



Bilkent University

Department of Computer Engineering

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## CS 464 Introduction to Machine Learning

Building Spotify Playlists Using Machine Learning

# Final Report

### Group 9

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## **1. Introduction**

We were trying to create a recommended playlists with songs that have similar features to a single song or multiple songs, or even an artist chosen by the user. Having said that, we are aimed to create new playlists that satisfy user tastes. While we were trying to achieve this, we utilized some machine learning algorithms and methods. One of these methods was finding the nearest  $N$  neighbours of a song where  $N$  is the desired playlist size. Another algorithm that we used is Random Forest Classifier, in which we get multiple songs from the user with rating them as 10. Then, by using the kNN algorithm as our labels, we tried to classify the songs from rating 1 to 10 and ratings with 10 are added to the playlist. We also tried a method where we get 100 songs from each playlist of the user, rated them as labels, and fed them into a Linear Regression model. We generated different playlists with these methods. The success of the results differed among methods according to our judgement.

## **2. Problem Description**

Discovering new songs according to self taste sometimes is a struggle these days. Therefore, we thought that implementing a playlist generator according to user taste could be beneficial. In order to achieve this, we decided to implement machine learning methods to Spotify's song dataset which consists of audio features of each song. With that, we would have estimations of similar songs to the user taste.

## **3. Methods**

For the project, we used the dataset named "Spotify Dataset 1921-2020, 160k+ Tracks" which is on Kaggle[1]. This dataset includes many different features of songs that are on Spotify. Some of the features represent the mood of a song such as danceability, energy, valence, tempo. These are measures from 0.0 to 1.0 except tempo, which is the BPM (Beat Per Minute) of the song that typically ranges from 50 to 150. Some of the features represent the properties of the sound of a song such as

loudness, speechiness, instrumentalness, and mode. These are also some measures from 0.0 to 1.0 except loudness (it ranges from -60 to 0). And also, there are some contextual features of a song in the dataset, which are acoustic and liveness. In the dataset, there are also some properties that are independent from the audio features of a song which are id of a song, duration of a song, year of a song, and whether it has explicit content or not. However, we removed the independent features except duration and year, since they are not beneficial for our models because they are not related to the audio features. We kept duration and year because user taste could differ in these.

### **3.1. Used Libraries and Tools:**

- We used Spotipy[2] to pull data from Spotify and create playlists on Spotify.
- We used Pandas[3] and NumPy[4] to store and manipulate the data.
- We used Sci-kit Learn[5] for its built-in models for Linear Regression, Random Forest and kNN.
- We used Jupyter Notebook[6] as the development environment.

### **3.2. k-Nearest Neighbour**

This method involves normalizing the feature set and fitting the data into a Nearest Neighbour classifier which finds the nearest N neighbours of the song that is chosen. The algorithm calculates the distances between the samples and generates a playlist of size N which consists of the songs that are closest in distance to the song that is chosen. The motivation behind choosing this method is to benefit it while implementing Random Forest Classifier and Linear Regression. We generate a label set with this method and use that label set while fitting the other models.

We used NearestNeighbors method of Sci-kit Learn library, in order to find the n nearest neighbours of the selected song, assuming all songs were placed in a d-dimensional space (d is the number of features), in terms of values of their features.

### 3.3. Random Forest Classifier

Since this project is a recommendation task and we don't have any predetermined labels, we chose to use the results of the nearest neighbor algorithm as labels of Forest Classifier. To conserve the integrity of the playlist, we used a weighted input for the Nearest Neighbour algorithm. In the weighted input, we multiplied the input song's features with the length of the playlist and then, we performed a column sum for all songs in the input playlist and took the average of the result. By doing this, we preserved the integrity of the whole playlist and also, the  $i^{\text{th}}$  song didn't lose its importance. So, for the training set, we use Nearest Neighbour algorithm and take the closest 5000 points of the weighted input. Then, we rate these points from 1 to 10 with equal amounts according to their distance to the chosen song. After pre-processing the dataset, we applied stratified 5-fold cross validation to this training set to find the set that gives the best performance. To find the best parameters, we used the grid search algorithm and tried several parameter settings. So, after finding the best set and parameter setting, we trained it using Random Forest Classifier. Our model predicts the ratings of the songs and we put the top 3 songs with rating 10 into our recommended playlist. We only use the top 3 of them because while using Random Forest Classifier, we give a playlist as an input. So, if there are so many songs in the playlist, it will be better to recommend 3 songs per song in the input playlist.

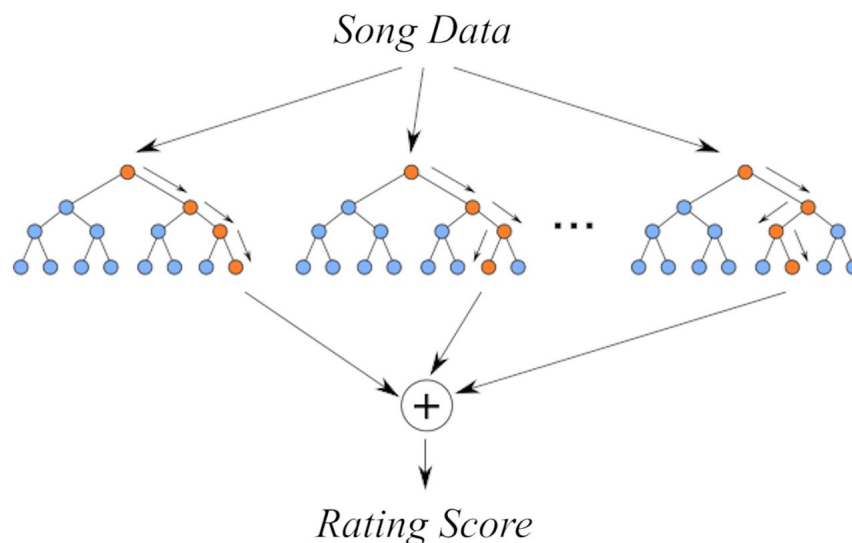


Figure 1: Random Forest

### 3.4. Linear Regression

5000 songs that are the closest to the original song, obtained as a result of the Knn method are used as the training data for the Linear Regression model. Since there is no label in the dataset, we created a feature called relevance to replace the label. Relevance score was assigned to these 5000 songs, with the first song having 100 points and the last song with 97 points. A difference of 0.0006 relevance points was obtained between each song. After that we trained the Linear Regression model of sci-kit learn using training data. Thus, the weight of each feature was determined. Using these weights, a relevance score was calculated for all songs in the data. Finally, based on a desired number of  $n$ ,  $n$  songs with a relevance score closest to 100 are determined and a playlist of  $n$  songs was created.

Thus, we used the KNN method as a sort of pre-filter that eliminates irrelevant songs in the data and as a tool that helps us to label the samples. Afterwards, the final playlist was created using the Linear Regression model on the relevant and labelled songs.

## 4. Results

The results were evaluated under three headings. First, only the results of the kNN method; secondly, the result obtained as a result of combining kNN and Random Forest classifier methods; and finally the result obtained by combining kNN and linear regression methods were examined.

When using kNN and Linear Regression, a selected song was input and a playlist of songs similar to that song was output. In the case of using Random Forest Classifier, a playlist of  $n$  songs was given as input and a playlist of  $3n$  songs was obtained as output. For each song in the original playlist, 3 songs similar to that song were put into the new playlist.

Since the taste of music is a subjective phenomenon and there is no precise way to measure the similarity of music, we used the questionnaire method to measure the accuracy of the models. The questionnaire was applied on 10 different people.

Also in the following part, there exists some sample playlists that are created by our methods, for some specific input songs. There are 15 songs in the sample playlists, in order to be able to see all songs in one image. In questionnaires, playlists with 25 songs are used.

## **4.1. kNN**

### **4.1.1. Sample Input Songs and Output Playlists**

This part contains two sample output playlists for 3 specific songs. First song is “STARGAZING” by Travis Scott and the second one is “Hips Don’t Lie” by Shakira and the last one is “Suite For Cello Solo No.1” by Bach.

- STARGAZING:<https://sptfy.com/5ljQ>
- Hips Don’t Lie:<https://sptfy.com/5ljP>
- Suite For Cello Solo No.1:<https://sptfy.com/5lk5>

Output playlists are as follows:

TITLE	ARTIST
♥ All Of The Lights	EXPLICIT Kanye West
♥ 11 Minutes (with Halsey feat. Travis Barker)	EXPLICIT YUNGBLUD, Halsey, Travis Barker
♥ I'll Be Fine	EXPLICIT Juice WRLD
♥ Love It If We Made It	EXPLICIT The 1975
♥ Welcome To The Party	EXPLICIT Pop Smoke
♥ God is a woman	EXPLICIT Ariana Grande
♥ Dear my friend (feat. Kim Jong Wan of NELL)	EXPLICIT Agust D, Kim Jong Wan
♥ Kiss	EXPLICIT Lil Peep
♥ All I Do Is Win (feat. T-Pain, Ludacris, Snoop Dogg & R...	EXPLICIT DJ Khaled, Ludacris, T-Pain, Snoop Dogg,...
♥ It's Been Awhile	EXPLICIT Staind
♥ UCLA	EXPLICIT RL Grime, 24hrs
♥ *Till I Collapse	EXPLICIT Eminem, Nate Dogg
♥ Snowchild	EXPLICIT The Weeknd
♥ Nothing Compares - Bonus Track	EXPLICIT The Weeknd
♥ Bound 2	EXPLICIT Kanye West

Figure 2: kNN Playlist for STARGAZING

TITLE	ARTIST
♥ Oops!...I Did It Again	Britney Spears
♥ ...Baby One More Time	Britney Spears
♥ La Boca - Remix	Mau y Ricky, Camilo, Lunay
♥ Ahora Es	Wisin & Yandel
♥ Lo Que Pasó, Pasó	Daddy Yankee
♥ Gris	J Balvin
♥ Vivir Mi Vida	Marc Anthony
♥ Marvin Gaye (feat. Meghan Trainor)	Charlie Puth, Meghan Trainor
♥ X (with KAROL G)	Jonas Brothers, KAROL G
♥ They Don't Care About Us	Michael Jackson
♥ Black Horse And The Cherry Tree	KT Tunstall
♥ Hit 'Em Up Style (Oops!)	Blu Cantrell
♥ Latina (feat. Maluma)	Reykon, Maluma
♥ No More Sad Songs (feat. Machine Gun Kelly)	Little Mix, Machine Gun Kelly
♥ Camuflaje	Alexis y Fido

Figure 3: kNN Playlist for Hips Don't Lie

TITLE	ARTIST
♥ Suite For Cello Solo No.3 In C, BWV 1009: 7. Gigue	Johann Sebastian Bach, Pierre Fournier
♥ June Bug	Lester Young
♥ Suite For Cello Solo No.2 In D Minor, BWV 1008: 3. Courante	Johann Sebastian Bach, Pierre Fournier
♥ Crazy Over Jazz	Lester Young
♥ Suite For Cello Solo No.1 In G, BWV 1007: 7. Gigue	Johann Sebastian Bach, Pierre Fournier
♥ Hai Dil Mein Milan Ki Aas	Talat Mahmood
♥ How About You?	Bill Evans
♥ Suite For Cello Solo No.3 In C, BWV 1009: 2. Allemande	Johann Sebastian Bach, Pierre Fournier
♥ Suite For Cello Solo No.3 In C, BWV 1009: 3. Courante	Johann Sebastian Bach, Pierre Fournier
♥ Kahin Dil Lagane Ka Saman Karle	Rajkumari
♥ We'll Find a Way	Victor Silvester and his Ballroom Orchestra
♥ 真善美	周璇
♥ Italy: Dormi e Riposa	G. Gangone
♥ Fascinating Rhythm	Oscar Peterson
♥ Italian Concerto in F Major, BWV 971: I. Allegro - Version of 1981	Johann Sebastian Bach, Glenn Gould

Figure 4: kNN Playlist for Suite For Cello Solo No.1

#### 4.1.2. Questionnaire Results

We applied the survey on 10 people. Each participant chose a song and a playlist of 25 songs was presented to them. Then they were asked how many of these songs were suited to their musical taste or were similar to the original song. Results are as follows:

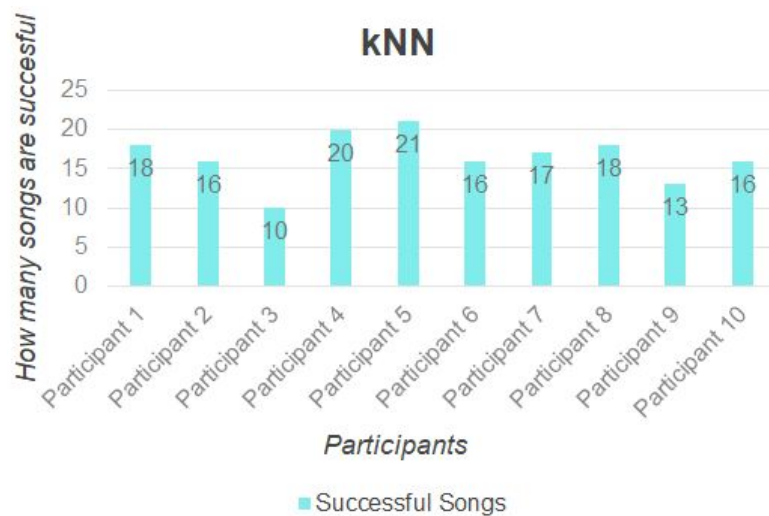


Figure 5: kNN questionnaire results



## 4.2. kNN + Random Forest Classifier

### 4.2.1. Sample Input Playlists and Output Playlists


In this part, different from the “kNN + Linear Regression” and “kNN”, instead of giving only on track as an input, we give a playlist that contains one or more songs. For the test, we chose two playlists that contain songs with “rap-trap” genre and “soft rock” genre. So, our first playlist is shown below:

BAŞLIK	SANATÇI	
Whopty	CJ	18 saat önce
Bank Account	21 Savage	17 saat önce
What You Know Bout Love	Pop Smoke	17 saat önce
The Plan - From the Motion Pic...	Travis Scott	18 saat önce
Godzilla (feat. Juice WRLD)	Eminem, Juice WR...	17 saat önce
WHATS POPPIN	Jack Harlow	17 saat önce
THE SCOTTS	THE SCOTTS, Tra...	17 saat önce

Figure 6: Rap playlist that we used for Random Forest Classifier

- Playlist 1 Link: <https://sptfy.com/5lm3>

The created playlist by Random Forest Classifier is shown below:



ÇALMA LİSTESİ

## Random Forest Classifier

Oluşturan: Altuğ Sevimay • 18 şarkı, 59 dk

DURAKLAT

Filtrele

BAŞLIK	SANATÇI
Breaking Me	Topic, A7S
FIND MY WAY	DaBaby
Hot (Remix) [feat. Gunna and Travis Scott]	Young Thug, Travis Scott, Gunna
ZEZE (feat. Travis Scott & Offset)	Kodak Black, Offset, Travis Scott
Hot (Remix) [feat. Gunna and Travis Scott]	Young Thug, Travis Scott, Gunna
Faucet Failure	Ski Mask The Slump God
NASA	Ariana Grande

Figure 7: The playlist created by Random Forest Classifier for the first playlist

- Random Forest Playlist 1 Link: <https://sptfy.com/5lm6>


Our, second playlist is shown below:

BAŞLIK	SANATÇI
♥ Whatever It Takes - Jorgen Odegard Remix	Imagine Dragons, Jorgen Odegard
♥ Sugar for the Pill	Slowdive
♥ I'd Rather Dance With You	Kings of Convenience
♥ Do You Feel It?	Chaos Chaos
♥ Bloodstain	Wrabel
♥ Let Go	BANNERS
♥ The Village	Wrabel
♥ Desert Flower	Auri
♥ Shot Someone	Hudson Taylor

Figure 8: Soft Rock playlist that we used for Random Forest Classifier

- Playlist 2 Link: <https://sptfy.com/5lm7>

The created playlist that contains recommended songs by Random Forest Classifier is shown below:



ÇALMA LİSTESİ

# Random Forest Classifier

Oluşturan: Altuğ Sevimay • 24 şarkı, 1 sa 39 dk

ÇAL ...

Q Filtrele

BAŞLIK	SANATÇI
♥ Never Mess With Sunday	Yppah
♥ Give It Away	Zero 7
♥ Come with Me	Preservation Hall Jazz Band
♥ I Wanna Be	Chris Brown
♥ Cigarettes On Patios	EXPLICIT BabyJake
♥ Seventeen	EXPLICIT MARINA
♥ Jolene	Zac Brown Band
♥ Country Band Man	Framing the Red

Figure 9: The playlist created by Random Forest Classifier for the second playlist

- Random Forest Playlist 2 Link: <https://sptfy.com/5lm8>

#### 4.2.2. Questionnaire Results

In this part, we asked the participants to share a playlist of 10 songs with us. Then we created a playlist of 30 songs for them using the Random Forest method and asked them to evaluate the songs in this playlist. The results are as follows:

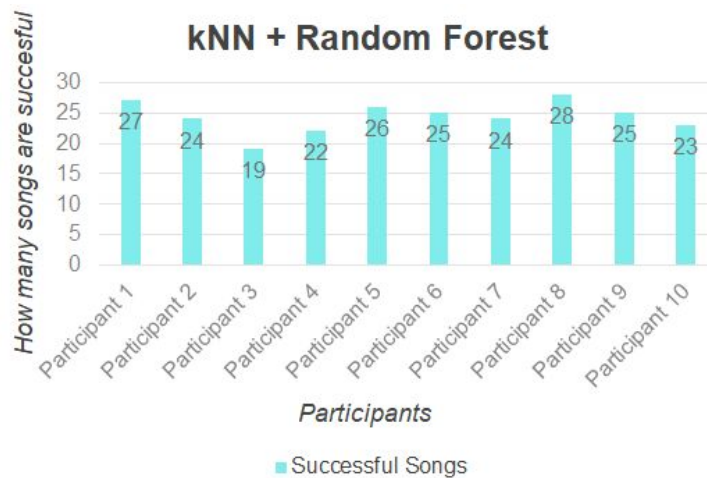


Figure 10: kNN + Random Forest questionnaire results

#### 4.3. kNN + Linear Regression

##### 4.3.1. Sample Input Songs and Output Playlists

This part contains two sample output playlists for 3 specific songs. First song is “STARGAZING” by Travis Scott, the second one is “Hips Don’t Lie” by Shakira and the last one is “Suite For Cello Solo No.1” by Bach.

- STARGAZING:<https://sptfy.com/5ljQ>
- Hips Don’t Lie:<https://sptfy.com/5ljP>
- Suite For Cello Solo No.1:<https://sptfy.com/5lk5>

Output playlists are as follows:

	TITLE	ARTIST	ALBUM
♡	Lord Pretty Flacko Jodye 2 (LPFJ2)	EXPLICIT A\$AP Rocky	AT.LONG.LAST.A\$AP
♡	Eye No, Alphabet St., Glam Slam, Anna Stesia, Dance ...	EXPLICIT Prince	Lovesexy
♡	Bath Salts	EXPLICIT Highly Suspect	Mister Asylum
♡	Best Day Ever	EXPLICIT Mac Miller	Best Day Ever (5th Anniversary Remastere...
♡	11 Minutes (with Halsey feat. Travis Barker)	EXPLICIT YUNGBLUD, Halsey, Travis Barker	11 Minutes (with Halsey feat. Travis Barker)
♡	Mama Cry	EXPLICIT YNW Melly	I AM YOU
♡	Runaway	EXPLICIT Silverstein, Down With Webster	Punk Goes Pop, Vol. 4
♡	Happy Song	EXPLICIT Bring Me The Horizon	That's The Spirit
♡	Youforia	EXPLICIT Mac Miller	Watching Movies with the Sound Off (Del...
♡	Midnight Thunderstorm Part 2	Lightning, Thunder and Rain Storm	Amazing Two Hour Midnight Thunderstorm
♡	Kirisute Gomen	EXPLICIT Trivium	Shogun (Special Edition)
♡	Riot	EXPLICIT Three Days Grace	One-X
♡	We Are	EXPLICIT Hollywood Undead	Notes From The Underground
♡	Mr. Jack	EXPLICIT System Of A Down	Steal This Album!
♡	Groupie Love (feat. A\$AP Rocky)	EXPLICIT Lana Del Rey, A\$AP Rocky	Lust For Life

Figure 11: kNN + Linear Regression Playlist for STARGAZING

	TITLE	ARTIST	ALBUM
♡	Sígueme Y Te Sigo	Daddy Yankee	Sígueme Y Te Sigo
♡	Dandole Remix	Omega, Gocho, Jo-Well	El Dueño Del Flow 2 (New Deluxe Version)
♡	Sour Candy (with BLACKPINK)	Lady Gaga, BLACKPINK	Sour Candy (with BLACKPINK)
♡	Sour Candy (with BLACKPINK)	Lady Gaga, BLACKPINK	Chromatica
♡	FIREWORK	TWICE	MORE & MORE
♡	Jopping	SuperM	SuperM - The 1st Mini Album
♡	Stayin' Alive	N-Trance, Ricardo Da Force	Stayin' Alive
♡	Perdoname	Deorro, DyCy, Adrian Delgado	Perdoname
♡	Virtual Diva	Don Omar	iDon
♡	Be My Lover	La Bouche	Greatest Hits
♡	Good as Hell (feat. Ariana Grande)	Lizzo, Ariana Grande	Cuz I Love You (Super Deluxe)
♡	FANCY	TWICE	FANCY YOU
♡	En los Montes en los Valles	Marcos Witt	Díos es Bueno
♡	Sit Next to Me	Foster The People	Sacred Hearts Club
♡	Love Shack	The B-52's	Cosmic Thing

Figure 12: kNN + Linear Regression Playlist for Hips Don't Lie

TITLE	ARTIST
♥ Phir Kabhi (From "M.S.Dhoni - The Untold Story")	Arijit Singh
♥ Contador de Reencontros - Ao Vivo	Gusttavo Lima
♥ Resala Men Taht El Maa Live Record	Abdel Halim Hafez
♥ Falstaff / Act 2: Siam pentiti e contriti...Reverenza	Giuseppe Verdi, Robert Bowman, Michael...
♥ Symphony No. 2 in C minor "Resurrection": V. Im Tempo des Sche...	Gustav Mahler, New York Philharmonic, B...
♥ Contador de Reencontros - Ao Vivo	Gusttavo Lima
♥ Symphony No. 2 in C Minor "Resurrection": V. Finale. Im Tempo d...	Gustav Mahler, Leonard Bernstein, New Y...
♥ Symphony No. 2 in C Minor "Resurrection": V. Finale. Im Tempo d...	Gustav Mahler, Bruno Walter, New York P...
♥ Mistake (Live At The Berlin Jazz Festival - 1978)	Fela Kuti
♥ Burn Down The Mission (Incl. My Baby Left Me / Get Back)	Elton John
♥ Symphony No. 7 in C Major, Op. 60 "Leningrad": I. Allegretto	Dmitri Shostakovich, Arturo Toscanini
♥ Symphony No. 3 in D Minor, Part I: I. Kräftig, Entschieden - Rema...	Gustav Mahler, Leonard Bernstein, New Y...
♥ Mulligan's Too	Gerry Mulligan Band
♥ Faker Lma Kont Ganby	Umm Kulthum
♥ He Loved Him Madly	Miles Davis

Figure 13: kNN + Linear Regression Playlist for Suite For Cello Solo No.1

#### 4.3.2. Questionnaire Results

We applied the survey on 10 people. Each participant chose a song and a playlist of 25 songs was presented to them. Then they were asked how many of these songs were suited to their musical taste or were similar to the original song. Results are as follows:

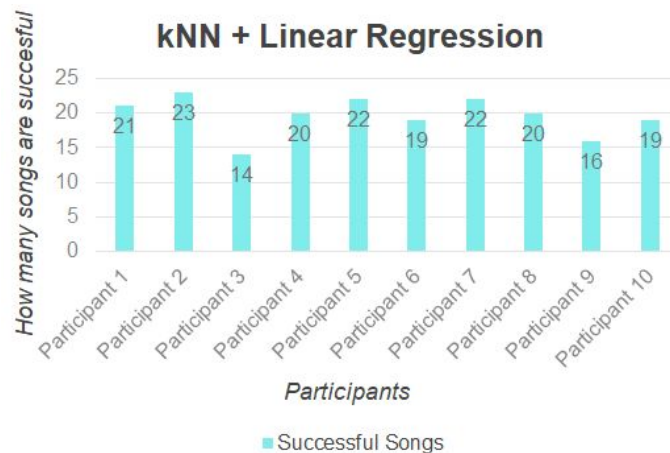


Figure 14: kNN + Linear Regression questionnaire results

## 4.4 Evaluating Output Playlists

While measuring the accuracy of the created playlists, we examined the songs in the playlists. The criteria we take into account and are subjective will be mentioned in this section.

STARGAZING is a song of trap genre. As expected, nearly all of the recommended songs are songs of trap genre. In addition, whether the songs are explicit or not is a good criterion to measure the success of the created playlists. As you can see, STARGAZING is an explicit song and nearly all the songs in the output playlists are explicit.

Hips Don't Lie is a song of the pop genre. As expected, nearly all of the recommended songs are songs of the pop genre. Another feature of the song is that it is performed by a Latin artist. The recommended playlists also include Spanish songs or songs performed by a Latin artists.

Suite For Cello Solo No.1 is a classical and instrumental work. Recommended playlists are generally consisting of instrumental works. It can also be considered that this work was composed in the 18th century. With a few exceptions, the songs in the playlists are works that were composed relatively early centuries.

The same criteria can be applied to the input playlists and the resulting output playlists for Random Forest. When a playlist consisting of trap tracks was given, an output playlist consisting of trap tracks was obtained. When given the soft rock themed playlist, a playlist consisting of soft rock pieces was obtained as output.

## 5. Discussion

In this section, we analyzed the results of the models.

### 5.1. k-Nearest Neighbour

In this project, our most basic algorithm was k-Nearest Neighbor. It was very well suited for the task that we have, finding songs that are similar to a given song.

Even though it is a super simple algorithm, with the dataset we have -approximately 160.000 songs- we are able to get good results with it. Most of the time we are getting very similar songs in our recommended playlist. However, in every playlist, there are 2-6 songs which are not very similar to the given. They are not very far away from the given song, considering the features but they can belong to different genres. Overall, we are happy with the results of the k-Nearest Neighbour algorithm and the questionnaire results are also supporting that most of the recommended songs are good recommendations.

## **5.2. k-Nearest Neighbour + Random Forest Classifier**

KNN algorithm was also needed for this model as a result of we do not have any predetermined labels for this recommendation task. While using this method, the recommended playlist was quite good with respect to given songs. However, some discordant songs could appear in the recommended playlist. Possible reason behind these kinds of minor disharmonies in the playlist would be that we do not have any labels. Although it is successful to get the closest songs from KNN and accept them as labels, sometimes two songs that are quite close to each other can have quite different styles.

## **5.3. k-Nearest Neighbour + Linear Regression**

In this method, we used the kNN algorithm to create labels since we do not have predetermined labels. We rated the 5000 songs that we picked with kNN from 100 to 97. After labeling these songs, we fit the model and predicted the ratings of each song in the dataset and chose the songs that have predicted ratings closest to 100 for the playlist. Since the kNN algorithm does not give perfect results, we might have been rated some irrelevant songs with high ratings, therefore, our model might be misled to include some irrelevant songs in the playlist. However, our results were quite good overall, according to the questionnaires and our self judgement.

## 6. Conclusion

In conclusion, we tried to solve the problem with 3 algorithms. KNN was the base algorithm and other two algorithms are used as classification and regression tasks. For the test, we do not have predetermined labels to calculate the performance metrics of our models. So, instead of using them, we used the questionnaire method to test our models' performance. The quality of the model is measured by the resemblance between input and output. Although our participants found recommended playlists quite successful, there were some minor disharmonies in our recommended playlist. So, in general, our model worked very successfully.

## 7. Appendix

- Questionnaire is done by each group member.
- KNN is done by Arda Akça Büyük and İsmail Yavuzselim Taşçı.
- Random Forest Classification is done by Can Aybalık and Ömer Altuğ Sevimay.
- Linear Regression is done by Oğuz Kaan İmamoğlu.

Our code implementation of the problem can be found at:

<https://github.com/ardaakcabuyuk/spotify-playlist-creator>



## 8. References

- [1] "Spotify Dataset 1921-2020, 160k+ Tracks", *Kaggle.com*, 2020. [Online]. Available: <https://www.kaggle.com/yamaerenay/spotify-dataset-19212020-160k-tracks>. [Accessed: 21- Dec- 2020].
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