# Surveying Techniques for Music Recommendation

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# Presentation - Key Points

1. Introduce the focus of my research and paper

2. Introduce recommender systems and use for music
3. Introduce their challenges and evaluation methods

4. Discuss recommender system techniques
5. Discuss music streaming services and recommendation techniques

# Research Motivations

- **Combination of Research Interests**
  - Machine learning and music (analysis and theory background)

- **Lack of Comprehensive Papers on Music Recommendation**
  - Many papers discuss individual techniques for music recommendation
  - Very few papers consider recommendation techniques across services

- **Base for future research and projects**

# Recommender Systems

- **Definition:** Machine learning algorithms designed to recommend *Items* to *Users* thought to be desirable by the users.

- User behaviour is stored as *Transactions*.

- **Motivations**
  - Assist with the information overload problem
  - Can benefit the users **and** the service provider

# Recommender Systems – Approaches

- Two common approaches:
  - Content-Based (CB)*
  - Collaborative Filtering (CF)*

- Many offshoots:
  - Context-based recommenders*
  - Conversational recommenders*
  - Constraint-based recommenders
  - Hybrid-models

*Starred items are selected for discussion today.

# Evaluating Recommendations

- **Accuracy Measures**
  - Predicted ratings →
  - Predicted usage
  - Predicted item rankings

$$RMSE = \sqrt{\frac{1}{|T|} \sum_{(u,i) \in T} (\hat{r}_{ui} - r_{ui})^2}$$

$$MAE = \sqrt{\frac{1}{|T|} \sum_{(u,i) \in T} |\hat{r}_{ui} - r_{ui}|}$$

$\hat{r}_{ui}$ = Predicted rating

$r_{ui}$ = Actual rating

- **Evaluation Metrics**
  - Recommender-based i.e. scalability, adaptivity, and confidence
  - Recommendation-based i.e. novelty, serendipity, diversity, presentation

# Evaluation Metrics for Music

- **Coverage**
  - How well do recommender systems cover the full library of songs available?

- **Discovery**
  - **Novelty -** Does the system allow the user to discover new music?
  - **Serendipity -** Does the system allow the user to discover new *unexpected* music?

- **Responsiveness**
  - How quickly does the system update its recommendations to user feedback?

# Item Challenges for Music Recommendation

- **Scalability**
  - Most streaming services feature millions to tens of millions of songs

- **Popularity Bias**
  - More popular songs may be favoured in recommendation
  - Long-Tail problem

- **Cold-Start Recommendation**
  - How to recommend new items (without ratings)?

# User Challenges for Music Recommendation

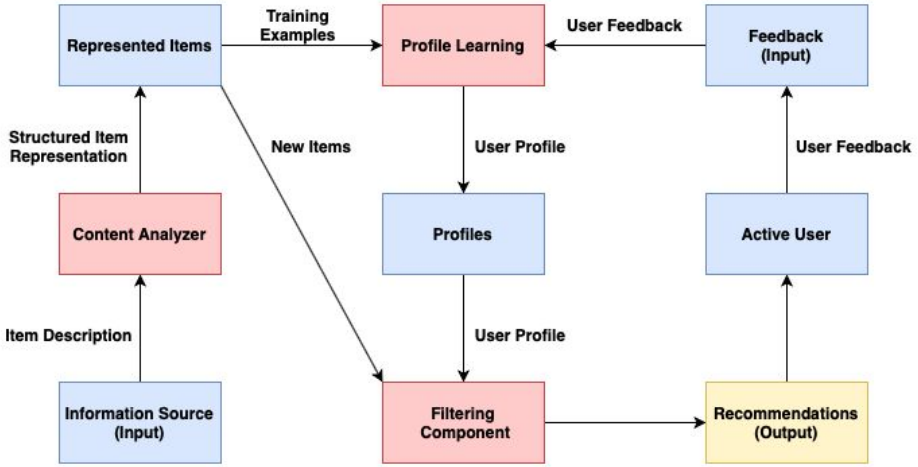
- **Collecting feedback**
  - Mostly implicit feedback (instead of explicit ratings)
- **Listening contexts**
  - Location, mood, and intention can vary
- **Cold-Start recommendation**
  - How to recommend items to new users?
- **Repeated recommendation**
  - Desire to listen to songs again

# Content-Based Approaches

- **Method:** Recommend new items using a learned **user profile** with previously liked items, and similarity measures for new items based on their 'content'.

- **Three primary steps:**
  - Preprocessing & Feature Extraction
  - User Profile Building
  - Item Filtering

- Left diagram features:
  - Objects & Data (blue)
  - Model components (red)
  - Output (yellow)



# Content-Based Approaches - Music

- **Audio Feature Extraction**
  - Analyze audio visually through spectrograms
  - CNNs can highlight specific audio characteristics

- **Text Feature Extraction**
  - Analyze textual information to determine characteristics
  - Ex. lyrics, reviews, blog posts, comments, labels, etc.

- **Measure Similarity**
  - Compare audio characteristics, genre, user descriptions, etc.

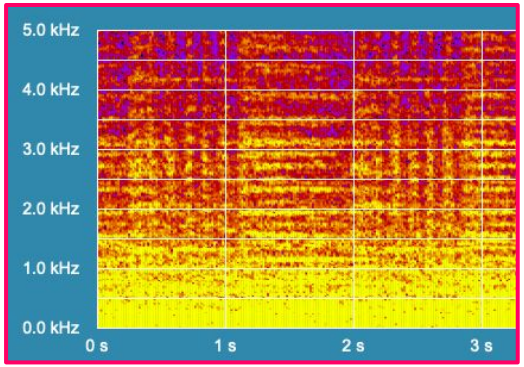



**Fig. 1** Spectrogram of an orchestral piece of music.

# Content-Based Approaches - Considerations

- **Advantages:**
  - Mitigates cold-start problem for new item recommendation
  - Recommendations are easily explained to users

- **Disadvantages:**
  - Feature extraction can be difficult
    - Requires domain knowledge
  - Lack of diversity in recommendations

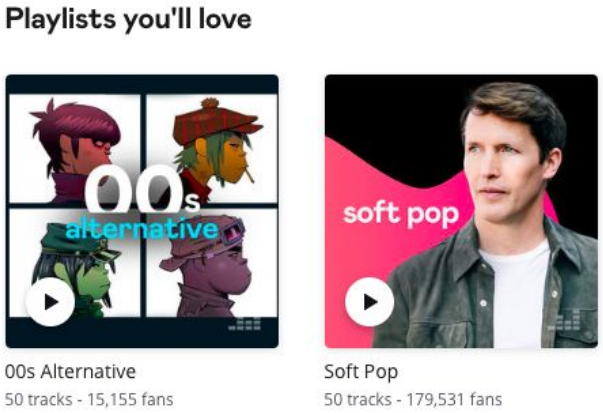



**Fig. 2** Playlists recommended using content-based filtering by song genre.

# Collaborative-Filtering

- **Method:** Recommend items to users by considering the preferences/ratings of *other users* similar to the user being recommended to.

- Neighbourhood-based Approaches
  - User-based (Use similar users)
  - Item-based (Use similar items based on user ratings for the items)

- Latent Factor Models
  - Transform items and users to the same space and consider inferred (latent) factors as patterns

# Collaborative-Filtering - Considerations

- Very popular approach (Netflix Competition)

- **Advantages:**
  - Good for item discovery
  - No domain knowledge needed

- **Disadvantages:**
  - Cold-start problem for new items (without ratings)
  - Prone to recommendation biases

# Context for Music Recommenders

- Context for the Listener
  - **When:** What time of day is it? What time of year is it?
  - **Where:** Where is the user listening from?
  - **What (Why):** Why is the user currently listening to music?
  - **Who:** Who is the user? (Demographic information)

- Context for the Items
  - What is the song's perceived genre?
  - Who is the musical artist or composer?
  - How do people describe this song?
  - What *mood(s)* does the song portray?

# Conversational Systems

- **Conversational Recommender Systems**
  - Get live feedback from users or specific requests based on listening intention
  - Tune recommendations not solely based on prior knowledge about user preferences

- **Why?**
  - User may perceive the recommender as being more 'intelligent'
  - Listening intention of the user isn't always captured in pre-built playlists

- **Pandora**
  - Dedicated voice assistant technology (more on this later)

# Music Streaming Services

- New emerging streaming services through the years
- Many websites offer some form of music recommendation service
- Highlighting a few today:
  - Spotify
  - Last.fm
  - Pandora

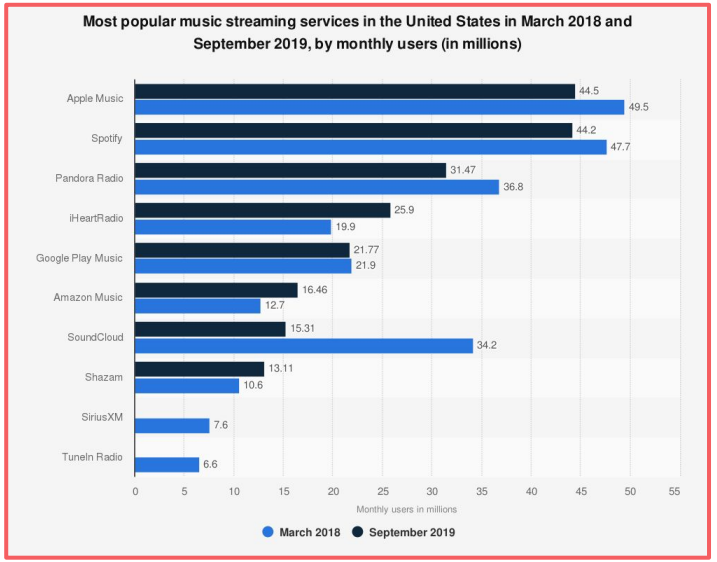



**Chart 1:** Most Popular Streaming Services in The United States (2018-2019)

# Spotify


- Music and audio streaming service
- Library of over 70 million songs (and counting)
- Founded in 2006, initial launch in 2008

- **Recommendation Features:**
  - User-tailored playlists i.e. "Discover Weekly", "Daily Mix"
  - Artist and genre radio
  - Playlists tuned to specific moods and listening contexts

# Spotify Playlist Selection

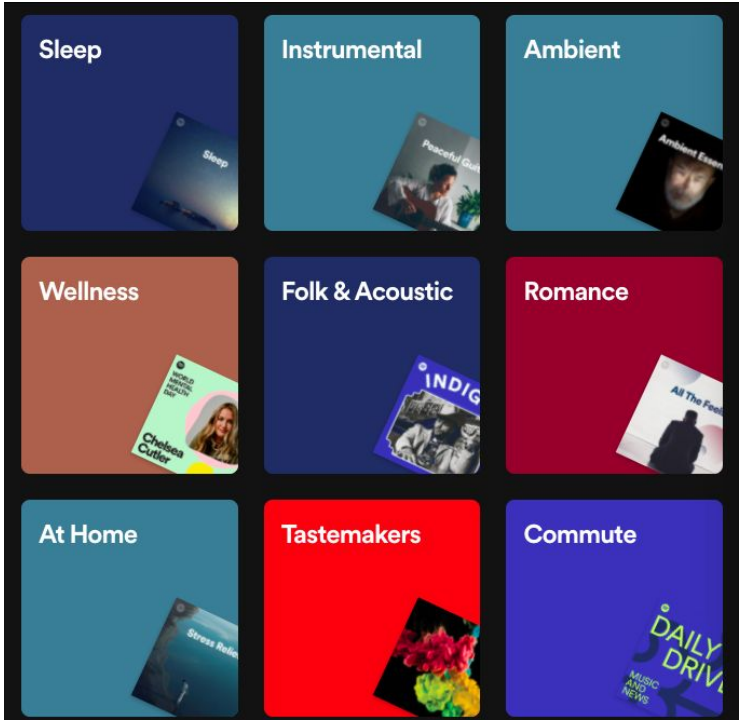



**Fig. 3a:** Playlists created by Spotify suited to specific genres and contexts

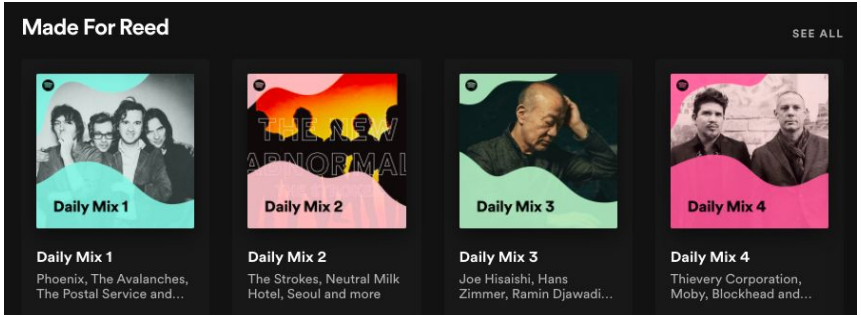



**Fig. 3b:** User-tailored playlists.

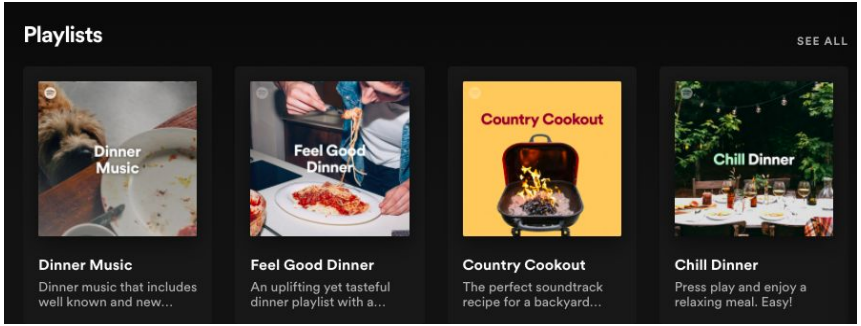



**Fig. 3c:** Playlists under the sub-category "Cooking"

# Spotify - Making Recommendations

- Relies on three primary components:
  1. Collaborative-Filtering
  2. Content-Based Analysis
  3. Natural-Language Processing

- Acquisition of music intelligence platform EchoNest in 2014 to assist content-based analysis

*Check out Engineering.AtSpotify for more information

# Last.fm


- Music recommendation service and 'social network'
- Former music streaming service
- Founded in 2002

- **Recommendation Features:**
  - Recommends songs to users in "streams" as personalized playlists
  - Integration with streaming services for *scrobbling*

- Developer API using Last.FM's music database

# Last.fm - Scrobbling

- **Scrobbling:** The process of collecting data related to audio streaming by users across various streaming services and some hardware devices.

- Recommendation uses **collaborative filtering** techniques

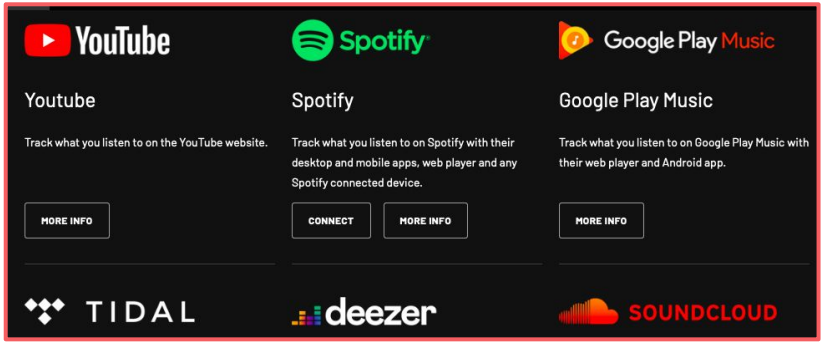



**Fig. 4:** Deezer's partners for Scrobbling

# Pandora

- Internet radio service with on-demand features
- Relatively small music library (~1 million songs estimated)
- Launched in 2005 for the U.S. and Australia (Now U.S. exclusive)

- **Features:**
  - User-tailored playlists and "modes"
  - Virtual assistant technology
  - Collects user feedback
  - Leverages context-based information

# Pandora - Music Genome Project

- Project used to classify songs according to a set of 450 attributes
  - Attributes were defined and rated by music experts
  - Attributes were rated on a numerical scale

- Unique approach for content-based recommendation

- Example attributes:
  - "Abstract Lyrics", "Blues Influences", "Electric Guitar Solo", "Heavy Syncopation", "Mellow Sounds", "Reggae Feel"

# Pandora - Virtual Assistant Technology

- Allows users to use voice-activated virtual assistant technology for song recommendation
  - Users can make vague music requests
    - *"Hey, Pandora: play something happy for cooking."*
  - Users can give feedback to adjust recommendations in real time
    - *"Hey, Pandora: play more like this."*

# State of Research & Going Forward

- **Current Progress:**
  - In the paper writing and revising stage

- **Next Steps:**
  - Present techniques as solutions to challenges
  - More research for context-based approaches
  - Explore integration of other ML domains

- **Looking Ahead:**
  - Experiment with personal music libraries
  - Developer APIs are available

# Conclusion

- **Music recommendation is:**

- A key feature of many internet radio and music streaming services

- Getting more sophisticated
  - Leveraging context factors
  - More data collection methods

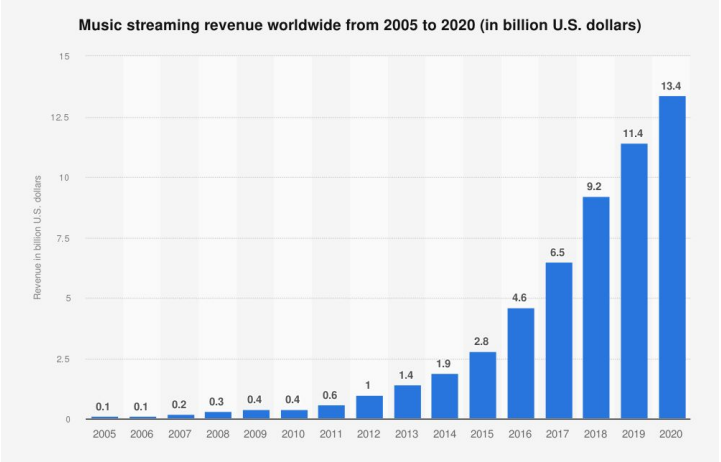



**Chart 2:** Worldwide Music Streaming Revenue Growth

**Spotify Users Have Spent Over 2.3 Billion Hours Streaming Discover Weekly Playlists Since 2015**

**Fig. 6**: Spotify Newsroom Headline.

# Images & Charts Used (For Presentation)

## Images:

[Fig. 1] Image created using Acedemo's Spectrograph program.

[Fig. 2] Images taken from Deezer.

[Fig. 3] Images taken from Spotify.

[Fig. 4] Image taken from Last.fm.

[Fig. 5] Image taken from Newsroom Spotify.

## Statistics Charts Used:

[Chart 1] Verto Analytics. (November 13, 2019). Most popular music streaming services in the United States in March 2018 and September 2019, by monthly users (in millions) [Graph]. In Statista. Retrieved November 29, 2021, from https://www.statista.com/statistics/798125/most-popular-us-music-streaming-services-ranked-by-audience

[Chart 2] MIDiA Research. (June 1, 2021). Number of music streaming subscribers worldwide from 2015 to 1st quarter 2021 (in millions) [Graph]. In Statista. Retrieved November 29, 2021, from https://www.statista.com/statistics/669113/number-music-streaming-subscribers/

# Thank You!