"MUSIC RECOGNITION USING AUDIO FINGERPRINTING"

[1]Prof.Shinde B.A.

[1]Professor,ComputerEngineeringDepartment,
DepartmentofComputerEngineering,SRCOECollegeofEngineering,Lonikand,Wagholi,Pune-412216
shindebabaso@gmail.com

[2]Mr.Sanket Chaudhari, [2]Mr.OmDivekar,[2]Mr.Pratik More,[2]Mr.Ravikant Gaikwad

[2]UGStudent,ComputerEngineering
DepartmentofComputerEngineering,SRCOECollegeofEngineering,Lonikand,Wagholi,Pune-412216
sanketchaudhari882001@gmail.com,omdivekar3006@gmail.com,morepratik935@gmail.com,ravikantsg.100@gmail.com

Abstract— *Audio fingerprinting and song recognition play crucial roles in modern music retrieval systems, facilitating song identification and access based on short audio samples. These technologies are instrumental in music discovery and copyright enforcement. This abstract provides an overview of their principles and applications.*

Audio fingerprinting entails converting an audio signal into a unique digital fingerprint, which is then matched with a database of precomputed fingerprints to identify the corresponding song. This process involves extracting distinct features from the audio, such as spectrogram patterns, and generating a compact representation for efficient storage and retrieval.

Song recognition utilizes these fingerprints to identify songs or audio snippets within extensive music libraries. This technology finds applications in music streaming services, copyright protection, and audio content recommendation.

The abstract also addresses the importance of robust fingerprinting algorithms, real-time processing, and challenges posed by noise and signal variations. Additionally, it emphasizes ethical and legal considerations in audio fingerprinting and song recognition, highlighting the need for privacy safeguards and copyright compliance.

Keywords—
Audiofingerprinting,Musicidentification,Acousticfingerprinting,Digitalsignalprocessing,Audiorecognition,Matching algorithm, Spectrogram analysis, Feature extraction, Pattern recognition, Signal processing techniques, Time-frequency analysis, Database querying.

INTRODUCTION

InAudiofingerprintingandsongrecognitionaretechnologiesand techniques designed to identify

and categorize audio content, particularly music. These tools have become increasingly important in our modern, digital world, where vast amounts of audio content are created, shared, and distributed across various platforms and devices.

Audiofingerprintinginvolvestheprocessofextractinguniqueand distinguishing features from an audio recording, such as the arrangementofsoundfrequencies,thepatternofpeaksandvalleys in the waveform, or other characteristics that make each piece of audio distinct. These features are then converted into a compact and recognizable representation, often called a" fingerprint" or" hash."Thisfingerprint servesasadigital signaturefortheaudio, allowing for quick and efficient identification.

Song recognition, on the other hand, is the application of audio fingerprinting technology to match an unknown audio sample against a vast database of pre-existing audio fingerprints. This process enables software to determine the source or origin of a song or audio clip, effectively answering questions like" What song is this?" or" Who is the artist behind this track?"

Audio fingerprinting and song recognition have a wide range of practical applications. They are commonly used in music streaming services to provide users with song information, including title, artist, and album, while listening to songs. These technologies also aid in copyright enforcement and content recognition,helpingtoidentifyandflagcopyrightedmaterialused without permission on various platforms. Furthermore, audio fingerprinting can be used in content recommendation systems, where it helps to personalize the user experience by suggesting music based on the audio content a user is listening to.

Thedevelopmentandrefinementofaudiofingerprintingandsong recognition technologies continueto play a vital role in themusic industry, media content identification, and various other fields where audio content is prevalent.These technologies exemplify the marriage of signalprocessing,data science, and machinelearning tocreateefficientandaccuratetoolsforaudioidentificationinour increasingly digital and connected world.

Audio fingerprinting and song recognition are technologies used to identify and classify audio content, particularly music, in the digital era. They extract distinctive features from recordings, creating a digital signature called a "fingerprint" or "hash." These technologies are used in music streaming services to provide song details, aid in copyright enforcement, and enhance user experience by suggesting music based on the user's audio content. The evolution and refinement of these technologies demonstrate the fusion of signal processing, data science, and machine learning, providing efficient tools for audio identification in the digital world.

Motivation

Audio fingerprinting and song recognition are vital technologies driven by the desire to enhance music-related experiences and services. These innovations empower music enthusiasts by providing seamless ways to identify and discover songs.Whether in publicspaces,ontheradio,orthroughpersonalplaylists,audio fingerprinting offers instant gratification. It fuels curiosity and sparksinterestinnewmusic,creatingadeeperconnectionbetween individuals and the songs they love.

Furthermore, audio fingerprinting serves practical purposes beyond personal enjoyment. It aids in copyright protection, ensuring artists receive due recognition and royalties. For businesses, it enables targeted marketing and playlist customization, enhancing customer engagement

Aim

TheMusicrecognitionwithaudiofingerprintingaimsto:
IdentifySongs:Quicklyrecognizeunknownsongsbytheirsound.
FindMusicbySound:Letuserssearchformusicusingsound,not text.
Auto Tagging: Automatically label music with tags based on its sound.
PersonalizedPlaylists:Createplaylistst ailoredtousers'tastes.
BetterRecommendations:Recommendsimilarmusicbasedon what users like.
Copyright Protection: Help prevent unauthorized use of music. EnhanceSecondScreen: Addinteractivefeaturestoshowsand events by syncing music with extra content.
Instant Music ID: Identifymusic instantly during live events or broadcasts.
Support Research: Aid researchers in studying music trends and patterns.
Accessibility:Make musiceasierto find and enjoy,especially for users with visual impairments.

Objectives

This Music recognition with audio fingerprinting aims to swiftly and precisely identify songs by analyzing their unique audio features. It supports various applications like automatic tagging, playlist creation, and copyright protection. This technology streamlines music search and accessibility across different platforms and devices.

Problemstatement

Even with recent progress, music recognition using audio fingerprinting faces obstacles in swiftly and precisely identifying songsacrossdifferentaudiosettings.Issueslikehandlingnoisyor low-qualityaudioinputscanreducesystemperformanceanduser satisfaction.Moreover,challengesinscalabilityandcompatibility hinder smooth integration across music platforms and devices.

Tackling these hurdles is vital to improve the dependability and effectivenessofmusicrecognitionsystems,offeringusersbetter experiences and supporting various

applications like creating personalized playlists, protecting copyrights, and enhancing accessibility.

ProblemDefinition

Theproblemofaudiofingerprintingandsongrecognitionrevolves around the need to efficiently and accurately identify and match audiocontentinavastanddiversemusicdatabase.Withthe increasing availability of digital music, streaming platforms, and user generated content, there is a growing demand for robust systems that can recognize songs or audio clips in real-time. This technology faces challenges such as noise interference, variations in recording quality, and the immense scale of music libraries. Additionally, intellectual property concerns require precise identification to ensure proper attribution and copyright compliance.

RESEARCHMETHODOLOGY

Assumptions:

1. High-Quality Audio Source - The system assumes that audio input isof sufficientquality and free from significant background noise to generate reliable audio fingerprints.
2. Adequate Processing Power - The system assumes access to computational resources capable of efficiently processing audio data for real-time or near-real-time recognition.
3. Standardized Audio Formats - The system assumes that audio inputsareincommonlyusedformats(e.g.,MP3,WAV)toensure compatibility.
4. Minimal Audio Alterations - Recognition assumes that audio tracks have not undergone extensive alterations, such as pitch shifting or heavy distortion.
5. Legal Copyright Compliance - The use of this technology assumescompliancewithcopyrightlaws,assongrecognitionmay involve copyrighted material.

Dependencies:

1. Accurate Database - Song recognition relies on a well- maintained and up-to-date database of audio fingerprints for matching, necessitating continuous updates and accuracy.
2. Internet Connectivity - For cloud-based recognition systems, a stable internet connection is essential to access remote databases and services.
3. Robust Signal ProcessingAlgorithms - The accuracy of audio fingerprinting relies on the effectiveness of underlying signal processing and pattern recognition algorithms.
4. RegularMaintenance-Regularmaintenanceandupdatesofthe recognition system are necessary to adapt to evolving audio technologies and potential security vulnerabilities.
5. User Privacy Considerations - The system must adhere to privacy regulations and obtain necessary permissions when handling user-generated audio data for recognition.

These assumptions and dependencies collectively support the reliability and effectiveness of audio fingerprinting and song recognition systems.

NonfunctionalRequirements

Non-functional requirements for music recognition using audio fingerprinting encompass various aspects crucial to the system's performance, scalability, security, and user experience:

1. Accuracy:Thesystemmustachievehighaccuracyinidentifying music despite variations in audio quality, background noise, or distortions.
2. SpeedandEfficiency:Rapidrecognitionandmatchingofaudio fingerprints within a large database, ensuring real-time or near- real-time responses for a seamless user experience.
3. Scalability:Ability to scale and handle an expanding music database without compromising performance, accommodating an increasing volume of audio fingerprint comparisons.

4. Robustness: The system should be resilient against environmental factors, diverse audio input sources, and be adaptable to changing technological environments.
5. Security:Ensuringtheprotectionofsensitivedata,securinguser information, and preventing unauthorized access or tampering of the music database and fingerprinting algorithms.
6. Compatibility:Compatibilitywithvariousdevices,fileformats, and operating systems to ensure broader accessibility and ease of integration into different platforms.
7. ResourceUtilization:Efficientuseofcomputationalresources, memory, and storage to optimize performance and minimize the system's footprint.
8. Reliability:Consistentperformanceinmusicrecognitionunder variousconditions,ensuringminimaldowntimeorsystemfailures.
9. Maintainability:Easeofmaintenance,updates,andadaptability to new technologies or industry standards without disrupting ongoing services.
10. User Experience:Prioritizing a user-friendly interface, providing intuitive and seamless interactions, and ensuring minimal latency in the recognition process to enhance user satisfaction.

Functional Requirements

The Functional requirements for an "Audio Fingerprinting and Song Recognition" system typically involve specifying the features and capabilities of the system. These requirements help ensure that the system performs its intended tasks effectively and accurately. Here are some functional requirements for such a system:

1. Audio Input Support:The system should support various audio input formats, including MP3, WAV, AAC, and more.
2. Real-time Recognition:The system should be capable of real- time audio recognition to identify songs as they are played.
3. Database Integration:The system should integrate with a comprehensive database of audio fingerprints and associated metadata to improve recognition accuracy.
4. Audio Preprocessing:The system should be able to preprocess input audio, removing noise, normalizing volume levels, and converting it to a consistent format.
5. Audio Fingerprinting:Generate unique audio fingerprints for each song in the database for

comparison with the input audio.

6. Matching Algorithm:Utilize a robust matching algorithm to comparethegenerated audio fingerprintswith thosein thedatabase and identify the closest match.
7. Recognition Confidence Score:Provide a confidence score or percentage to indicate the system's certainty in the song's identification.
8. Multi-platform Support:Ensure that the system can be integrated into various platforms, such as mobile apps, web applications, and desktop software.
9. Multi-language Support:Support recognition for songs in different languages and dialects.
10. Bulk Recognition: •Allow users to recognize multiple audio files in a batch process, returning results for each.
11. Offline Mode:Provide the ability to recognize songs offline without an internet connection using a local database.

SoftwareRequirements(PlatformChoice)

- OperatingSystem:Windows11
- IDE:VisualStudioCode
- Programming Language:Python

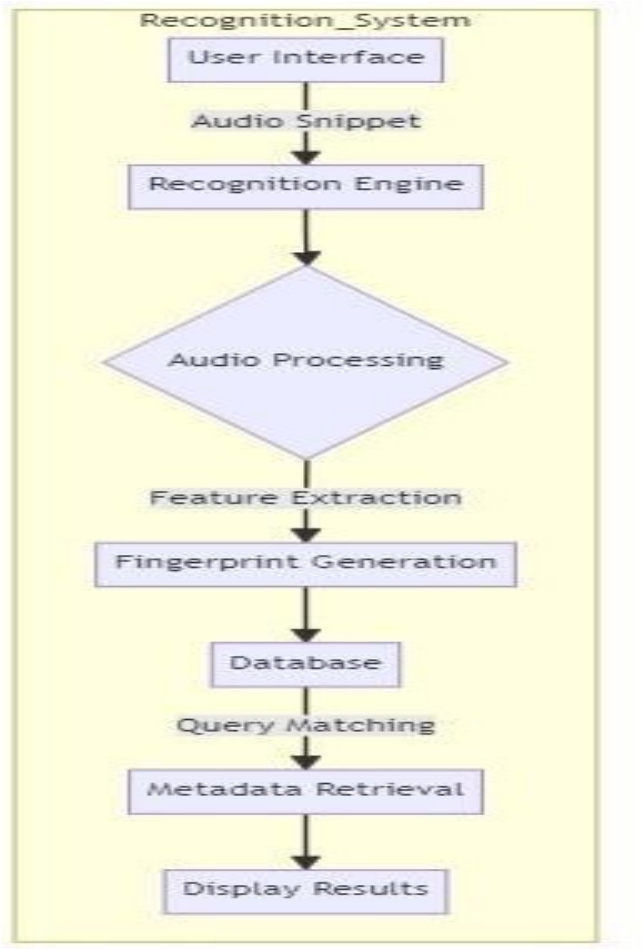
HardwareRequirements

- Processor:Intel(R)Core(TM)i5-4460CPU@3.20GHz
- 3.20 GHz
- RAM: 1GB orMore
- Hard disk:80GBor more
- Monitor: 15"LCD monitor
- Keyboard: Normalor Multimedia
- Mouse:Compatible mouse

SystemDesignandArchitecture

1. AudioInput:Capturesaudiofromsourceslikemicrophones or files.
2. Preprocessing:Enhancesaudioqualityandreducesnoise.
3. FeatureExtraction:Identifieskeyfeaturesintheaudio.
4. Fingerprinting:Createsuniquefingerprintsforeachsong.
5. DatabaseManagement:Storesfingerprintsforquick retrieval.
6. Matching Algorithm:Comparesinputfingerprintwith database entries.
7. Decision-making: Determines the song'sidentity based on matches.
8. UserInterface:Allowsuserstointeractwiththesystem. Feedback andAdaptation: Improves performance based on user input.
9. Integration:Workswithvariousapplicationslikemusic players and recommendation systems.

Figure1.1:SystemArchitecture



DataFlowDiagram

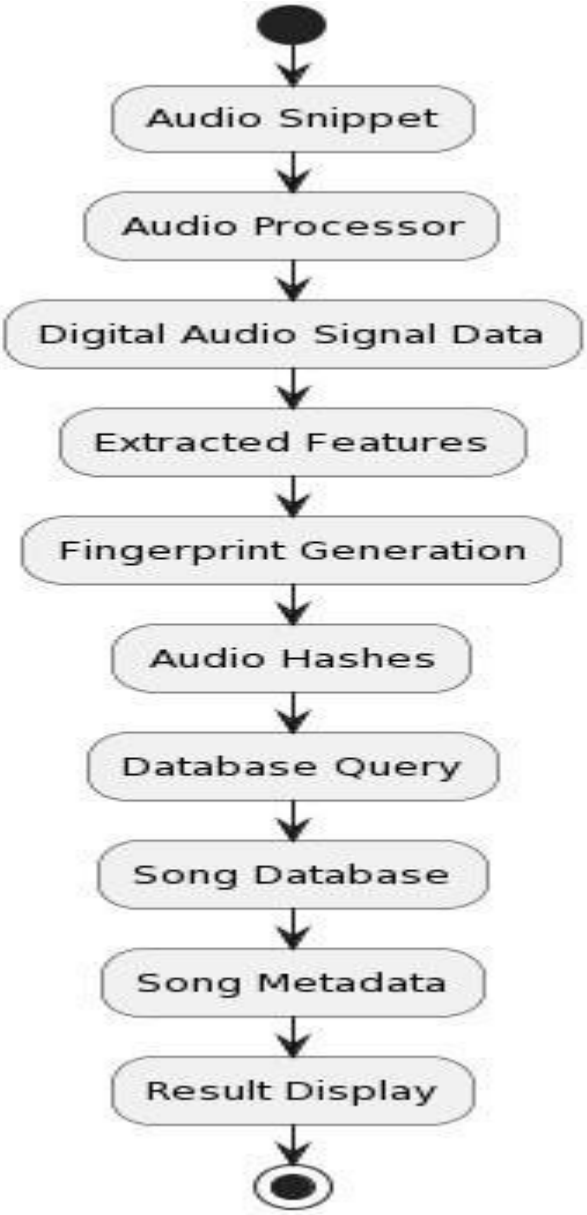


Figure1.2:DataFlowDiagram

- Audio Input: Captures audio from sources like microphones or files.
- Preprocessing:Enhancesaudioqualityandreducesnoise.
- FeatureExtraction:Identifieskeyfeaturesintheaudio.
- Fingerprinting:Createsuniquefingerprintsforeachsong.
- DatabaseManagement:Storesfingerprintsforquick retrieval.
- MatchingAlgorithm:Comparesinputfingerprintwithdatabase entries.

- Decision-making:Determinesthesong'sidentitybasedon matches.
- UserInterface:Allowsuserstointeractwith the system.
- FeedbackandAdaptation:Improvesperformancebasedonuser input.
- Integration:Workswithvariousapplicationslikemusicplayers and recommendation systems

LowLevelData Flow Diagram

1. Input:Getaudiofileorstream.
2. SpectralAnalysis:Break audiointospectralimages.
3. WaveletComputation:Extracttopfeatures.
4. BinaryRepresentation:Createcompact representation.
5. Min-HashSub-Fingerprinting:Generatesub-fingerprint.
6. DatabaseCreation:Storesub-fingerprintsand metadata.
7. QueryProcessing:Analyzeincomingaudio.
8. Sub-FingerprintMatching:Comparewithdatabase.
9. FingerprintMatching:Findbestmatch.
10. MetadataRetrieval:Getinfoforthebestmatch.

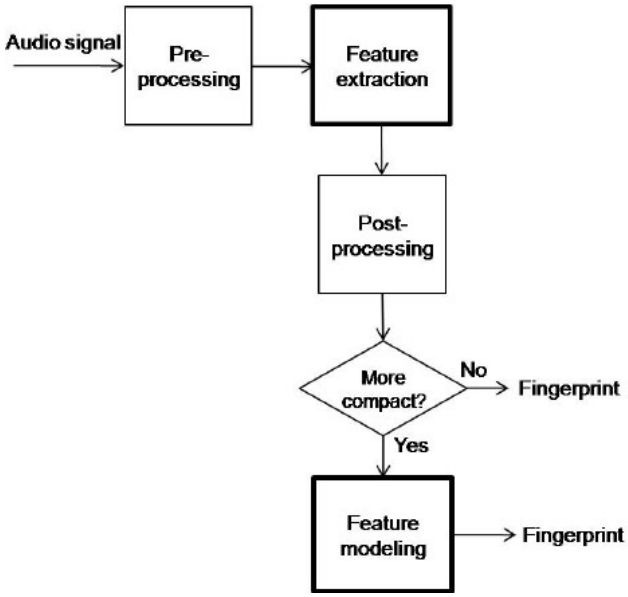
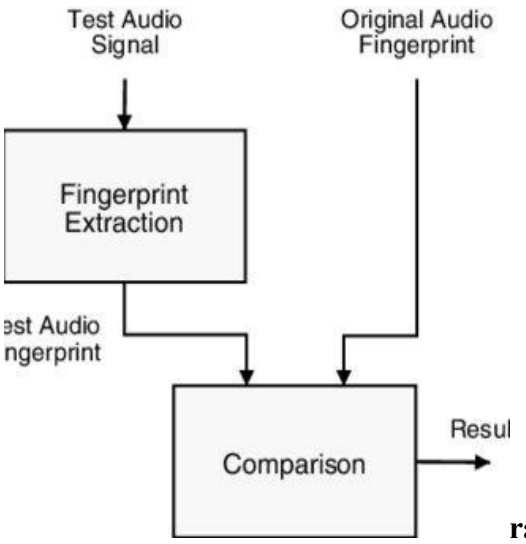


Figure1.3:LowLeveldataflow



ram

UseCase Diagram

Actors:

1. User:Submitsaudioforrecognition.
2. System:Musicrecognitionsystem.

UseCases:

1. GenerateAudioFingerprint:Systemcreatesuniquefingerprints.
2. StoreAudioFingerprint:Systemsavesfingerprintsand metadata.
3. MatchAudioSample:Usersubmitsaudioforrecognition.
4. PreprocessAudio:Systemenhancesaudio quality.
5. RetrieveMusicMetadata:Systemgetsadditionalinfo.
6. HandleNoiseandDistortion:Systemmanagesnoisy audio.
7. ScaleandPerformance:Systemhandleslargeloads. Relationships:

- Usersubmitsaudioforrecognition.

- Systemperformsalllistedtasks.

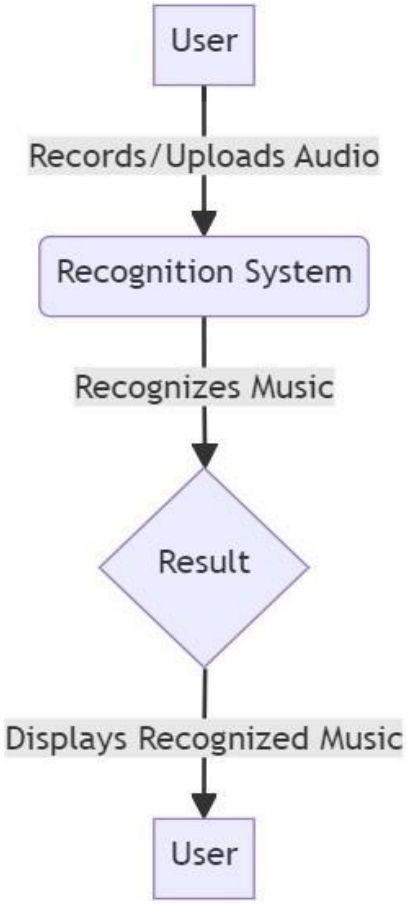
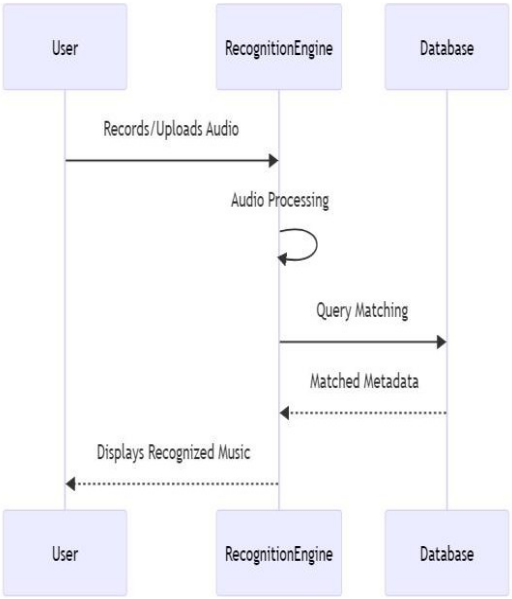


Figure1.4:UseCase Diagram

Sequence Diagram:



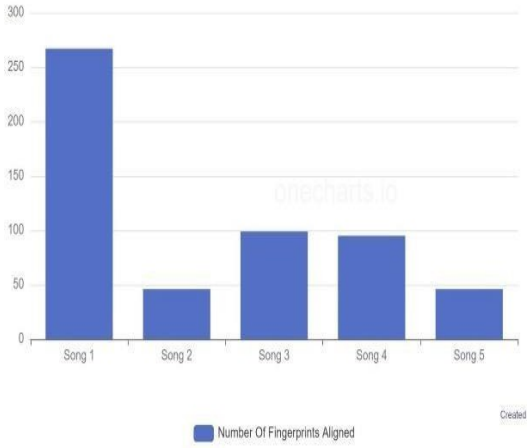
ResultandDiscussion:

Number of Seconds	Number Correct	Percentage Accuracy
1	27 / 45	60.0%
2	43 / 45	95.6%
3	44 / 45	97.8%
4	44 / 45	97.8%
5	45 / 45	100.0%
6	45 / 45	100.0%

Figure1.7:Accuracyofmodelbasedonaligningfingerprints is shown in following bar chart

Figure1.8:AccuracyofMatchingsnippetsbasedon number of seconds recorded is as follows

CONCLUSION



1. EffectiveTechnology:Audio fingerprinting and song recognition technology has evolved to become a highly effective method for identifying and categorizing music. It has found applications in various domains, including music streaming services, copyright enforcement, and even in consumer apps.
2. Improved User Experience: This technology has significantly improvedtheuserexperienceintheworldofmusic.Userscannow easily identify and access songs they hear in various contexts, which enhances their overall engagement with music.
3. Copyright Protection:Audio fingerprinting plays a crucial role

incopyrightprotectionbyhelpingrightsholdersidentifyinstances ofunauthorizeduseordistributionoftheirmusic.Thishasbecome increasingly important in the digital age.

4. Challenges in Accuracy: While audio fingerprinting and song recognition have made great strides in accuracy, there are still challenges, especially in noisyorlow-quality environments. False positives and misidentifications can occur, and continuous development is necessary to address these issues.
5. Privacy Concerns: The use of audio fingerprinting for song recognition has raised privacy concerns. Users may be uncomfortable with the idea that their listening habits can be trackedandanalyzed.Strikingabalancebetweenconvenienceand privacy is an ongoing challenge.
6. CommercialApplications:Companiesinthemusicindustryand beyondareinvestinginaudiofingerprintingtechnologytoenhance theirservices.Thistechnologyhascommercialpotentialinvarious sectors,suchasadvertising,whereitcanbeusedtotarget specific demographics based on listening habits.
7. International Implications: Audio fingerprinting and song recognition have international implications, especially in the context of copyright enforcement and licensing. Ensuring cross-border cooperation and adherence to international copyright laws is essential.
8. Continued Development: The field of audio fingerprinting and song recognition is still evolving. Continuous research and development are essential to improve accuracy, reduce false positives, and address emerging challenges in the digital music landscape.
9. UserEducation:Educatingusersabouthowaudiofingerprinting technology works, its benefits, and potential privacy concerns is crucial.Transparencyanduserconsentshouldbeattheforefrontof its implementation.

ACKNOWLEDGEMENT

It gives me an immense pleasure and satisfaction to present this Research Paper on **" MUSICRECOGNITIONUSINGAUDIO FINGERPRINTING"**whichistheresultofunwaveringsupport, expertguidanceandfocuseddirectionofmyguide**Prof.Shinde**

B.A.andPG-coordinator**OmBanduDivekar**towhomIexpress mydeepsenseofgratitudeandhumblethanksto**ProfShindeB.A.**

H.O.D. for his valuable guidance throughout the presentation work.ThesuccessofthisResearchPaperhasthroughoutdepended upon an exact blend of hard work and unending co-operation and guidance,extendedtomebythesupervisorsatourcollege.Further I am indebted to our principal **Dr. Sujata Rao Mam** whose constantencouragementandmotivationinspiredmetodomybest. Last but not the least, I sincerely thank to my colleagues, the staff and all other who directly or indirectly helped me and made numerous suggestions which have surely improved the quality of my work

REFERENCES

1. Cano, Pedro, Eloi Batle,Ton Kalker, and Jaap Haitsma. ”A review of algorithms foraudio fingerprinting.” In 2002 IEEE Workshop on Multimedia Signal Processing., IEEE, St.Thomas, VI, USA, 2002, pp. 169-173.
2. ACRCloud Docs [Online] Available: https://www.acrcloud.com/docs/acrcloud/introduction/audi
3. Avery Wang. ”An Industrial Strength Audio Search Algorithm.” In ISMIR, vol.2003, pp. 7-13, 2003.
4. Samuel Kim, Erdem Unal, and Shrikanth Narayanan. ”Music fingerprint extractionfor classical music cover song identification.” In 2008 IEEE International Conference on MultimediaandExpo,IEEE,Hannover,Germany,pp.1261-1264, 2008.
5. Prem Seetharaman, and Zafar Rafii. ”Cover song identification with 2d fouriertransform sequences.” In 2017 IEEE International Conference on Acoustics, Speech and Signal Processing(ICASSP),IEEE,NewOrleans,LA,USA,pp.616-620, 2017.
6. Keansub Lee, and Daniel PWEllis. ”Detecting music in ambient audio by longwindow autocorrelation.” In 2008 IEEE International Conference on Acoustics, Speech and Signal Processing, IEEE, Las Vegas, NV, USA, pp. 9-12, 2008.
7. WeiXiong,XiaoqingYu,andJianhuaShi.”Animproved audio fingerprinting algorithm with robust and efficient.” IET International Conference on Smart and Sustainable City 2013, Shanghai, China, pp. 264-267, 2013.
8. Jaap Haitsma, and Ton Kalker. ”A highly robust audio fingerprinting system.” InISMIR vol. 2002, pp. 107-115, 2002.
9. Shumeet Baluja, and Michele Covell. ”Audio fingerprinting: Combining computervision data stream processing.”In2007IEEEInternationalConferenceonAcoustics, Speech and Signal Processing-ICASSP’07, IEEE, Honolulu, HI, USA, 2007.
10. Mehryar Mohri, Pedro Moreno, and Eugene Weinstein. ”Robust music identification, detection, and analysis.” In 8th International Conference on Music Information Retrieval, ISMIR 2007, pp. 135-138, 2007.
11. Shumeet Baluja, Michele Covell, ”Waveprint: Efficient wavelet-based audio fingerprinting”, Journal of Pattern Recognition, vol. 41, no. 11, pp. 3467-3480, November 2008.
12. ThomasC.Walters,DavidA.Ross,andRichardF.Lyon. ”Theintervalgram:Anaudiofeatureforlarge-scalemelody recognition.”InProc.ofthe9thInternationalSymposiumon Computer Music Modeling and Retrieval (CMMR), pp. 295-310, 2012.
13. Beat Gfeller, Ruiqi Guo, Kevin Kilgour et al. ”Now Playing: Continuous low-powermusic recognition.” In 31st Conference on Neural Information Processing Systems (NIPS 2017), Long Beach, CA, USA, 2017.