SPOTIFY RECOMMENDATION MODEL

SOME FACTS ABOUT SPOTIFY

Swedish audio streaming founded in Sweden in 2006

The name is a combination of “spot" and “identify“

About 35%-40% share of the music streaming market

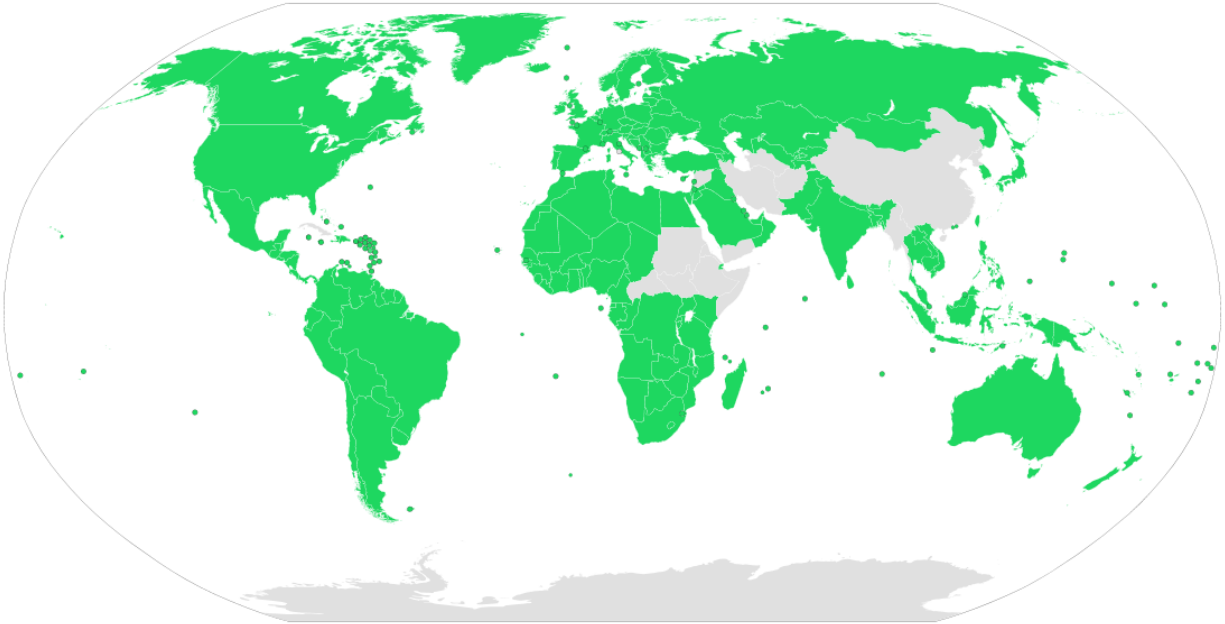
345 million users (155 million paying subscribers)

Over 50 million songs / 7 million artist

Over 3 billion playlists

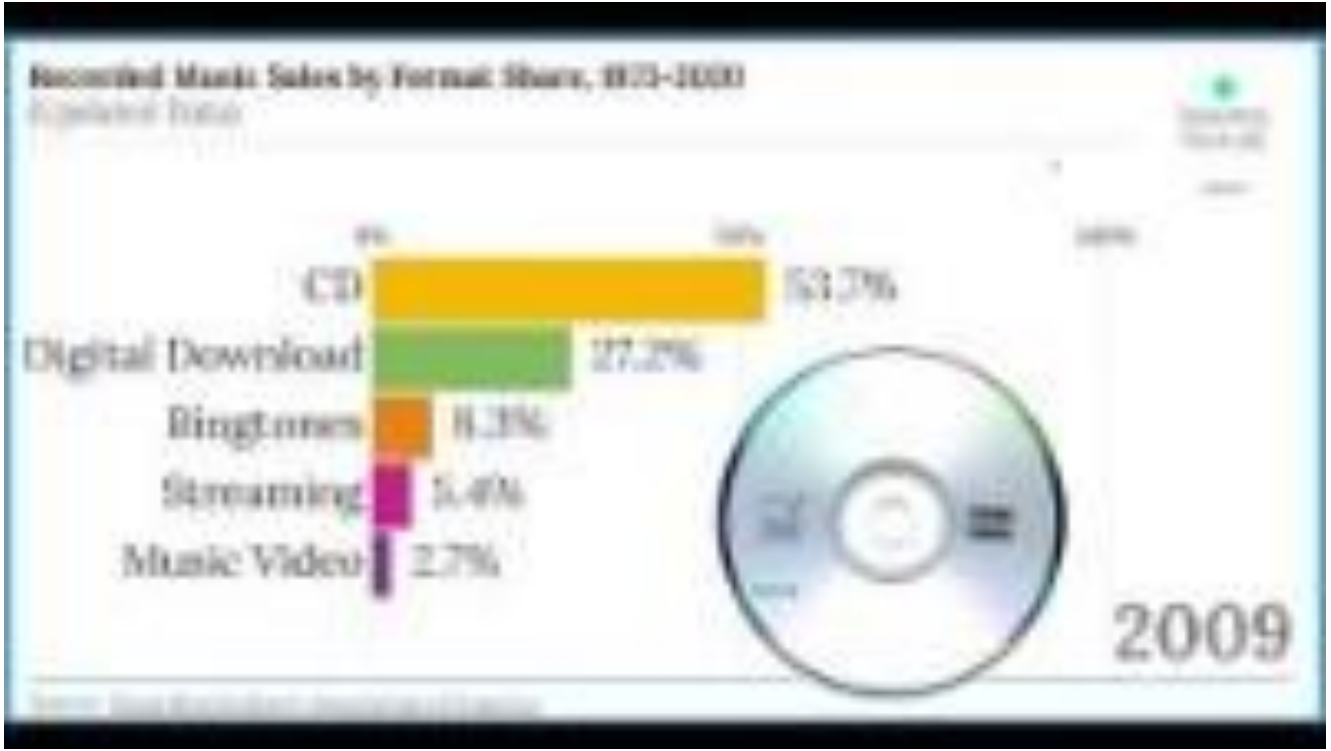
About 25% of the songs on Spotify haven’t been played yet

AVAILABILITY OF SPOTIFY BY COUNTRY



Spotify is available in 184 countries (January 2022)

RISE AND FALL OF MUSIC FORMATS



The Music Streaming Industry & Personalization

FIRST STEPS

Year 2000

Songza creates playlist using human experts

Pandora introduced manual tagging attributes of songs

SPOTIFY KEY TO SUCCESS

Strong recommendation and personalization engine powered by data and machine learning

Spotify acquired EchoNest (2014) , a spin-off from MIT

Spotify's Investment in Machine Learning

THREE-PART ALGORITHM
(not a single revolutionary recommendation model)

1. Collaborative Filtering models, which analyze *your* behaviour and *others'* behaviour.

2. Natural Language Processing (NLP) models, which analize text.

3. Audio models, which analyze the raw audio tracks themselves.

1. COLLABORATIVE FILTERING (I)

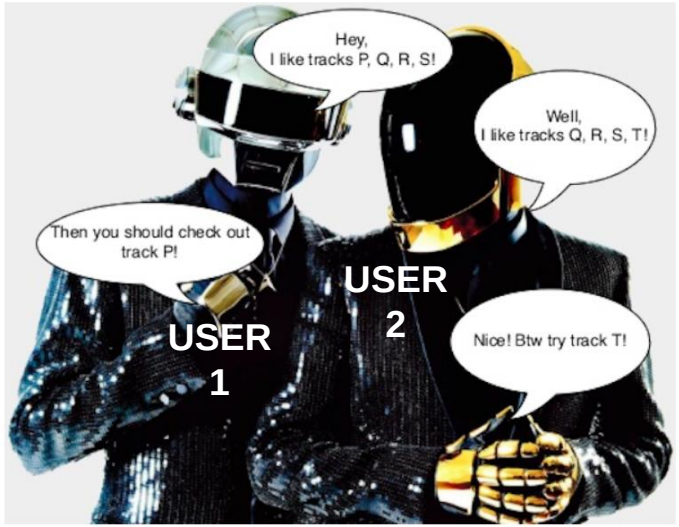


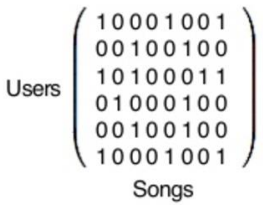
Image source: Collaborative Filtering at Spotify, by Erik Bernhardsson, ex-Spotify.

Basic assumption

If Person 1 has the same opinion as Person 2 about an issue, then Person 1 is more likely to agree with Person 2 about another issue than they would a randomly selected person…
and Spotify has millions of users listening to millions of songs.

User 1 likes songs P, Q, R, S
User 2 likes songs Q, R, S, T
Because they have songs Q, R, and S in common, Spotify assumes they are similar users with similar tastes. Spotify then recommends Song T to User 1, and Song P to User 2.

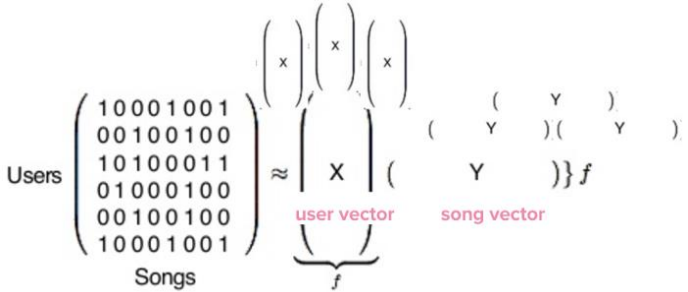
1. COLLABORATIVE FILTERING (II)



Matrix with rows (users) and columns (songs)

$$\min_{x,y} \sum_{u,i} c_{ui}(p_{ui} - x_u^T y_i - \beta_u - \beta_i)^2 + \lambda(\sum_u \|x_u\|^2 + \sum_i \|y_i\|^2)$$

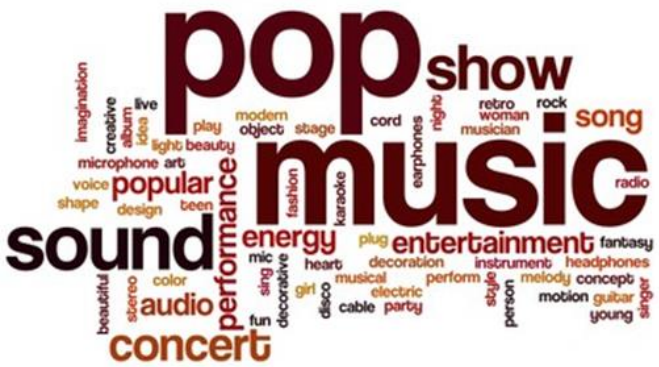
Matrix factorization formula



Two types of vectors:

- X or user vector (one single user's taste)
- Y or song vector (one single song's profile)

2. NATURAL LANGUAJE PROCESSING (NLP)



- Scrape data in blog posts and other written articles about music, to figure out what people are saying about specific artist and songs (adjectives and particular language), and artist and songs frequently mentioned together.
- Creation of a database with these words.
- NLP model uses these terms and weights to create a vector representation of the songs.

n2 Term	Score	np Term	Score	adj Term	Score
dancing queen	0.0707	dancing queen	0.0875	perky	0.8157
mamma mia	0.0622	mamma mia	0.0553	nonviolent	0.7178
disco era	0.0346	benny	0.0399	swedish	0.2991
winner takes	0.0307	chess	0.0390	international	0.2010
chance on	0.0297	its chorus	0.0389	inner	0.1776
swedish pop	0.0296	vous	0.0382	consistent	0.1508
my my	0.0290	the invitations	0.0377	bitter	0.0871
s enduring	0.0287	voulez	0.0377	classified	0.0735
and gimme	0.0280	something's	0.0374	junior	0.0664
enduring appeal	0.0280	priscilla	0.0369	produced	0.0616

"Cultural vectors" or "top terms" as used by the Echo Nest.

3. RAW AUDIO MODEL (I)

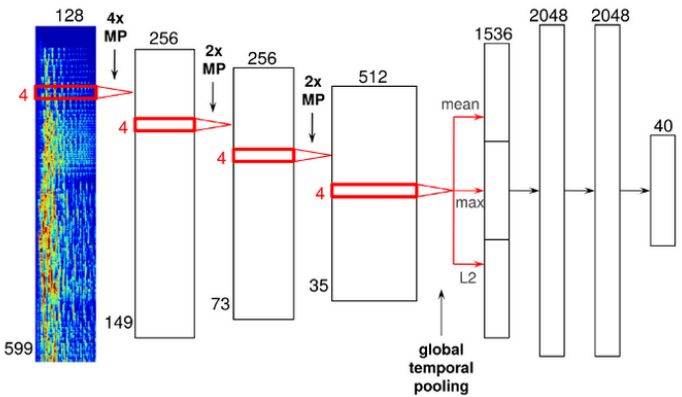
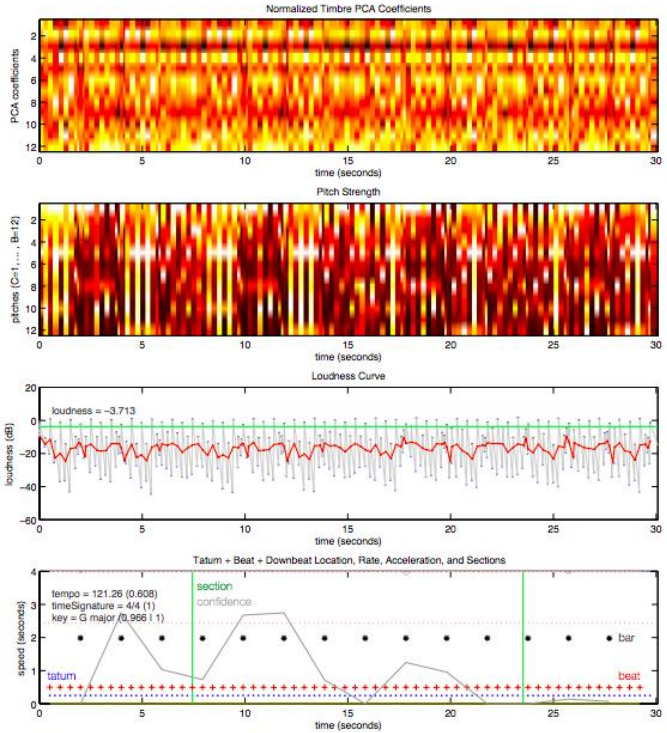


Image source: Recommending music on Spotify with deep learning, Sander Dieleman.

- Spotify uses convolutional neural networks to process song data, providing characteristics about a song, such as tempo, loudness, key and time signature.
- Neural network consists of four convolutional (thick bars on the left) and three dense layers (more narrow bars on the right).
- This 3rd method does not discriminate between the popularity of artist and songs, and no matter how recently a song was released.

3. RAW AUDIO MODEL (II)



Plot of data for 30-second of an audio track.

Song's key characteristics allows Spotify to understand fundamental similarities between songs and detect which users might enjoy them, based on their own listening history.

FUTURE TRENDS - ETHICAL IMPLICATIONS

- Use of data gathered on listener habits not only to recommend hit music, but also to create music as well (To engage listeners with more hits or to reduce artist royalties?)
- How we can be sure that the algorithms are neutral?
- Same song/artist recommendations for free and premium users in the future?


IRON
HACK