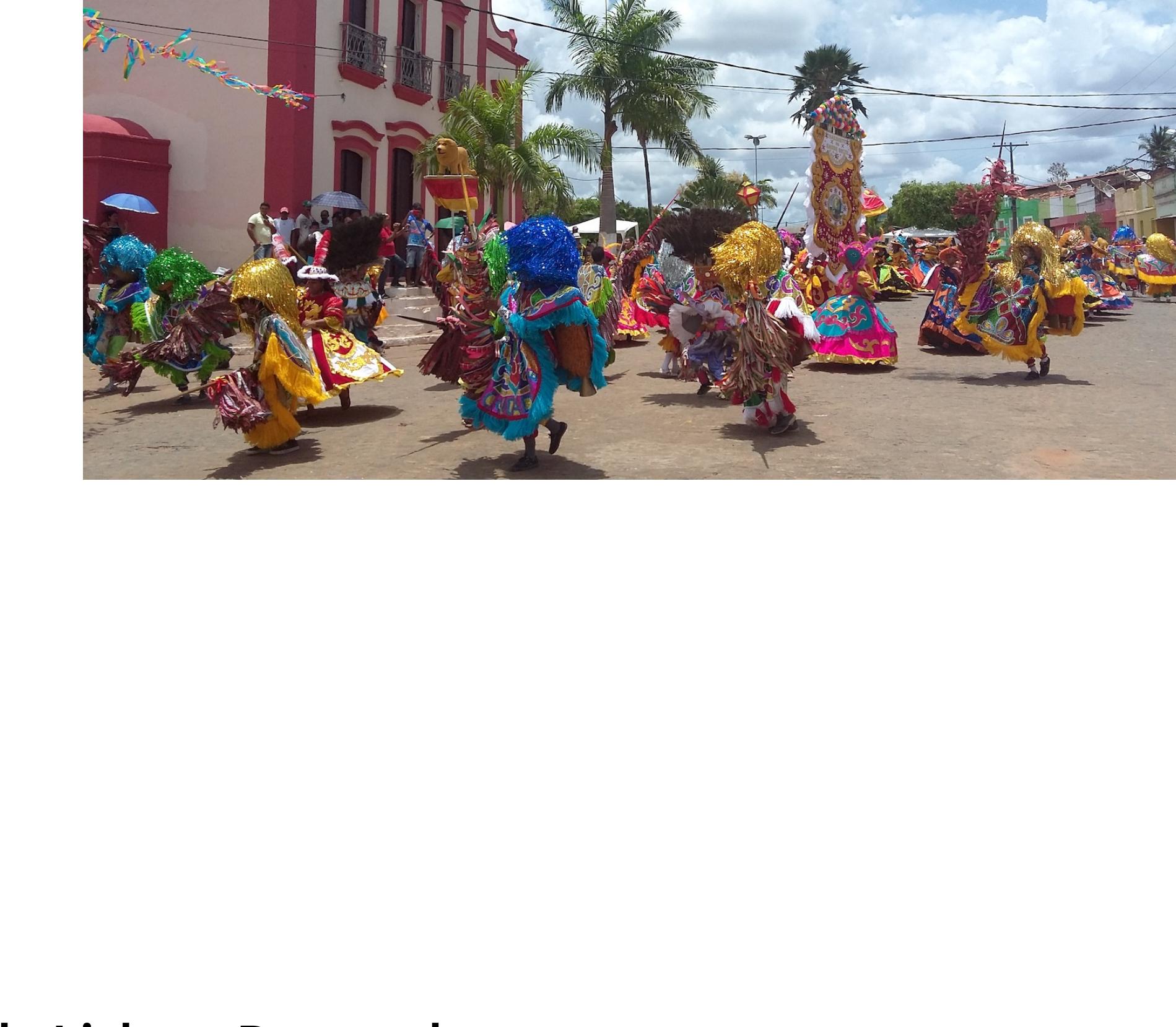


# Moving in Time: Computational Analysis of Microtiming in Maracatu de Baque Solto



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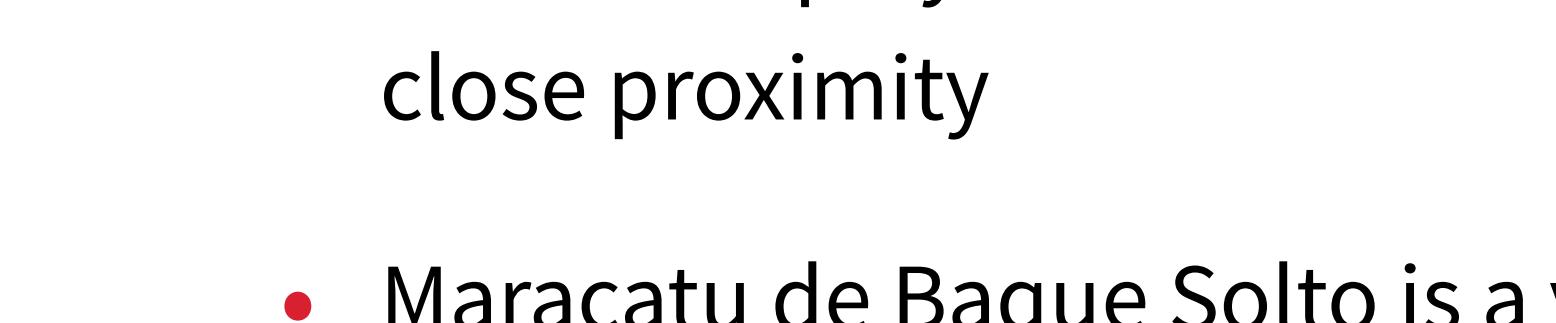
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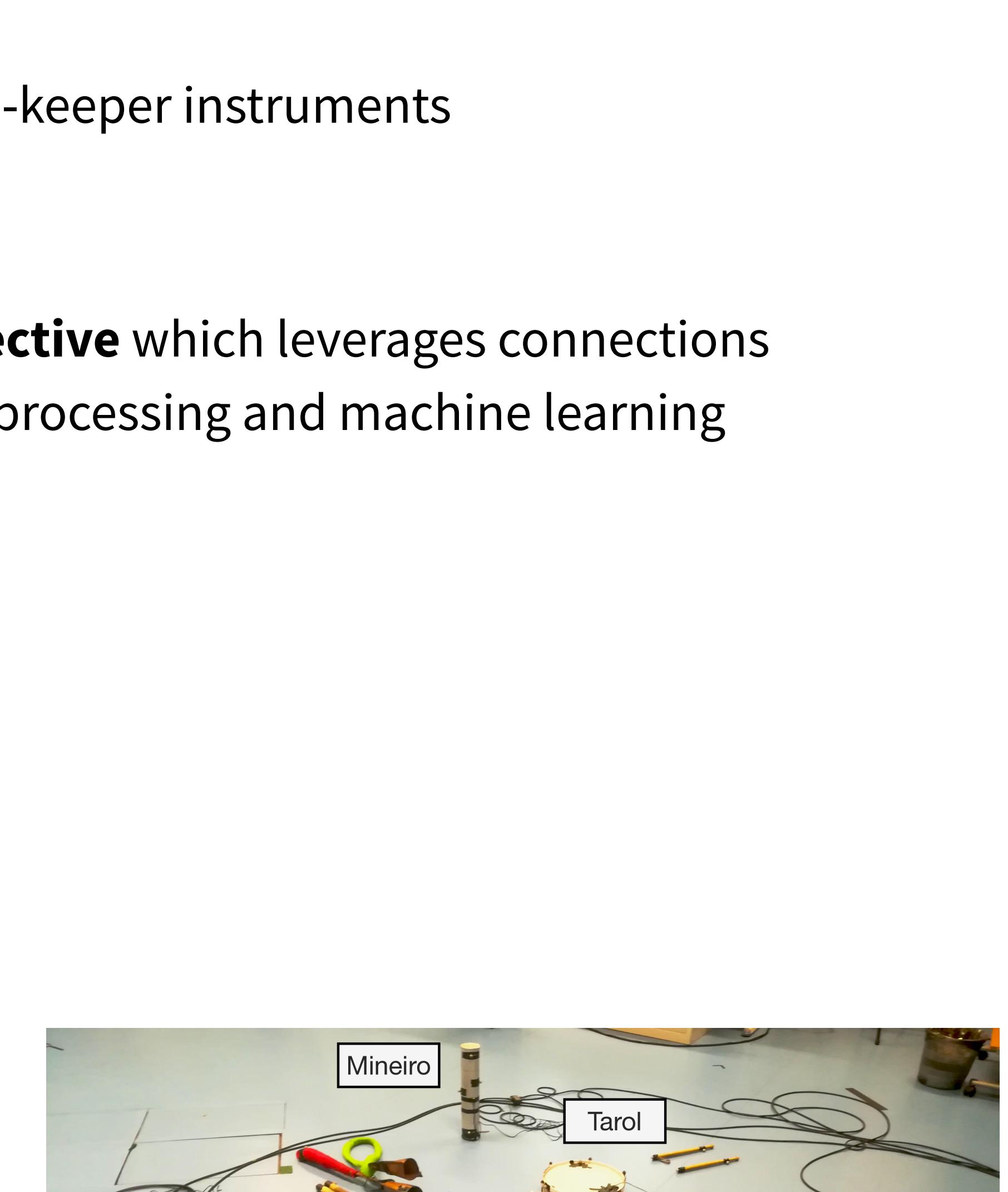
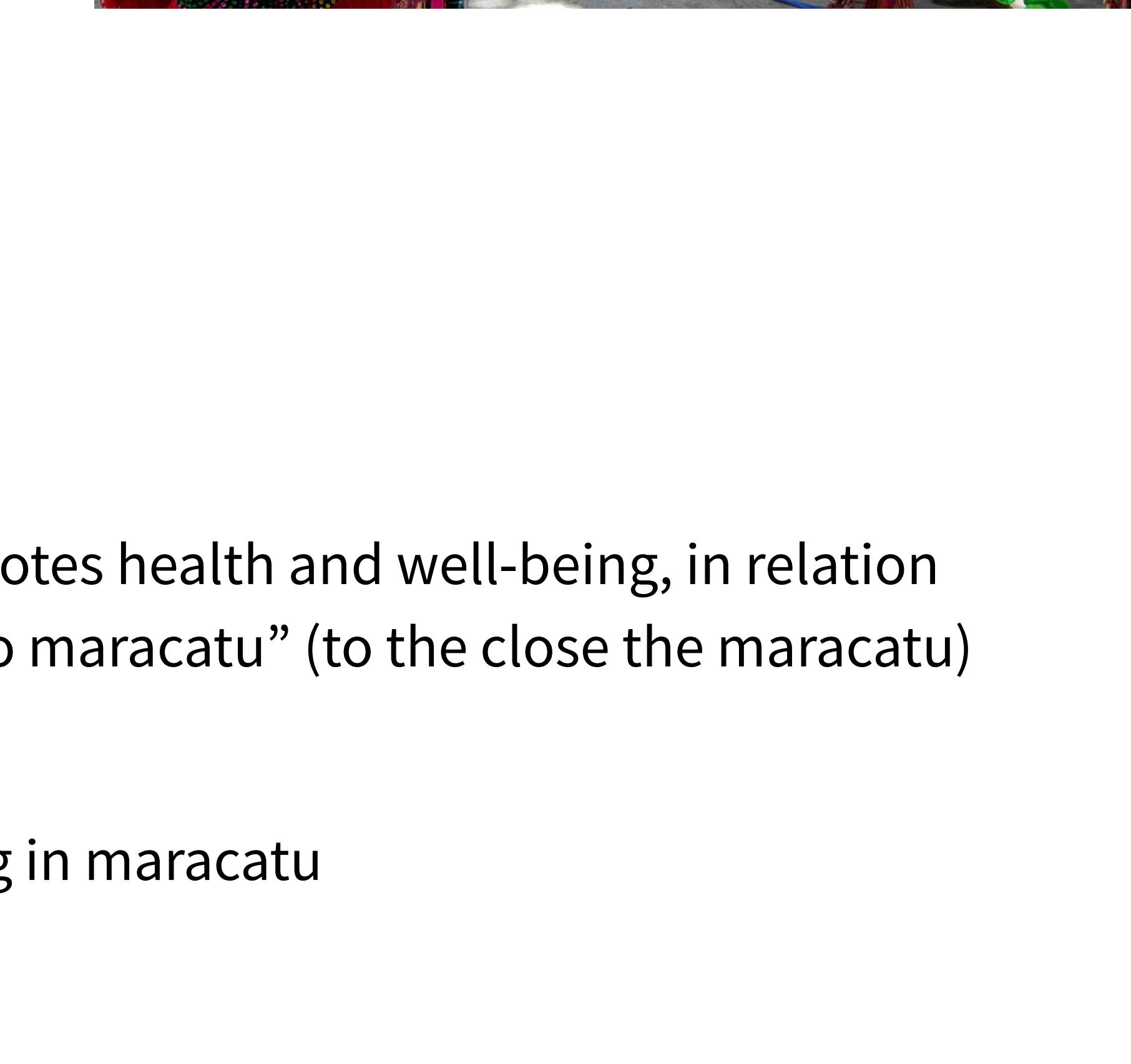
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## Maracatu de Baque Solto

- Carnival practice in rural Pernambuco in North Eastern Brazil
- Performances comprise short alternating periods of improvised poetry followed by music and dancing
- Performances can last several hours
- Musicians play as loud and fast as possible and in close proximity
- Maracatu de Baque Solto is a very localised musical practice that has not been widely studied
- Our work is part of the multidisciplinary project: “HELP-MD: The Healing and Emotional Power of Music and Dance” <https://www.help-md.eu>

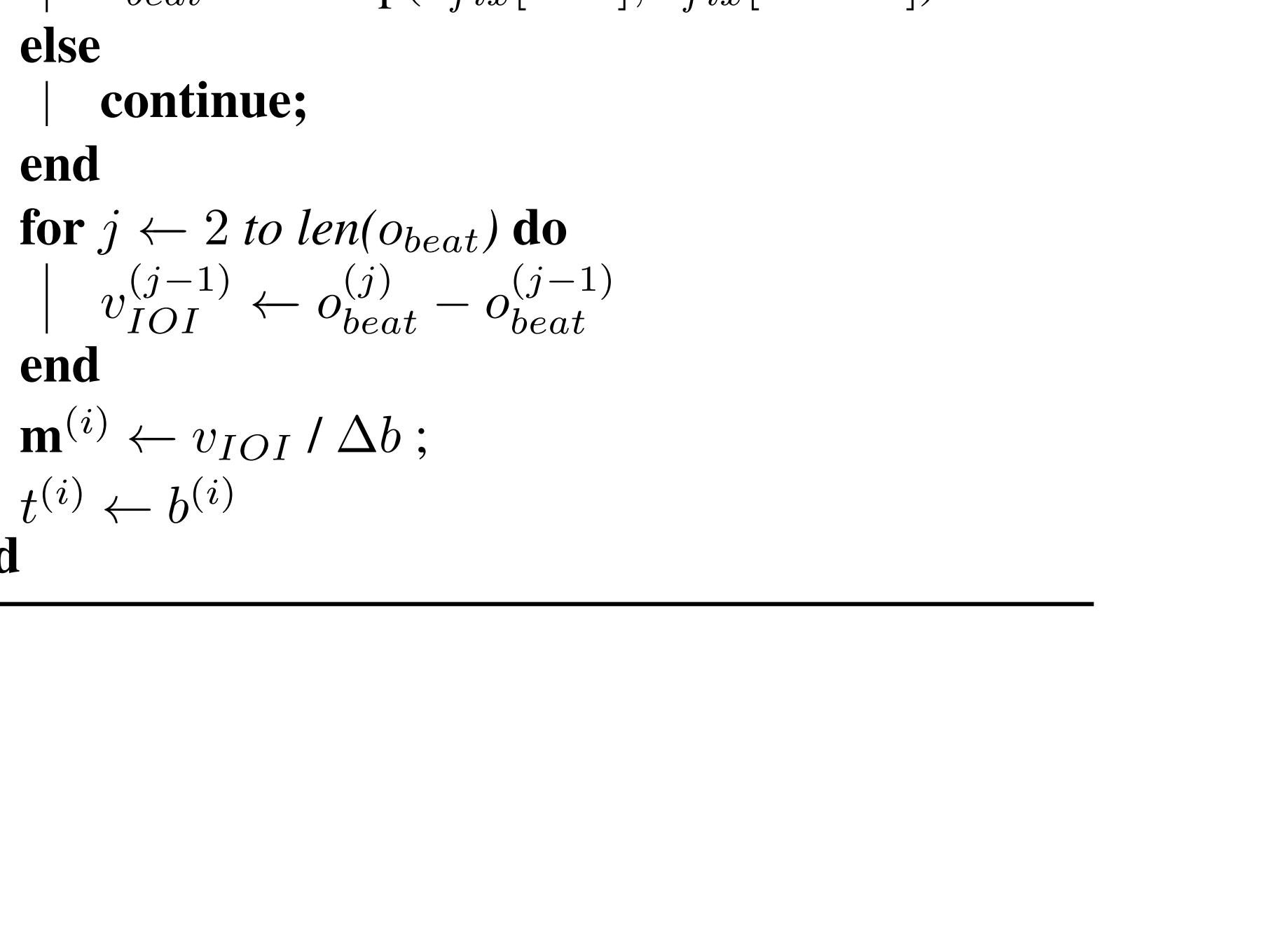
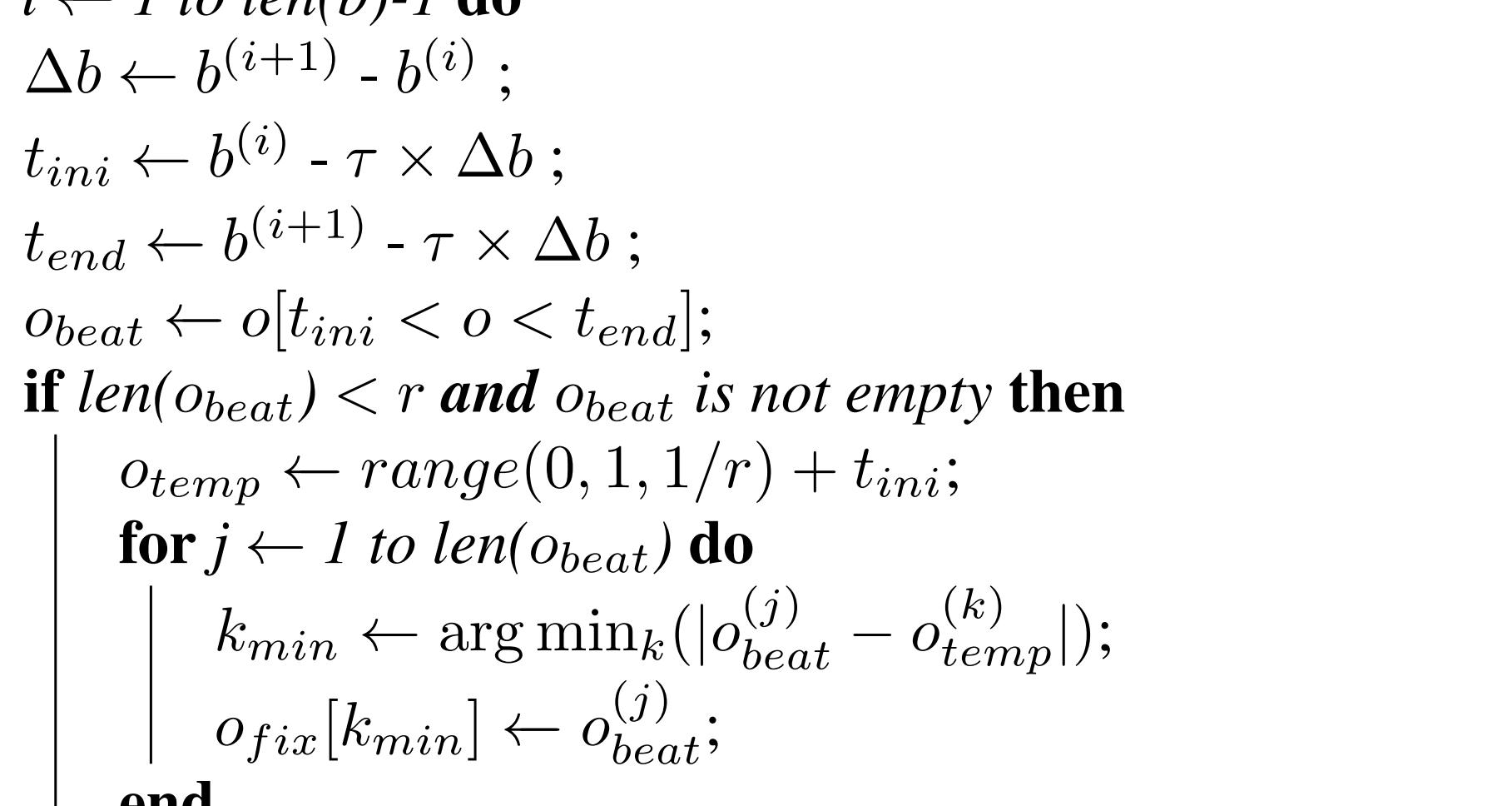


## Motivation and Objectives

- **Longer term:** Understand how maracatu performance promotes health and well-being, in relation to the concepts of “consonânciam” (consonance) and “fechar o maracatu” (to close the maracatu)
- **Shorter term:** Study the presence and nature of microtiming in maracatu
  - Devise a methodology for isolated signal acquisition
  - Manually annotate the onset and beat structure
  - Estimate continuous microtiming profiles relative to time-keeper instruments
- Conduct the work from a **strongly multidisciplinary perspective** which leverages connections between ethnomusicology, audio engineering, music signal processing and machine learning

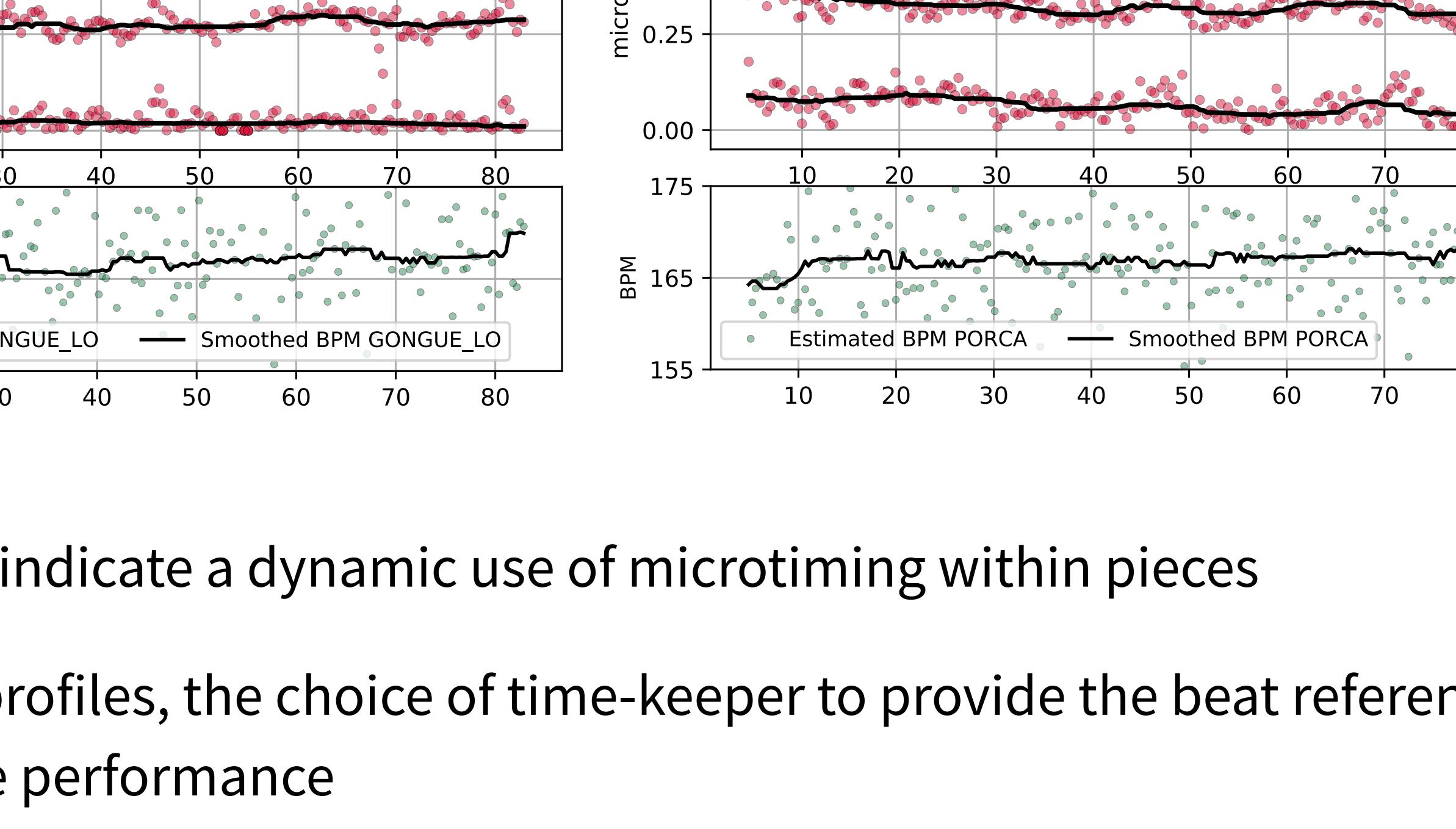
## Signal Acquisition with Contact Microphones

- Focus on the analysis of the “terno”
- Contact microphones were attached in an unobtrusive manner on each of the five instruments
- 1x Mineiro, Tarol, Porca
- 2x Gongué and Bombo
- Multi-track recordings acquired at an outdoor, fixed location maracatu performance in Lisbon, Dec. 2019
- Additional recordings taken in the Motion Capture Laboratory (FMH, Univ. Lisbon) for multimodal analysis of music and dance



## Onset Annotation

- 34 pieces in the concert, totalling 22 minutes
- For 7 mics, this gives 238 excerpts to annotate
- We focus on two (potential) time-keepers: **porca & gongué low** and two more expressive instruments: **tarol & bombo high**
- We used a semi-automatic process with *instrument-specific* neural networks for onset detection and subsequent manual correction
- Approximately 45,000 annotated onsets
- Often more than 20 onsets per second of the mixture



## Microtiming Analysis

- Inspired by the existing approach of (Fuentes et al, ISMIR 2019), we developed an algorithm that we feed onset times and beats
- We can perform “within-instrument” and “between-instrument” analysis
- Estimate a normalised microtiming profile per sub-division of the beat
- Look for systematic, i.e. intentional, deviations from quantised metrical positions according to Western music notation

### Algorithm 1: Microtiming modelling

```
Input:  $b, o, \tau, r$ 
Output:  $m, t$ 
for  $i \leftarrow 1$  to  $\text{len}(b)-1$  do
     $\Delta b \leftarrow b^{(i+1)} - b^{(i)}$ ;
     $t_{ini} \leftarrow b^{(i)} - \tau \times \Delta b$ ;
     $t_{end} \leftarrow b^{(i+1)} - \tau \times \Delta b$ ;
     $o_{beat} \leftarrow o|t_{ini} < o < t_{end}|$ ;
    if  $\text{len}(o_{beat}) < r$  and  $o_{beat}$  is not empty then
         $o_{temp} \leftarrow \text{range}(0, 1, 1/r) + t_{ini}$ ;
        for  $j \leftarrow 1$  to  $\text{len}(o_{beat})$  do
             $k_{min} \leftarrow \arg \min_k (|o_{beat}^{(j)} - o_{temp}^{(k)}|)$ ;
             $o_{fix}[k_{min}] \leftarrow o_{beat}^{(j)}$ ;
        end
         $o_{beat} \leftarrow \text{interp}(o_{fix}[\text{nan}], o_{fix}[\sim \text{nan}])$ 
    else
        | continue;
    end
    for  $j \leftarrow 2$  to  $\text{len}(o_{beat})$  do
         $v_{IOT}^{(j-1)} \leftarrow o_{beat}^{(j)} - o_{beat}^{(j-1)}$ 
    end
     $m^{(i)} \leftarrow v_{IOT} / \Delta b$ ;
     $t^{(i)} \leftarrow b^{(i)}$ 
end
```

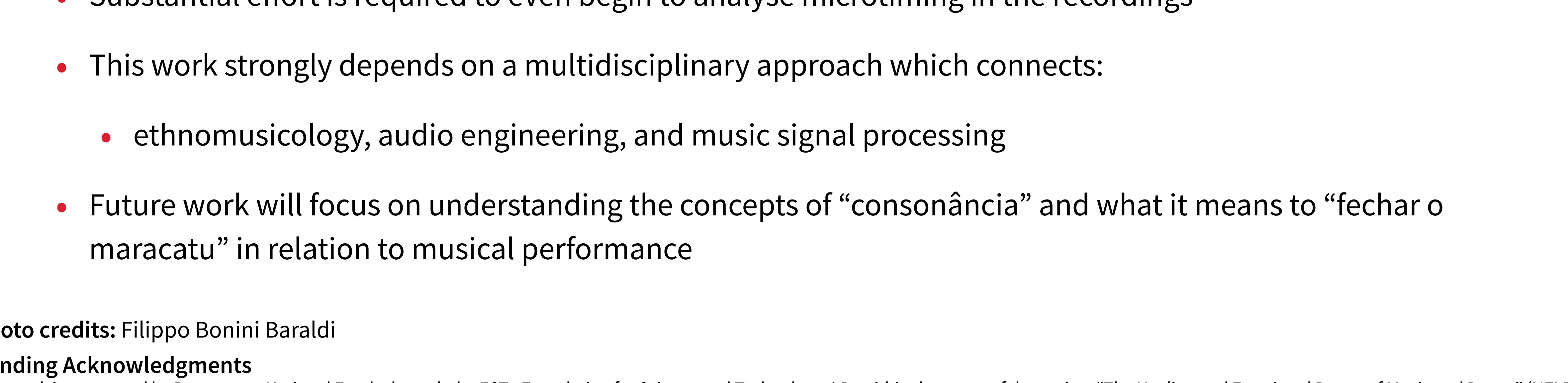


Photo credits: Filippo Bonini Baraldi

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## Conclusions

- First computational study of Maracatu de Baque Solto which suggests a dynamic use of microtiming
- Substantial effort is required to even begin to analyse microtiming in the recordings
- This work strongly depends on a multidisciplinary approach which connects:

- ethnomusicology, audio engineering, and music signal processing

- Future work will focus on understanding the concepts of “consonânciam” and what it means to “fechar o maracatu” in relation to musical performance