

Music recommenda tion System - Spotify

Collaborative Filtering and
Feedback System

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The ideal music recommender

- maximize user's satisfaction
- Recommend songs to hit top songs of user's favourite list
- Nowadays streaming music provides best services such as Soundcloud, Deezer, Spotify

Spotify

- Uses various ways of recommendation
- 100 mio. monthly active users with millions of songs and playlists
- Three main services for recommendation and a feedback system

Spotify track

The screenshot displays the Spotify mobile app interface for the album 'Starboy' by The Weeknd. The left sidebar contains navigation options: 'Suchen' (Search), 'Browse', 'Deine Musik' (Your Music), and 'ZULETZT ABGESPIELT' (Recently Played). Under 'ZULETZT ABGESPIELT', several items are listed: 'Starboy' (ALBUM), 'Black' (PLAYLIST), 'Grateful' (ALBUM), and 'Indian' (PLAYLIST). At the bottom of the sidebar, there is an 'App installieren' (Install App) button and a user profile for 'doublem4901'.

The main content area shows the album 'Starboy' by 'Von The Weeknd', released in 2016 with 18 songs. A prominent green 'PLAY' button is visible. Below the album title, there are options for 'SPEICHERN' (Save) and a three-dot menu.

The tracklist on the right side of the screen lists 10 tracks:

1. Starboy (Daft Punk) - 3:50
2. Party Monster - 4:09
3. False Alarm - 3:40
4. **Reminder** - 3:38
5. Rockin' - 3:52
6. Secrets - 4:25
7. True Colors - 3:26
8. Stargirl Interlude (Lana Del Rey) - 1:51
9. Sidewalks (Kendrick Lamar) - 3:51
10. Six Feet Under - 3:57

The bottom player bar shows the current track 'Reminder' by The Weeknd is playing at 0:32 of 3:38. The player includes standard controls: shuffle, previous, play/pause, next, and repeat. A volume icon and a full-screen icon are also present on the right side of the player bar.

Spotify track

```
{
  "danceability" : 0.560,
  "energy" : 0.527,
  "key" : 2,
  "loudness" : -9.783,
  "mode" : 1,
  "speechiness" : 0.0374,
  "acousticness" : 0.516,
  "instrumentalness" : 0.0000240,
  "liveness" : 0.156,
  "valence" : 0.336,
  "tempo" : 93.441,
  "type" : "audio_features",
  "id" : "2z7D7kbpRcTvEdT71tdiNQ",
  "uri" : "spotify:track:2z7D7kbpRcTvEdT71tdiNQ",
  "track_href" : "https://api.spotify.com/v1/tracks/2z7D7kbpRcTvEdT71tdiNQ",
  "analysis_url" : "http://echonest-analysis.s3.amazonaws.com/TR/-ENytQjtFbuv9XJtXVpEI2tp9PXqI7k",
  "duration_ms" : 168720,
  "time_signature" : 4
}
```

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1. Content-based recommendation

- Without user's evaluation or ratings
- Uses machine language to acquire information
- Algorithms: decision trees, neural networks and vector-based methods

2. Knowledge-based recommendation

- Based on demands and preferences of user
- Predictions decided by functions and features of objects

3. Collaborative Filtering - KNN

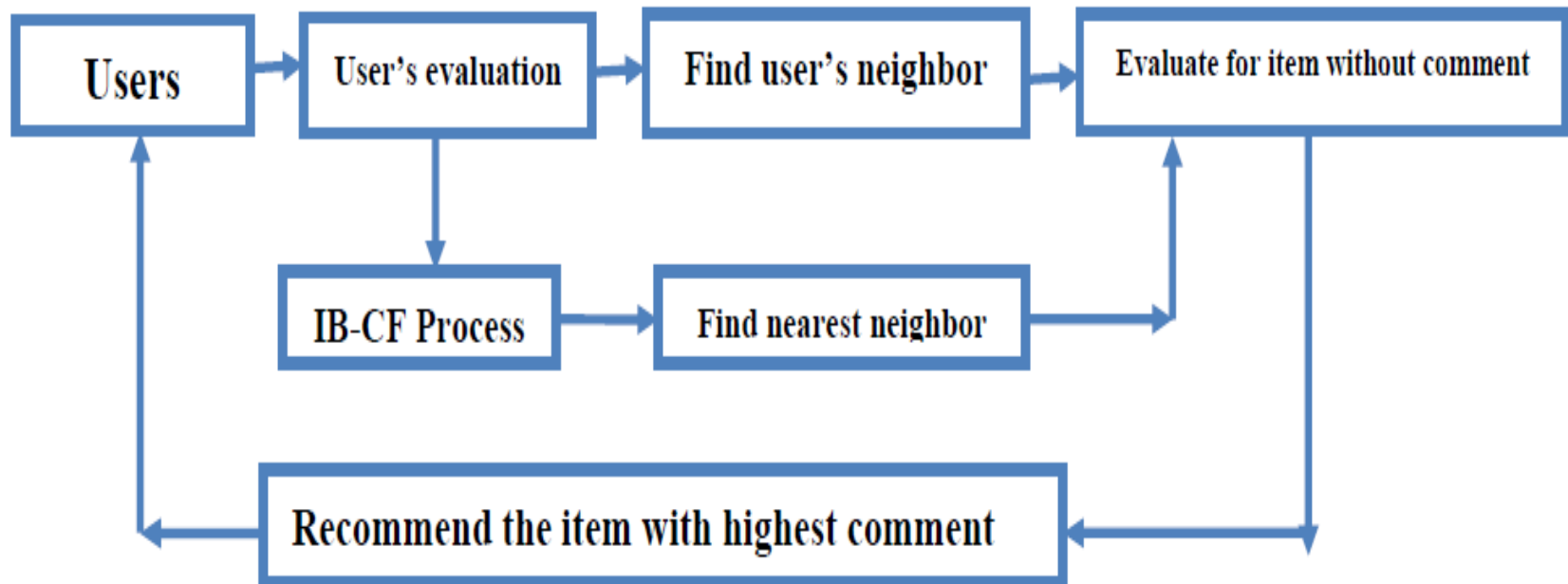
- Uses K-nearest neighbour (KNN) technique
- Music taste of users calculates distance between different users
- Search for neighbour users who share similar interest in music and recommend content
- Daily life: friend's recommendation

Categories:

Memory-based	Model-based	Hybrid
Predict items based on previous ratings	Uses algorithms and models preferences	Combining both models and outperforms them

[2]

Collaborative Filtering - Flowchart



[1]

Collaborative Filtering - Approach (1)

Neighborhood Models:

$$\hat{r}_{ui} = \frac{\sum_{j \in S^k(i;u)} s_{ij} r_{uj}}{\sum_{j \in S^k(i;u)} s_{ij}} \quad [4]$$

Minimize cost function:

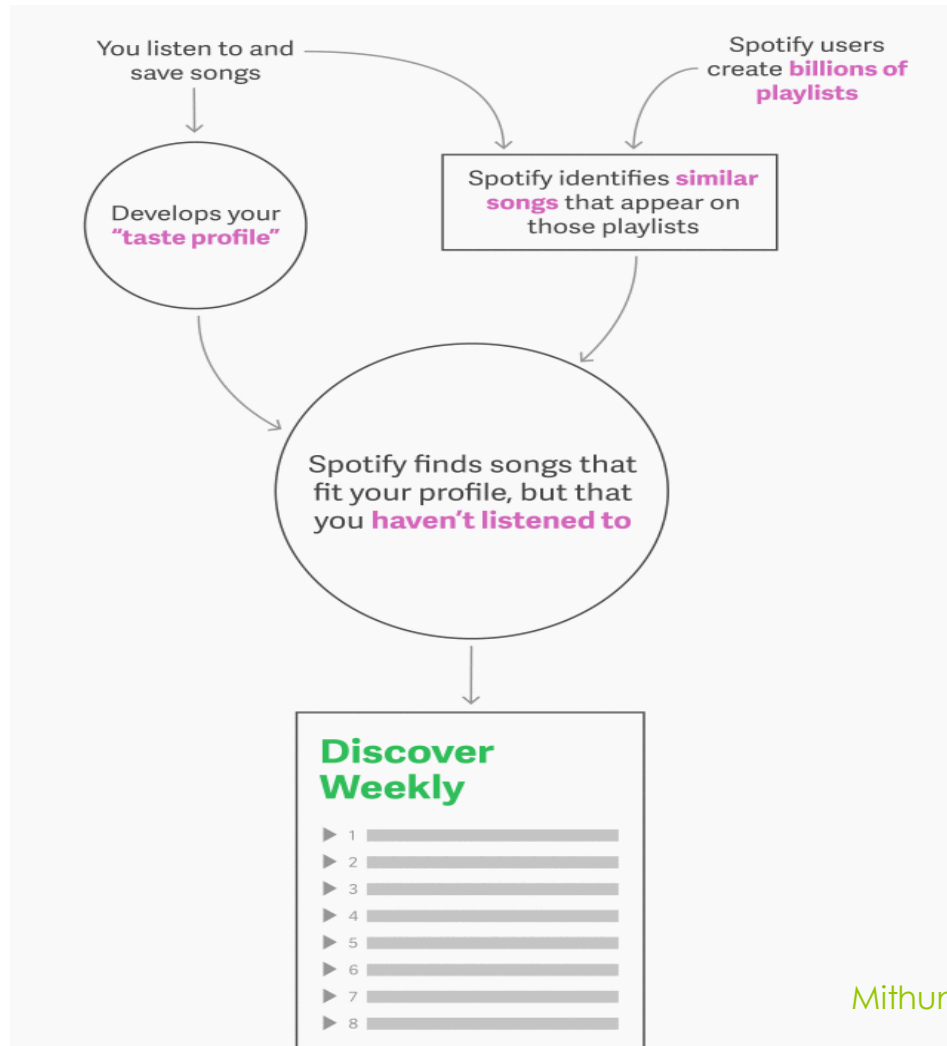
$$\min_{x^*, y^*} \sum_{u,i} c_{ui} (p_{ui} - x_u^T y_i)^2 + \lambda \left(\sum_u \|x_u\|^2 + \sum_i \|y_i\|^2 \right) \quad [4]$$

Collaborative Filtering – Approach (2)

1. Initialize user & item vectors
2. Fix item vectors and solve for optimal user vectors
3. Fix user vectors and solve for optimal item vectors
4. Repeat till convergence

$$x_u = (Y^T C^u Y + \lambda I)^{-1} Y^T C^u p(u) \quad y_i = (X^T C^i X + \lambda I)^{-1} X^T C^i p(i)$$

In Spotify: Discover Weekly Playlist



[6]

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My discover weekly playlist

The image shows a Spotify interface with a dark theme. On the left is a navigation sidebar with options like 'Suchen', 'Browse', and 'Deine Musik'. The main area features a playlist cover for 'Dein Mix der Woche' by Spotify, with a 'PLAY' button and 'NICHT MEHR FOLGEN' option. To the right is a list of 9 songs with their durations. At the bottom, a player bar shows the current song 'All The Way Up (Remix)' by Fat Joe, Remy Ma, JAY Z, French Montana, and InfaRed, with a progress bar at 1:01 / 4:44.

Dein Mix der Woche
Von Spotify
30 SONGS

PLAY

NICHT MEHR FOLGEN ...

App installieren

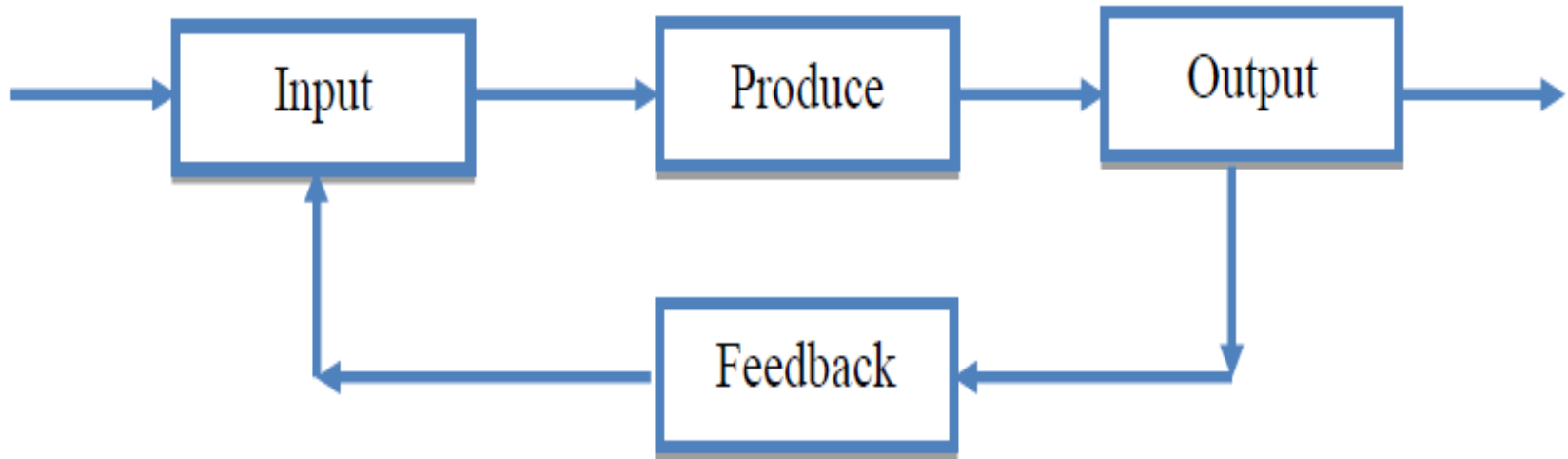
doublem4901

1. **Mon ami** 3:15
Still Fresh - Mon ami
2. **All The Way Up (Remix)** 4:44
Fat Joe, Remy Ma, JAY Z, French Montana, InfaRed - All The Way Up (Remix) (feat. French Montana ...)
3. **Need Somebody** 3:31
Zolo, Tory Lanez - Need Somebody
4. **Say Less** 3:24
Dillon Francis, G-Eazy - Say Less
5. **Tupac Shakur** 4:26
Lil Cezer - Tupac Shakur
6. **Childish (feat. Yg)** 3:55
Bobo Norco, YG - Childish (feat. Yg)
7. **Kronan** 3:12
Blizzy - Djungelblå
8. **Askungen** 3:39
Ozzy - Askungen
9. **Mamacita** 3:39
KESI, Benny Jamz - Mamacita

All The Way Up (Remix)
Fat Joe, Remy Ma, JAY Z, French Montana, InfaRed

1:01 / 4:44

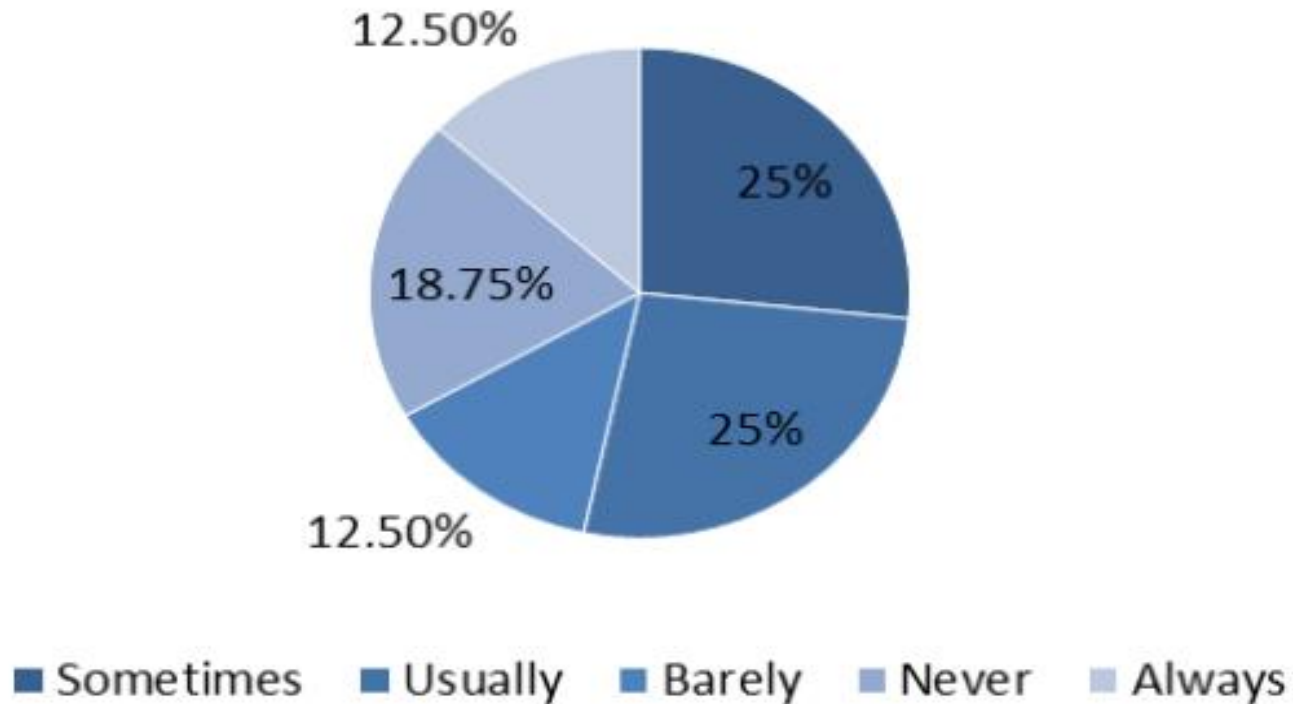
Feedback System



Theory of general feedback system [1]

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Results in Spotify



Frequency of pressing „like“ when users find songs matching their taste [1]

Conclusion – Collaborative Filtering

Advantages	Disadvantages
Evaluates information that is difficult to be analysed	Cold-start problem
Avoids low accuracy by matching items with neighbourhood users	Unusual taste leads to poor recommendations
Provides users with not similar recommendations but based on taste	Personalization weakened with popular songs recommended
	Big amount of data needed

Conclusion – feedback system improvements

- Time delay of correcting measures
- Requirements, features and development for every system
- Users moods are not important which leads into the inaccuracy problem

Papers

- [1]: Exploring drawbacks in music recommendation systems
- [2]: A survey of music recommendation systems and future perspectives
- [3]: A model-based music recommendation system for individual users and implicit user groups
- [4]: Collaborative Filtering for implicit feedbacks

Sources

- [5]: <https://developer.spotify.com/spotify-echo-nest-api>
- [6]: <https://qz.com/571007/the-magic-that-makes-spotifys-discover-weekly-playlists-so-damn-good>

Time for your questions!