing approaches cannot be scaled (fixed rules, trained from dataset, curve fitting, etc).

### Requirements:

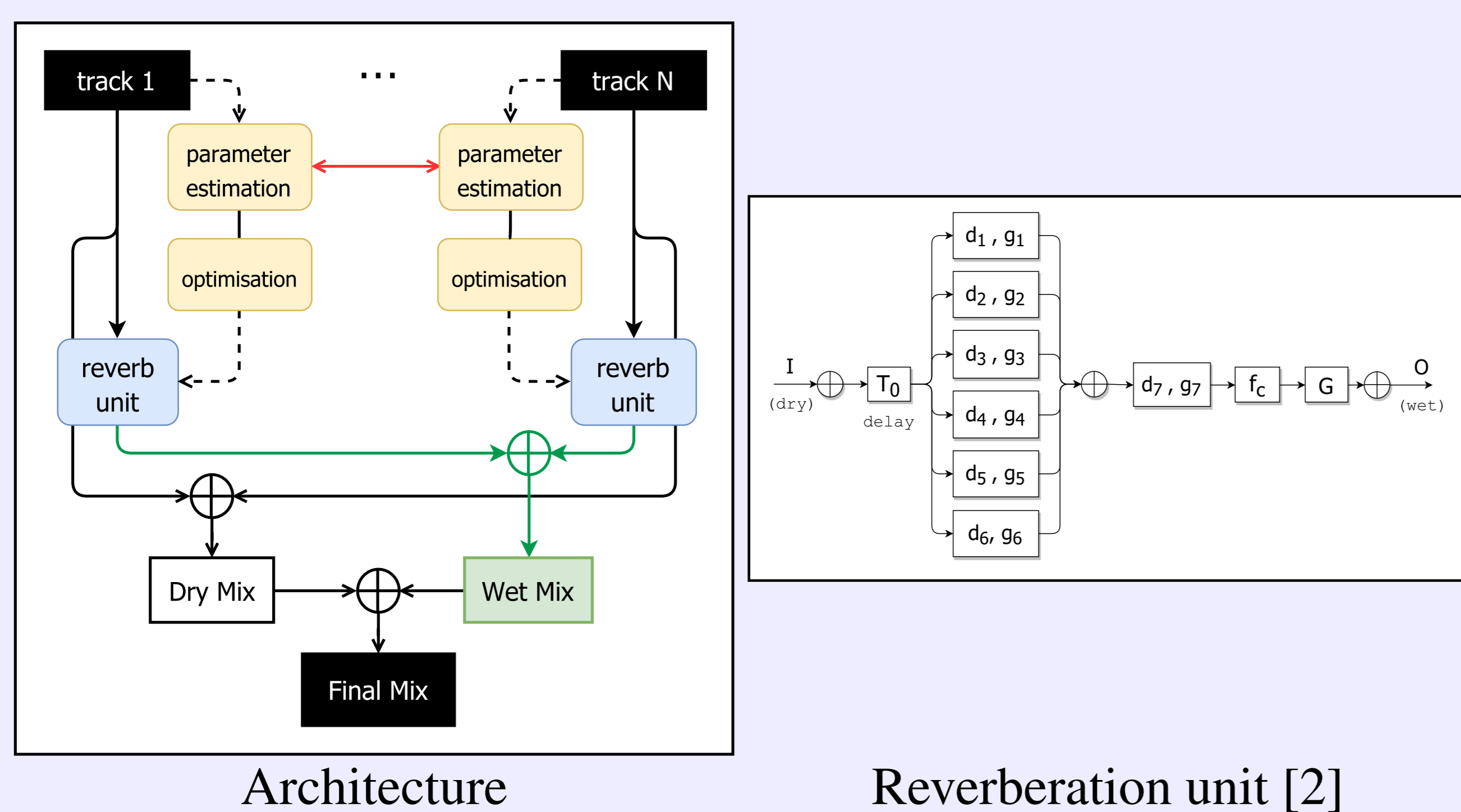
- Knowledge-informed prediction with different levels of confidence.
- Expressive and flexible.
- Structure prediction in a domain with high level of interconnection.

## 2 A model for structured prediction

- **HL-MRFs**<sup>1</sup>: weighted probability density functions over continuous variables. Weights represent confidences in discrete predictions [1].
- **PSL**<sup>2</sup>: intuitive interface for HL-MRFs.
  - Templates for potentials can be created using first-order logic.
  - Predicates specify relationships in the input data

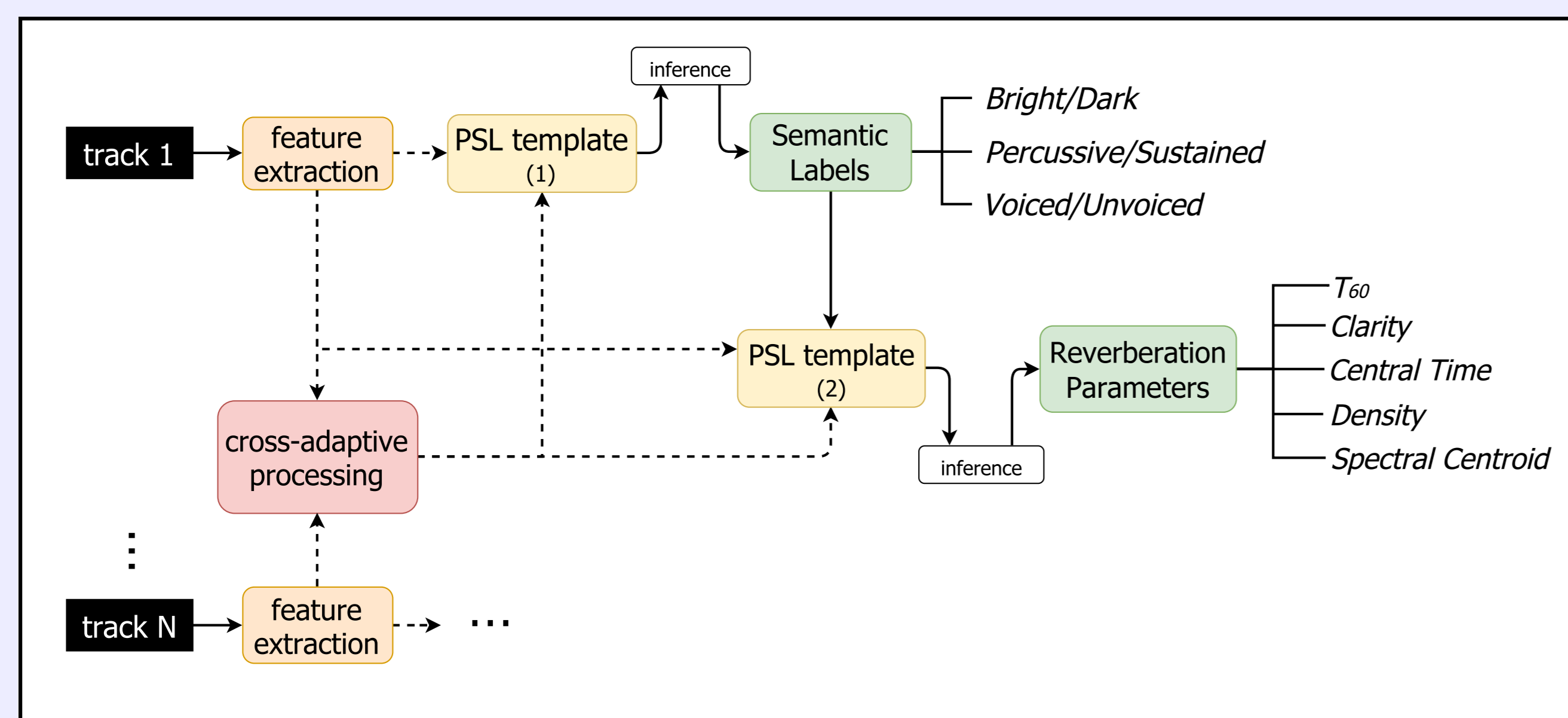
<sup>1</sup>Hinge-loss Markov random fields  
<sup>2</sup>Probabilistic Soft Logic

## 3 Implementation



Architecture

Reverberation unit [2]



Parameter Estimation

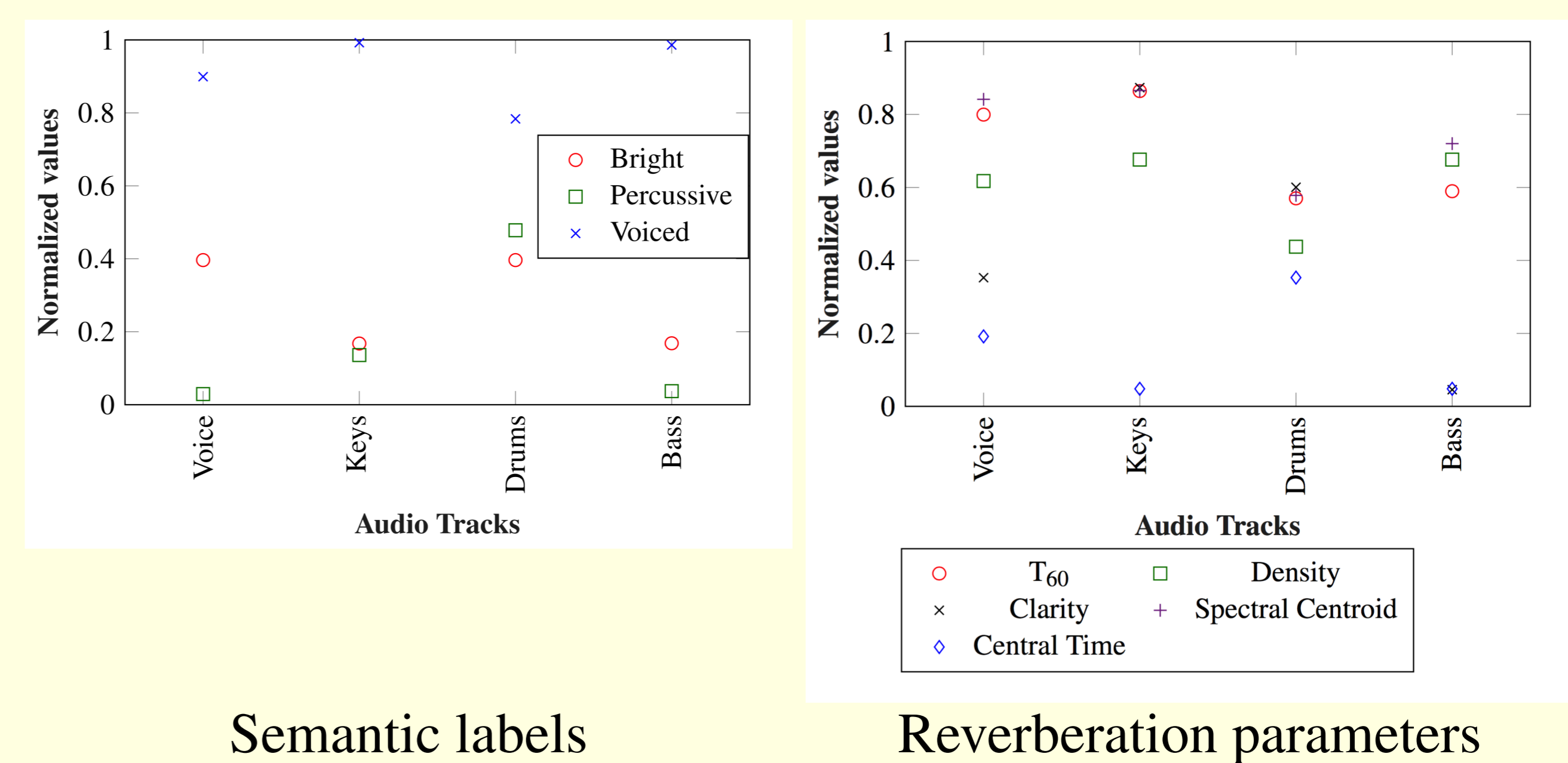
## 4 PSL templates

- Best practices [3] are laid out as logical or linear combinations.
- Weights based on comparative evidence and experimentation.
- **Universal Constants:** *Track, Feature, Property*<sup>1</sup>, *Parameter*
- **Predicates:**
  - *Feature(track, feature name)*: observations from analysis.
  - *Property(track, property name)*: rules based on literature.
  - *Parameter(track, parameter name)*: interconnection between extracted data and reverb parameters.

<sup>1</sup>Semantic labels

## 5 Results

- Data from Open Multitrack Testbed.



Semantic labels

Reverberation parameters

- Rules satisfaction:

- “Percussive instruments require shorter and denser reverbs”.
- “Denser reverbs with longer early reflections for voiced sounds”.
- “Gen. avoid sending many low-frequency elements to a reverb”.
- “Higher spectral centroid allows for more reverb”.

## 6 Conclusions

- 1st<sup>1</sup> effort to design an automatic multitrack reverberator.
- The model identifies complex relationships among input signals and applies effect according to pre-specified rules.
- HL-MRF and PSL, together, offer an intuitive interface and fast inference process.
- Rule’s weights could be learned from either large or small datasets.
- Pre and post-processing of the tracks may improve performance.

<sup>1</sup>To the best of author’s knowledge



[1] S. H. Bach, M. Broecheler, B. Huang and L. Getoor. Hinge-loss Markov random fields and probabilistic soft logic. *arXiv preprint arXiv:1505.04406*, 2015.

[2] Z. Rafii and B. Pardo. Learning to Control a Reverberator Using Subjective Perceptual Descriptors. In *110th Intl. Soc. Music Information Retrieval Conf.*, Kobe, Japan, 2009.

[3] P. D. Pestanta. Automatic mixing systems using adaptive digital audio effects. Ph.D. thesis, Universidade Catolica Portuguesa, 2013.