

Automatic Tempo-based Classification of Argentine Tango Music

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Abstract

Tempo-based classification is a popular technique to classify music, with applications in media-art projects, systematic study of music etc. The success of this technique using dance music genres has typically been found to be over 70%, yet it was mostly evaluated using standardized music genres, such as ballroom music. Argentine tango is a music genre, originating in Buenos Aires at the end of the 19th century, which has gained a lot of popularity since its creation and is currently being danced in social settings all over the world (see side Photo taken in San Francisco, courtesy of Ref. [10]). There are three music types which define the Argentine tango played in social settings; although these types have different *meters* from one another, their *tempi* feature variations influenced by the trends of the era of composition and the composers' personal style. Therefore, Argentine tango seemingly makes a good, yet interesting candidate to explore for tempo-based classification schemes.

In this report, we construct and evaluate an automatic, bayes tempo classifier with application to Argentine tango music, using a library with more than 2,000 pieces. We find that the accuracy of our classifier stands at 79%, which is well within the bound set by similar schemes applied to ballroom music, proving our original point that tempo is a promising feature in the classification of Argentine tango. We also come up with interesting insights about how to improve classification schemes for this particular musical genre.



Introduction

Tempo-based classification is a popular method to classify a collection of music, as can be shown by the proliferation of music classifying tools [References 5 and 6], which has been particularly successful in the classification of dancing music. The reason why this method has been particularly successful with dancing music is because dancing music typically features a tight tempo distribution, and different dancing genres have distinct tempi, making it a "clear" choice for the classifier to guess the right genre based on tempo. Yet the accuracy of approaches using tempo alone cannot typically exceed 80% (see References [1] and [3]). In order to achieve higher accuracy, typically other musical features (e.g. melody, pitch etc) need

to be used in filters [Reference 4]. At any case with or without complex filters, automatic music classification is a very useful technique for incorporating into media-art projects and systematic study of music.

Unfortunately, tempo-based classification has mostly been applied to Ballroom dancing music. Argentine tango is a dancing musical genre with origins in Buenos Aires at the end of the 19th century, which quickly spread over the world and is currently danced socially in many places all over the world. Argentine tango is completely distinct compared to its Ballroom peer, both in terms of its tempo distribution and its feeling. What is more, the music which is played in social settings consists of three types, the *tango*, the *milonga* and the *vals*. Yet although the meter corresponding to each type (4/4, 2/4 and 3/4 in respect) is applied uniformly, the tempi tend to be influenced by trends at the decade of composition and tastes of the composers. Because Argentine tango has been overlooked by previous works on dancing music, and because of its wide popularity and interesting characteristics, in this work we focus on the study of this particular genre.

Our main contribution with this report is the creation and evaluation of an automatic bayes classifier for Argentine tango music, which we construct using a library with over 2,000 full (not sample) tango pieces. Besides, we are able to prove our original point that tempo-based classification is successful with Argentine tango music, based on the fact that our classifier has an accuracy of 79%, comparing well with similar approaches used with Ballroom music. Yet, our analysis suggests that more features will need to be used in order to improve further a classifier's accuracy. The rest of this report is structured as follows: in the section "Related Work", we present the tools and techniques related to our work, in the section "Methodology" we describe our experimental methodology, including the details of the bayes filter and our library, in the section "Results and Discussion" we present our results and some discussion, whereas in the section "Conclusion" we conclude this report.

Related work

Automatic music classification has been a topic of broad research interest. It can be roughly characterized based on the level of the features used, i.e. *low-level*, such as tempo, or *high-level*, such as timbre, melody, instrumentation etc. Although low-level features are easy to extract using a beat-extracting tool, and extremely useful for automatic characterization of music, the level of accuracy of low-level classifiers typically gets saturated below 80%. Techniques using more complex rhythmic patterns, as an alternative to the strong-beat tempo, have been used in order to improve a classifiers' accuracy. One such technique, for example, uses periodicity patterns to classify ballroom music, and achieves accuracy of up to ~80% (see References [2] and [3]). High-level features on the other hand, are harder to extract and process, yet they can improve the accuracy of the prediction significantly, and especially when used in combination with low-level features (as in Reference [4]). In our work, since according to our knowledge this is the first work to explore the genre of traditional Argentine tango, and since the scope of this report is limited, we only experiment with tempo as a feature.

Various tools have been created to assist with the extraction of both low and high level features (as in References [5] and [6]). Most tools offer a graphical interface to communicate the dynamic variation of the extracted features. Because we focus on tempo-based classification, we choose a tool which has been widely used for projects requiring tempo extraction, called Beatroot (see Reference [5]). Besides a graphical interface, Beatroot also provides with a batch

processing mode, which is useful for the massive tempo extraction over our large library, which is required in our experiments.

Methodology

Our methodology consists of the following steps:

1) Database preparation:

First of all, all pieces in our library are labeled according to their genre. Had this not been the case, we will have had to apply the labels manually. Second, we transform the format of the pieces in the library (mp3) into a format which is readable by Beatroot, e.g. wav. For this operation, we use a format converting tool which is part of iTunes.

2) Tempo extraction using Beatroot:

In the batch processing mode, Beatroot spits the interarrival beats of all strong beats that it can detect into a text file. We run all pieces in our database through Beatroot to get a text file for each song. Then, for each piece, we calculate its average beat using the text file.

3) Creation of the tempo distribution for each genre:

We calculate the tempo distributions for each of the tango, milonga and vals types, by calculating both the average tempi and the variations. The results of this step are summarized in Table 1:

Table 1: Tempo Distributions for the Three Tango Types.

Tango Music Type	Average Tempo [BPM]	Variation [BPM ²]
Tango	Detected: 125/ Actual: 63	108
Milonga	129	1016
Vals	142	1192

Note that tango has a detected average tempo of 125 BPM (Beats Per Minute). Yet, its actual average tempo is half the detected one, i.e. 63 BPM. This is because Beatroot detects all strong beats in a meter, and because in the case of tango, each meter has two strong beats, one on the first beat of the meter and one on the third one. Another interesting observation which we can make from this table is that tango has a very tight tempo distribution, i.e. the variation is only 108 BPM², while both Milonga and Vals have a 10x wider distribution, their variations being 1016 and 1192 BPM² in respect.

4) Construction of the naive bayes classifier:

The posterior probabilities according to the bayes formula for the three tango music types can be expressed as:

- $P(\text{tango} \mid \text{tempo}) = P(\text{tango}) * P(\text{tempo} \mid \text{tango}) / \text{Evidence}$
- $P(\text{milonga} \mid \text{tempo}) = P(\text{milonga}) * P(\text{tempo} \mid \text{milonga}) / \text{Evidence}$
- $P(\text{vals} \mid \text{tempo}) = P(\text{vals}) * P(\text{tempo} \mid \text{vals}) / \text{Evidence}$

where:

- $P(\text{tango})$, $P(\text{milonga})$ and $P(\text{vals})$ are the prior probabilities, based on the number of pieces belonging to a type over the total number of pieces in the library

and where:

- $P(\text{tempo} \mid \text{tango})$, $P(\text{tempo} \mid \text{milonga})$ and $P(\text{tempo} \mid \text{vals})$ are the likelihood probabilities, which are calculated using the tempo distributions

and where:

$$- \text{Evidence} = P(\text{tango}) * P(\text{tempo} \mid \text{tango}) + P(\text{milonga}) * P(\text{tempo} \mid \text{milonga}) + P(\text{vals}) * P(\text{tempo} \mid \text{vals})$$

5) Evaluate accuracy of classifier

In order to evaluate the accuracy of the classifier, we run the whole library through the classifier, and evaluate the classifier's prediction. The number of successes constitutes the accuracy of our classifier.

Results and Discussion

The details of our evaluation are summarized in Table 2 below:

Table 2: Classifier Accuracy per Type.

Tango Music Type	N of samples	Likelihood Probabilities	Classifier Success
Tango	1,797	0.76	93.6%
Milonga	255	0.11	7.5%
Vals	306	0.13	49.8%
	Total: 2,358		Weighted Average: 79% Simple Average: 50%

Our results indicate that tango is the most successfully predicted type with 93.6% accuracy, followed by vals with 49.8% accuracy, and milonga with 7.5% accuracy. Interestingly, the accuracy of our simulator diverged significantly across the three types. There are several reasons how to explain this. First of all, tango has a much higher probability of likelihood, and a much tighter tempo distribution compared to the other two types. These facts obviously gave a lot of confidence to the classifier regarding tango. Milonga on the other hand, has a very low likelihood probability and a 10x greater variance compared to tango. These facts alone reduce the confidence of the classifier regarding the detection of milonga. To make matters worse, the actual milonga tempo is very close to the detected tango tempo (129 BPM vs. 125 BPM), which combined with the high confidence of the classifier in regards to tango, lead to the very high missprediction rate for milonga. Lastly, the classifier's accuracy for vals is 49.8%. This is because vals has quite a distinct tempo compared to milonga and tango, therefore it is possible for the classifier to make more confident predictions regarding vals compared to milonga, yet the accuracy is only modest because of its low likelihood probability and fairly large variance.

A straightforward solution in order to improve the accuracy of the simulator is to adjust Beatroot such that it detects the beat corresponding to the tempo, instead of any strong beat within the meter. One way to do so is by adding hints from the melody, for example a melodic phrase typically starts at the beginning of the meter and finishes at its end, and so the classifier could mark these beginning and end points in order to try to figure out the tempo. Using such hints, the prediction accuracy of all types would improve.

Another idea which can be used in order to improve the classifier's accuracy is to include features related to the era of composition. Most Argentine tango pieces were composed in between the late 1910's and 1960's, where the pieces composed at earlier decades, and specifically the pieces of milonga and vals types, have a slower tempo compared to the ones composed in the later decades. We could therefore create various filters based on the tempo distributions per decade.

Yet Argentine tango music is mostly influenced perhaps by specific composers' tastes. Although most composers who created what we perceive as classical Argentine tango music followed specific rules, such as the same meter, mostly similar tempo and similar dramatic, each of them incorporated their personal influences into their work. For example, Biagi's compositions are influenced by his affinity to jazz, which resulted in the tempo not always falling exactly on the beat (Reference [7]). D'Arienzo compositions, on the other hand, fall precisely on the beat (he was called the "King of Beat"), and his compositions are complexly orchestrated (Reference [8]). For a finer grain classification therefore, we could use musical features specific to composers.

Conclusion

In this report, we proved our initial intuition that tempo-based classification is a promising technique for the classification of the unexplored yet very popular Argentine tango music. Yet, because the composition of this music evolved significantly over the decades and across various composers, we observed that there is generally a lot more room to improve the accuracy of classification.

References

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- [9]: Argentine tango reference: http://en.wikipedia.org/wiki/Argentine_tango
- [10]: Photo courtesy of Evelyn Lu. Website: <http://luluaperture.smugmug.com/>