Automated Region-of-Origin Classification of Traditional Music from Peninsular Spain

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Abstract

Music Information Retrieval (MIR) is a popular field of research that attempts to automate the extraction of musical features from pieces of music. However, these techniques are usually applied to contemporary and classical music, and there is a substantial lack of research in the area of traditional music. To find if traditional music can be classified in similar ways that contemporary music is, traditional music from peninsular Spain was studied. Spain was divided into a series of regions corresponding to different musical traditions. A dataset of traditional music from peninsular Spain was built, that represented these different musical traditions. A Convolutional Neural Network was trained to attempt to classify the data depending on its region of origin. The achieved accuracy (51.4%) was not as high as state-of-the-art Music Genre Classifiers, but shows that there is potential to further develop this research.

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1. Introduction

In recent years, interest in the field of Music Information Retrieval (MIR) has grown significantly, particularly in the field of Music Genre Classification (MCR) (Doraisamy et al. 2008, Ramírez et al. 2019). Research utilising Convolutional Neural Networks (CNN) has been found to be effective at performing this task. However, these studies often focus on contemporary musical genres and classical music, and traditional music is entirely absent from relevant datasets such as the GTZAN dataset (Tzanetakis, 2002).

This project attempts to carry out some initial research in the field of automated classification of audio recordings of traditional music, and to research the challenges that this field presents. Due to the incredibly wide scope of this problem, this project focuses specifically on traditional music from peninsular Spain. Further research should be carried out with traditional music from other parts of the world, as each region of the world will present its own challenges.

Traditional music is strictly tied to culture and geography since each part of the world has its own styles of musical tradition. Therefore, it makes sense to classify traditional music according to place of origin, rather than genre, as the latter is a modern construct that mostly serves a marketing purpose.

The goal of this project is to train an Artificial Intelligence (AI) to the effect that, given a piece of traditional music from peninsular Spain, it can infer its region of origin. Despite the diversity of traditional music across peninsular Spain, cultural distinctions are inherently ambiguous, and there is an inevitable amount of cultural overlap between neighbouring regions. This makes it difficult to reliably distinguish pieces of music from neighbouring regions, for both humans and machines. This is the very root of the problem that this project tries to solve.

It is important to define what this project understands by traditional music. This project explores pieces transmitted through oral tradition that originate in between the 15th and 19th century. This style of music was usually performed by lower-class people from rural communities as a part of everyday life or seasonal festivities. Working with this kind of music can present difficulties, because these traditions have been mutated and distorted throughout the years (Navarro Cáceres, 2018). Furthermore, traditional music is not reliably written down in score, unlike classical or modern music.

Throughout the 19th and 20th centuries, efforts such as the IMF-CSIC collection of Spanish traditional music (Ros-Fábregas, 2013) attempted to compile pieces of Spanish musical tradition in written form. These manuscripts are known as cancioneros (Navarro Cáceres, 2018). However, my project focuses on the classification of audio recordings. Therefore, the data utilised for it corresponds to commercial recordings of traditional music, which are, in most cases, recorded and released between the second half of the 20th century and present day.

This project does not explore the following: Spanish classical music, clerical and religious music such as Gregorian Chant, Singer-Songwriters, Folk-Fusion contemporary artists, Flamenco music, traditional music from other parts of the world, including but not limited to Portugal, France, Gibraltar and the 2 autonomous cities (Ceuta and Melilla) and 2 archipelagos (Balearic and Canary Islands) that belong to the Spanish state.

The research stages are defined by the challenges presented in the project's goal.

Firstly, the machine learning process requires a series of labels to be defined such that they correspond to regions. The divisions between these regions should not be arbitrary and should

roughly correspond to the different musical traditions in peninsular Spain. Research is necessary to ensure this.

Secondly, the AI requires a dataset that provides training data. This dataset should be large enough to be able to represent the diversity of Spanish folklore, whilst also allowing the Neural Network to find patterns corresponding to each region. If no dataset is found, a custom one should be built.

Thirdly, this data needs to be processed and a model developed that is suitable to the project's goals. Research is required to discover appropriate techniques.

This research did not fully achieve its main goal, as the developed AI does not have very high accuracy. However, these results were very promising, and show that it is likely that such an AI can be developed with further research.

2. Background

The aim of this project is to develop an AI that can classify traditional music from peninsular Spain, through the association of previously unseen pieces of traditional music with a geographical area of the peninsula. The cultural context of Spain should be considered to accurately define labels useful for the AI. Existing research on the topic of automated music classification and traditional music should also be analysed, in order to extract conclusions on which approach is most appropriate for this project.

2.1: Spanish Cultural Context

There are several properties that are useful to delimit peninsular Spain into a set of cultural regions. This delimitation must consider different styles of traditional music, instrumentation and spoken language, which are essential traits in defining the geographical borders of these musical cultures.

2.1.1: Administrative division of Spain

The Spanish state is divided into 16 Autonomous Communities, 1 Statutory Community and 2 Autonomous cities, as established in the Ley Orgánica 9/1992 (Jefatura del Estado, 1992). Out of these, only 14 Autonomous Communities and 1 Statutory Community form part of the peninsula and are consequently relevant to this study. These territories are further subdivided into 47 provinces.

There exists a correlation between the variation of musical forms seen in peninsular Spain and its administrative division (see section 2.1.2). However, this correlation is not complete. For instance, Navarra is linguistically divided into a Bascophone region, a non-Bascophone region and a mixed region (Presidencia del Gobierno de Navarra, 1986). Similarly, Basque musical folklore is strongly related to the musical folklore of the Bascophone areas of Navarra. Conversely, the non-Bascophone areas of Navarra are home to similar musical traditions to those of its eastern neighbouring region, Aragón (Gembero-Ustárroz, 2016). Like Navarra, regions in Spain such as Valencia, Asturias, etc. have strongly linked musical traditions with their neighbours.

This division was established in the late 20th century (Jefatura del Estado, 1992). The analysed music predates these divisions, in some cases predates Spain itself. The history of the shifting political divisions of the Iberian Peninsula illustrates the volatile nature of these borders. As such, these borders do not give due consideration to culture, making it necessary to study the musical cultures themselves.

2.1.2 Musical tradition of Spain

The most common form of traditional Spanish music is the jota (Barreiro, 2000). It is a style of music originating in the 18th and 19th centuries, usually sung by one person and accompanied by a dance. It is found across most regions of north and central Spain. It is usually in 3/4 meter (Barreiro, 2000). There is a large regional diversity in the style and instrumentation used in the Jota.

This way, the Jota del Ebro, the style of Jota most common in the regions of Aragón, La Rioja and Spanish-speaking Navarra, is often slower than jotas from other parts of Spain (Barreiro, 2000). Jotas of the northwest of the peninsula utilise bagpipes, tambourines and pandeiros (Donostia, 1947). The Jota Montañesa, found in Cantabria, utilises a wind instrument called the pitu montañés.

The Muiñeira is another musical tradition associated with a dance. It originated in the 16th century, and can be only found in the north-west of the peninsula: namely Galicia, Asturias and León. It is almost always instrumental, with the bagpipe as its main instrument, and a wide array of percussion instruments to accompany it. It is always in 6/8 meter.

The north-west of Spain is mostly known for the use of the bagpipe, with musical traditions such as the Alalá (a sung piece usually accompanied by bagpipe and hurdy gurdy) (Portables, 2015, Donostia, 1947) and the Alborada (instrumental bagpipe pieces in 2/4). Not all Galician folk music has bagpipes since there is also a long-lasting tradition of female performers singing alone or accompanied only by pandeiretas (tambourines). The lyrics of these pieces, if they have any, are usually in the Galician language or in the Astur-Leonese dialect.

Moving further along the northern coastline, styles like the Tonada can be found. It is a style, not intended for dance, usually sung A Capella or accompanied by harps, and can be found in Asturias and Cantabria. (Barros, 1964) The Cantabrian version of Tonada is also known as the Tonada Montañesa.

The Basque Country (Euskal Herria in Basque) features several unique instruments: the txistu (a flute with three holes) (Donostia, 1947) and the trikitixa (a diatonic accordion) being the most famous examples. They also use instruments such as the Txulubita or the Albogue (Donostia, 1947). Traditional music from the Basque Country is usually sung in the Basque language.

On the eastern coast of the peninsula, the Catalan-speaking regions of Catalunya and Valencia are mostly known for the Sardana, a traditional dance. The accompanying music is performed by ensembles known as coblas. Coblas are composed of 11 musicians, who play 12 instruments: a flabiol, a tamboril, two tibles, two tenoras, two trumpets, two trombones, two fiscornios and a double-bass (Colomé, 1989). These pieces are instrumental. Other forms of musical tradition exist in Catalunya, and they are mostly sung in the Catalan language.

Music from central Spain, particularly the north of Castilla, is characterised by the frequent use of the Mi mode and the La mode (Navarro Cáceres, 2018, García Pérez, 2013). The Jota and the Seguidilla are the most common forms of musical tradition throughout central Spain.

Andalusian culture was significantly influenced by Arabic and Romani cultures. Additionally, in Andalucía, Easter is of great cultural importance, thus their musical tradition is often inherently tied to these celebrations. Andalusian music mainly consists of the musical traditions of the Sevillana, the Fandango, the Soleá, the Granaína, the Malagueña and the Saeta, among others. Music from Andalucía is mostly known to use Andalusian cadence. (García Gallardo, 2014)

Sevillanas are a dance in 3/4 accompanied by a vocal performance and a Spanish guitar. The use of palmas (a particular form of clapping) is frequent. They are mostly common in the regions of Huelva, Sevilla, Málaga and Cádiz. Similarly, Fandangos also have ternary meter and are accompanied by guitar.

Saetas are an example of the connection between traditional music and Easter celebrations in Andalucía. They are slow, A Capella songs that accompany Easter processions. (Galiano-Díaz, 2018)

The music of Murcia overlaps with the music of Andalucía and the south of Castilla, and is characterised by the musical forms of the Malagueña and the Seguidilla. Traditional music from Murcia is often performed by ensembles known as cuadrillas de ánimas, that are common in some regions of Andalucía (such as Almería and Granada) and the south of Castilla (such as Albacete).

Similarly, Extremadura also shares musical traditions with both Castilla and Andalucía. The Jota and the Fandango are the most common forms of musical tradition in Extremadura.

2.2 Machine Learning

Little research has been made on the intersection between the fields of Spanish traditional music and Computer Science. Most of this research, such as Calvo-Zaragoza (2018) has been done in the field of Optical Musical Recognition (OMS), partly thanks to the IMF-CSIC collection of Spanish traditional music, a series of more than 25.000 traditional melodies in manuscript. Other research, such as Project HISPAMUS (Iñesta, 2018) used different machine learning techniques to automate the transcription of musical scores written in Spain between the 15th and 19th centuries. Projects such as Navarro Cáceres (2018), have attempted to emulate the sound of traditional music of Spain (in this case, of Castilla-León) through Machine Learning techniques. This research, despite dealing with the intersection between computer science and traditional Spanish music, does not attempt to extract data from audio recordings, or perform any classification.

However, research on automated classification of traditional music has been carried out in other cultures around the world, such as research on Traditional Malay Music (Doraisamy et al. 2008). This paper utilised different feature selection techniques to classify Malay Music into a series of musical genres. It achieved high accuracy of up to 88.6% and concluded that feature selection was crucial to increase this accuracy.

Extensive research has been carried in the field of Automatic Music Genre Classification, such as (Tzanetakis, 2002, Silla, 2008, Ramírez, 2019, Ghildiyal 2020). Although there are many differences between classification according to music genre and according to region of origin, there are certain parallels between the two that can be useful. For example, timbre information can be useful to classify by genre (for example, the saxophone is commonly used on jazz, but not on heavy metal). Likewise, it can be useful to classify by region of origin. In the case of peninsular Spain, instruments like the bagpipe are commonly found in music that originates from Galicia and the North-west of Spain, but not in music that originates in Andalucía and the south of Spain.

Early research in the field pointed to the detection of pitch, rhythm and timbre features, and achieved an accuracy of 63% utilising statistical pattern recognition classifiers (Tzanetakis, 2002). More recent research often utilises Convolutional Neural Networks (CNN), using Spectrograms as input. These experiments have achieved generally good results, usually between 80% and 90% accuracy (Pelchat, 2020, Zhang, 2016). In these experiments, the results are mostly affected by three parameters: the dataset and labels used; the pre-processing carried out on the audio data; and the architecture of the network.

2.3 Approach

A custom dataset will be built for this project due to the lack of pre-existing datasets in this field of study. Out of the different approaches that were considered, ultimately it was decided that Spotipy (Lamere, 2014), which is a Python package that allows to import data from the streaming platform Spotify (Spotify, 2006), was an appropriate tool for the task. Spotipy enables easy access to large amounts of commercial music recordings, through accessing Spotify's web API.

The audio data that Spotipy fetches will be pre-processed and converted into spectrograms. A spectrogram is a 2D representation of sound in the frequency domain, instead of the time domain. Spectrograms reframes an audio recording as a sum of different frequencies, which provides insight into the harmonic and timbral properties of the recording. Spectrograms have been found to be useful when attempting to automate the extraction of these properties from audio recordings (Pelchat, 2020, Zhang, 2016). To create a spectrogram, one must apply a Short-Term Fourier Transform (STFT) to an audio signal.

This data will be used to build a model through supervised learning, which consists of using a fully labelled dataset to build a mathematical model. In contrast, unsupervised learning consists of using a dataset that has no labels, in which case the AI's task consists on cluster detection (Pelchat, 2020, Rajanna, 2015). For this project, supervised learning is the desired technique since the labelling of data according to region is important to this study.

Deep learning will be used to build the model, a machine learning technique that is effective at extracting abstract features from complex datasets. This ability is key in music classification (Rajanna, 2015). Neural Networks (NN) are a type of Deep Learning that attempts to emulate the behaviour of a human brain, by emulating a net of connected neurons that transmit signals to each other. Each neuron performs operations on received input signals sent by other neurons, and outputs the result to other neurons. The weight of these neurons is adjusted throughout the learning process, with the aim to match the output of the overall network with the desired output. Convolutional Neural Networks (CNN) are a type of NN that can process multi-dimensional vectors (Pelchat, 2020). In this case, since multi-dimensional spectrograms will be the input data, CNN is the desired type of NN.

When utilising a NN to build a model, data is commonly split into three sets: the training set, the validation set and the testing set. The training set is used to train the model. The CNN attempts to classify a given spectrogram, and this result is compared to the expected result. The weightings of the network are then recalculated, aspiring to improve accuracy. After the training set has been processed entirely, which is known as an epoch, the network is tested with previously unseen data using the validation set. Finally, once all the epochs are completed, the model is tested with the testing set, at which stage it can be determined whether the model has been trained effectively. Models are described as overfit when the accuracy achieved for the testing set is significantly lower than the accuracy achieved for the training set. Overfitting occurs when the produced mathematical model becomes too specific to the training data.

2.4 Expected results

Following research about both Machine Learning and traditional Spanish music, my prediction is that the AI developed for this project will not achieve an accuracy as high as the average Music Genre Classifier. Firstly, because classification of traditional music is seemingly a more challenging task since there is a high amount of cultural overlap between regions of Spain. Secondly, this is the first piece of research done in this area, and it is unlikely that any definitive results will be reached.

However, promising results are likely to be found. The AI will probably perform very accurately for the CAT, GAL and AND labels, due to their highly distinctive properties. It will perform adequately for regions such as EUS and ARG, but will struggle more with the remaining regions, due to the high overlap between them.

3. Methodology

The implementation was written in Python 3.7.13. Google Collaboratory was used to harness Google's hardware power to run the code. Most of the code was heavily inspired or directly borrowed from TensorFlow tutorials and documentation (TensorFlow, 2022). Necessary changes to the code were made. Additionally, the following libraries were utilised:

- Spotipy (Lamere, 2014), a lightweight Python library for the Spotify Web API. This was used to obtain the data.
- FFmpeg-python, a Python wrapper for the FFmpeg utility (Kroening, 2017). This was used to convert the audio data from *mp3* format to *wav* format.
- TensorFlow, a widely used machine learning platform (Abadi, 2015).

3.1 Definition of labels

One of the first challenges that this project presented was the division of peninsular Spain. Each label should correspond as much as possible to regions specific to certain musical cultures. The currently established administrative borders of the Spanish state, explored in section 2.1.1, were used as a starting point to determine the definition of these labels. However, strictly following these borders would be unjustified, as they do not correlate entirely with the way Spain is divided musically.

Looking at the variation of the musical traditions explored in section 2.1.2, it was concluded that for the purposes of this project, Spain would be split into 9 distinct regions, as seen in figure 1.

AND - Andalucía
ARG - Aragón + Rioja
CNT - Cantabria
CST - Castilla + Madrid
CAT - Catalunya + Valencia
EUS - Basque Country
EXT - Extremadura
GAL - Galicia + Asturies + León
MUR - Murcia
Navarra (ARG / EUS)

Figure 1: Area covered by each label (Created with https://www.mapchart.net)

From now on, the labels will be referred to using the three-letter keys, as in the image above.

There are some important considerations to note about this division. Firstly, the region of Navarra (in green and orange stripes) is the only one whose music is split across different labels, and recordings from Navarra will be split depending on whether they are from the Bascophone (EUS) or Non-Bascophone (ARG) regions. Secondly, the regions of Asturias of Cantabria were difficult to classify, due to Asturias sharing traits with both Galician music (GAL) and Cantabrian music (CNT), despite most Cantabrian music being far removed from Galician music. It is likely that the decision of separating Asturias and Cantabria into different labels will have some impact on the accuracy of the AI. Thirdly, the regions of Murcia and Extemadura were particularly challenging to classify, since little literature was found on the traditional music of these areas. It is unclear whether this will impact the accuracy negatively.

3.2 Construction of Dataset

The next step of the implementation was to find a dataset. Due to the high specificity of the research, a custom dataset had to be created. In this section, the construction process will be described, as well as the properties of the dataset.

In the initial stages of research, it was harder than expected to find digital recordings of Spanish traditional music. This is why I decided to use the *Spotipy* Python package to request tracks from Spotify (as explained in section 2.3). Unfortunately, this also presented a restriction: only commercial recordings are available on Spotify, and most field studies on traditional music are never commercialized. The decision to utilise recordings available in Spotify instead of finding researchers who had recorded pieces of traditional music of around Spain was largely influenced by time constraints.

Available recordings of traditional music from different parts of peninsular Spain were classified into a series of Spotify playlists. Through *Spotipy*, 30 second clips were extracted from each of the songs in these playlists. Unfortunately, the Spotify Web API had a limit of 100 songs per request. As a consequence, several playlists for each label were created, which made the process of organising them significantly more difficult and more time-consuming. The clips provided by the API were in *mp3* format, so *ffmpeg-python* was used to convert them to *wav*, which contained a processable, uncompressed audio waveform.

Many challenges were faced when constructing these datasets. (Pelchat, 2020) found that having an equal number of songs per label increases accuracy, so it was attempted to achieve a similar number of recordings for each region of peninsular Spain. However, some labels such as MUR, EXT and CNT, suffered from relatively low availability of data, which limited the potential of the project. Traditional music from EUS was harder to find than any other region, due to the language barrier: I cannot read Basque. In the end, it was decided 300 recordings for each label would be used in the machine learning process, due to RAM limitations.

To find music for the different labels, different sources were used. Educational compilation albums made during the Francoist dictatorship, a time period during which there was a great interest in promoting traditional music, were valuable despite the political abhorrence tied to them, because of their detailed chronicling of the different musical traditions of Spain. An example of this is *Antología del Folklore Musical de España* (Various Artists, 1949). Other compilation albums tied to specific styles of music, such as *Les Millors Sardanes* (Cobla la Principal de la Bisbal, 1990) for CAT or *Las Sevillanas Más Populares* (Various Artists, 2011) for AND, were also useful. Additionally, the catalogues of specific contemporary artists who dedicated their careers to playing traditional music,

such as Leilía for GAL, were used to complete the dataset. A list of all the albums used as a source of recordings for the dataset is available in the appendices.

A significant delay for the project happened when loading the dataset for the first time, as it was found that *Spotipy* did not have access to a large portion of the recordings on Spotify. I speculate that this might be tied to the availability of these recordings in different countries: not all songs available in Spotify are available everywhere, and requests to the Spotify Web API might be tied to a specific region. This theory is supported by the fact that the missing tracks were usually tied to specific artist or labels. As a consequence, additional research had to be carried out to find pieces of traditional music that *Spotipy* could access.

Another significant delay happened when, after poor initial results, I decided to scrutinise the dataset and subsequentially reconstruct it. Many recordings were found to be mislabelled in the original dataset, an issue that particularly affected the labels of EUS, CAT, CST and AND.

Large amounts of the music initially labelled as EUS belonged to the Basque-speaking region of Iparralde, in France, and was incorrectly added to the dataset. If the project aimed to contemplate this region, these pieces of music could be included, but the scope of the project is limited to peninsular Spain only.

A vast collection of compilations albums released by the famous folk festival Tradicionàrius, held annually in the city of Barcelona, were initially labelled as CAT. However, it was later found that, despite these albums mainly contained traditional music from Catalunya and Valencia, they also contained smaller amounts of international folk outfits that performed in the festival, as well as singer-songwriters. Separating these manually was considered a task that was too labour-intensive to be carried out, so these albums were completely removed.

Chotis music was initially considered for this project, and labelled as CST, due to its ingrained place in Madrid culture. However, after further research, it was found that the Chotis was actually a style of traditional music originating from Bohemia that became popular in many cities across Europe during the 19th century, including the capital of Spain, Madrid. Due to the fact that the genre does not have its roots on Spanish tradition, pieces belonging to it were discarded from the dataset.

A lot of Flamenco music was incorrectly labelled as AND. Nowadays, there is a lot of overlap between Flamenco and traditional music from Andalucía (particularly Fandangos and Soleás), as Flamenco performers are very inspired by and often perform pieces of traditional music, and vice versa. However, Flamenco is not a tradition, but a scenic performance that only virtuosos perform, and it is much more rooted in spectacle than in everyday rituals and festivities. Therefore, it was attempted to remove most Flamenco music from the dataset. Some recordings of traditional pieces performed by Flamenco artists were kept.

The size of the dataset can be seen in figure 2.

Region	Recordings used
AND	300
ARG	300
CNT	300
CST	300
CAT	300
EUS	250
EXT	300
GAL	300
MUR	300

Figure 2: Number of recordings used per label

3.3 Pre-processing and training

The dataset is randomly shuffled, and subsequentially split into a training set, a validation set and a testing set, through an 80/10/10 split. The STFT of every 30 second clip in the dataset is computed, in order to transform them into spectrograms.

To classify the spectrograms into labels, a CNN is trained. This training is carried out by passing the training spectrograms through a series of processing layers, that attempt to extract relevant features. First, the data is resized, to reduce the processing time as well as the RAM use. Then, the data is normalised. The following layers perform 2D convolution and Max Pooling, to down sample the data and highlight the most relevant features.

To reduce overfitting, the dropout technique is used. This technique consists of randomly ignoring the output of certain neurons of the network. After this step, the data is flattened into a 1D array. The next layer is a dense layer, that condenses the data into an array of size 128. After that, the dropout technique is applied again, and another dense layer condenses the data into an array of length equal to the number of labels. In this moment, the CNN has arrived at a conclusion on which label corresponds to the input spectrogram. Depending on the result of the prediction, the model is then updated, to try to improve the results. After each epoch, the accuracy of the model is tested on the validation data.

Following experimentation with different numbers of epochs, it was decided that 9 epochs was an adequate number. Less than 9 epochs would not usually reach the model's full potential, but more than 9 would result in too much overfitting, and the accuracy in the validation and testing data would start to decrease.

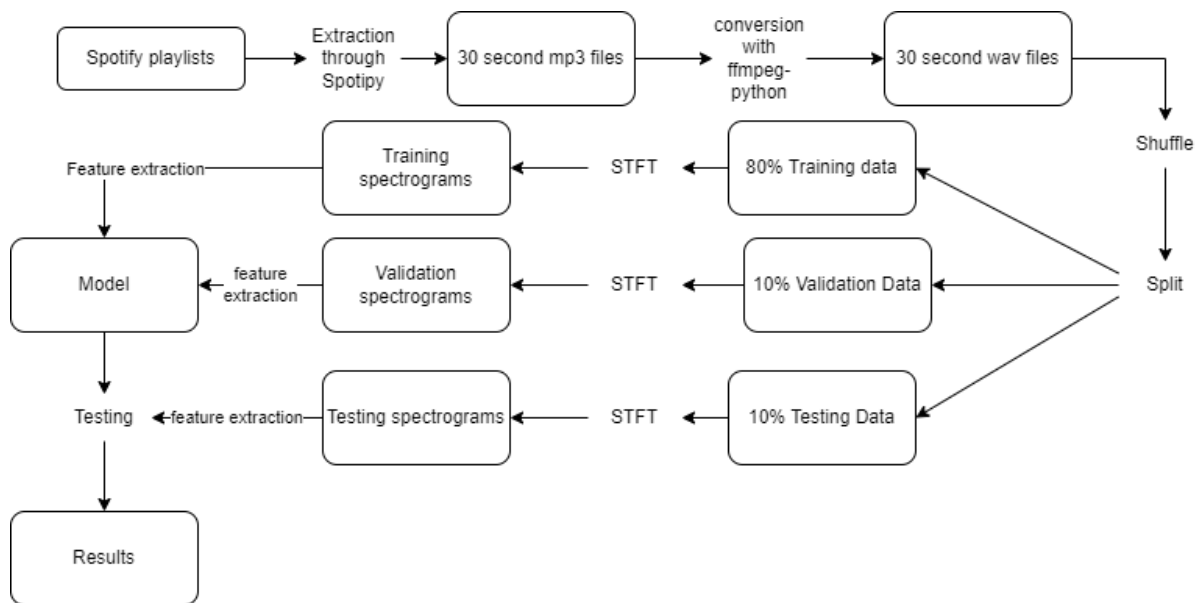A diagram that represents the flow of data can be seen in figure 3.

Figure 3: Data flow diagram

3.4 Experiment Results

Initial experiments were carried out in early stages of the project, with a dataset of 900 songs (100 per label). These experiments achieved low accuracy, so it was decided that a larger dataset was to be used. At this point, I discovered that Google Collab's free program has a limitation of RAM use for each single session. As the size of the dataset increased, the machine learning process required more and more powerful computation, and this limit was eventually reached. It was decided that a dataset size of 2700 struck a nice balance between a large enough size to be representative, and a small enough size to not surpass the limit on RAM use. However, not enough EUS music was found to reach this amount. Experiments carried out on this initial dataset were not fruitful, as the achieved accuracy was lower than expected, with an average accuracy of 38%. A detailed breakdown of the achieved initial results can be seen in figure 4, where the rows signify the real labels and the columns the prediction made by the AI.

		Prediction								
		AND	ARG	CNT	CST	CAT	EUS	EXT	GAL	MUR
Real Label	AND	34.4%	5.2%	10.4%	20.8%	7.3%	9.4%	6.3%	2.1%	4.2%
	ARG	9.5%	20.2%	16.7%	14.3%	3.6%	10.7%	6.0%	13.1%	6.0%
	CNT	4.0%	7.1%	50.5%	5.1%	6.1%	8.1%	4.0%	11.1%	4.0%
	CST	4.5%	4.5%	6.8%	34.1%	13.6%	6.8%	14.8%	10.2%	4.5%
	CAT	4.2%	5.6%	6.9%	23.6%	37.5%	0.0%	13.9%	6.9%	1.4%
	EUS	3.4%	16.9%	20.2%	10.1%	4.5%	22.5%	9.0%	7.9%	5.6%
	EXT	3.2%	8.6%	4.3%	16.1%	8.6%	16.1%	33.3%	6.5%	3.2%
	GAL	1.2%	2.4%	14.5%	2.4%	1.2%	4.8%	8.4%	57.8%	7.2%
	MUR	5.6%	4.7%	9.3%	14.0%	1.9%	1.9%	4.7%	2.8%	55.1%

Figure 4: Confusion matrix of initial experiments

At this stage, it was discovered that a large amount of data in the dataset had been mislabelled. The use of a newly built dataset saw the accuracy increase to up to 54%. In attempting to further increase this accuracy, minor changes were made to the architecture of the Neural Network. These

changes did not have a major impact on the accuracy, but incurred more RAM use, so it was decided to use the original architecture.

The experiment with the newly built dataset was repeated numerous times to gain an accurate insight of the strengths and weaknesses of the developed AI. An average accuracy of 51.4% was achieved. A breakdown of the results is shown in figure 5.

		Prediction								
		AND	ARG	CNT	CST	CAT	EUS	EXT	GAL	MUR
Real Label	AND	51.7%	5.2%	2.8%	11.8%	1.9%	2.8%	10.0%	1.9%	11.8%
	ARG	1.1%	48.9%	13.3%	12.2%	3.2%	1.6%	5.9%	4.3%	9.6%
	CNT	3.6%	14.2%	47.2%	9.1%	5.6%	1.5%	4.1%	10.2%	4.6%
	CST	3.3%	10.3%	8.9%	37.4%	6.5%	3.7%	11.2%	3.7%	15.0%
	CAT	3.2%	4.1%	3.6%	7.7%	74.7%	0.5%	4.5%	0.5%	1.4%
	EUS	4.7%	1.0%	2.6%	10.9%	6.3%	50.5%	9.4%	11.5%	3.1%
	EXT	8.4%	3.0%	3.4%	10.8%	7.9%	2.5%	45.8%	6.4%	11.8%
	GAL	5.1%	9.2%	8.7%	9.2%	4.1%	6.7%	10.8%	40.0%	6.2%
	MUR	7.0%	5.0%	2.0%	5.5%	2.0%	4.5%	7.0%	2.5%	64.5%

Figure 5: Confusion matrix of final experiments

4. Evaluation

The achieved accuracy was slightly lower than expected, but shows a lot of potential for further development, as the developed AI has some understanding of the musical properties of each region of peninsular Spain. This demonstrates the thesis that it is possible to carry out this classification. Overall, results show that music can be correctly classified around 50% of the time. When pieces of music are incorrectly classified, they are often misclassified as music from a neighbouring region.

The AI can correctly classify music from the AND label with an average accuracy of 51.7%. Music from the AND label is most often misclassified as CST (11.8%), EXT (10%) and MUR (11.8%), which are the three labels that AND shares a border with, and three regions whose musical tradition often overlaps with that of AND's (particularly in the case of EXT and MUR). Only 15% of the AI's errors correspond with labels that do not have an overlap with the music of AND. Music from no label is often misclassified as AND. It is safe to affirm that the AI has a satisfying understanding of the musical traditions of AND.

Music from the ARG label can be detected with an average accuracy of 48.9%. Music from the ARG label is often misclassified as CST (12.2%), a label it shares a border and has cultural overlap with, mostly through the Jota. Music from the ARG label is also often misclassified as CNT (13.3%). I have not been able to find a relationship between these two labels, but this relationship is further reinforced by the fact that music from the CNT label is very often misclassified as ARG (14.2%). Overall, the AI can detect music from the CNT with an accuracy of 47.2%, and other than its puzzling link with ARG, mistakes when trying to categorize CNT music are spread relatively evenly. The percentage of songs from the CNT label misclassified as GAL was lower than expected (10.2%), as there is a strong relationship between Cantabrian and Asturian traditional music. This is possibly due to the fact that the GAL label is unevenly balanced and does not contain enough songs from Asturias for the link with the CNT label to be apparent. Further research is required to determine the reason why the AI links the CST and ARG labels, but the results for the ARG and CNT labels are mostly satisfactory.

The CST label is the label with the lowest average accuracy (37.4%). Fortunately, the errors are mostly spread between ARG (10.3%), EXT (11.2%) and MUR (15%), which are three regions that Castilla shares a lot of musical heritage with, such as the Jota and the Seguidilla. However, it is worth noting that CST is not only the label that gets misclassified the most, but also the one that gets erroneously labelled the most. 66% of the data labelled as CST belongs to other labels. This is possibly due to the fact that CST is the label that covers the largest region, and the only one that shares borders with every other label. The low accuracy of the CST is, to a degree, to be expected, but it is likely that it could be increased.

The AI can very reliably detect music from the CAT label. This label holds the highest accuracy, with 74.7%. This is likely to do with the fact the wind instruments used in Catalan traditional music have a very characteristic timbre that is very different to other wind instruments in peninsular Spain. Music from the CAT label is not often mislabelled, and the AI does not show any strong bias towards any of the other labels when incorrectly classifying music from the CAT label. Similarly, none of the regions were often mislabelled as CAT. The AI's understanding of music from the CAT label is excellent.

Music from the EUS label is classified accurately with an accuracy of 50.5%. Errors are spread relatively evenly throughout the rest of the regions, the most common one being GAL (11.5%). These two labels do not share a border, but they share some percussion instruments, such as the tambourine, and both belong to the northern coast of Spain, which has a different style of music than the southern coast. It is worth noting that the EUS label is the one that is given as an answer by the AI the least often, and that the AI has a high precision in this regard: 66.8% of the times a recording gets labelled as EUS are correct. This is almost as high as CAT's precision (68.8%). The AI shows a mostly satisfying understanding of EUS traditional music, but also has vast room for improvement.

Music from the EXT label is detected with an average accuracy of 45.8%. It is often misclassified as MUR (11.8%) and CST (10.8%). Despite the fact that the EXT and MUR labels share no borders, they both share musical traditions with Castilla and Andalucía, and therefore have some overlap. Strangely, music from EXT was only misclassified as AND with a frequency of 8.4%. This is much lower than expected, as they are two regions that have strong cultural links. The AI's understanding of EXT shows vast room for improvement.

Notably, the AI's understanding of the musical tradition of GAL is much lower than expected. Despite the region's use of characteristic instruments that are not found on other parts of Spain, such as the bagpipe or the hurdy-gurdy, the accuracy is 40%. Furthermore, the AI does not seem to detect a relationship between the music of the GAL label and the CST (9.2%) and CNT (8.7%) labels, being more often miscategorised as EXT (10.8%). Further research is required to understand these results. Increasing the accuracy of the GAL label is imperative to improve this AI.

The AI can detect music from the MUR label with ease (64.5%). This was surprising since it has a lot of overlap with music from its neighbouring regions, particularly with Andalucía and Castilla. Music from the MUR label was not commonly misclassified as any specific label. Music from the AND (11.8%), CST (15%) and EXT (11.8%) labels were commonly misclassified as MUR. All of these three labels share musical traditions with Murcia, further reinforcing the idea that the AI has an accurate understanding of music from the MUR label.

Overall, the AI has an average accuracy of 51.4%. It is worth noting that this is the accuracy using the testing set. The average accuracy of the training set is 63.3%, which means that the model is overfitted.

There are many potential sources of errors that could decrease the accuracy of the developed solution. Due to time constraints, not much research was done on the field of Neural Network architectures, and the architecture remains unchanged from the example that the TensorFlow official site provides. Despite the fact that this architecture has proven itself to show promising results, it is highly likely that a better architecture could be design that would greatly increase the accuracy of the NN.

Likewise, there were some variables that were never altered or experimented with. The dataset split (80% training data, 10% validation data, 10% testing data) was chosen as a starting point as suggested by my supervisor, and other splits were not tested. It is likely that a different split could increase the accuracy. Similarly, the 30s long audio clips could be split up into shorter audio clips, which would also impact the accuracy.

There are also limitations on the approach taken to define the labels. The division used is highly subjective and should be subject to further discussion and research. Some areas are much larger than others, which inevitably leads to an unbalance in the amount of available data. Additionally, some areas have a much more diverse folklore than others, and therefore it is more difficult to discover patterns in them. The CST label covers a notoriously larger area than any other label, whereas labels like CNT cover very small areas.

Google collab's limitation on RAM usage greatly limited the implementation of my solution, as it stopped me from using larger datasets.

Using a custom dataset also carries some limitations that might have impacted the result of the experiment. Due to time constraints, I have not been able to thoroughly check the dataset to ensure its rigorousness as much as I hoped. As a consequence, there might be tracks that are incorrectly labelled. Furthermore, many regions suffer from an internal uneven split. For example, most of the music in the GAL label originates from Galicia, and very little of it corresponds to music from Asturias and León. Despite the fact that these three regions have very similar musical traditions, this disequilibrium might have caused problems when trying to detect patterns in the underrepresented regions that comprehend the GAL label. Similar issues occur with the AND, ARG, EUS, CAT and CST labels.

Additionally, the dataset might also suffer from biases due to it being constructed by only one person. I might have unintentionally given too much or too little importance to some musical traditions or areas of Spain, an issue that could be solved by collaborating with other researchers with different views of the subject.

Moreover, the scope of my research is limited, and it is likely that there is a lot of data online that could be used to expand the size this dataset and make it more representative, but that did not emerge in my research. This issue is further reinforced by the existing language barrier mentioned in section 3.2, as most resources that talk about Basque music are in Basque language.

However, the greatest limitations to my dataset come from the use of Spotify as my only source of audio recordings. Traditional music is not a genre particularly known for its commercial recordings, as most performers of this kind of music rely much more on the support from their local community, and do not aspire to have a career in the music industry. As a consequence, there is a relatively low availability of traditional music in commercial sites such as Spotify. Therefore, the dataset constructed for this experiment is not truly representative of traditional music as a whole.

5. Future work

There is a large amount of work that could be done to get better results and to expand the scope of the project. Collaboration and further research on both the construction of the dataset and the machine learning process are some of the key elements that should be considered in the continuation of this project.

Firstly, this is a project that exists in the intersection between music, computer science and Spanish sociocultural studies. Consequently, collaboration is imperative, as musicologists and people with a deep knowledge of Spanish culture could provide invaluable insight to this research. Their input and research would be very valuable to achieve better results, whilst also lending the project more credibility. Input from them is likely to impact the labelling of data, potentially leading to an increase or decrease in the number of labels, or changes in the areas that these labels cover. It would also help to find contributors to the construction of the dataset in general, as I have personal biases and a limited scope of research. Additionally, Basque speakers would help surpass the language barrier mentioned in section 3.2.

It would be very useful for the project to have expert knowledge on the harmonic intricacies of the different traditions of Spanish music, as it could potentially clear up some of the unsolved questions that this project raises. Unfortunately, my knowledge of formal music theory is limited, and researching it was outside the scope of this project.

Research on why the GAL label was so difficult for the machine to distinguish, and on the link between CNT and ARG music should be carried out to understand how to increase the accuracy of the AI.

Secondly, the dataset has a lot of room for improvement. The already existing dataset should be thoroughly checked to ensure that all data is labelled correctly. Additionally, further research should be carried out in order to have a larger, more representative dataset. Internal unbalances in labels that represent more than one style should be corrected.

A new dataset could be constructed utilising various sources, such as Spotify, Youtube and archives of recordings, etc. If resources were available, it would be useful to carry out field studies, and gather some of the recordings personally by contacting associations and collectives that perform and preserve musical tradition throughout peninsular Spain.

As seen in this project, an improved dataset can have a great impact on the accuracy of an AI. Throughout the project, the quality of the dataset has increased greatly, but it is still far from perfect.

Thirdly, further research should be carried out on the field of Machine Learning. As seen in the discussed literature, there are many techniques that can be used to extract features from audio recordings, and many approaches to perform machine learning. More complex pre-processing applied to the spectrograms could highlight the important parts of the spectrogram, leading to a potential increase in accuracy. Some of the reviewed literature utilised considerably shorter audio samples, which could increase the size of the dataset greatly without having to look for more recordings. Different data splits other than 80/10/10 should be considered and experimented on, in order to find if there is a more optimal split.

Additionally, as discussed in section 4, it is highly likely that changes to the architecture of the neural network would also lead to an increase in accuracy. This field was hardly researched in this project

due to time constraints, so this step is the most imperative to enact, and also the most likely to increase the accuracy.

A comparative study using different machine learning techniques and comparing the results should be carried out, to find the optimal solution to this problem.

It is important to remember that, when initially envisioned, the project's initial aim was to build an AI able to classify traditional music from around the world into its country of origin. This idea was too ambitious and had to inevitably be limited to a smaller scope. However, the dataset constructed on this project and the conclusions extracted from the machine learning techniques applied to this dataset are a first step on the completion of such an AI. The incorporation of data from non-peninsular Spain, as well as data from Portugal, the south of France and the north of Africa seem like the next logical steps for the expansion of the scope of this AI.

6. Conclusions

An AI was developed in order to classify the traditional music of peninsular Spain into its region of origin. An average accuracy of 51.4% was achieved. The developed AI exceeds at detecting music from the regions of Catalunya and Murcia and achieves acceptable levels of accuracy for the regions of Andalucía, Cantabria, Extremadura, Andalucía and Aragón. However, the AI fails at detecting music from the regions of Castilla and Galicia. These are promising results that show that, with further research, it is likely that an AI could be developed that can reliably classify traditional Spanish music into its region of origin.

7. Reflection on learning

Working on a final year project was a very formative experience. It allowed me to apply my Computer Science knowledge to fields I am passionate about and motivated me to learn about many topics, as well as incorporating many new skills.

This project was my first immersion in several previously uncharted territories. It was my first attempt at developing an AI, as well as one of my first large-scale computer science projects. I feel like the code I wrote and my solution are not the most sophisticated, but it is a step forward for me. I have learnt a lot about how Neural Networks work. Additionally, despite my pre-existing knowledge in some of the traditions, I now have a much more comprehensive understanding of traditional Spanish Music, after having researched extensively in order to build the datasets.

 Furthermore, I have also learnt things about the scientific method and how to carry out research. One of my biggest mistakes and regrets in this project is that I did not write down the data of almost any of my early experiments, and only considered that it might have been interesting to discuss them in the report when it was too late. It was only in very late stages of the project when my record keeping became organised and efficient. On the future, my record-keeping will be more organised as a result of this experience.

I also found that my methodology is often chaotic, and that it is hard for me to work on projects in a linear manner. I would constantly go back and make changes to the dataset, making my experiment results outdated. This made writing the report a complicated task. Through this project, I have learnt to have a more organised workflow.

Additionally, I made the common mistake of procrastinating. If I had worked as hard as I did on the last two months throughout the whole project, it is likely that the project would have gotten much better results. In the future, I should try to stick to my initial plan and work on schedule.

In summary, my experience completing this project not only taught me about music and AI, but also about my work ethic, the scientific method, record-keeping, and organisational skills.

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Bullonera, La (1980) *Punto* [Streaming] Warner Music Spain. Available at: https://open.spotify.com/album/1TnOI1PrNaKhZ3CIq9kNX4?si=Rk2Pvpr1RoqshyLSGDTFHQ

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https://open.spotify.com/album/6ty4UOfETA8XZplJyuK6Ez?si=PtE_zG5LR52VSdooNw0hAg

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https://open.spotify.com/album/4LdAtdQXvPwOvaNezVsByG?si=cTzRMIuGRqubnl9WDQdFpA

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https://open.spotify.com/album/4kmzMPLCgm27rpz54aolKn?si=sxYc7_vOQt6zjM9fDrSJDQ

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https://open.spotify.com/album/6rO5MLIsFCJP7255v4kUXZ?si=6qMFiVTFSb6vcnb1PywqTA

Díaz, Benito (1991) *El Sarruján de Carmona* [Streaming] SGAE. Available at:
https://open.spotify.com/album/29VXq77tEPVbSAX1mPJZYW?si=NIM76iyMTJqKaMNMggI7yA

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https://open.spotify.com/album/5e4ri336OqCqJEkxhm1vhX?si=PC8590v_QkCp9MIrOyOT1A

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https://open.spotify.com/album/6JVrfwsUhkbCihSPfSYNfA?si=2SwHKx9WS2eOgYpU9UAgPw

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https://open.spotify.com/album/3UZXRCDEzX2pcvWFlDTlw3?si=BO8gPXezSZiFKk0HGzSyDA

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https://open.spotify.com/album/7fiFcBJ72uVfhQyDjiaWCo?si=M0qhqXuoRAC4VRAh9sFDnQ

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https://open.spotify.com/album/1nGJKAakU7qC6P2kzBVRn9?si=sprHdca0TE-Bk0L91-2_Xw

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https://open.spotify.com/album/4kmzMPLCgm27rpz54aolKn?si=sxYc7_vOQt6zjM9fDrSJDQ

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https://open.spotify.com/album/09g9o495xj2HZlWnfs24UY?si=UWk-FFBiRp6iBcFP1qqgGQ

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https://open.spotify.com/album/70h6Kv7cFxJG3uf3P4ZPi9?si=otct5iYZQpeVD00C3U92cA

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https://open.spotify.com/album/5H1vplyxgZsTCChoprnEbg?si=ehKg5azXQNOz1jicXNMDLQ

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https://open.spotify.com/album/7Kk3DPrmlCdBHIPY8vbIdE?si=uiDyit0lTa-VDX1XBH_pEw

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[Streaming] Several records. Available at:
https://open.spotify.com/album/3ZhkKfsUGMK9lEZwcuc1dC?si=i5uR3ENqTcyE1pAWUJMlCQ

Arrabel (2014) *Madrid. Música Tradicional Castellana* [Streaming] Several records. Available at:
https://open.spotify.com/album/07wwQoWAjNQATEbHpWcAMf?si=JHx5aVHFSrO61lE39E3rQg

Candeal (2009) *Ancha es Castilla* [Streaming] Several Records. Available at:
https://open.spotify.com/album/5IJOIlZcgnHlOSeILFePFw?si=pPeP5yC7S4a7ySWklacCQA

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Candeal (1992) *Cancioneros de la Música Tradicional (Vol. 2)* [Streaming] Several records. Available
at: https://open.spotify.com/album/0EVSaIj9gJ0haCrapwRrcV?si=isvBtD3gRGWOS3c_ufH8EA

Candeal (1981) *Coplas del pueblo* [Streaming] Warner Music Spain. Available at:
https://open.spotify.com/album/6PwGXAeadi65JawmHP05UI?si=yBUidUNQRpSAO6hq2GCJsg

Candeal (1994) *La Picaresca de Candeal* [Streaming] Several records. Available at:
https://open.spotify.com/album/58vjjCdO7J3ItLNO3a6N55?si=8NK4bdO6TSOIj5j3plKybg

Clave de Folk (1999) *Castilla / León* [Streaming] Discoloco. Available at:
https://open.spotify.com/album/7nEjPEHj1pMEAJOm1eNWZA?si=eGJOF2ZLTXyz0ShV_FHfsA

Clave de Folk (1999) *Castilla la Mancha* [Streaming] Discoloco. Available at:
https://open.spotify.com/album/575fsQPGC7Tkv7wubj2XAl?si=oiQSu4IcTweRxeWJdeTx4g

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https://open.spotify.com/album/4g4w5bEBQtAr3J1wGZvDK5?si=uDp7SnwUScmCvdntQxOa7w

Grupo de Danzas Castellanas Diego Porcelo (2014) *Cantando las mejores Jotas Castellanas*
[Streaming] Several records. Available at:
https://open.spotify.com/album/6rVDu15h0FEDBpRySj7MvU?si=s9Q231s0QrCFBJiRNJSEXw

Hadit (2016) *Por las Dos Caras. Canciones Tradicionales Castellanas.* [Streaming] Several records.
Available at:
https://open.spotify.com/album/6PQ1UzqEq757zgTCDAinF8?si=nu982o_TRLWObuxka6oJsg

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https://open.spotify.com/album/1OQEl7YfHre8vzkWzeo2AW?si=fa73e1YwSvGPgO5NvAh9tg

Viguela (2016) *Temperamento. Traditional Music from Spain* [Streaming] ARC. Available at:
https://open.spotify.com/album/7hlw3I2DL1JV4uw99h5BtC?si=DYFhhhLFRe-nyNLguC-Wvw

Zagala (2018) *Zagala* [Streaming] RockCD Records. Available at:
https://open.spotify.com/album/1V0QmWu7sToj1LzLm7Ahwo?si=oyiYwoX9T_OOYyJ8UwzFbA

Various Artists (1949) *Antología del Folklore Musical de España* [Streaming] Efen. Available at**:** https://open.spotify.com/album/1f6kIke2oHtLPkRLr99ik8?si=8sW48j5fTRuIl5_ibSJw2w

Various Artists (2015) *España y su folklore* [Streaming] Artyvoz digital. Available at: https://open.spotify.com/album/58InXBl5vbBIA3Vdq2VaY1?si=cIhO6SWuQr-hRneA7ucBPQ

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Agrupació Cultural Folklórica Sagrada Familia (2011) *Folklore de Cataluña. Sardanas, Castellers y Canción Popular Catalana.* [Streaming] Producciones Ar Available at: https://open.spotify.com/album/6lDDEPgFhR4OhHJQvzfRrz?si=4eHdTuedTF-jB2LDBQhy4A

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Bitanya (1993) *Som. Música Tradicional* [Streaming] Picap. Available at: https://open.spotify.com/album/2xI32lqVS7pKXlRTBwrbPa?si=KDel3OmdQdK_roSeZYTOkA

Cobla Barcelona (1967) *Sardanes* [Streaming] Ekipo. Available at: https://open.spotify.com/album/6LmOf9xXm8VkhiVwDQLVmO?si=5JyDy9HyR7SZ4QkqWqoZBQ

Cobla Barcelona, Coll, J. (1957) *Selección de Sardanas, Vol. 1* [Streaming] BNF Collection. Available at: https://open.spotify.com/album/2IU4jqHHjMv8ed9Tr0N6j3?si=JdWtPyZoQLCc3JBddYivMQ

Cobla Caravana (1999) *Sardanes* [Streaming] Discmedi. Available at: https://open.spotify.com/album/7MJ0ut02Je7EpSlAWzWwqj?si=dACy9gaPRZCuUJUuR1NRgQ

Cobla de Sardanes la Moreneta (2014) *Cançó Catalana* [Streaming] Open records. Available at: https://open.spotify.com/album/5xwNPOpQl40sF39igKc7Ef?si=sY1L1Om6SRyPg9w8PECv9g

Cobla de Sardanes la Moreneta, Mar Endins (2014) *Cançons de la Nostra Terra Catalana* [Streaming] Open Records. Available at: https://open.spotify.com/album/5DM7d1lASZUt0s6ftNOfdg?si=sm5HsufSQbSbjhlD2x2iqg

Cobla de Sardanes la Moreneta, (2013) *Cançons Tradicionals de la Terra-Racons de Catalunya* [Streaming] Open Records. Available at: https://open.spotify.com/album/6Wwl3tkz41Ozk5AgjjXXB8?si=MyAbEgYfSrGYY67qecVGZA

Cobla de Sardanes la Moreneta (2013) *Catalunya de Tot Cor* [Streaming] Open Records. Available at: https://open.spotify.com/album/4z3BC9oLfbfu2Z61EtHVY4?si=7EJAIbvBRGSm36JFSiTp1g

Cobla de Sardanes la Moreneta (2014) *La Música del 9n* [Streaming] Open Records. Available at: https://open.spotify.com/album/5TLVubG4H8lXVLVx4TiMju?si=wnJBU8i2R0G6SsNxXcP7nw

Cobla de Sardanes la Moreneta (2014) *Les cançons de la Terra-Catalunya al Cor* [Streaming] Open Records. Available at:
https://open.spotify.com/album/5L1aWORaFiWoy4DzyE2cDn?si=FV2DjQ6EQcaDwOIwHqoAtA

Cobla de Sardanes la Moreneta (2013) *Les Cançons de la Terra-Catalunya Terra Edins Vol. 2* [Streaming] Open records. Available at:
https://open.spotify.com/album/62rGf3OQJywf8EvaeuTkQD?si=iryHkNMUQ0ysof8c6Fgksg

Cobla la Principal de la Bisbal (1990) *Les Millors Sardanes* [Streaming] Divucsa Music. Available at:
https://open.spotify.com/album/1cHKozeY7Jw46fX2T9tqWY?si=TJFqO0QTT_2_2mqpxn76Pg

Cobla la Principal de la Bisbal (2008) *Sardanes. La festa.* [Streaming] K Industria Cultural. Available at:
https://open.spotify.com/album/63pMzo9IWOAEThsP14UO41?si=IFmivfOYRwu_-hnteRQxpw

Formación Folclórica (2011) *Sardanas (Vol. 1)* [Streaming] SGAE. Available at:
https://open.spotify.com/album/7vKcx8GEYxF3HX81hYdmHG?si=mWa_FV1jRb6DC1hRaLGQdw

Grup del Vallés (2009) *Sardanas* [Streaming] Bela Records. Available at:
https://open.spotify.com/album/01TOyVHl629m5qvSXYmlPd?si=LPcW8eVbSWSlNKHEgO_k8Q

Various Artists (2010) *Folk Tradicional dels Països Catalans* [Streaming] Picap. Available at:
https://open.spotify.com/album/2fiFiU1237qvUkopc1S6Ae?si=eLjVJozORfK-7HkFs44MEg

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https://open.spotify.com/album/5OxakrxcObBv1Ib60ci3MM?si=OGZKUyUgQcqjx_K8JGGrSQ

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