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The Design and Implementation of a Location-based System for Music Recommendation on the Web

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ABSTRACT

Music serves as a universal medium for expressing emotions and entertainment. With advancements in technology and artificial intelligence, online systems for sharing and recommending music have grown, but a gap remains in location-based, emotion-aware music suggestions. This article proposes a novel system that combines location and emotional context to recommend music. Users can attach songs tied to specific locations and memories on a map, enabling intelligent suggestions for others. The system's hybrid design incorporates user feedback, distinguishing it from existing models. Challenges like incomplete databases and limited user preference data at launch were addressed during implementation. This project aims to enhance music sharing by integrating emotional and geographical contexts, offering a personalized and interactive experience for users.

Keywords: Music, Recommendation Systems, Location-Based Services, Web GIS, Artificial Intelligence

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1 Introduction

All of us have, to some extent, listened to songs or sounds throughout our lives that evoke specific memories. These memories can remind us of the presence or absence of a person, evoke a sense of nostalgia, or place us in a particular situation. Some of these memories are formed in specific locations, and each time we listen to that sound or song, it can help reconstruct the image of that place in our minds. With this explanation, a mental connection between music, place, and memories can be imagined. This mental connection inspires the idea of creating a location-based system for sharing auditory memories in the form of recorded sounds or songs. Accordingly, this proposed system allows users to share these sounds along with their emotions within a location context and on a map. In this way, each user can attach their desired song or sound to specific coordinates on the map. From that point on, these coordinates will serve as audible coordinates for other users to listen to. In this system, using artificial intelligence technologies, when another user passes through the same location, they can be prompted to access a playlist based on the shared sounds. In this case, the user can listen to the suggested music while learning about the emotions and memories of other individuals who have passed through that place. This process can lead to the formation of shared auditory memories among individuals without them having to meet or communicate with each other, a process that is formed solely in the context of a location. This proposed process is considered as a basis for designing a location-based music recommendation system called Audible Coordinates (ACOORD).

This article is organized into four sections. The second section reviews related research and similar projects in this area. The third section discusses the theoretical foundations of the research. The fourth section explains the implementation process and architecture of the system. Finally, the fifth section summarizes and discusses the challenges ahead.

2 Background of the Research

With the expansion of technology and the widespread use of smartphones, the use of location-based services has gained increasing attention. In these services, the location of users serves as a basis for providing various services. Examples of these services include location-based social networks [1], location-based games [2], the health sector [3], and transportation services [4]. Here, we will review studies that recommend music to users based on their location.

In [5], regarding the increasing volume of online music, the necessity of launching context-aware recommendation systems is discussed. One of the parameters considered as contextual information for users is the user's favorite locations. In this process, location names have been tagged to songs, and a set of similarity criteria has been established to match songs with places based on the labeled resources. In the mobile application developed in this research, the evaluation process has been carried out by examining the ratings that users have given to the suggested songs. In [6], the positive impact of music on the motivation and performance of individuals while running is examined, and a system for recommending and playing Spotify songs based on location in the city of Zaragoza is presented. This system is a location-based mobile application that predicts the next suggested song. These predictions are made by an intelligent system that combines regression techniques with spatial and musical data and performs the music recommendation process by classifying data based on trained models. An important point is that in this research, the runner's location is not directly used to provide recommendations; rather, it is utilized to infer their feelings based on their current situation.

In [7], the user's location is mentioned as one of the most important aspects that has been overlooked in artificial intelligence techniques for facilitating context-aware music recommendations. This paper presents a music recommendation system that effectively identifies suitable songs for various popular locations in everyday life. To achieve this goal, a Location-aware Topic Model (LTM) is proposed, which extracts the relationship between songs and locations using a Music Concept Sequence Generation (MCSG) scheme. Comparisons with other music recommendation systems demonstrate the superior performance of the designed system in recommendation accuracy by associating the content of locations with music.

In [8], a music recommendation system has been developed using real-time contextual data and information about the user, such as time, location, weather, and facial expressions. In this system, machine learning algorithms like CNN and DNN are employed to create a model that can classify song samples in various styles and recommend music based on the user's contextual parameters using the APIs of Spotify and LastFM. The ultimate goal of the paper is to provide personalized music recommendations to users.

The topic of music recommendations based on location has also been addressed in similar research [9], [10], [11], [12], [13]. However, in most of these studies, the user must be in the exact specified location to receive recommendations (and not just in the vicinity), or the system merely identifies the type of location based on the user's position and provides music recommendations related to that location. In contrast, the proposed system takes into account the distance and proximity to neighboring points. In this case, the user can receive a list of suggested songs from the system even while on the move, based on their proximity to a set of points. Furthermore, existing systems either require a vast amount of data to train their AI models or depend on APIs from other music recommendation systems to provide their services, which are generally not available in our country. The proposed system will be able to make recommendations even at the initial launch phase, when there is not a large volume of data available, by utilizing spatial analyses (finding the nearest points, determining the user's position within specified ranges) from a smaller dataset. As more users engage with the system and the volume of data increases, the system will also be able to provide better recommendations. Additionally, the system will offer users the ability to record ambient sounds and directly upload music files, eliminating the need to access songs through APIs of other systems, which is a requirement for most existing services.

3 Theoretical Foundations

The system proposed in this project is essentially a combination of individuals, mobile computing, artificial intelligence-based systems, recommendation algorithms, service-oriented architectures, and Geospatial Information Systems (GIS). Accordingly, it can be considered a subset of Web GIS, Location-Based Service, and recommendation systems, leveraging the advantages of each of these systems to provide services to users. The following section will detail the specifics related to each of these systems.

3-1 Location-Based Services (LBS)

Location-Based Services utilize spatial data to provide services and information tailored to the specific location of the user. In these systems, users' positions are determined using Wi-Fi networks, cellular networks, and GPS receivers installed on users' smartphones. Once the users' locations and contextual information are received, the data analysis and processing begin, and the results are sent to the user [14].

3-2 Web GIS Systems

Web GIS are considered a new generation of GIS that utilize web technologies for the storage, visualization, analysis, and distribution of spatial data over networks and the internet. These systems typically consist of a web server and a client, which can be a web browser, a desktop application, or a mobile application. However, due to the need for scalability and expandability of systems resulting from the significant growth of spatial data and the increasing number of users, the client-server architecture may not adequately meet user demands. Therefore, it is essential to consider more advanced architectures for the development of these systems. One type of architecture used in Web GIS systems is Service-Oriented architecture. In this architecture, different components of an application are defined as independent and reusable services. These services communicate with each other through standard communication methods such as SOAP or REST. The primary goal of this architecture is to enhance the flexibility and scalability of the systems, allowing each service to be developed, deployed, and managed independently.

3-3 Recommendation Systems

Recommendation systems are a subset of artificial intelligence-based systems that provide users with suggestions in various domains based on a set of characteristics associated with the user or content, utilizing machine learning algorithms. In a general classification, these systems can be categorized into three main groups [15]:

- Content-based systems: These systems recommend items to users based on their past preferences and behaviors. This type of system analyzes the user's historical data, such as usage history and feedback, and suggests items that are similar to those the user has previously interacted with.

- Collaborative filtering systems: These systems recommend items to users based on the preferences and behaviors of other similar users. They analyze the historical data of the user as well as data from other users with similar preferences and suggest items that similar users have previously liked or interacted with. This type of recommendation system is classified into two categories: user-user collaborative filtering and item-item collaborative filtering. User-user collaborative filtering recommends items based on the preferences of similar users, while item-item collaborative filtering recommends items to the user based on the priorities of similar items.
- Hybrid recommendation systems: These systems utilize the capabilities of both content-based filtering and collaborative filtering techniques to provide more accurate and diverse recommendations. This type of system combines user data, item data, and other contextual information to generate recommendations. In this case, content-based filtering is used to recommend items that are similar to those the user has previously interacted with, while collaborative filtering is used to recommend items that other similar users have liked or interacted with [16].

Another important issue related to recommendation systems is the user feedback on the recommendations provided to them by the system. This feedback can be explicitly expressed by the user to indicate their satisfaction with a recommendation, or it can be implicitly determined based on the user's interactions with the system. Based on this feedback, the suggestions offered to a user can be customized more accurately, and the quality of the recommendations from the recommendation system can also be evaluated accordingly [17].

3-4 Location-Based Music Recommendation Systems on the Web

The system to be implemented in this project is a combination of LBS, Web GIS, and recommendation systems. Users can access this system through their web browsers and receive music playback recommendations based on their current location and the information available in their profiles. This system utilizes a combination of auditory patterns, song characteristics, users' emotions at the time of uploading sounds, and their feelings while using the system to suggest playlists of songs and recorded sounds. Therefore, it can be classified as a hybrid recommendation system. In addition to music suggestions from the system, by leveraging Web GIS capabilities, users can view a list of all locations where other users have uploaded sounds. Music enthusiasts who love discovering and listening to new music can identify and listen to popular location-based songs or well-known tracks in their desired locations in this way. Unlike most other recommendation domains, which primarily rely on collaborative filtering methods, music recommenders have traditionally embraced content-based approaches. However, in recent years, music recommendation models have utilized both content-based and collaborative data. Accordingly, this paper employs hybrid methods for music suggestion.

A common challenge in most recommendation systems is the cold start problem. This challenge refers to the situation where there is a new user, and therefore there is no historical data upon which to base recommendations. Additionally, at the time of system launch, the number of uploaded sounds may not be sufficient to require complex analyses for playlist suggestions. As the number of sounds, locations, and user interactions with the system increases over time, machine learning techniques can be employed to provide suggested playlists. Therefore, the implementation of the proposed system occurs in two phases: initial and advanced.

In the initial phase, the system executes a location-descriptive query in the system's database based on the user's emotions when requesting the suggested list, the predominant style of the proposed music, the distance from musical points, the time, and the ratings given to various songs, and sends the result to the user. In this phase, there is no need for a large volume of data.

In the advanced phase, due to the high volume of data, artificial intelligence methods and machine learning techniques are used to suggest playlists. In this phase, the most important data include the user's interactions with the system and their usage history. These interactions consist of listening to a song, uploading a song, or rating a song by the user in a specific location. The overall process of song playlist suggestion in the advanced phase is illustrated in Figure (1).

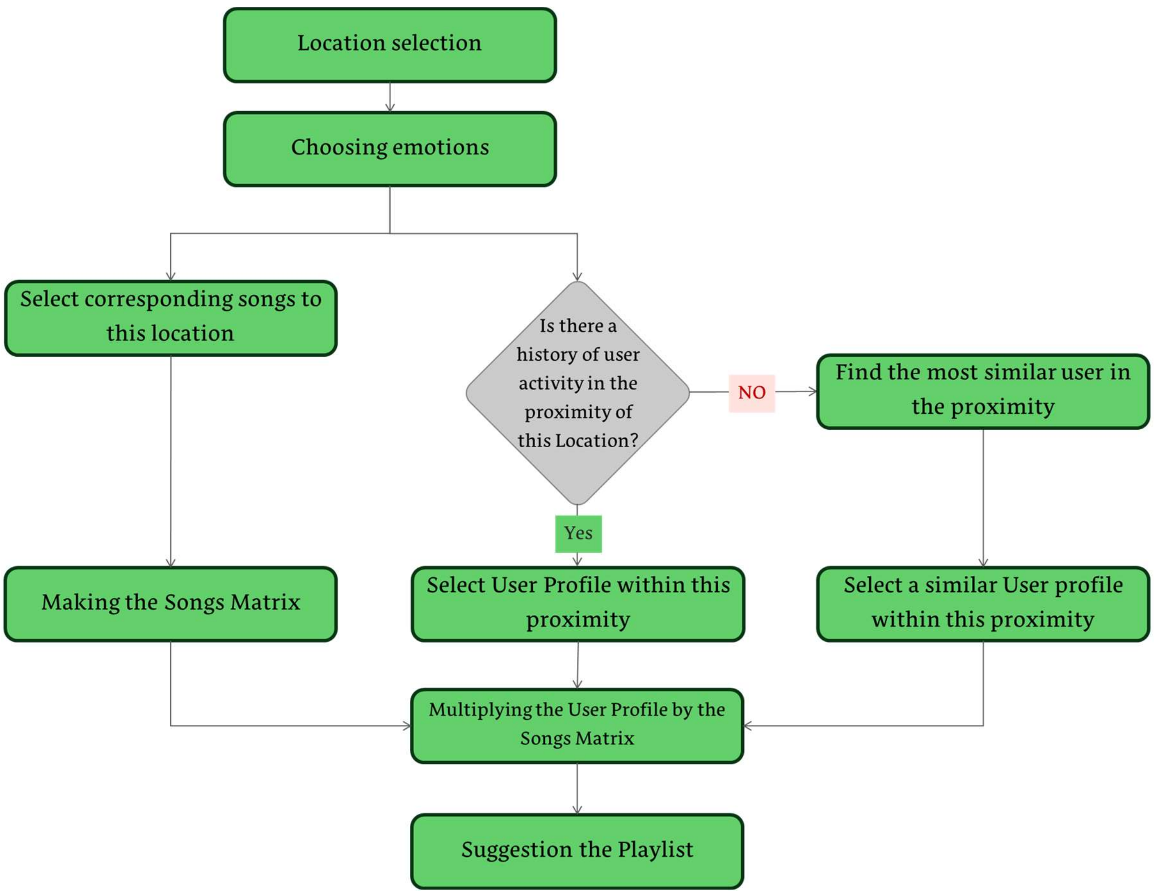

Figure 1. General process of music recommendation in the advanced phase

In this phase, for each of the different locations in which the user has received a list of suggested songs from the system and the emotions they felt at that moment, a user preference list (user profile) is created based on the ratings the user has given to various songs. This list weights the user's interest in different music styles at that location and with that specific emotion. Now, if the user finds themselves in a new location, the list corresponding to the closest place where they have previously listened to a song or rated a song is selected. By multiplying this list with the song-loading matrix in the new location, a weighted matrix is obtained. By calculating the average of these weights, the recommendation matrix is derived. The overall process of these calculations is illustrated in Figure (2).

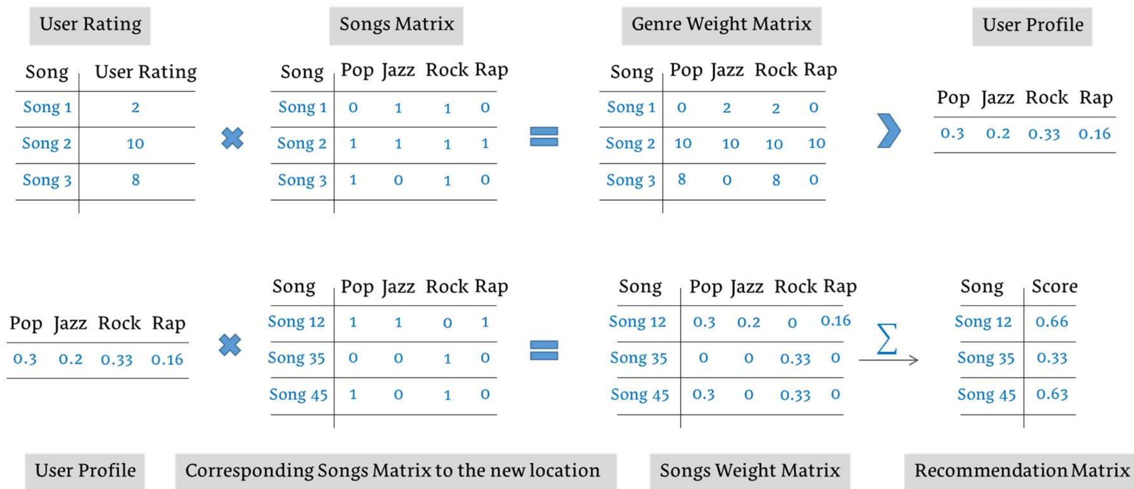

Figure 2. Overall process of calculations

This recommendation method is intended for cases where the user has a previous history of using the system and listening to music near the desired point. If these conditions do not exist, the profile of the most similar users in that area is taken into account in the calculations. To find similarity between users, characteristics such as gender, age, type of activity, and predominant emotions are used in relation to Cosine Similarity. Equation 1 shows this similarity [19]:

$$Cosine\ Similarity(X,Y) = \frac{X.Y}{|X|*|Y|} \qquad \text{(Eq.1)}$$

In this equation, X.Y represents the dot product of the two vectors, and |X| and |Y| are the lengths of the two vectors.

When a user rates the recommendation list, their profile is recalculated and updated in that location to be used in future recommendations. An important point that needs to be discussed here is the evaluation of the recommendations provided by the system. For this, criteria such as the average ratings given to all songs in a list, the duration of time the user listened to each song in that list, or the ratings given to the first three songs in the list can be calculated.

4 Implementation

The proposed system is an intelligent music recommendation system that provides its services based on the user's location and emotions. The proposed architecture for implementing this location-based web system is a service-oriented architecture. This architecture is illustrated in Figure (3).

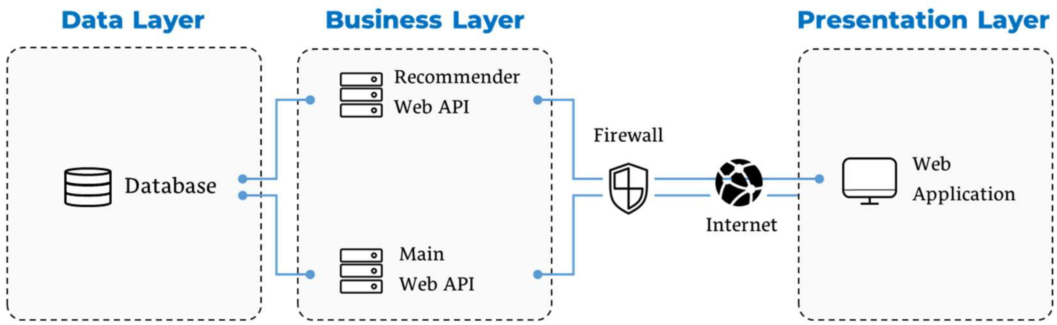

Figure 3. Proposed Architecture of the System

In this architecture:

- The database contains a collection of information and data that exist in the system or are intended to be uploaded by users. This data includes user information, sounds details, pinned locations, spatial areas, users' listening interests, ratings, song playback information, and suggested playlists. The database used in this project is SQLite, with the SpatiaLite extension installed on it.
- The recommendation section analyzes the data upon receiving a user request. This section is a WebAPI developed using Django technology. In the initial phase, the analysis process is based on the spatial-descriptive-temporal filtering of the data in the database, and in the second phase, it uses the scikit-learn library. This library provides an easy-to-use framework for building recommendation systems and is designed to work well with large and sparse datasets. It also allows for customization of the system according to specific needs.
- The main WebAPI of the system: This part is responsible for controlling user access to the system, managing user access levels, receiving uploaded music and ratings given by users, as well as storing this information in the database.
- User interface: The section for user interaction with the system is a website implemented with the MVT architecture within the Django framework. Logging into the system, displaying the base map, showing positions registered by users, enabling song playback by selecting any of the points, allowing music uploads, receiving a suggested playlist from the system, and providing ratings for songs are the main features of the user interface. Data display is carried out using the OpenLayers library.

According to Figure (4), when a user wants to upload music to the system, they select the upload tool and then click on their desired location on the map. This action opens the music upload form, allowing the user to proceed with the upload.

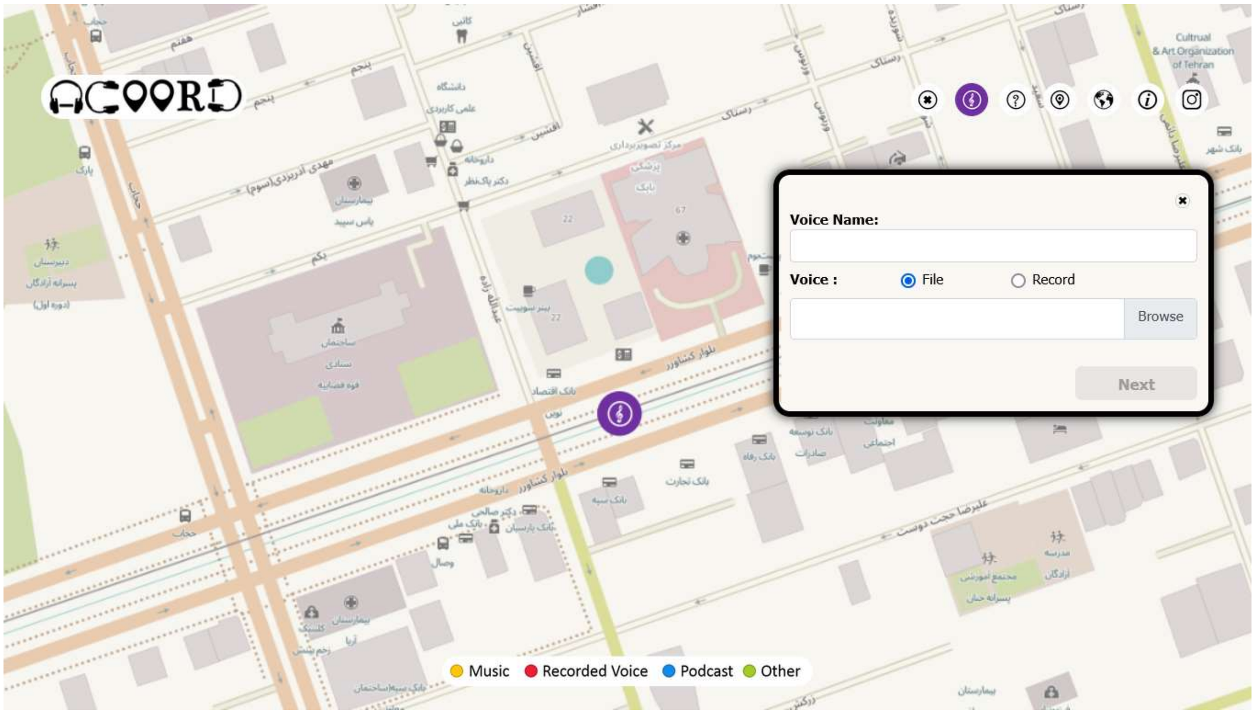

Figure 4. Music Upload Form in the Proposed System

After the system administrator's approval, this music will be available for playback in the system. Now, if another user passes by that location, similar to Figure (5), the system will suggest this music to them, and the user will be able to listen to it.

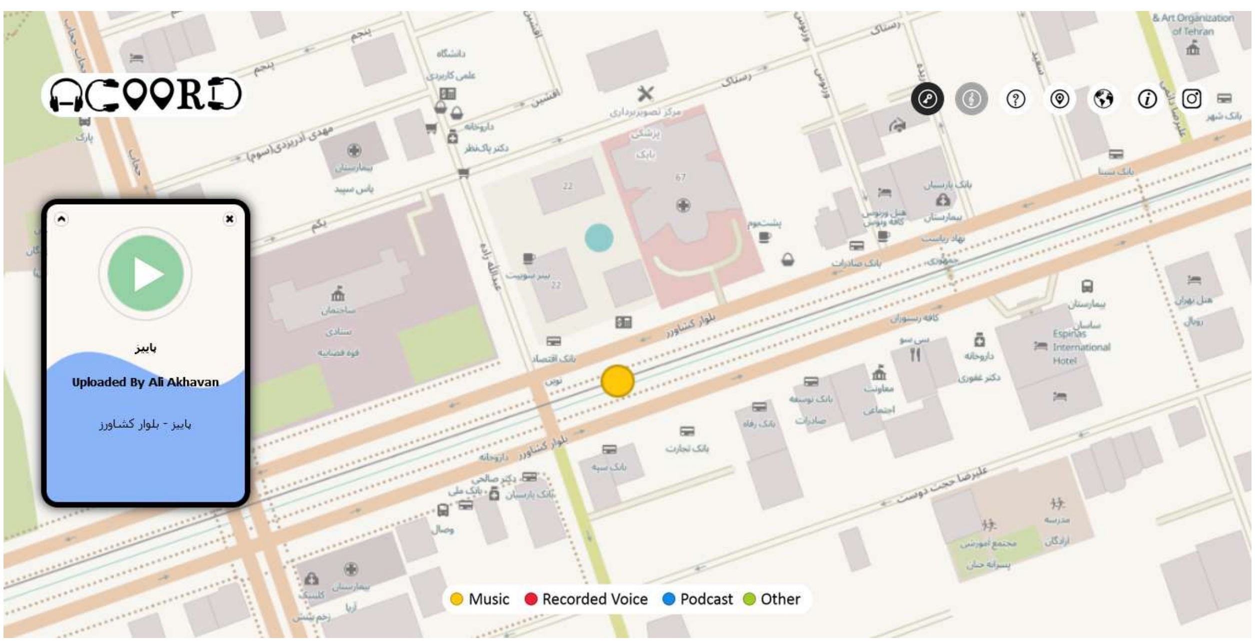

Figure 5. Listening to the recommended music in the system

5 Conclusion

With the expansion of technology and the widespread use of smartphones, alongside the growth of location-based services, there remains a noticeable gap in memory-based location services. Unfortunately, most existing music recommendation methods are based on stylistic features that cannot meet the emotional needs of listeners [20]. Since a part of this nostalgic feeling is conveyed through listening to songs or recorded sounds, this paper presents and implements the idea of designing a music recommendation system based on location and emotion. This system relies on artificial intelligence and utilizes machine learning algorithms. The proposed system is a web-based location service that receives user requests through the user interface layer and, based on these and other available data in the database, sends a list of recommended songs for the user's current location. The recommendation system acts based on location concepts and analyses such as proximity, neighborhood, and specific boundaries in relation to music suggestions. Additionally, by considering both initial and advanced phases, it has managed to address the challenge of incomplete databases at the start of operation. The system employs techniques from content-based filtering as well as collaborative filtering for music recommendations.

The quality of this service can be evaluated based on user feedback and ratings given to the playlists. As the number of user feedback increases concerning the recommended playlists, various statistical tests can be employed to evaluate the system's performance concerning the quality of recommendations based on the locations and emotions of users.

Although various considerations have been taken into account in the design and implementation of this system, challenges still exist that need attention. The first concern is the content uploaded by users to the system. Users may share any type of content, so it is essential to control this content from security, ethical, and other perspectives before allowing others access. When the number of users is low, this can be managed manually, but as the user base grows, an intelligent solution is necessary. The next challenge involves copy-rights of the music, for which a mechanism must be established to prevent the dissemination of copyrighted music. The unavailability of GPS in densely populated urban areas and indoor environments, along with concerns regarding user data security due to location tracking, are other challenges that must be addressed before launch. Alongside these challenges, suggestions for improving the quality of services provided by this system are proposed here. Considering additional parameters such as user movement speed, type of user activity (reading, driving, etc.), and weather conditions can lead to more customized playlists, or special routes based on the user's favorite songs can be suggested for traveling from one point to another. Furthermore, with the increase in data volume—users, songs, and user ratings—data analysis can be conducted to extract hidden patterns within the data. For example, using artificial intelligence methods such as clustering various locations and assigning an overall sentiment to songs, different areas of the city can be classified based on the general emotions of individuals. This emotional zoning of the city can be utilized in governance and urban planning for space management, location-based advertising, spatial marketing, tourism, and security.

References

[1] Xiang, H., Xie, M., & Fang, Y. *Study on The Architecture Space-Social Network Characteristics Based On Social Network Analysis: A Case Study Of Anshun Tunpu Settlement*. Ain Shams Engineering Journal, 15(1), 102333, 2024.

[2] Maia, L.F., Nolêto, C., Lima, M., Ferreira, C., Marinho, C., Viana, W., & Trinta F., *LAGARTO: A LocAtion Based Games AuthoRing Tool Enhanced with Augmented Reality Features*, Entertainment Computing 22: 3–13. 2017.

[3] Horta, E.T., Lopes, I.C., & Rodrigues, J.J.P.C., *Ubiquitous MHealth Approach for Biofeedback Monitoring with Falls Detection Techniques and Falls Prevention Methodologies*, In Mobile Health, Cham: Springer, 2015.

[4] Bucher, D., Jonietz, D., & Raubal, M., *A Heuristic for Multi-Modal Route Planning*, In Progress in Location-Based Services 2016, 211–229. Cham: Springer, 2017.

[5] Schedl, M., & Schnitzer, D., *Location-Aware Music Artist Recommendation*, International Conference on Multimedia Modeling, 2014.

[6] Álvarez, P., Zarazaga-Soria, F.J., & Baldassarri, F.J., *Mobile music recommendations for runners based on location and emotions: The DJ-Running system*, Pervasive and Mobile Computing, Volume 67, 101242, 2020.

[7] Cheng, Z., & Shen, J., *On Effective Location-Aware Music Recommendation*, ACM Transactions on Information Systems 34(2):1-32, 2016.

[8] Dawar, S., Chatterjee, S., Hossain, M.F., & Malarvizhi, S., *Music Recommendation System Using Real Time Parameters*, International Conference on Recent Advances in Electrical, Electronics, Ubiquitous Communication, and Computational Intelligence (RAEEUCCI), Chennai, India, pp. 1-6, 2023.

[9] Kaminskas, M., Ricci, F., *Emotion-Based Matching of Music to Places. Emotions and Personality in Personalized Services*, Human–Computer Interaction Series. Springer, Cham. 2016.

[10] Braunhofer, M., Kaminskas, M., & Ricci, F., *Location-aware music recommendation*. International Journal of Multimedia Information Retrieval, Vol.2 (1), pp.31-44, 2023.

[11] Kaminskas, M., Ricci, F., *Location-adapted music recommendation using tags*, User Modeling, Adaptation, and Personalization, 2011.

[12] Kaminskas, M., Ricci, F., & Schedl, M., *Location-Aware Music Recommendation Using Auto-Tagging and Hybrid Matching*, In Proceedings of the 7th ACM conference on Recommender systems. Association for Computing Machinery, New York, USA, 17–24., 2013.

[13] Lee, W.P., Chen, C.T., Huang, J.Y., & Liang, J.Y., *A Smartphone-Based Activity-Aware System for Music Streaming Recommendation*, Knowledge-Based Systems 131: 70–82, 2017.

[14] Özdal Oktay, S., Heitmann, S., & Kray, C., *Linking Location Privacy, Digital Sovereignty and Location-Based Services: A Meta Review*. Journal of Location Based Services, 18(1), 1–52, 2023

[15] Klimashevskaia, A., Jannach, D., Elahi, M., & Trattner, C., *A Survey on Popularity Bias In Recommender Systems*. User Modeling and User-Adapted Interaction, 1-58, 2024.

[16] Deldjoo, Y., Jannach, D., Bellogin, A., Difonzo, A., Zanzonelli, D*., Fairness in recommender systems: research landscape and future directions*, User Model User-Adap Inter 34, 59–108, 2024.

[17] Gao, C., Zheng, Y., Wang, W., Feng, F, He, X., Li, Y., *Causal Inference in Recommender Systems: A Survey and Future Directions*. ACM Trans. Inf. Syst. 42, 4, Article 88, 2024.

[18] Deldjoo, Y., Schedl, M., Knees, P., *Content-driven music recommendation: Evolution, state of the art, and challenges*, Computer Science Review, 51, 100618. 2024.

[19] Rinjeni, T.P., Indriawan, A. & Rakhmawati, N.A., *Matching Scientific Article Titles using Cosine Similarity and Jaccard Similarity Algorithm*, Procedia Computer Science, 234, 553-560, 2024.

[20] Liu, Z., Xu, W., Zhang, W., Jiang, Q., *An emotion-based personalized music recommendation framework for emotion improvement*, Information Processing & Management, 60 (3), 103256, 2023.