

# Music Search Engines: Specifications and Challenges

Alexandros Nanopoulos, Dimitrios Rafailidis, Maria M. Ruxanda, and Yannis Manolopoulos

**Abstract**—Nowadays we have a proliferation of musical data available over the Web. One of the imperative challenges is how to search these vast, global-scale musical resources to find preferred music. Recent research has envisaged the notion of Music Search Engines (MSEs) that allow for searching preferred music over the Web. In this paper, we examine the growing research topic of MSEs, and provide potential specifications to follow and challenges to face.

**Keywords**—Multimedia Information Retrieval; Audio input/output; Sound and Music Computing; Web Search.

## 1. INTRODUCTION

Successful technologies, like the Web, file compression, or handheld music devices, changed the way that music is distributed and consumed, resulting to a unique characteristic: never before we had access to such global-scale, vast amount of musical resources. Novel opportunities are created for the music industry, by increasing the demand for music. Several commercial systems have been developed with varying objectives, e.g., online purchasing of tracks/albums or music recommender systems. As well, the research field of Music Information Retrieval (MIR) responded promptly by active research within the topics of music search and retrieval, such as the International Conferences on Music Information Retrieval (ISMIR) (<http://ismir.net>) supported by the emergence of the web service MIREX (the Music Information Retrieval Evaluation eXchange: <http://music-ir.org/mirexwiki>) that standardizes datasets used for the evaluation of the proposed MIR algorithms.

Several issues have emerged, both technological and economical. Among them there is the imperative need to address one big challenge: how to search the vast amount of available musical resources to find preferred music? Numerous existing commercial systems rely on simple searching by metadata (song titles or artist names). This has significant limitations [2], such as the ambiguity or the inability to search for songs with specific musical characteristics. By viewing the Web as a global-scale musical resource, we confront new issues that, so far, have not been thoroughly addressed. Motivated by this fact and inspired by web search engines, recent researches [4,7] have envisaged the development of *music search engines* (MSE). MSEs search preferred music over the Web. Other multimedia types, such as images, have already been included in web search engines. Due to the vehement competition between search-engine vendors and the proliferation of online musical content, developments in the field of MSEs will appear in the near future [12].

The objective of this article is to tackle the growing research topic of MSEs, and to provide potential specifications to follow and challenges to face. For this reason, we have examined 60 existing commercial and research prototype systems, henceforth called *music exploration systems*. In this paper we focus on 20 of the most prominent music exploration systems to identify possible solutions (Section 2). Next (Section 3), we present specifications for MSEs, based on findings from the present survey. Moreover, we describe the challenges that have not been considered so far by music exploration systems, which have to be addressed by MSEs. Finally, we furnish our conclusions (Section 4).

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## 2 CHARACTERISTICS OF EXISTING MUSIC EXPLORATION SYSTEMS

### Functionalities

The most common functionalities found in existing systems are the following:

- *Search by metadata for music-related information:* (artists biography, music reviews, new releases, concerts dates, etc). Known examples are *Allmusic* and *Yahoo!Music*.
- *Search for Lyrics:* *Lyrics.com* and *SearchLyrics.com*.
- *Media Management and Track Identification:* identify metadata for tracks (*Gracenote*). Others (*MusicIP*) organize identified music. With track identification systems (*Shazam*), users record tracks and the system outputs metadata.
- *Search by Track/Artist for music browsing (discovery and listening of music):* popular systems (*Last.fm*, *iTunes*, *Yahoo!Music*) search with various criteria. More narrow criteria may also be used (*Mp3Realm*, *SkreemR*). There exist some systems (*Musipedia* and *Sloud*) where users query by humming.
- *Recommend Similar Music:* based on seed elements (artist, track) users are recommended similar tracks or artists. Popular recommender systems are *Pandora*, *Last.fm*, *Yahoo!Music*, *OneLlama*, and *Musicoverly*.
- *Generate Playlists:* automatic generation of playlists, that satisfy user constraints [1].

### Input/Output

The types of input that are provided by existing music exploration systems can be broadly grouped in two categories: textual input and audio input.

*Textual input* refers to pure textual information, e.g., metadata (*SearchSounds* and *SkreemR*), lyrics (e.g., *Lyrics.com*), or high level textual features, like “smart words” [7] (‘driving music’ or ‘artist with aesthetic voice’) or “tags” [8], which have started to be used in *Amazon* and *Last.fm* (Figure 1b). Other textual features represent high-level concepts, like mood or genre – see *Musicoverly* (Figure 1a) and *MusicRainbow* [9] (Figure 1c).

*Audio input* can be a track or low-level features extracted from a track, to be used for Querying-by-Example. Some systems (*MusicIP*) allow users to input an existing track either from a catalog or to upload one (*Orpheus*), and others to generate audio by recording (*Shazam*), or humming (*Sloud* or *Musipedia* –Figure 2e). An alternative way is to select various low-level features extracted directly from the audio (Figure 2d for *Sony’s Music Browser*).

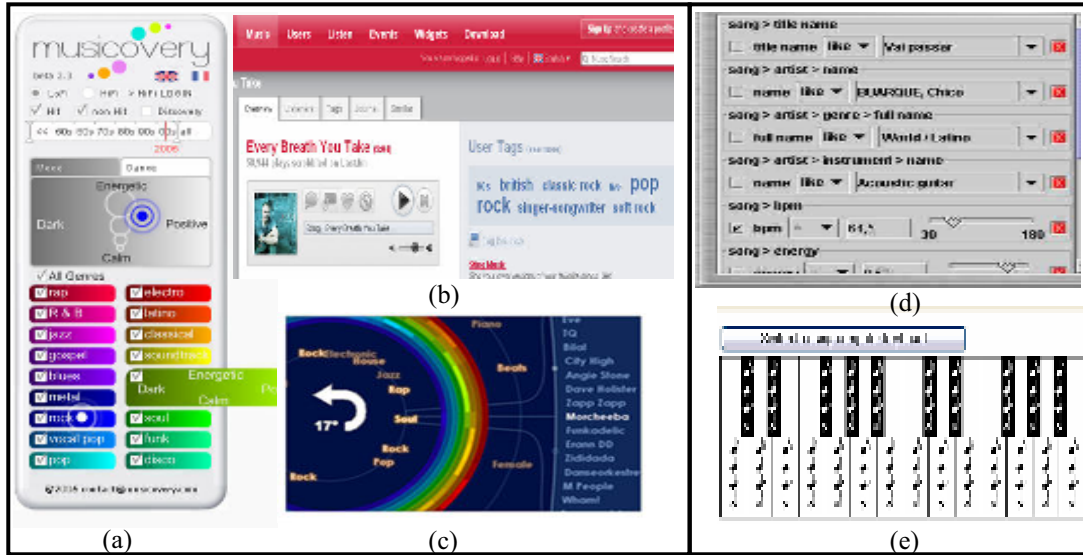


Figure 1: Examples of input.

Input types can be characterized along the following three dimensions. (i) Easiness of interaction: how easily a user provides input; (ii) Control on recall: ability to input various criteria and increase coverage by finding several relevant results; (iii) Control on precision: ability to input exact criteria and find accurate results. Table 1 describes the three corresponding dimensions. Overall, high-level textual features can be considered as the best input type, because they do not have a low mark in any dimension.

	<i>Query specification</i>	<i>Easiness of interaction</i>	<i>Control on recall</i>	<i>Control on precision</i>
<b>Textual input</b>	<i>Metadata</i>	High	Low	Low
	<i>Lyrics</i>	Medium	Low-Medium	Low-Medium
	<i>High-level textual features</i>	High	High	Medium-High
<b>Audio input</b>	<i>QBE based on audio</i>	Low (humming, recording) – High (existing audio)	Low-Medium	Low-Medium
	<i>QBE based on audio features</i>	Low	Medium-High	High

Table 1: Comparison of input types (QBE stands for Query-by-Example).

Output should be displayed in an intuitive, artistic, and appealing manner. We can group output in two basic categories: *non-audio* output and *audio* output. Non – audio provides information about music (*Allmusic* Figure 2a), not the music itself. Media management systems (*Gracenote* and *MusicIP*) display metadata (Figure 2b). Audio-output is presented with links to archives of songs (*Mp3Realm* and *ScreamR*) An interactive radio box (Figure 2c) is used by *Yahoo!Music*, *Pandora* and *Last.fm*. Other systems display playlists (*OneLlama*-Figure 2d and *MusicIP*), or coloured networks (*Musicoverly*-Figure 2e and *Search Inside The Music* by Sun Microsystems-Figure 2f).

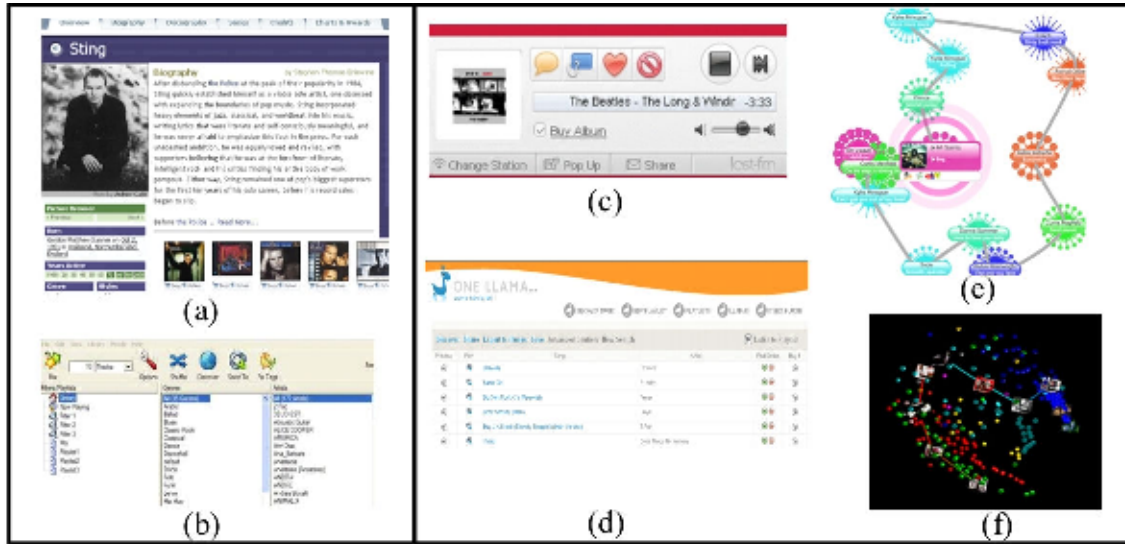


Figure 2: Examples of output.

### Similarity measures

Similarity measures quantify how much alike songs (or artists etc) are to each other. Three general types of similarity measures exist:

- *Audio similarity measures*: are based on audio features, like Mel-Frequency Cepstral Coefficients (MFCCs) and computed with statistical methods, like the Gaussian Mixture Models (GMMs). They cannot capture similarity in terms of human perception [2], but they do not require any human input.
- *Social similarity measures*: are based on features, like tags, collaborative data, playlists, and human opinions, collected from social media sites. They can discover relationships that may be difficult to detect from audio [2]. However, they require a reasonable amount of reliable social features.
- *Hybrid similarity measures*: combine the advantages of audio and social similarity measures, by fusing social with audio features [2,6,7,9].

In Figure 3, known music exploration systems are plotted, where placement is qualitative along two clear axes that represent the audio and the social similarity.

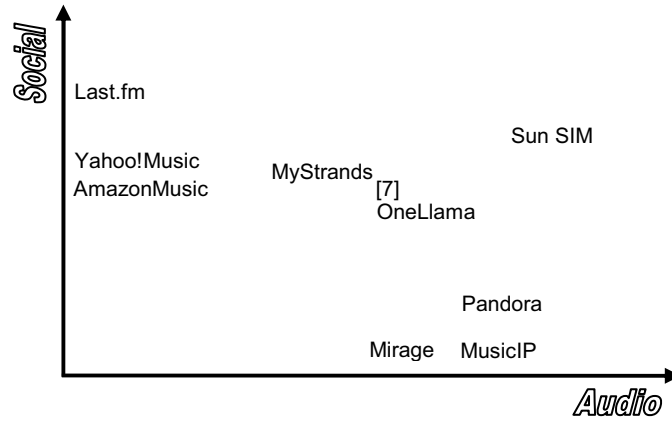


Figure 3: The two dimensions of music similarity.

## 3 SPECIFICATIONS AND CHALLENGES

### Specifications

This section describes the most important specifications for MSEs, by evaluating possible solutions that have been followed. We avoid making exclusive decisions. For each specification we prioritize the presented solutions according to their appropriateness for MSEs.

*Functionalities*: An MSE can have many functionalities. The most important is to search for tracks and artists, because it helps users to find relevant music. Searching for music-related information is important too and is already provided by engines like GoogleMusic.

*Input/Output types*: Metadata is indispensable for input, but may not be adequate. Based on conclusions from Table 1, the most important input type for an MSE is the high-level textual features (they encapsulate metadata). An additional graphical mechanism (see Figure 1c) can help the input process. Audio files as an input type do not allow users to specify any detailed searching criteria. An alternative use is first to extract audio features from an input track, and then provide these features for an “advanced search”. Output in the form of Figures 2e and 2f is more appealing

than simple lists of hyperlinks. Graphical output summarizes various aspects: musical characteristics (mood, genre), metadata and relationships between results.

*Similarity measures:* Hybrid similarity measures are the most promising ones and should be preferred.

*Architecture and copyright issues:* MSE can directly follow the paradigm of web search engines. Content Delivery Networks (CDNs) reduce delivery times (especially for video clips). MSEs could operate in decentralized architectures, such as P2P. Regarding copyright issues, an MSE can act as an intermediate layer. This way, audio output can be provided through external links, in a streaming form, or/and as music snippets.

### *Challenges*

When considering the Web as a big musical resource, we face novel challenges. In this section we describe some of them, which are imperative to solve and have an implementation of real-world MSEs.

The first challenge is how to crawl for musical data. Following web search engines, crawling in MSEs has to identify musical data, either from context or through other sources (catalogues). A prioritization scheme can address the volume of available music data and fast rate of their change. Focused crawlers [5] can be used, but novel approaches are needed too [4]. Due to copyright issues, we can either copy a track or extract features that will help just to index it.

The second challenge concerns the indexing of crawled data, to facilitate fast and accurate retrieval. We have to index huge volumes of acoustic features, which is hard. Established techniques, like GMMs of MFCCs are time demanding [11] and not easily indexable.

The third challenge is about how to rank the results delivered by an MSE. Most existing systems rank search results only by music similarity. However, web search engines rank results according to authority induced from hyperlink analysis (e.g., PageRank). For multimedia data the issue of ranking is very important [3,13]. Nevertheless, in music browsing, serendipity and exploration are important distinctive factors. The balancing between authority ranking and factors like serendipity have just started to be considered [10].

Finally, there is the issue of integration: MSEs can either be independent or can be integrated in existing web search engines. Web search engines have started to provide the ability for searching non-textual like images. The same can be expected for musical audio [12]. Nevertheless, independent MSEs are also expected to appear.

## 4 CONCLUSION

We examined the growing research topic of music search engines. According to latest research findings, we envisage MSEs as systems for searching preferred music over the Web. We believe that, like other multimedia types (i.e., mainly images), music searching will become a mainstream operation in search engines. The competition between search-engine vendors and the vast amount of available musical content that is online are promising for fast developments in this field.

In this article, we first provided a survey of the solutions adopted by existing music exploration systems. Next, according to this survey, we described possible solutions for the case of MSEs. Finally, we presented some of the main challenges that have to be confronted when implementing a real-world MSE.

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#### APPENDIX (CATALOG WITH DESCRIBED SYSTEMS AND THEIR DISTINCTIVE FUNCTIONALITIES)

<b>1. Allmusic:</b> <a href="http://www.allmusic.com">www.allmusic.com</a>	Metadata for music-related information, search by Track/Artist, listen music samples	<b>13. MyStrands:</b> <a href="http://www.mystrands.com">www.mystrands.com</a>	Metadata for music-related information, search by Track/Artist, discover and listen music, recommend similar music
<b>2. Amazon:</b> <a href="http://www.amazon.com">www.amazon.com</a>	Metadata for music-related information, discover music and buy	<b>14. OneLlama:</b> <a href="http://www.onellama.com">www.onellama.com</a>	Metadata for music-related information, search by Track/Artist discover and listen music, recommend similar music, generate Playlists
<b>3. Gracenote:</b> <a href="http://www.gracenote.com">www.gracenote.com</a>	Identify metadata for tracks, search by Track/Artist, listen music, generate Playlists	<b>15. Orpheus:</b> <a href="http://mirsystems.info/index.php?id=392">mirsystems.info/index.php?id=392</a>	Search by Track/Artist, discover and listen music, recommend similar music
<b>4. iTunes:</b> <a href="http://www.apple.com/itunes">www.apple.com/itunes</a>	Organize music, search by Track/Artist, discover and listen music, generate Playlists	<b>16. Pandora:</b> <a href="http://www.pandora.com">www.pandora.com</a>	Search by Track/Artist, discover and listen music, recommend similar music, generate Playlists
<b>5. Last.fm:</b> <a href="http://www.last.fm">www.last.fm</a>	Metadata for music-related information, search by Track/Artist, discover and listen music, recommend similar music, generate Playlists	<b>17. SearchLyrics:</b> <a href="http://www.searchlyrics.com">www.searchlyrics.com</a>	Links to search by metadata for music-related information, links to search for Lyrics, links to search by Track/Artist for music browsing
<b>6. Lyrics.com:</b> <a href="http://www.lyrics.com">www.lyrics.com</a>	Search for Lyrics, search by Track/Artist, listen music	<b>18. SearchSounds:</b> <a href="http://www.searchsounds.net">www.searchsounds.net</a>	Links to search by Track/Artist for music browsing
<b>7. Mp3realm:</b> <a href="http://mp3realm.org">mp3realm.org</a>	Search by Track/Artist, discover and listen music	<b>19. Shazam:</b> <a href="http://www.shazam.com">www.shazam.com</a>	Metadata for music-related information, identify music, discover music and buy
<b>8. Mirage:</b> <a href="http://hop.at/mirage">hop.at/mirage</a>	Search by Track/Artist, listen music, generate Playlists	<b>20. SkreemR:</b> <a href="http://skreemr.com">skreemr.com</a>	Search by Track/Artist discover and listen music, recommend similar music
<b>9. MusicIP:</b> <a href="http://www.musicip.com">www.musicip.com</a>	Organize music, search by Track/Artist, listen music, generate Playlists	<b>21. Sloud:</b> <a href="http://www.sloud.com">www.sloud.com</a>	Identify music, search by Track/Artist, discover and listen music
<b>10. Musicoverly:</b> <a href="http://www.musicoverly.com">www.musicoverly.com</a>	Search by mood, discover and listen music, recommend similar music, generate Playlists	<b>22. Sony Music Browser:</b> <a href="http://www.csl.sony.fr/items/2004/music-browser">www.csl.sony.fr/items/2004/music-browser</a>	Search by Track/Artist, discover and listen music, recommend similar music, generate Playlists
<b>11. Musipedia:</b> <a href="http://www.musipedia.org">www.musipedia.org</a>	Identify music, search by tunes, melodies and musical themes	<b>23. Sun Search Inside the Music (Sun SIM):</b> <a href="http://research.sun.com/projects/dashboard.php?id=153">research.sun.com/projects/dashboard.php?id=153</a>	Organize music, search by Track/Artist, discover and listen music, recommend similar music, generate Playlists
<b>12. MusicRainbow:</b> [9]	Search by Track/Artist discover and listen music, recommend similar music	<b>24. Yahoo!Music:</b> <a href="http://new.music.yahoo.com">new.music.yahoo.com</a>	Metadata for music-related information, search for Lyrics, search by Track/Artist, listen music, recommend similar music, generate Playlists