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Detection of Manipulation in audio files using metadata and spectrograph analysis

Submitted By

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Project submitted to

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In partial fulfilment of the University Regulations for the Degree

BACHELOR OF SCIENCE

IN

FORENSIC SCIENCE

UNDER THE GUIDANCE OF

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Assistant Professor

Department of Forensic Science

Batch 2020-2023

DEPARTMENT OF FORENSIC SCIENCE

CERTIFICATE

This is to certify that the project entitled **“Detection of Manipulation in audio files using metadata and spectrograph analysis”** is a record of bonafide study and research carried out by **ROHAN MATHEW**, under my supervision and guidance as the partial fulfilment of the University regulation for the course of **B.Sc. in Forensic Science.**

Date: 31-05-2023
Place: Bengaluru

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DECLARATION

I **ROHAN MATHEW** hereby declare that this major project entitled **“Detection of Manipulation in audio files using metadata and spectrograph analysis”** is a bonafide and genuine research work carried out by me under the guidance of **Mr. DON CAEIRO** .This project, in full or part, has not been submitted to this or any other University before, for the award or any degree.

Place: Bengaluru

Date: 31-05-2023

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ABSTRACT

In the current rapidly Advancing digital technology have made it possible to use strong tools for editing and enhancing audio content in today's audio manipulation. Digital audio workstations (DAWs) offer fine-grained editing features that make it simple for users to cut, copy, paste, and rearrange audio portions. To get a balanced sound, mixing entails altering levels, panning, and applying effects to individual recordings. In this study there were 35 audio samples which were collected which included 30 audio recordings from Android of the versions (10-13) and 5 audio recordings from IOS of the version 16. Software's such as Reaper and Audacity were used to edit the audio recordings.

Metadata analysis of edited and original audio was done in media info and spectrogram recordings were visualized under sonic visualizer and Spectrum analyser. After the analysis it was noted that alterations were been done to file obtained.

Key words: Audio manipulation, Spectrogram, Metadata, Alterations,

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INTRODUCTION

INTRODUCTION

Digital Forensics is an order to investigate and solve crimes, as well as to verify the validity and integrity of digital data. Digital forensics is the process of gathering, examining, and preserving digital evidence. It entails the extraction and interpretation of data from computers, mobile devices, and other digital storage media using specific tools and procedures.

Data breaches, fraud, cybercrime, and other crimes involving the theft of intellectual property are only a few of the cases where digital forensics are used in criminal and civil investigations. Moreover, it is employed in corporate and governmental investigations to find internal risks, stop them, and make sure that data privacy and security laws are being followed. The field of digital forensics is quickly developing as the emergence of new tools and methods are created to keep up with the dynamic nature of cybercrime. It is a vital part of contemporary law enforcement and cybersecurity and calls for a blend of technical expertise, legal understanding, and investigative experience.

The gathering, preservation, analysis, and presentation of electronic data that can be used as evidence in a legal investigation are all part of the investigation of digital evidence. In order to recover lost, encrypted, or concealed data, it involves looking through digital devices like computers, smartphones, and other electronic devices. It also entails looking through the metadata and other pertinent data linked with the digital files. It takes specialized knowledge and proficiency in computer forensics and data recovery to conduct an investigation of digital evidence, which is a challenging process. The basic procedures for looking into digital evidence are as follows:

- Evidence identification: The first stage is to determine which digital evidence needs to be gathered and examined. Data from computers, mobile phones, servers, and other electronic devices may be included in this.

- Evidence gathering: To prevent data from being changed or lost during the collection process, the evidence is gathered using specialised instruments and methods. To protect the integrity of the evidence, the data is typically duplicated to a different storage device and the original device is protected.

- Evidence preservation: To prevent tampering or destruction, the gathered evidence is stored in a safe, controlled environment. It is necessary to safeguard the evidence in a way that ensures its admission in court.

- Evidence analysis: The data is examined to determine its relevance and authenticity. This could include recovering deleted files, examining metadata, analysing communication records, and employing other techniques to detect patterns or anomalies in the data.

- Evidence presentation: The evidence is presented in a clear, concise, and understandable manner to the court. This could include creating reports, charts, or other visual aids to help the judge or jury understand the data.

During the conduction of the above methods the investigator must make sure that he\she must abide by the laws without violating any personal rights of the individual.

SOUND

Sound is a physical phenomenon that travels through a medium, such as air or water, in the form of a mechanical wave. The wave propagates by compressing and rarefying the particles in the medium, creating a disturbance that moves through it. The nature of sound is characterised by several properties, including frequency, amplitude, wavelength, and speed.

Since the early times of the 1980s when the CD'S were been used to the times of digital phones, the Internet, and podcasts the usage of sound has drastically transformed the whole industry in the 21st century. An American computer scientist Alan kay understood the ability of sound and how much of an impact it would have using in a computer.

By now we all have seen the expanding capabilities of sound in personal computers. "Speaking" computers became renowned and common in all the place and as time went by there we invented microphones for the user to use to speak with the computer and so on.

Sound plays a significant role in the modern world and has many uses across various fields. Here are some examples:

1. Entertainment: Sound is used extensively in the entertainment industry, including music, movies, and video games. It sets the tone, creates an atmosphere, and helps to evoke emotions in the audience.

2. Communication: Sound is used for communication in various forms, including radio, telephone, and public address systems. It helps people to connect and convey messages over long distances.

3. Education: Sound is a crucial component in education, especially in the case of language learning. Audio resources such as podcasts, audiobooks, and online courses are widely used for this purpose.

4. Medical applications: Sound is used in various medical applications, including ultrasound imaging, hearing aids, and cochlear implants. These technologies help doctors and patients in diagnosis and treatment.

5. Acoustics: Sound is used in architecture and design to improve the acoustics of buildings and spaces, such as concert halls, auditoriums, and classrooms.

6. Acoustics: Sound is used in architecture and design to improve the acoustics of buildings and spaces, such as concert halls, auditoriums, and classrooms.

These days sound play a major role in the field of multimedia and here are a few lists of them

1. The most obvious benefit of using audio is that it can provide an interface for visually impaired users, but it also has a number of other benefits for all users:

2. It can convey meaning and serve as an additional channel of communication. It enables the incorporation of redundancy into the presentation of information, so that if the meaning is unclear to a user based solely on visual information, the audio may clarify it.

3. Different learners employ various learning strategies, and audio can provide additional information to support various learning styles. For example, some users may learn more by hearing than by reading a piece of text.

4. Audio can enhance the sense of realism. Musical cultural associations allow you to convey emotion, time period, geographic location, and so on. However, when using audio in this manner, keep in mind that meanings may differ across cultures. Sound spatialization methods are now available, providing the effect of 3D sound and allowing the addition of environmental acoustic effects such as reverberation. For example, Microsoft has defined the device-independent DirectSound interface for spatial sound as part of DirectX for the Windows platform.

5. It can be used to draw attention to important events. Non-speech audio, such as the sound of breaking glass to indicate an error, may be easily identified by users. Because audio can successfully capture the user's attention, it must be used with caution so as not to distract from other media.

6. Communication ease - users may respond better to spoken word than to other media. 'Sound bytes' from satisfied customers, for example, can be used in a company presentation.

(Coorough & shuman, 2005, #)

SOUND QUALITY

Sound quality is critical in any audio recording or listening experience. It refers to a sound's qualities that determine its clarity, accuracy, and overall appeal. Sound quality varies according to the source of the sound, the recording or playback equipment, and the environment in which the sound is heard.

Clarity, pitch, timbre, volume, and distortion are all factors that influence sound quality. Clarity is the ability to distinguish individual sounds, which is required for intelligibility. Pitch describes the highness or lowness of a sound, whereas timbre describes the distinct tone or colour of a sound. The loudness or softness of a sound is defined as volume, and distortion occurs when the original sound is altered in some way, resulting in a different sound quality. Understanding the factors that influence sound quality is critical for ensuring that audio recordings are clear and accurate, as well as enjoyable and engaging listening experiences. Paying attention to sound quality can make a significant difference in how a message is received and perceived, whether it's music, speech, or other forms of audio content.

In the case of recording the sound it can be differentiated into **mono** and **stereo** sound

A type of audio recording or playback that uses a single channel to reproduce sound is referred to as mono sound. All audio signals are mixed and played back through a single speaker or headphone in mono sound, producing a monaural or "single channel" listening experience. Until the mid-twentieth century, the mono sound was the standard for most audio recordings and playback systems. Certain applications, such as voice recordings, podcasts, and phone conversations, continue to use mono sound. Mono sound has some limitations when compared to stereo sound. Because all of the audio signals are mixed together, distinguishing individual sounds or instruments in a mix can be more difficult. However, there are some advantages to mono sounds, such as being more compatible with older playback equipment and being easier to mix and edit in certain situations.

Stereo sound is a type of audio recording or playback in which sound is reproduced using two separate channels, resulting in a more immersive and realistic listening experience. Stereo sound divides audio signals into two channels, with each channel being played back through a separate speaker or headphone. This allows for more spatially accurate sound representation, with sounds panned to the left or right channel depending on their location in the stereo pitch. In the mid-twentieth century, the stereo sound was introduced and quickly became the standard for most music recordings and playback systems. Since then, it has become commonplace in modern audio technology, from headphones and speakers to movie theatres and concert halls.

Stereo sound can create a more immersive and natural listening experience, which is one of its main advantages. Stereo sound can more accurately represent the spatial positioning of sounds, such as the placement of instruments in a mix or the location of sound effects in a movie, by separating the audio signals into two channels. Stereo sound can also improve audio recording clarity and detail, making it easier to distinguish individual sounds and instruments. Stereo sound, on the other hand, necessitates more advanced recording and playback equipment than mono sound and may not be compatible with older playback systems.

(Li et al., 2014, #)

DIGITIZATION OF SOUND

Digital sound has revolutionised the way we create and experience music, movies, and other forms of media. It involves the use of computers and digital technology to produce, manipulate, and reproduce sound. Unlike traditional analog sound, digital sound is stored and processed as binary data, allowing for greater precision and flexibility. Software synthesisers allow you to create new sounds using a variety of synthesis methods, such as subtractive, additive, and FM synthesis. Samplers allow you to use recordings of real instruments or sounds and manipulate them to create something new. Further the digitised sound can be categorised by sampled sound and synthesised sound.

The process of converting analog sound signals into digital data that can be stored, processed, and transmitted in a variety of digital formats are referred to as the digitalization of sound. The analog sound wave is sampled at a specific rate and bit depth, and the samples are then converted into digital data using an analog-to-digital converter (ADC). Once digitised, the sound can be manipulated, edited, and saved in a variety of digital formats such as WAV, MP3, AAC, and FLAC. When compared to analog sound, digital sound is more resistant to degradation and noise, making it ideal for long-term storage and distribution. The way we create, distribute, and consume music and other types of audio content has been transformed by digital sound. It has allowed for the development of new technologies such as streaming services and digital audio workstations, which have transformed the music industry and other related fields.

A sampled sound is a sample that can be used to embellish, add texture, or make loops to a track. Sample sounds, which might be vocal, instrumental, or sound effects, can be used in a variety of methods to create original and cutting-edge sounds. Sampled sound is the digital representation of analog sound signals created through the sampling process.

A continuous analog sound wave is converted into a series of discrete digital samples that represent the amplitude of the sound wave at specific points in time during this process. The sample rate is the rate at which these samples are taken, and it is typically measured in Hertz (Hz). The higher the sample rate, the better the digital samples can represent the original analog sound wave. The digital representation of analog sound signals created by the sampling process is known as sampled sound. During this process, a continuous analog sound wave is converted into a series of discrete digital samples that represent the amplitude of the sound wave at specific points in time. The sample rate is the frequency with which these samples are taken, and it is usually measured in Hertz (Hz). The higher the sample rate, the more accurately digital samples can reproduce the original analog sound wave.

A Synthesised sound refers to the creation of new sounds using electronic means. In music production, software synthesisers are often used to create synthesised sounds. These synthesisers allow producers to manipulate sound waves and create new sounds from scratch. One of the advantages of using synthesised sound is the ability to create unique and original sounds that cannot be achieved with traditional acoustic instruments.

The various parameters that control the sound can be adjusted in real-time, allowing for a wide range of sounds to be created. This has made the synthesised sound a popular tool in music production, as well as in fields such as film and video game sound design.

Subtractive synthesis, frequency modulation synthesis, granular synthesis, and wavetable synthesis are just a few of the techniques used to create synthesised sound. Each of these techniques employs a different method of manipulating sound waves to produce new and distinct sounds.

In short, multimedia developers use sampled sounds to capture naturally occurring sounds such as human speech, music, phone calls, and so on, for editing purposes.

(Bhagtan et al., 2022, 6-10)

QUANTIZATION OF SOUND

Quantization of sound is the process of representing an analog sound signal with a digital signal by converting continuous variations in air pressure (sound waves) into discrete numerical values. Because computers and other digital devices can only store and manipulate digital data, this process is critical for digital audio recording, processing, and playback. Each sample is quantized by assigning a numerical value to it. This is accomplished by measuring the amplitude of the sound wave at each sample point and assigning a numerical value corresponding to the number of bits used to represent the sample. The greater the number of bits used, the more precisely the amplitude can be represented and the greater the dynamic range of the digital signal.

Audio transmission is the process of sending sound or speech signals from one location to another via various communication channels. Audio signals can be transmitted using a variety of methods, including wired and wireless technologies.

Physical cables are used to transmit electrical signals between devices in wired audio transmission. This can include traditional analog methods such as the 3.5mm headphone jack as well as newer digital methods such as HDMI or Ethernet cables. Because it is less susceptible to interference and signal loss, wired transmission is generally regarded as more reliable and secure.

The use of electromagnetic waves to transmit audio signals between devices is what wireless audio transmission entails. Bluetooth, Wi-Fi, and cellular networks are all examples of such technologies. Wireless transmission is more convenient and flexible than wired transmission because it allows for greater mobility and freedom of movement, but it is more susceptible to interference and signal loss.

The transmission method chosen is determined by several factors, including the distance between devices, the desired audio quality, and the level of security required.

(Xiaochang & Mills, n.d., #)

FILE FORMAT

When in the case of downloading or streaming an audio, digital audios have been used in different platforms and software's and it is been saved in the form of file format some of them are enlisted as

AIFF - Apple Macintosh computers frequently employ the audio file format AIFF (Audio Interchange File Format). It was created by Apple Computer in 1988 and, like WAV (Waveform Audio File Format), preserves high-quality audio data while being uncompressed. AIFF files can hold audio data in a range of sampling rates, bit depths, and channel configurations. They commonly have the extension ".aiff" or ".aif." These may be imported into a variety of audio software packages and are frequently used for recording and editing audio files.

MP3 - A digital music file format called MP3 (MPEG-1 Audio Layer 3) uses lossy compression to minimize the quantity of audio data while maintaining a respectable degree of sound quality. One of the most popular digital audio file types is MP3, which can be played on a variety of gadgets like PCs, cell phones, and portable media players. MP3 files are often formed by encoding audio data using a particular codec and have the extension ".mp3". As a result of this codec's analysis of the audio data and removal of extraneous or redundant information, the file size is reduced. MP3 files are not exact replicas of the original source and may suffer from some quality loss as a result of the compression process, which removes part of the original audio data.

WAV - Uncompressed audio data is stored in WAV (Waveform Audio File Format), a digital audio file format. It was created by Microsoft and IBM and is frequently used in computers with the Windows operating system.WAV files, which commonly end in ".wav," are used to hold high-quality audio recordings of all kinds, including music and voiceovers. WAV files offer a high level of audio quality since they are uncompressed and retain all of the original audio data.WAV files offer a high level of audio quality and may be altered without sacrificing any data, making them a common choice in professional audio settings like recording studios.

MIDI - Electronic musical instruments, computers, and other devices can communicate with one another via the MIDI (Musical Instrument Digital Interface) standard. Since its initial introduction in 1983, it has evolved into a music industry standard. MIDI messages are digital instructions that can be used to control the volume, tempo, notes played, and other elements of musical performance. Instead of actual audio samples, MIDI data contains instructions on how to create audio sounds, which may be played back on any MIDI-compatible device.

MIDI data is stored in MIDI files, a category of digital audio file format. Every device that supports MIDI can play back files with the extension ".mid," which are commonly used for MIDI files. MIDI files are substantially smaller than other audio file formats like WAV or MP3 since they do not contain actual audio samples.

Other file formats include **DCR, QUICKTIME (MOV), SWF.**

CYBER CRIME

With the unpredicted growth in the recent field of technology and multimedia, there has been an increase in the number of crimes along with it and this can be categorized as cybercrimes. Cybercrime refers to criminal activities conducted via the internet or other digital networks. Cybercrime has become an increasingly common form of criminal activity as technology and the internet have advanced. Cybercriminals use a variety of techniques to gain access to personal or confidential information, disrupt computer systems, and commit fraud, including hacking, phishing, malware, and social engineering. Individuals, businesses, government organizations, and even entire countries can be the targets of cybercrime. Cybercrime is a serious problem with serious financial, legal, and social ramifications. Individuals and organizations must take precautions to protect themselves from cyber threats, such as using strong passwords, regularly updating software, and being wary of suspicious emails or messages. Furthermore, law enforcement and governments all over the world are working to combat cybercrime through increased regulation and international cooperation.

Cybercrime refers to criminal activities conducted via the internet or other digital networks. Following are some examples of cybercrime:

1. Phishing is the practice of tricking people into disclosing personal information such as passwords and credit card numbers via bogus emails or websites.

2. Malware is software that is designed to harm or disrupt computer systems. Malware is capable of stealing personal information, spying on users, and hijacking computer systems.

3. Ransomware is a type of malware that encrypts a user's files and then demands payment for the decryption key.

4. Identity theft occurs when someone's personal information, such as their name, address, and social security number, is stolen and used fraudulently.

5. Cyberstalking is the use of the internet or other digital communication tools to harass or threaten another person.

6. DDoS attacks: These involve flooding a website or server with traffic, causing it to become unavailable to users.

Audio cybercrime refers to illegal activities carried out using audio technology or platforms, such as voice phishing scams, audio piracy, and unauthorised audio surveillance. The increased use of audio-based technologies, such as voice assistants, smart speakers, and audio messaging apps, has increased the potential for audio-based cybercrime.

Voice phishing is an example of a cybercrime in audio, which involves using social engineering tactics to trick people into disclosing sensitive information such as passwords or credit card numbers. Audio deepfake technology can be used by cybercriminals to impersonate a trusted individual, such as a bank representative, and persuade the victim to reveal their information.

Another illustration is audio piracy, which refers to the unlicensed distribution of audio content protected by copyright, such as music or podcasts. Content creators and distributors may suffer financial losses as a result of this. Finally, unauthorised audio surveillance involves listening in on private conversations without the consent of the parties involved. This may infringe on privacy rights and result in the collection of sensitive information.

To keep one’s audio file secured Individuals and organisations should take measures to protect their audio-based devices and platforms, such as using strong passwords, keeping software up to date, and exercising caution when sharing sensitive information, to combat cybercrime in audio. Audio content creators and distributors can also use digital rights management tools to prevent unauthorised distribution. Furthermore, law enforcement agencies can collaborate to identify and prosecute cybercriminals who commit audio-based cybercrimes.

(Wolfe, 2020, #)

WHAT IS AUDIO EDITING?

The process of manipulating and modifying recorded sound to achieve a desired result is known as audio editing. It entails modifying the characteristics of an audio recording, such as volume, tone, timing, and quality, with specialised software and tools. Audio editing can be used to remove unwanted noise or hiss, adjust a recording's volume or equalisation, cut or splice different parts of a recording together, add special effects or filters, and improve the clarity of spoken words or music. Audio editing necessitates a good ear for sound, working knowledge of audio software, and knowledge of audio principles such as frequency, amplitude, and phase. It can be a difficult and time-consuming process, but with the right tools and techniques, it is possible to produce high-quality audio recordings that sound great and serve their intended purpose.

SOFTWARES USED FOR AUDIO EDITING

1. REAPER - The digital audio workstation (DAW) program REAPER was created by Cockos Incorporated. It is utilised for audio track recording, editing, and mixing and is renowned for its adaptability, customization options, and effectiveness while handling complicated tasks. The adaptable user interface of REAPER, which enables users to customise the program to their unique needs and preferences, is one of its key characteristics. Both audio pros and fans use REAPER because of its robust automation features, sophisticated routing options, and support for numerous device inputs and outputs.

2. AUDACITY - A free and open-source digital audio editor and recording program is called Audacity. It has capabilities including multitrack recording, audio effects, noise reduction, and more that let users record and edit audio files. WAV, MP3, AIFF, and Ogg Vorbis are just a few of the audio file types that Audacity is compatible with. Musicians, podcasters, and audio engineers regularly use Audacity, which is available for Windows, macOS, and Linux. While its extensive features make it suited for professional audio editing and production, its straightforward user interface makes it simple for beginners to learn and use. Audacity can be used to find any changes in the provided audio's spectrogram.

3. Sonic Visualizer - The data in audio files that contain music can be visualised and examined using the free, open-source software Sonic Visualiser. It is a desktop application that runs on Windows, Linux, and Mac, the three most popular operating systems. Sonic Visualiser, which is designed to be user-friendly and simple to use, offers a variety of tools for visualising, annotating, and analysing music audio files. You may import audio files in a number of different formats, view audio waveforms and spectrograms, comment the audio signal, layer those annotations over it, and observe the pitch contour, note onset times, and other aspects of the audio signal with Sonic Visualiser. Sonic Visualiser is distributed under the GPL-2.0-or-later licence and is usually suggested for anyone studying music or audio.

4. Spectrum Analyser- A spectrum analyser is a online source that separates an input signal into its frequency components, usually an audio or radio frequency signal. It examines these components' amplitudes at various frequencies and presents the results on a graph or screen. The frequency range is represented by the horizontal axis, and the amplitude or power level is shown by the vertical axis.

   Radio frequency analysis, audio engineering, telecommunications, scientific research, and telecommunications are just a few of the industries that frequently use spectrum analysers. They aid in deciphering a signal's frequency content, spotting interference or noise, and making educated decisions concerning signal processing and troubleshooting.

AUDIO AUTHENTICATION

The process of confirming an audio recording's validity and identifying whether it has been changed, manipulated, or altered in any way is known as audio authentication. This is frequently used to assess the reliability and validity of audio evidence in forensic investigations, court cases, and media reports. Spectral analysis, digital signature, comparison with original recordings, and voice analysis are just a few of the methods employed in audio authentication. These methods include checking the audio signal's frequency and loudness, adding a digital signature or watermark, comparing records, and assessing the speaker's voice traits. The difficult process of audio authentication necessitates knowledge of audio engineering, digital signal processing, and forensic investigation.

Audio authentication techniques include digital signature analysis, which involves using cryptographic algorithms to generate a unique digital signature for an audio recording, and audio watermarking, which involves embedding a unique digital code into the audio recording to identify its origin and detect any unauthorised changes.

(Koenig & Douglas, 2009, #)

SPECTROGRAM

Spectrogram is a three-dimensional graph that displays how the strength of a signal's various frequency components changes over time. The frequencies contained in a sound stream over time are depicted visually in a spectrogram. A spectrogram's vertical axis depicts frequency, while its horizontal axis represents time. The colour or brightness of the associated point in the graph represents the strength of each frequency at a specific time. Stronger or more intense frequencies are represented by darker areas, whilst weaker or less intense frequencies are represented by lighter areas. Spectrograms are involved in disciplines such as music, acoustics, speech processing, and audio engineering, spectrograms are frequently employed. They are used to see and recognize patterns and changes in sound over time, as well as to analyse sound signals and pinpoint specific frequency components.

TYPES OF SPECTROGRAMS

Depending on the type of signal being analysed and the particular application, various spectrogram types can be employed. Here are a few illustrations:

1. The most typical kind of spectrogram is called a short-time Fourier transform (STFT) spectrogram, which involves breaking a signal into smaller pieces, performing the Fourier transform on each piece, and then charting the resulting frequency spectra across time.

2. Like the STFT spectrogram, the Constant-Q transform (CQT) spectrogram employs a logarithmic frequency scale that is more in line with how people perceive sound.

3. Wavelet transform spectrogram: This technique analyses data in the time and frequency domains by using wavelet functions rather than the Fourier transform.

4. Mel spectrogram: This customised spectrogram is frequently utilised in music analysis and speech processing. It uses a filter bank to create a picture that is more understandable and instructive by simulating how the human auditory system responds to various frequencies.

5. Cepstral representation spectrogram: This kind of spectrogram accentuates the spectral properties of a signal through an altered version known as a cepstral representation. It is frequently used in speech processing to examine the vocal tract's characteristics.

A spectrogram is a graphic depiction of a signal's frequency spectrum over time. It's an effective tool for evaluating audio signals and for spotting altered audio.

You can search for visual patterns in a spectrogram that signify changes in the audio stream in order to locate altered audio. These patterns could be:

· Changes in amplitude that occur suddenly can occur when audio is altered, both in terms of loudness and intensity. A spectrogram will show this as abrupt vertical shifts in the frequency content.

· Spectral anomalies: The frequency content of the signal may alter when audio is modified. A spectrogram can show this as portions of the frequency spectrum that stand out from the background.

· Anomalies in the time domain: When audio is modified, the time-domain waveform may change. A spectrogram will show these changes as variations in the waveform's pattern over time.

You must first become familiar with the typical spectrogram patterns of the audio you are examining in order to detect altered audio using a spectrogram. You will be able to spot any unusual patterns that might point to editing as a result. Afterwards, you can enlarge certain portions of the spectrogram to get a closer look at the signal and search for patterns. It is significant to highlight that identifying altered audio in a spectrogram can be difficult and necessitates audio analysis knowledge. However, expert audio editors may conceal their adjustments using methods like spectral smoothing or crossfading, which can make the edits more difficult to spot.

(Wyse, 2017, #) (Levy et al., 2022, #)

METADATA

Data that describes other data is referred to as metadata. It offers details on a specific piece of data, including its format, author, creation date, location, and other information. In digital systems like databases, webpages, and file systems, metadata is frequently utilized to assist identify, manage, and organize data. The titles and descriptions of web pages, the tags and categories applied to blog entries, and the date and time stamps of files on a computer are a few examples of metadata that are frequently used.

STRUCTURAL METADATA

Data organisation and structure-related information, as opposed to data content, is referred to as structural metadata. It offers details on the arrangement, relationships, and connections of data within a system.

Structured metadata examples include.

- Data models used to define and link data elements and properties.
- Definitions of the schema: The description of the data structure, including the relationships, constraints, and data types.
- Data file formats, including encoding and compression techniques, are referred to as file formats.
- Table of contents: A document or file system's hierarchical structure.
- These are the routes taken to move around a website or other system.
- Data transformations, sources, and destinations through time are referred to as the data lineage.

In order to ensure correct data structure and administration, structural metadata is crucial. Moreover, it can support data integration, reuse, and discovery across several platforms.

ADMINISTRATIVE METADATA

Information used to manage and administer data resources, such as digital files or records, is referred to as administrative metadata. It contains details on the production, administration, and utilisation of data as well as the administrative and technical procedures entailed in its upkeep.

Administrative metadata includes, for instance:

- Descriptive data: This includes details about who created the data, when it was created, how it was formatted, and any pertinent contextual data.

- Technical information: This contains any technical specifications or needs, as well as details about the technology and software used to create and manage the data.

- Information on data access and use comprises details about who has permission to access the data, how it can be used, and any restrictions or usage limitations.

- Information on data preservation: This covers details on how the data is being kept safe and up to date over time, including backup and storage techniques.

Administrative metadata ensures that data is correctly organised, preserved, and available to those who need it, which is crucial for effective data management and preservation.

DESCRIPTIVE METADATA

A type of metadata known as descriptive metadata offers details on the context and content of a resource. It gives a description of the features of the resource, including its title, creator, date, subject, and format, as well as any other pertinent details that aid in recognizing and comprehending the resource.

People can find, access, and manage resources like books, articles, films, photographs, and other forms of digital information with the use of descriptive metadata. Users can search for resources using various criteria, such as subject, title, author, and others, and it gives them a better idea of what the resource is about before they access it. Title, creator, date, subject, keywords, abstract, publisher, and format are a few examples of descriptive metadata. Descriptive metadata can be generated manually or automatically, and it can either be saved in a distinct metadata record or integrated in the resource itself.

(Six et al., 2018, #)

REVIEW OF LITETARURE

REVIEW OF LITERATURE

1. **AUTHENTICATION OF DIGITAL AUDIO RECORDING USING FILE'S SIGNATURE AND METADATA PROPERTIES**

In this study area of digital audio recording authentication utilises file signature and metadata features aims to create ways for verifying the authenticity of digital audio recordings.This problem's proposed solution is to leverage the file's signature and metadata properties for authentication. The file's signature is a unique identifier generated when a file is saved and is based on the contents of the file. A digital audio file's metadata attributes include information such as the date and time of production, the equipment used to make the recording, and other identifying information.

The authenticity of a digital audio recording can be determined by analysing both the file's signature and metadata features. The study may include the development of algorithms or software tools capable of analysing the file's signature and metadata attributes to detect any tampering or alteration of the recording.

(Gangwar & Pathania, 2020, #)

2. **ANALYSING AUDIO-RECORDED DATA : USING COMPUTER SOFTWARE APPLICATIONS**

(Hutchinson, 2005, #)

In this research topic it Analyses audio-recorded data using computer software applications which is a research area that tries to develop methods and strategies for analysing and interpreting data obtained in audio recordings. In research projects, audio recordings are often used to gather and analyse data such as interviews, focus groups, and conversations, particularly in the social sciences and humanities.

Audio-recorded data is analysed using computer software tools. These applications include specialised software programmes that enable researchers to more efficiently and precisely transcribe, code, and analyse data. Software systems such as NVivo, Atlas.ti, and Transana, for example, give tools for academics to transcribe audio recordings, organise data, and analyse material.

To better analyse audio-recorded data, the research may include designing and testing new software programmes or altering current ones. The study may also look into ways to connect multiple software tools to speed up the analytical process.

(Hutchinson, 2005, #)

3. A NOVEL AUDIO FORENSIC DATA-SET FOR DIGITAL MULTIMEDIA FORENSICS

In this study the dataset of audios will be used to train and test forensic tools and procedures, allowing researchers and practitioners to assess the efficacy of various audio analysis methods and algorithms. The dataset would most likely contain a variety of audio recordings with variable properties, such as various types of noise, varying degrees of compression, and various sorts of audio processing.

The purpose of this project is to provide a helpful resource for the audio forensic community, assisting in the advancement of novel audio analysis techniques and technologies. Researchers and practitioners will be able to compare and assess different approaches and develop more reliable methods for audio forensic analysis by developing a standardised dataset.
(Khan et al., 2017, #)

4. AN AUTOMATIC DIGITAL AUDIO AUTHENTICATION/FORENSICS SYSTEM

This Research is used to analyse the audio recordings using various approaches and algorithms to extract information that may be used to identify the source, the recording device, or any potential tampering. Signal processing, statistical analysis, machine learning, and pattern recognition are some of the techniques that can be employed in this system.

The technology has a wide range of uses, including law enforcement investigations, audio creation, and legal challenges involving audio evidence. It would aid in ensuring the integrity and validity of digital audio recordings, as well as providing a reliable technique for detecting any tampering or manipulation.
(Ali et al., 2017, 1-1)

5. CURRENT DEVELOPMENTS AND FUTURE TRENDS IN AUDIO AUTHENTICATION

In this Study there is a use of modern signal processing and machine learning techniques to analyse audio recordings and extract information that can be used to identify the source, the recording device, or any potential tampering is one of the most recent breakthroughs in audio authentication. Researchers are also looking into novel methods for detecting and analysing audio artefacts like noise and distortion, which can suggest tampering.

Future advancements in audio authentication are likely to include the incorporation of many forms of analysis, such as audio, picture, and video analysis, to provide a more thorough understanding of digital media authenticity and integrity. There may also be a greater emphasis on developing automatic audio authentication systems that use artificial intelligence and machine learning to analyse and verify audio recordings in real time.

Other potential future developments in audio authentication include the development of new hardware and software tools that can be used to record and analyse audio recordings, as well as the use of blockchain technology to create safe and tamper-proof digital signatures for audio recordings more precisely and accurately.
(Gupta et al., 2012, 50-59)

6. Digital multimedia audio forensics: past, present and future

(Zakariah, 2018, #)

To analyse and authenticate audio recordings in the past, audio forensics mostly used conventional methods and procedures. These methods involved activities like speaker recognition, audio augmentation, and audio authenticity checking. However, new difficulties have evolved in the sector as a result of improvements in digital multimedia technology and the expanding accessibility of sophisticated audio editing tools.

Statistical analysis tools, machine learning algorithms, and digital signal processing techniques are all combined in the current status of digital multimedia audio forensics. The accuracy and effectiveness of audio forensics activities have increased as a result of these developments. To handle problems like audio alteration detection, source verification, and audio synchronisation analysis, researchers and practitioners now have effective tools and approaches at their disposal.

Digital multimedia audio investigation will likely see positive advancements in the future. The capabilities of audio forensics systems are expected to improve as the fields of deep learning, machine learning, and artificial intelligence continue to grow. Automated and intelligent audio analysis may be possible with these technologies, which would speed up and improve the process.
Additionally, it is anticipated to become more crucial to combine audio forensics with other multimedia forensics fields, such picture and video forensics. The goal of multimedia forensics is to offer a thorough examination of various media formats, enabling cross-modal analysis and verification.

7. DETECTION OF ALTERATIONS IN AUDIO FILES USING SPECTROGRAPH ANALYSIS

In this Research paper a sizable dataset of audio files with known changes, such as reverb, equalisation, compression, and noise reduction, is gathered at the outset of the study. The frequency distribution and signal amplitude of the audio files are then examined using a spectrograph to spot any alterations

The researchers train a model that can recognise changes in audio signals using machine learning algorithms. The dataset of manipulated audio recordings is used to train the model, which is subsequently evaluated. Analysis of audio signals is used in the research project "Detection of alterations in audio files using spectrograph analysis" to spot any edits or manipulations performed to the original recording. A technique for visualising sound in the frequency domain that can shed light on the audio's qualities is spectrograph analysis.
A sizable dataset of audio files with known changes, such as reverb, equalisation, compression, and noise reduction, is gathered at the outset of the study. The frequency distribution and signal amplitude of the audio files are then examined using a spectrograph to spot any alterations.
The researchers train a model that can recognise changes in audio signals using machine learning algorithms. The dataset of manipulated audio recordings is used to train the model, which is subsequently evaluated.

(Krishnan & Caeiro, 2021, #)

METHODOLOGY

METHODOLOGY

AIM

To detect manipulated audio files by making use of different Software's, Application and methods to understand and detect changes made to the audio files by using metadata and spectrograph analysis.

OBJECTIVE

- To detect manipulation in audio files using metadata analysis
- To detect manipulation in audio files using spectrogram analysis
- To determine which tool is better for spectrographic analysis of audio file.
- To propose a technique to detect manipulated audio files

SAMPLES

In this research work on detecting the alteration made to audio files 6 sample audio files were collected using devices from Android 10-13 and iOS13-16. 6 Samples were collected as part of research.

<table>
<tr><th>SL.NO</th><th>DEVICE</th><th>DEVICE NO</th><th>MODEL</th><th>SOFTWARE USED FOR SPECTROGRAM ANALYSIS</th><th>FORMAT TYPE</th></tr>
<tr><td>1.</td><td>A-12</td><td>1</td><td>RMX3151</td><td rowspan="2">Sonic Visualiser</td><td>.WAV</td></tr>
<tr><td></td><td>A-12.1</td><td>2</td><td>OPPOA55</td><td></td></tr>
<tr><td>2.</td><td>A-11</td><td>3</td><td>RMX2001</td><td rowspan="2">Spectrum Analyzer</td><td>.WAV</td></tr>
<tr><td></td><td>A-12</td><td>4</td><td>RMX3151</td><td></td></tr>
<tr><td>3.</td><td>A-12</td><td>5</td><td>RMX3151</td><td rowspan="2">Sonic Visualiser</td><td>.WAV</td></tr>
<tr><td></td><td>A-13</td><td>6</td><td>V2126</td><td></td></tr>
<tr><td>4.</td><td>A-12</td><td>7</td><td>RMX2151</td><td rowspan="2">Sonic Visualiser</td><td>.WAV</td></tr>
<tr><td></td><td>A-11</td><td>8</td><td>RMX2001</td><td></td></tr>
</table>

5.	A-12	9	RMX3151	Sonic Visualiser	.WAV
	A-12	10	RMX2151		
6.	A-13	11	RMX3242	Spectrum Analyzer	.WAV
	A-12	12	CPH2381		
7.	A-12	13	RMX3151	Sonic Visualiser	.WAV
	A-10	14	SM-M315F/DS		
8.	A-12	15	CPH2381	Sonic Visualiser	.WAV
	A-13	16	RMX3242		
9.	A-12	17	RMX3151	Sonic Visualiser	.WAV
	iOS-15.6	18	MKRQ2LLA/A		
10.	A-13	19	RMX3392	Sonic Visualiser	.WAV
	iOS-15.7.2	20	MNCP2J/A		
11.	A-11	21	VIVO Y75	Spectrum Analyzer	.WAV
	A-11	22	RMX3151		
12.	A-12	23	SM-M515F	Sonic visualiser	m4a
	iOS- 16	24	3J765HN/A		
13.	A-12	25	RMX3151	Sonic Visualiser	.WAV
	iOS16.2	26	MRY42HN/A		
14.	A-11	27	MotoG 30	Spectrum Analyzer	.WAV
	A-12	28	V2126		
15.	A-12	29	Redmi Note 11	Sonic Visualiser	.WAV
	A-11	30	Vivo Y75		

16.	A-9	31	M1806E7TI	Sonic Visualiser	.WAV
	A-10	32	VIVO1806		
17.	A-10	33	VIVO1806	Sonic Visualiser	.WAV
	A-9	34	M1806E7TI		
18.	A-10	35	VIVO1806	Sonic Visualiser	.WAV
	A-12	36	SM-M515F		
19.	A-12	37	SM-M515F	Sonic Visualiser	.WAV
	A-10	38	VIVO1806		
20.	A-12	39	RMX2193	Spectrum Analyzer	WAV
	A-10	40	RMX1801		
21.	A-12	41	Moto G 30	Spectrum Analyzer	WAV
	A-10	42	CPH2127		
22.	A-10	43	CPH2127	Spectrum Analyzer	WAV
	A-12	44	MotoG 30		
23.	A-12	45	RMX2193	Spectrum analyser	WAV
	A-12	46	CPH2381		
24.	A-12	47	RMX2193	Spectrum analyser	WAV
	iOS 16	48	iPhone 12		
25.	A-12	49	RMX2193	Spectrum Analyzer	WAV
	A-12	50	CPH2381		
26.	A-12	51	Motog (XT21292)	Spectrum Analyzer	WAV
	A-10	52	SM-M315F/DS		

27.	A-10	53	SM-M315F/DS	Spectrum Analyzer	WAV
	A-11	54	RMX3151		
28.	A-11	55	RealmeNarzo30	Spectrum Analyzer	WAV
	A-13	56	V2126		
29.	A-13	57	V2126	Spectrum Analyzer	WAV
	A-11	58	RealmeNarzo30		
30.	A-12	59	CPH2381	Spectrum Analyzer	WAV
	A-12	60	RMX2151		
31	iOS-16	61	iPhone 12	Spectrum Analyzer	m4a
32	iOS-16	62	iPhone 13	Spectrum Analyzer	m4a
33	iOS-16	63	iPhone 16	Sonic Visualiser	m4a
34	iOS-16	64	iPhone 12 mini	Sonic Visualiser	m4a
35	IOS - 16	65	iPhone 11	Sonic Visualiser	m4a

PROCEDURE

Procedure for the collection of audio recordings in Android and IOS phone

- In this research 35 audio files were collected which consisted of 30 Android devices used for the recording.
- 5 Audio recordings have been collected which consisted of 5 IOS phone from the version 15 was used for the purpose of recording.

- A conversion (Script) which was been used to record the audio for all the 35 audio files and the sentences marked in the bold was the part of the audio recording which were been subjected to editing by altering/removing the part of the audio and a different audio was pasted to the audio file.
- The alterations have been carried out in the software Reaper v6.71 and Audacity which was used to cut/paste the audio.

Procedure for comparison of metadata in both original and edited audio

- Open the media info software.
- Select file, the dialogue box appears and select the audio file from the drop down and click on finish.
- Click on the view option and select **HTML** and the details of metadata appears.
- The above method can be followed for both original and edited audio files.
- Compare the metadata of both original and edited audio files from the characteristics such as Created date, Modified date, Bit Rate, File Size, Sampling rate, Stream Size, and Producer.

Procedure for analysing the spectrogram.

SONIC VISUALIZER

- Open the Sonic Visualizer software and click on the file option.
- A dialogue box appears and select the respective audio file for Spectrogram Analysis.
- As the audio file is opened in the form of waveform convert the audio from waveform to spectrogram graph
- Follow the above instructions for both Original and edited audio files and combine them both to detect any type of alterations.

SPECTRUM ANALYZER

- Open the spectrum analyzer website.
- Click on the file option, then a dialogue box appears.
- Select the respective audio files for viewing the spectrogram.
- After selecting the audio files click on logarithmic frequency scale.
- Follow the above instructions for both original and edited audio files and combine them both to detect any type of alterations.

RESULTS

RESULTS

METADATA

ANDROID

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	15 February 2023	04 April 2023
Modified date	15 February 2023	04 April 2023
Encoded date	-	2023-02-22 21-25-24
Bitrate	16 bits	2 117 kb/s
File size	1.13 MiB	18.9 MiB
Sampling rate	8 000 Hz	44.1 kHz
Bit depth	16 bits	24 bits
Stream size	1.13 MiB (100%)	18.9 MiB (100%)
Channels	1 channel	2 channels
Duration	1 min 13sec	1 min 14 sec
Producer	-	REAPER

TABLE 1: Original and edited audio data of Device no. 19 and 20

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	03 February 2023	04 April 2023
Modified date	03 February 2023	04 April 2023
Encoded date	-	2023-02-23 16-23-24
Bitrate	705.6 kb/s	2 117 kb/s
File size	5.85 MiB	17.8 MiB
Sampling rate	44.1KHZ	44.1 kHz
Bit depth	16 bits	24 bits
Stream size	5.85 MiB (100%)	17.8 MiB (100%)
Channels	1 channel	2 channels
Duration	1 min 9 sec	1 min 10 sec
Producer	-	REAPER

TABLE 2: Original and edited audio data of Device no. 13 and 14

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	26 May 2023	27 May 2023
Modified date	26 May 2023	27 May 2023
Encoded date	-	2023-05-26 23-05-40
Bitrate	128 kb/s	2 117 kb/s
File size	1.22 MiB	20.4 MiB
Sampling rate	8 000 Hz	44.1 kHz
Bit depth	16 bits	24 bits
Stream size	1.22 MiB (100%)	20.4 MiB (100%)
Channels	1 channel	2 channels
Duration	1 min 19 s	1 min 20 s
Producer	-	REAPER

TABLE 3: Original and edited audio data of Device no. 11 and 12

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	03 February 2023	01 May 2023
Modified date	03 February 2023	01 May 2023
Encoded date	-	2023-05-01 18-58-01
Bitrate	128 kb/s	2 117 kb/s
File size	1.06 MiB	17.8 MiB
Sampling rate	8 000 Hz	44.1 kHz
Bit depth	16 bits	24 bits
Stream size	1.06 MiB (100%)	17.8 MiB (100%)
Channels	1 channel	2 channels
Duration	1 min 9 sec	1 min 10 sec
Producer	-	REAPER

TABLE 4: Original and edited audio data of Device no. 21 and 22

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	25 May 2023	25 May 2023
Modified date	25 May 2023	25 May 2023
Encoded date	-	2023-05-25 20-36-22
Bitrate	705.6 kb/s	2 117 kb/s
File size	6.69 MiB	20.3 MiB
Sampling rate	44.1 kHz	44.1 kHz
Bit depth	16 bits	24 bits
Stream size	6.69 MiB(100%)	20.3 MiB (100%)
Channels	1 channel	2 channels
Duration	1 min 19 s	1 min 20 s
Producer	-	REAPER

TABLE 5: Original and edited audio data of Device no. 3 and 4

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	27 May 2023	27 May 2023
Modified date	27 May 2023	27 May 2023
Encoded date	-	2023-05-27 11-57-39
Bitrate	128 kb/s	2 117 kb/s
File size	1.23 MiB	20.5 MiB
Sampling rate	8 000 Hz	44.1 kHz
Bit depth	16 bits	24 bits
Stream size	1.23 MiB (100%)	20.5 MiB (100%)
Channels	1 channel	2 channels
Duration	1 min 20 s	1 min 21 s
Producer	-	REAPER

TABLE 6: Original and edited audio data of Device no. 15 and 16

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	26 January 2023	06 February 2023
Modified date	04 February 2023	06 February 2023
Encoded date	-	2023-02-06 21-29-01
Bitrate	32.0 kb/s	128 kb/s
File size	323 KiB	1.25 MiB
Sampling rate	48.0 kHz	44.1 kHz
Bit depth	16 bits	24 bits
Stream size	323 KiB (100%)	1.25 MiB (100%)
Channels	1 channel	2 channels
Duration	1 min 22 s	1 min 23 s
Producer	-	Reaper

TABLE 7: Original and edited audio data of Device No. 31 and 32

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	04 February 2023	06 February 2023
Modified date	26 January 2023	06 February 2023
Encoded date	-	2023-02-06 21-55-06
Bitrate	768 kb/s	2117 Kbps
File size	7.73 MiB	21.6 MiB
Sampling rate	48.0 kHz	44.1 KHz
Bit depth	16 bits	24 bits
Stream size	7.73 MiB (100%)	21.6 MiB (100%)
Channels	1 channel	2 channels
Duration	1 min 24 s	1 min 25s
Producer	-	REAPER

TABLE 8: Original and edited audio data of Device no. 35 and 36

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	26 January 2023	07 February 2023
Modified date	04 February 2023	07 February 2023
Encoded date	-	2023-02-07 21-06-32
Bitrate	768 Kbps	2117 Kbps
File size	7.67 MiB	21.4 MiB
Sampling rate	48.0 KHz	44.1 KHz
Bit depth	16 bits	24 bits
Stream size	7.67 MiB (100%)	21.4 MiB (100%)
Channels	1 channel	2 channels
Duration	1 min 23s	1 min 24 s
Producer	-	REAPER

TABLE 9: Original and edited audio data of Device no. 33 and 34

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	26 January 2023	16 February 2023
Modified date	04 February 2023	16 February 2023
Encoded date	-	2023-02-16 16-18-14
Bitrate	705.6 Kbps	2117 Kbps
File size	6.98 MiB	21.2 MiB
Sampling rate	44.1 KHz	44.1 KHz
Bit depth	16 bits	24 bits
Stream size	6.98 MiB (100%	21.2 MiB (100%)
Channels	1 channel	2 channels
Duration	1 min 23 s	1 min 24 s
Producer	-	REAPER

TABLE 10: Original and edited audio data of Device no. 37 and 38

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	04 February 2023	07 February 2023
Modified date	04 February 2023	07 February 2023
Encoded date	-	2023-02-07 20-43-30
Bitrate	128 Kbps	2117 Kbps
File size	1.10 MiB	18.5 MiB
Sampling rate	8000 Hz	44.1 KHz
Bit depth	16 bits	24 bit
Stream size	1.10 MiB	18.5 MiB
Channels	1 channel	2 channels
Duration	1 min 12 s	1 min 13 s
Producer	-	REAPER

TABLE 11: Original and edited audio data of Device No. 29 and 30

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	04 February 2023	06 February 2023
Modified date	04 February 2023	06 February 2023
Encoded date	UTC 2023-01-31 09:46:04	2023-02-06 21-00-43
Bitrate	128 Kbps	2117 Kbps
File size	1.24 MiB	28.2 MiB
Sampling rate	44.1 KHz	44.1 KHz
Bit depth	16 bits	24 bits
Stream size	1.22 MiB	28.2 MiB
Channels	1 channel	2 channels
Duration	1 min 20 s	1 min 21 s
Producer	-	REAPER

TABLE 12: Original and edited audio data of Device no. 23 and 24

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	February 17, 2023	February 17, 2023
Modified date	February 17, 2023	February 17, 2023
Encoded date	---	---
Bitrate	16 bits	16 bits
File size	128 kb/s	128 kb/s
Sampling rate	1.17 MiB	1.16 MiB
Bit depth	8000 Hz	8000 Hz
Stream size	1.17 MiB (100%)	1.16 MiB (100%)
Channels	1 channel	1 channel
Duration	1 min 16 s	1 min 16 s
Producer	---	---

Table13: Original and edited audio data of Device no. 25 and 26

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	January 18, 2023	January 18, 2023
Modified date	January 18, 2023	January 18, 2023
Encoded date	---	---
Bitrate	16 bits	16 bits
File size	32.0 kb/s	52.5 kb/s
Sampling rate	283 KiB	464 KiB
Bit depth	48.0 kHz	48.0 kHz
Stream size	283 KiB (100%)	464 KiB (100%)
Channels	1 channel	1 channel
Duration	1 min 12 s	1 min 12 s
Producer	-	-

Table 14: Original and edited audio data of Device no. 7 and 8

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	February 17, 2023	February 17, 2023
Modified date	February 17, 2023	February 17, 2023
Encoded date	---	---
Bitrate	16 bits	16 bits
File size	128 kb/s	128 kb/s
Sampling rate	1.13 MiB	1.16 MiB
Bit depth	8000 Hz	8000 Hz
Stream size	1.13 MiB (100%)	1.16 MiB (100%)
Channels	1 channel	1 channel
Duration	1 min 14 s	1 min 14 s
Producer	---	---

Table 15: Original and edited audio data of Device no. 1 and 2

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	January 20, 2023	January 20, 2023
Modified date	January 20, 2023	February 7, 2023
Encoded date	---	---
Bitrate	16 bits	16 bits
File size	128 kb/s	128 kb/s
Sampling rate	1.10 MiB	1.01 MiB
Bit depth	8000 Hz	8000 Hz
Stream size	1.10 MiB (100%)	1.01 MiB (100%)
Channels	1 channel	1 channel
Duration	1 min 12 s	1 min 6 s
Producer	---	---

Table 16: Original and edited audio data of Device no. 9 and 10

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	February 17, 2023	February 17, 2023
Modified date	February 17, 2023	February 17, 2023
Encoded date	---	---
Bitrate	16 bits	16 bits
File size	128 kb/s	128 kb/s
Sampling rate	1.10 MiB	1.18 MiB
Bit depth	8000 Hz	8000 Hz
Stream size	1.12 MiB (100%)	1.18 MiB (100%)
Channels	1 channel	1 channel
Duration	1 min 13 s	1 min 13 s
Producer	---	---

Table 17: Original and edited audio data of Device no. 17 and 18.

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	February 17, 2023	February 17, 2023
Modified date	February 17, 2023	February 17, 2023
Encoded date	---	2023-01-19 22-18-21
Bitrate	16 bits	24 bits
File size	128 kb/s	117 kb/s
Sampling rate	1.21 MiB	19.1 MiB
Bit depth	8000 Hz	44.1 kHz
Stream size	1.12 MiB (100%)	19.1 MiB (100%)
Channels	1 channel	2 channels
Duration	1 min 19 s	1 min 15 s
Producer	---	REAPER

Table 18: Original and edited audio data of Device no. 5 and 6

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	05 Feb2023	05 Feb 2023
Modified date	05 Feb 2023	4 APRIL 2023
Encoded date	-	2023-04-04 15-31-33
Bitrate	128 kb/s	2117 kb/s
File size	1.34 MiB	21.7 MiB
Sampling rate	8000 kHz	44.1 kHz
Bit depth	16 bits	24 bits
Stream size	1.34 MiB (100%)	21.7MiB (100%)
Channel	1 channel	2 channels
Producer	-	Reaper
Duration	1 min 27 sec	1 min 26 sec

TABLE 19: Original and edited audio data of Device no. 45 and 46

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	05 Feb 2023	05 Feb2023
Modified date	05 Feb 2023	04 April 2023
Encoded date	-	2023-04-04 15-38-03
Bitrate	128 kb/s	2117kb/s
File size	1.19 MiB	19.3 MiB
Sampling rate	8000 Hz	44.1kHz
Bit depth	16 bits	24 bits
Stream size	1.19 MiB (100%)	19.3MiB (100%)
Channel	1 channel	2 channels
Producer	-	Reaper
Duration	1 min 17 sec	1 min 16 sec

TABLE 20: Original and edited audio data of Device no. 43 and 44

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	05 Feb2023	05 Feb 2023
Modified date	05 Feb 2023	04 April 2023
Encoded date	-	2023-04-04 15-41-20
Bitrate	128 kb/s	2117kb/s
File size	1.24 MiB	20.1MiB
Sampling rate	8000kHz	44.1kHz
Bit depth	16 bits	24 bits
Stream size	1.24 MiB (100%)	20.1(100%)
Channel	1 channel	2 channels
Producer	-	Reaper
Duration	1 min 21 sec	1mi 19 sec

TABLE 21: Original and edited audio data of Device no. 41 and 42

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	05 Feb 2023	05 Feb 2023
Modified date	05 Feb l 2023	04 April 2023
Encoded date	-	2023 04-04 15-35-18
Bitrate	128kb/s	2117kb/s
File size	1.14MiB	18.3MiB
Sampling rate	8000 kHz	44.1kHz
Bit depth	16 bits	24bits
Stream size	1.14 MiB (100%)	18.3MiB (100%)
Channel	1channel	2 channels
Producer	-	Reaper
Duration	1 min 14 sec	1min 12 sec

TABLE 22: Original and edited audio data of Device no. 47 and 48

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	05 Feb 2023	05 Feb 2023
Modified date	05 Feb 2023	04 April 2023
Encoded date	-	2023-04-04 15-31-33
Bitrate	128kb/s	2117kb/s
File size	1.34 MiB	21.7MiB
Sampling rate	8000kHz	44.1khz
Bit depth	16 bits	24 bits
Stream size	1.34 MiB (100%)	21.7MiB (100%)
Channel	1 channel	2 channels
Producer	-	Reaper
Duration	1 min 12 sec	1 min 13 sec

TABLE 23: Original and edited audio data of Device no. 49 and 50

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	05 Feb,2023	05 Feb 2023
Modified date	05 Feb 2023	11 May 2023
Encoded date	-	2023-05-11 15-10-39
Bitrate	128 kb/s	2117kb/s
File size	1.19 MiB	18.6MiB
Sampling rate	8000kHz	44.1kHz
Bit depth	16 bits	24 bits
Stream size	1.19MiB (100%)	18.6MiB (100%)
Channel	1 channel	2 channels
Producer	-	Reaper
Duration	1 min 13 sec	1 min 12 sec

TABLE 24: Original and edited audio data of Device no. 39 and 40

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	Feb 12, 2023	March 01, 2023
Modified date	Feb 12, 2023	March 01, 2023
Encoded date	---	2023-03-01 09-31-10
Bitrate	16 bits	24 bits
File size	705.6 kb/s	2117 kb/s
Sampling rate	7.19 MiB	20.4 MiB
Bit depth	44.1 kHz	44.1 kHz
Stream size	7.19 MiB (100%)	20.4 MiB (100%)
Channel	1 channel	2 channels
Producer	1 min 25 s	1 min 20 s
Duration	---	Reaper

TABLE 25: Original and edited audio data of Device no. 53 and 54

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	Jan 27, 2023	Feb 27, 2023
Modified date	Jan 27, 2023	Feb 27, 2023
Encoded date	---	2023-02-27 15-44-02
Bitrate	16 bits	24 bits
File size	128 kb/s	2117 kb/s
Sampling rate	1.36 MiB	22.7 MiB
Bit depth	8 000 Hz	44.1 Hz
Stream size	1.36 MiB (100%)	22.7 MiB (100%)
Channel	1 channel	2 channels
Producer	1 min 28 s	1 min 30 s
Duration	—	Reaper

TABLE 26: Original and edited audio data of Device no. 57 and 58

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	Feb 12, 2023	March 01,, 2023
Modified date	Feb 12, 2023	March 01, 2023
Encoded date	---	2023-03-01 09-14-14
Bitrate	16 bits	24 bits
File size	411.2 kb/s	2117 kb/s
Sampling rate	6.49 MiB	18.2 MiB
Bit depth	44.1 kHz	44.1 kHz
Stream size	6.49 MiB (100%)	18.2 MiB (100%)
Channel	1 channel	2 channels
Producer	1 min 17 s	1 min 12 s
Duration	---	Reaper

TABLE 27: Original and edited audio data of Device no. 51 and 52

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	Feb 12, 2023	March 01, 2023
Modified date	Feb 12, 2023	March 01, 2023
Encoded date	---	2023-03-01 09-23-55
Bitrate	16 bits	24 bits
File size	128 kb/s	2117 kb/s
Sampling rate	1.44 MiB	22.4 MiB
Bit depth	8 000 Hz	44.1 Hz
Stream size	1.44 MiB (100%)	22.4 MiB (100%)
Channel	1 channel	2 channels
Producer	1 min 34 s	1 min 28 s
Duration	---	Reaper

TABLE 28: Original and edited audio data of Device no. 55 and 26

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	Feb 18, 2023	Feb 18, 2023
Modified date	Feb 27, 2023	Feb 27, 2023
Encoded date	---	2023-02-27 15-58-19
Bitrate	16 bits	24 bits
File size	128 kb/s	2117 kb/s
Sampling rate	1.20 MiB	19.0 MiB
Bit depth	8 000 Hz	44.1 Hz
Stream size	1.20 MiB (100%)	19.0 MiB (100%)
Channel	1 channel	2 channels
Producer	1 min 18 s	1 min 15s
Duration	---	Reaper

TABLE 29: Original and edited audio data of Device no. 27 and 28

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	Feb 21, 2023	Feb 24, 2023
Modified date	Feb 21, 2023	Feb 24, 2023
Encoded date	---	2023-02-24 12-00-58
Bitrate	16 bits	24 bits
File size	128 kb/s	2117 kb/s
Sampling rate	1.19 MiB	18.5 MiB
Bit depth	8 000 Hz	44.1 Hz
Stream size	1.19 MiB (100%)	18.5 MiB (100%)
Channel	1 channel	2 channels
Producer	1 min 17 s	1 min 13s
Duration	---	Reaper

TABLE 30: Original and edited audio data of Device no. 59 and 60

IPHONE

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	26 May 2023	26 May 2023
Modified date	26 May 2023	26 May 2023
Encoded date	-	2023-05-28 00-28-14
Bitrate	64.0 kb/s	2 117 kb/s
File size	622 KiB	19.2 MiB
Sampling rate	48.0 kHz	44.1 kHz
Bit depth	-	24 bits
Stream size	587 KiB (94%)	19.2 MiB (100%)
Channels	1 channel	2 channels
Duration	1 min 14 s	1 min 16 s
Writing application	com.apple.VoiceMemos (iPhone Version 16.4.1 (a) (Build 20E772520a))	
Producer	-	REAPER

TABLE 31: Original and edited audio data of Device No. 63

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	03 March 2023, 14:01:49	04 April 2023, 17:30:07
Modified date	03 March 2023, 14:01:54	04 April 2023, 17:30:15
Encoded date	2023-04-04 17-30-07	2023-04-04 17-30-07
Bitrate	66.8 kb/s	2 117 kb/s
File size	529 KiB	16.6 MiB
Sampling rate	48.0 kHz	44.1 kHz
Bit depth	-	24 bits
Stream size	498 KiB (94%)	16.6 MiB
Channels	1 channel	2 channels
Duration	1 min 3 s	1 min 4s
Writing application	com.apple.VoiceMemos (iPhone Version 16.3.1 (Build 20D67))	
Producer	-	REAPER

TABLE 32: Original and edited audio data of Device No. 64

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	May 9, 2023	May 9, 2023
Modified date	May 9 , 2023	May 9, 2023
Encoded date	---	---
Bitrate	16 bits	16 bits
File size	117 kb/s	91.2 kb/s
Sampling rate	956 KiB	695 KiB
Bit depth	48.0 kHz	48.0 kHz
Stream size	955 KiB (100%)	695 KiB (100%)
Channels	1 channel	2 channels
Duration	1 min 7 s	1 min 2 s
Writing application	---	---
Producer	-	-

Table 33: Original and edited audio data of Device no. 65

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created Date	4 May 2023	4 May 2023
Modified Date	4 May 2023	24 May 203
Encoded Date	UTC 2023-05-04 10:20:46	2023- 05-24 20-58-07
Bitrate	64.0kb/s	2117 kb/s
File size	480 KiB	15.0 MiB
Sampling rate	48.0kHz	44.1kHz
Bit depth	-	24 bits
Stream size	452 KiB	15.0 MiB
Channel	1	2
Producer	-	Reaper
Duration	58 s 562 ms	59 s 560 ms
Writing application	Com.apple.VoiceMemos(iPhone Version 16.4.1(Build 20E252)	

TABLE 34: Original and edited audio data of Device no. 62

PARAMETERS	ORIGINAL AUDIO	EDITED AUDIO
Created date	May 04, 2023	May 05, 2023
Modified date	May 04, 2023	May 05, 2023
Encoded date	2023-05-04 10:16:35 UTC	2023-05-05 09-49-47
Bitrate	---	24 bits
File size	66.7 kb/s	2117 kb/s
Sampling rate	526 KiB	15.7 MiB
Bit depth	48.0 kHz	44.1 Hz
Stream size	495 KiB (94%)	15.7 MiB (100%)
Channels	1 channel	2 channels
Duration	1 min 4 s	1 min 2s
Writing application	com.apple. VoiceMemos (iPhone Version 16.3.1 (Build 20D67))	-
Producer	-	Reaper

TABLE 35: Original and edited audio data of Device no. 61

PARAMETERS OF THE METADATA

1. **Created, Modified Date and Encoded date.**

   Created date refers to the date since the Audio file was generated or made available. It shows when the Audio was recorded and **Modified date** shows the date when the audio was altered most recently these alterations can be any addition, modification or removal of the data.

   On the other hand, **Encoded date** refers to change in the format of the Audio file this can help [us in understanding the media history and alterations undergone.

   Comparing the above data, it has been noted that there has been change in the both the original and edited audio in created and modified date.

   When observing encoded date, it only appears in the edited audio file.

2. **Bit rate and Bit Depth**

   Bit rate is the number of bits that is transferred over a period of time. Bit rate usually determines the size and quality of the audio file. **Bit Depth** shows the precision and resolution of the data which determines the dynamic range and level of the given audio,

   The above represented metadata shows there is an increase of both bit rate and bit depth in the edited audio compared to the original.

3. **File size and Stream size**

   File size represents the digital file that contains the audio recording it denotes the amount of storage space needed for the audio file.

   Stream size refers to the amount of audio data being processed or analysed at any given time during the audio processing.

   Whilst observing the above metadata obtained it is noted there is a steady increase in both file and steam size in the edited audio

4. Channel and Duration

Channel represents the number of audio channels present in the given audio recording. Mono audio signals have 1 channel while stereo audio signals have 2 channels. **Duration** symbolises the time covered of a particular audio file.

In the above case of the metadata details there is an increase in the number of channels from 1 to 2 and a rise in the duration from 1 to 2 seconds in the Edited audio file.

5. Producer and Writing Application

Producer usually refers to a person, organisation or a software which was used to create the given audio file and **Writing application** is similar as that of the producer which is either a software or application to create or change in the audio file.

In the case of producer, the name of the software application appears in the edited audio and is the same for both the Android and IOS

Writing application shows the name of the software in the original audio and it only appears for IOS.

SPECTROGRAM

The give table represents the legend which has different parameters and labels used to mark the changes appearing the spectrographic images.

PARAMETERS	LABELS
Silence	A
Longest duration	B
Increase in frequency	C
Compressed wide/narrow band spectrum	D
Signal Dropout	E
Change in spectrum pattern	F
Sudden discontinuities	G

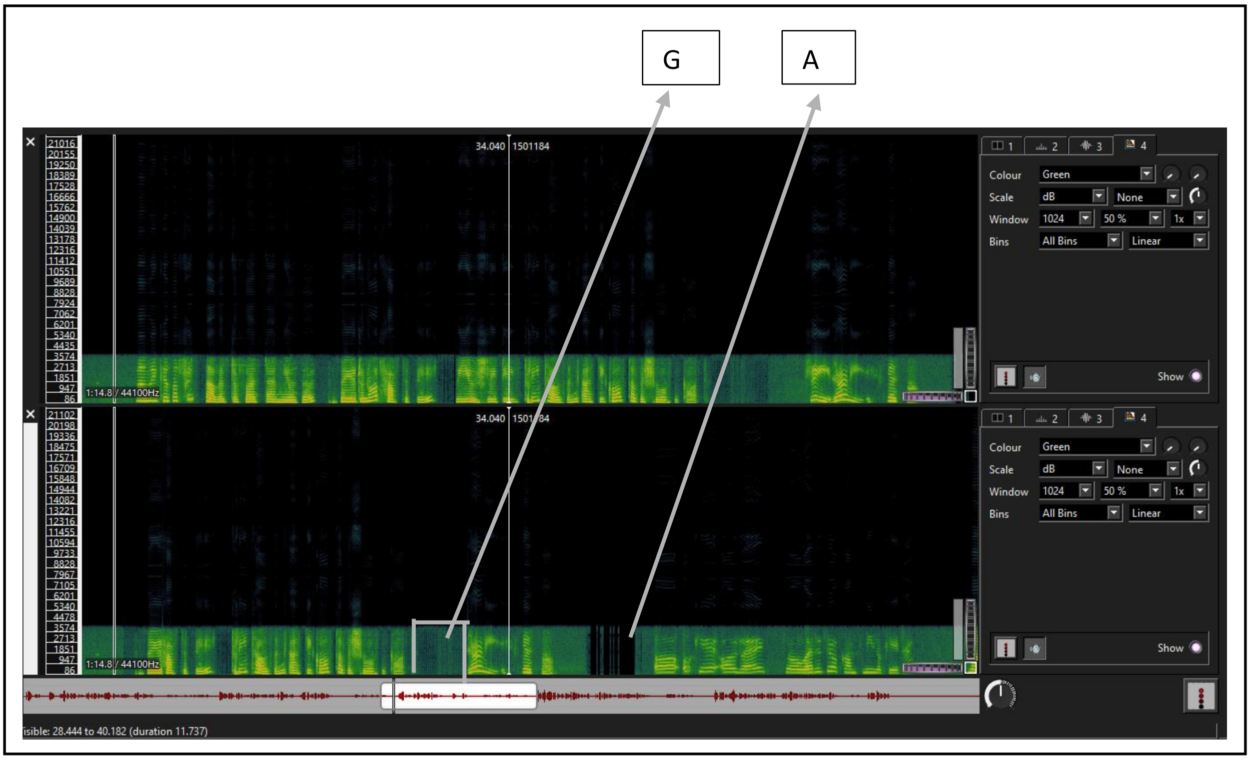

Figure 1 Image showing comparison between original(top) and edited(bottom) audio file between devices no. 19 – 20.

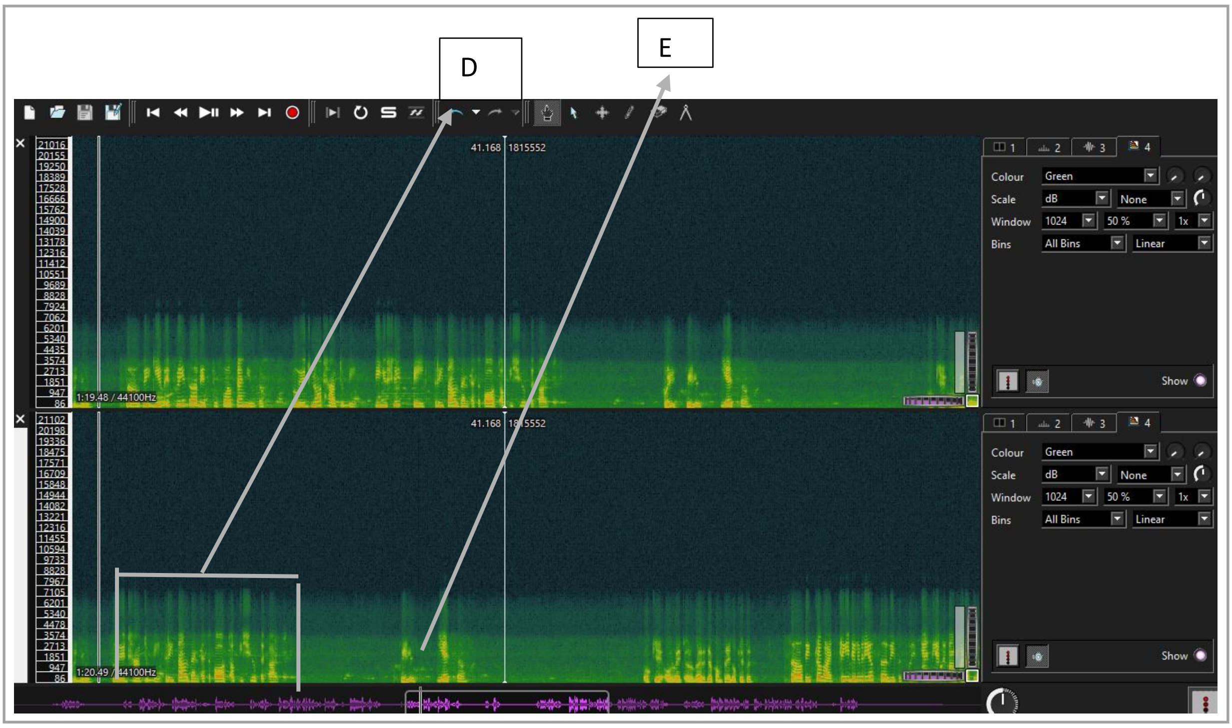

Figure 2 Image showing comparison between original(top) and edited(bottom) audio file between devices no.13-14

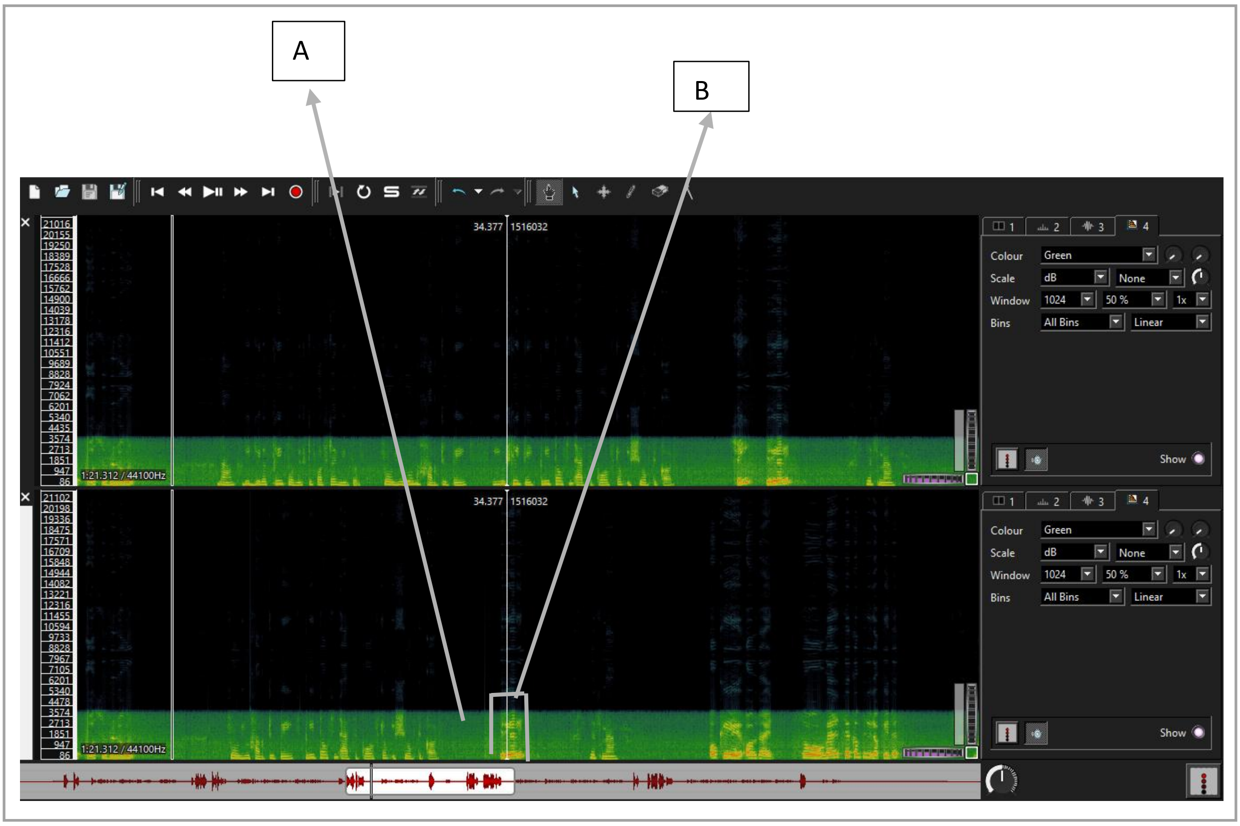

Figure 3 Image showing comparison between original(top) and edited(bottom) audio file between devices no.15-16

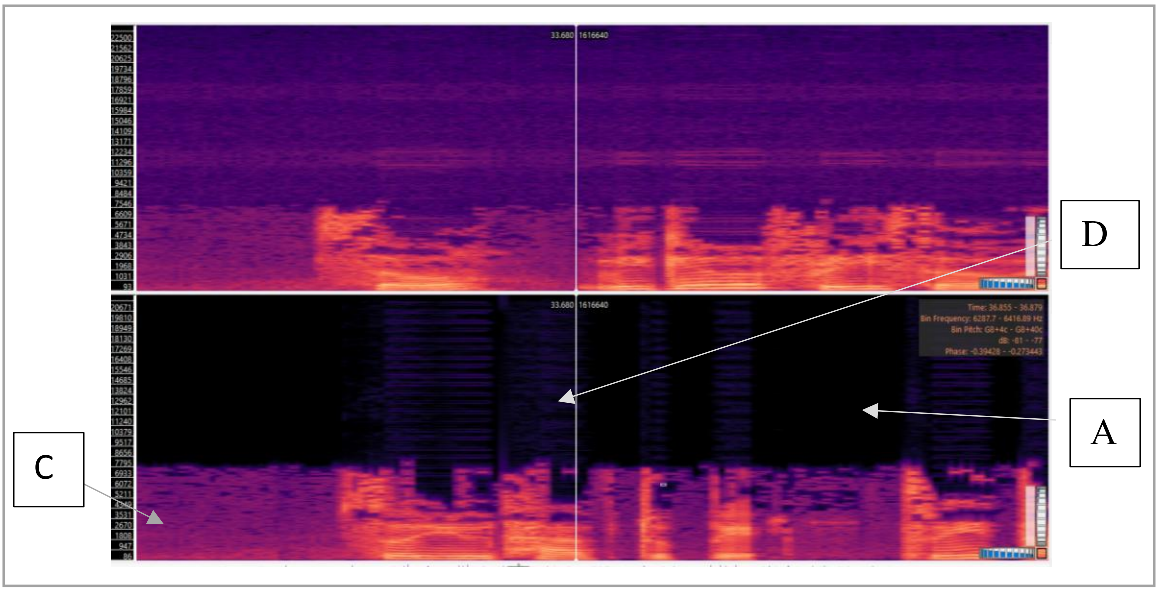

FIGURE 4 Image showing comparison between original(top) and edited(bottom) audio file between devices No.31 And 32

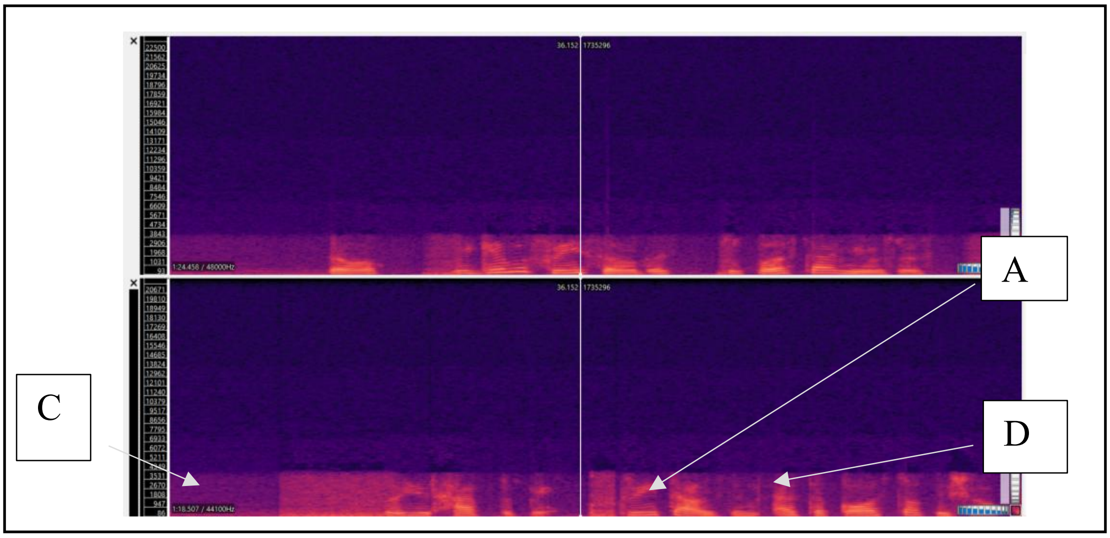

FIGURE 5 Image showing comparison between original(top) and edited(bottom) audio file between devices no.35 And 36

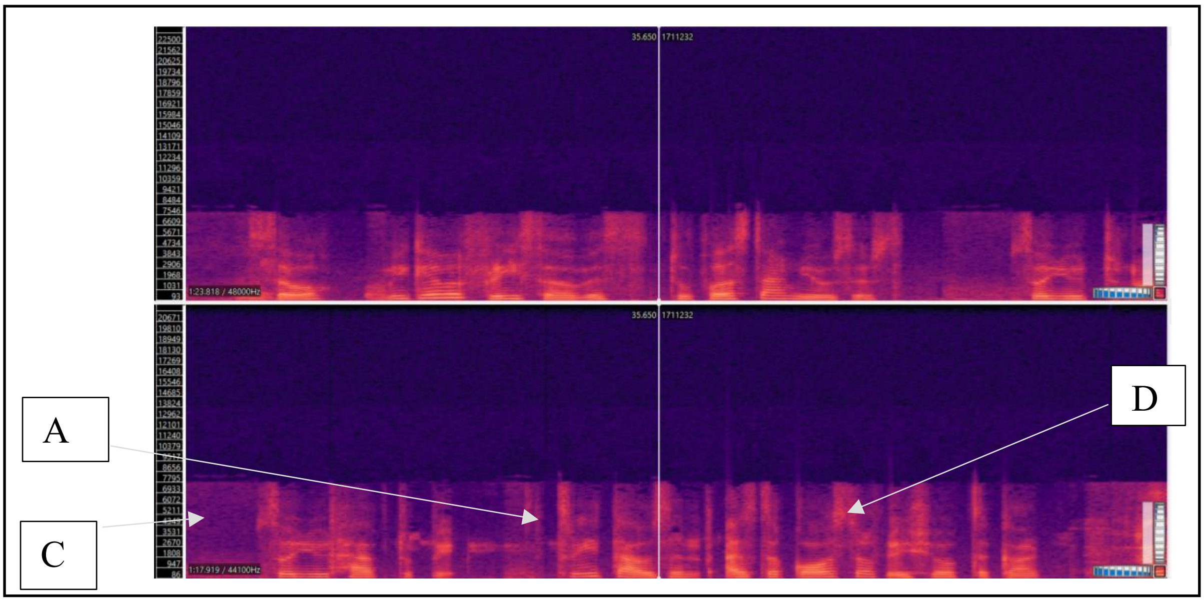

FIGURE 6 Image showing comparison between original(top) and edited(bottom) audio file between devices no. 33 And 34

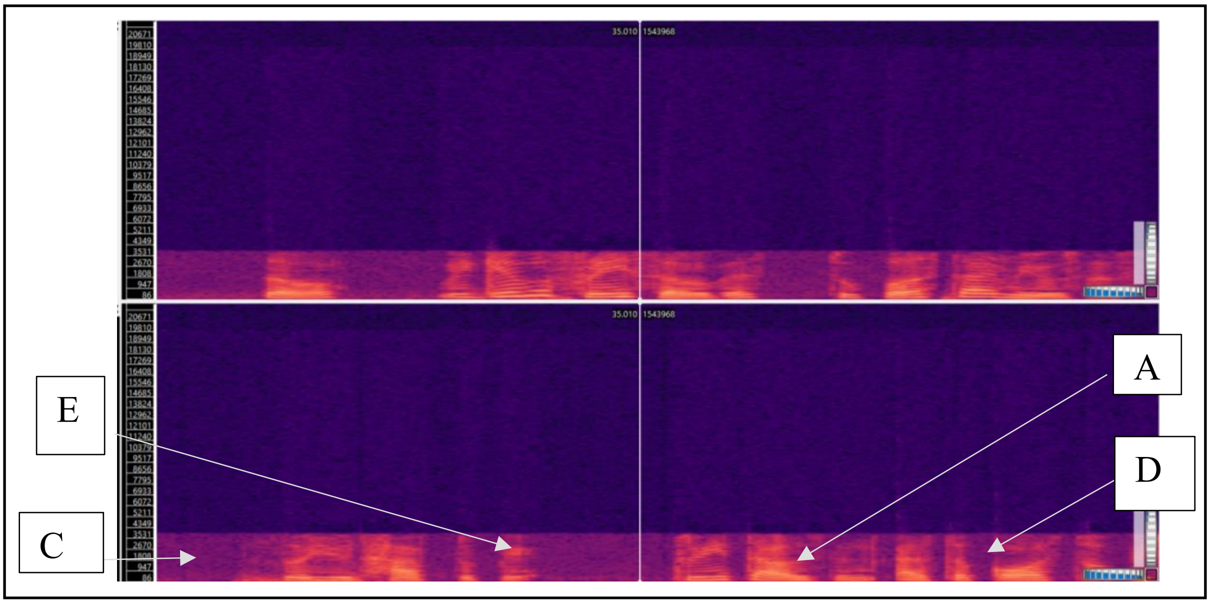

FIGURE 7 Image showing comparison between original(top) and edited(bottom) audio file between devices no.37 And 38

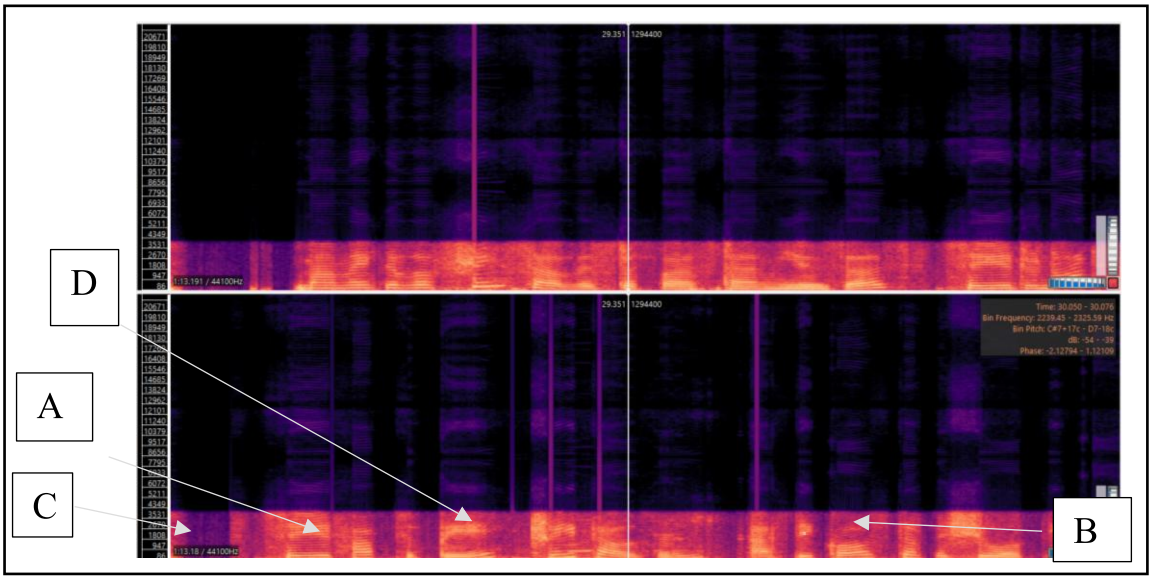

FIGURE 8 Image showing comparison between original(top) and edited(bottom) audio file between devices no.29 And 30

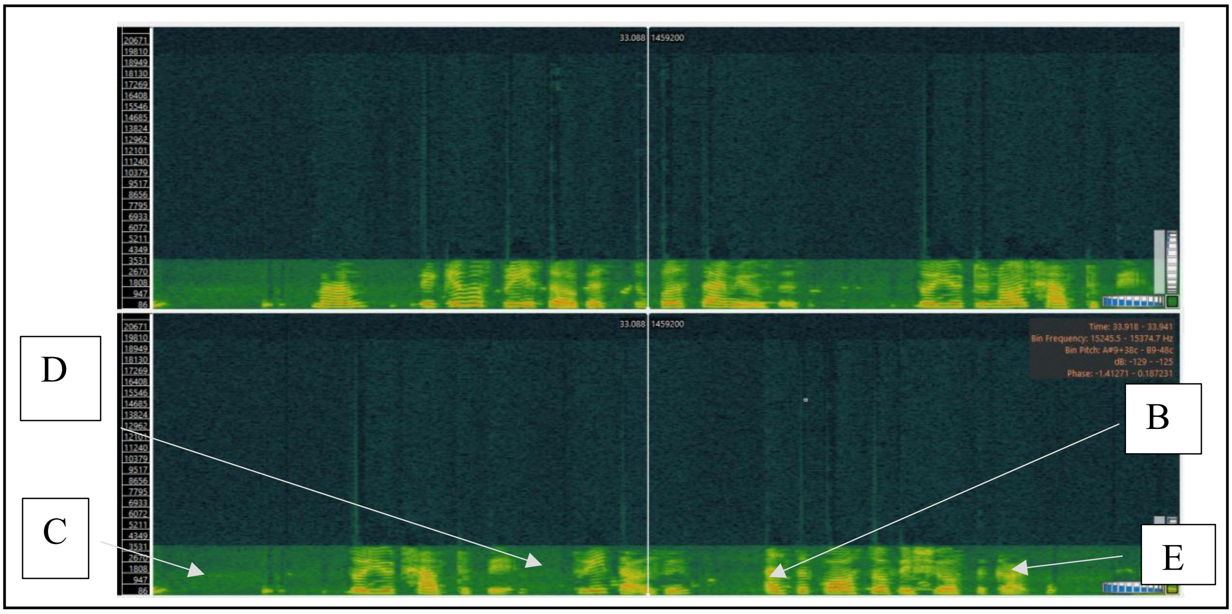

FIGURE 9: Image showing comparison between original(top) and edited(bottom) audio file between devices no.23 And 24

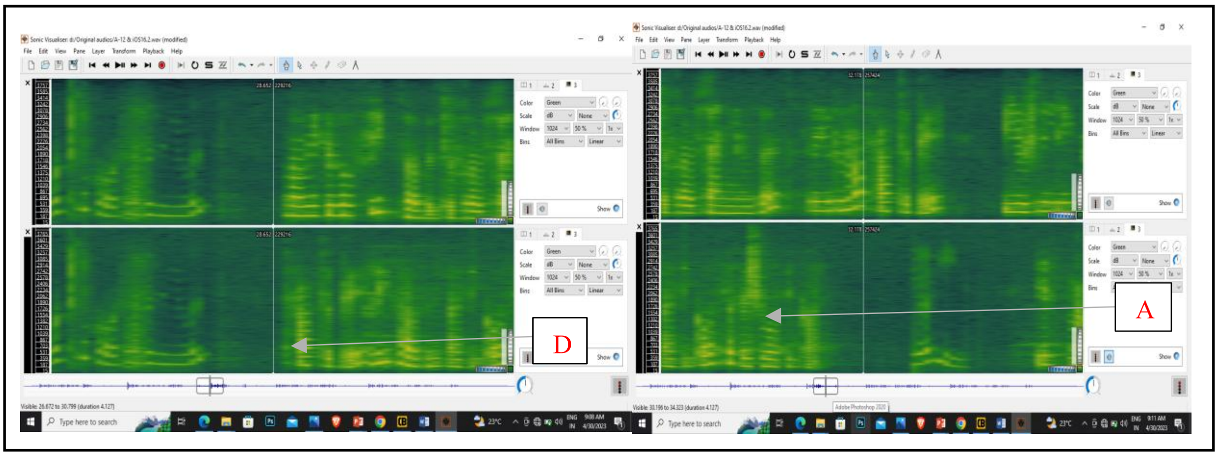

Figure10 : Image showing comparison between original(top) and edited(bottom) audio file between devices no.25 and 26

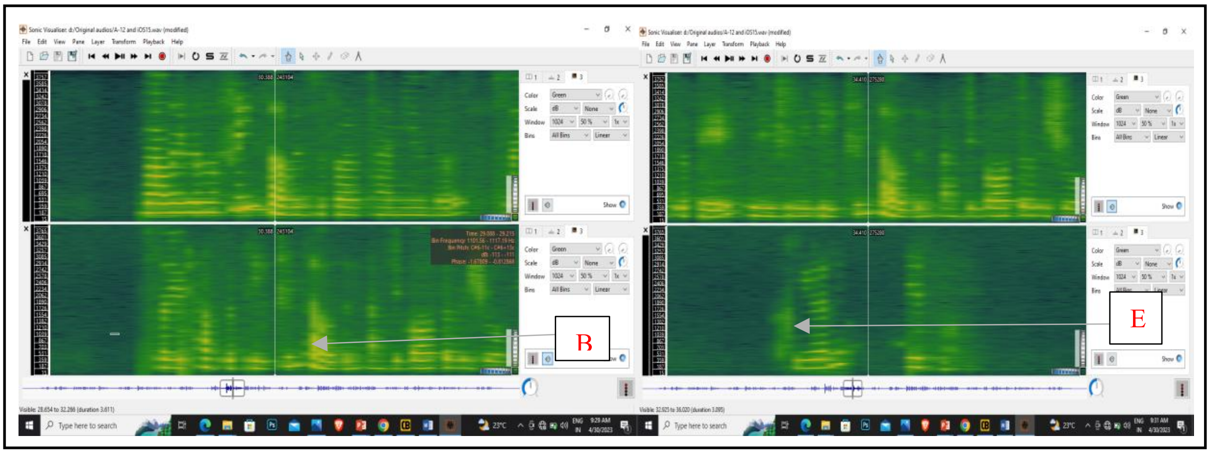

Figure 11: Image showing comparison between original(top) and edited(bottom) audio file between devices no. 17 and 18.

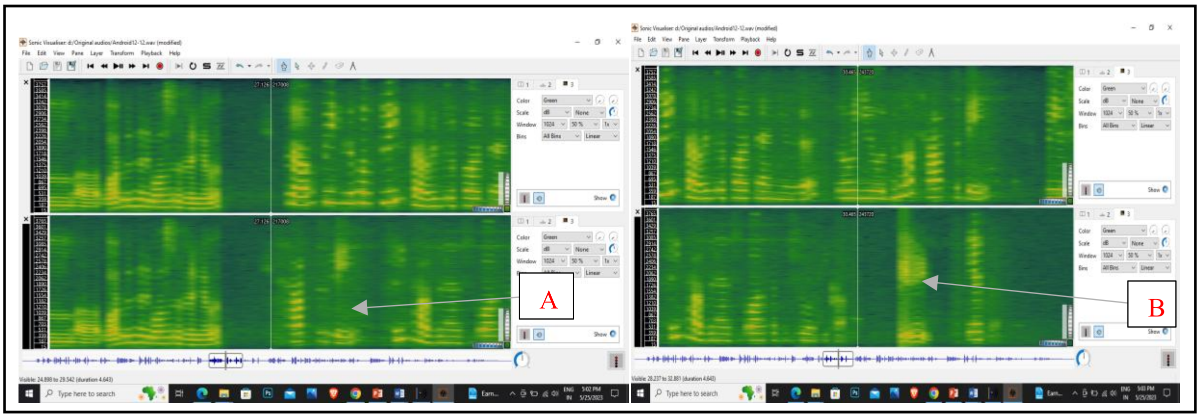

Figure 12: Image showing comparison between original(top) and edited(bottom) audio file between devices no.9 and 10

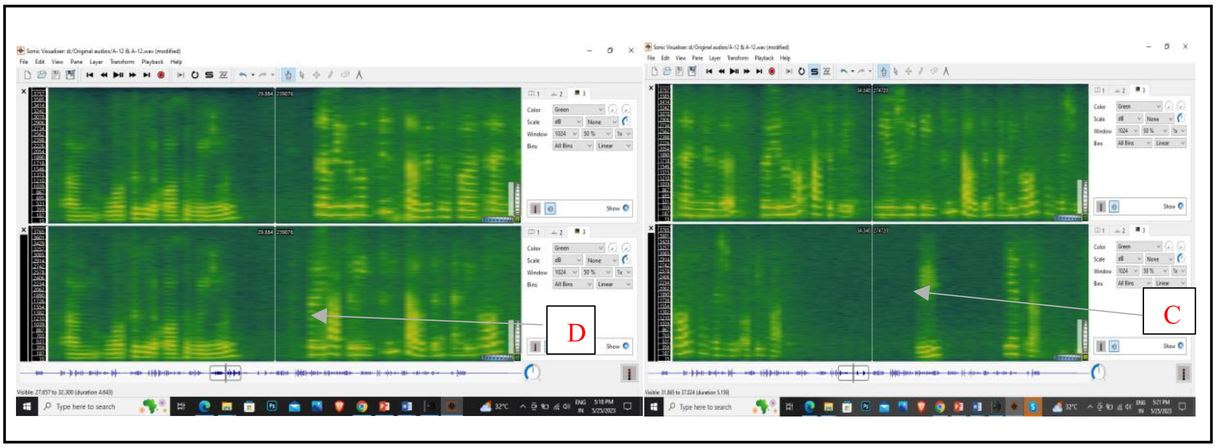

Figure 13: Image showing comparison between original(top) and edited(bottom) audio file between devices no.1 and 2

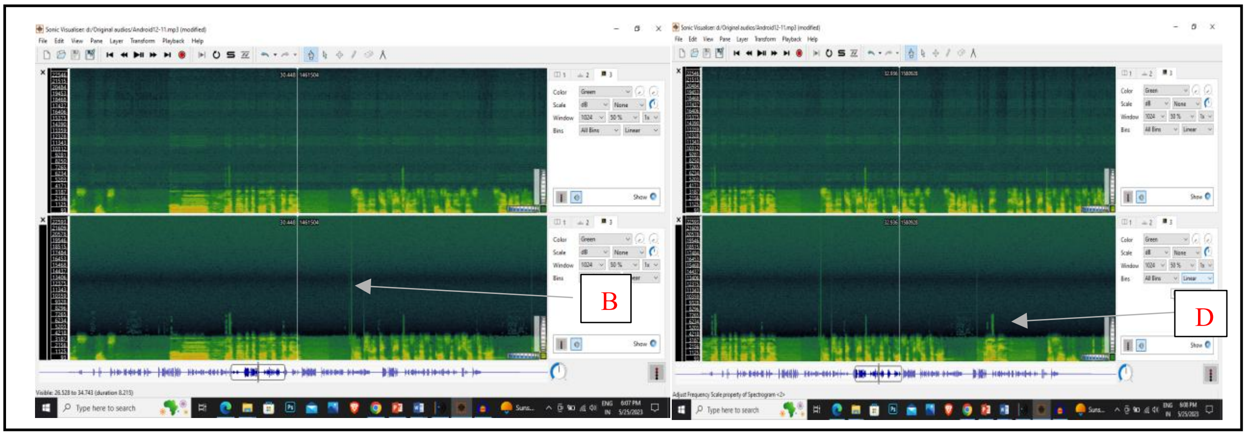

Figure14: Image showing comparison between original(top) and edited(bottom) audio file between devices no.7 and 8

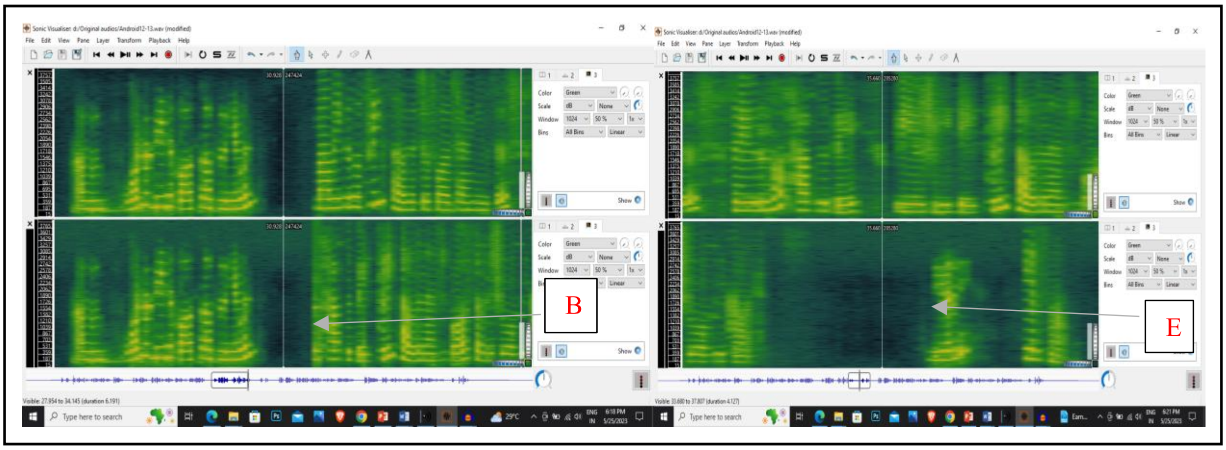

Figure 15: Image showing comparison between original(top) and edited(bottom) audio file between devices no. 5 and 6

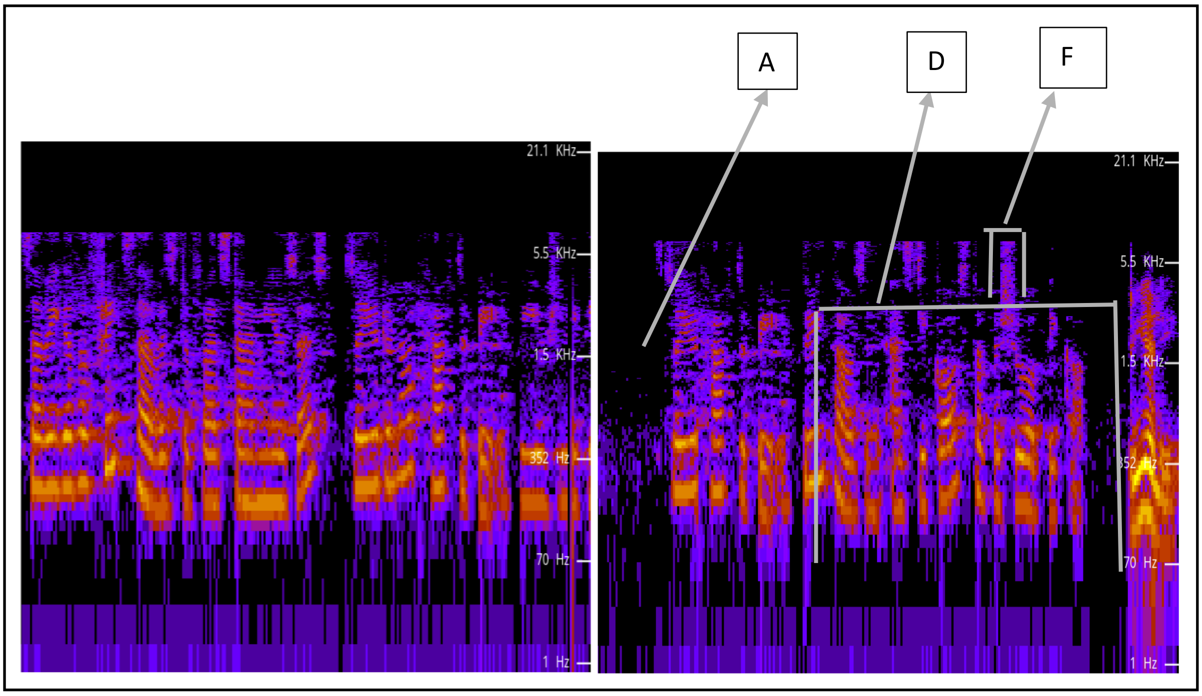

FIGURE 16: Image showing comparison between original(left) and edited(right) audio file between devices no. 3-4

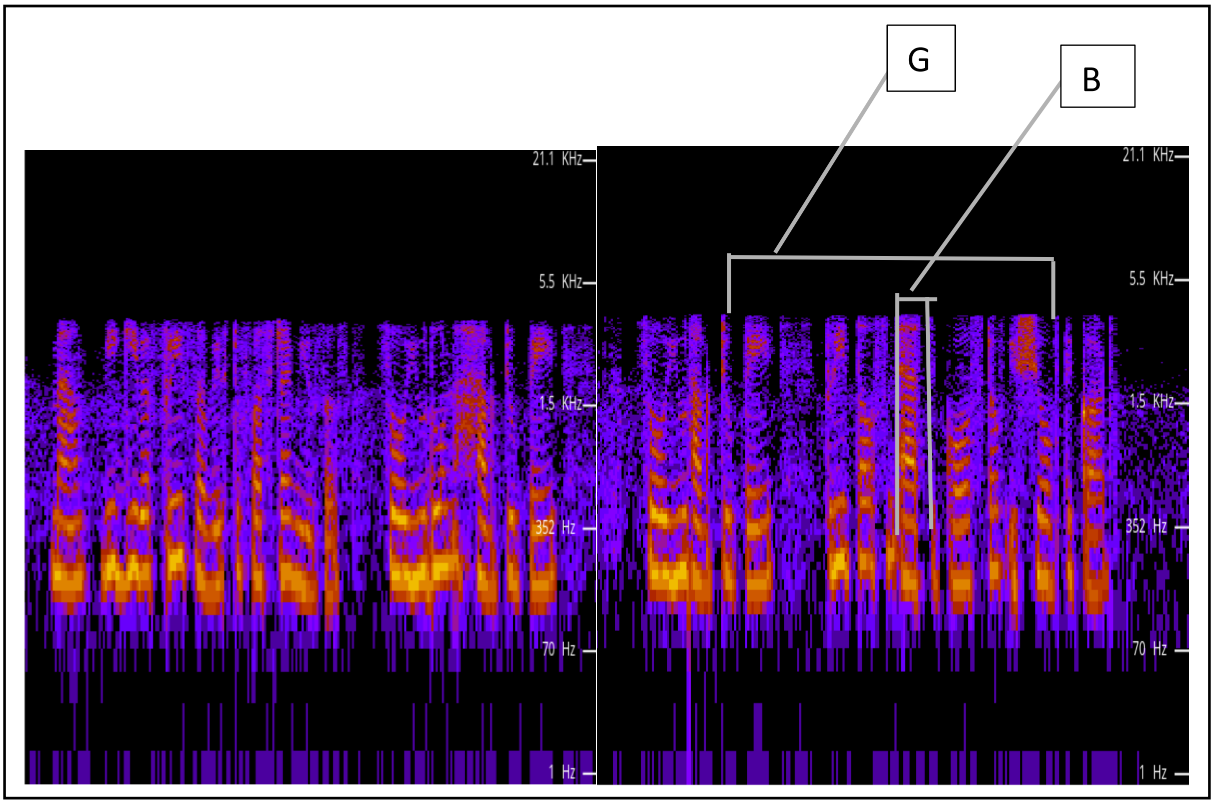

FIGURE 17: Image showing comparison between original(left) and edited(right) audio file between devices no. 11-12

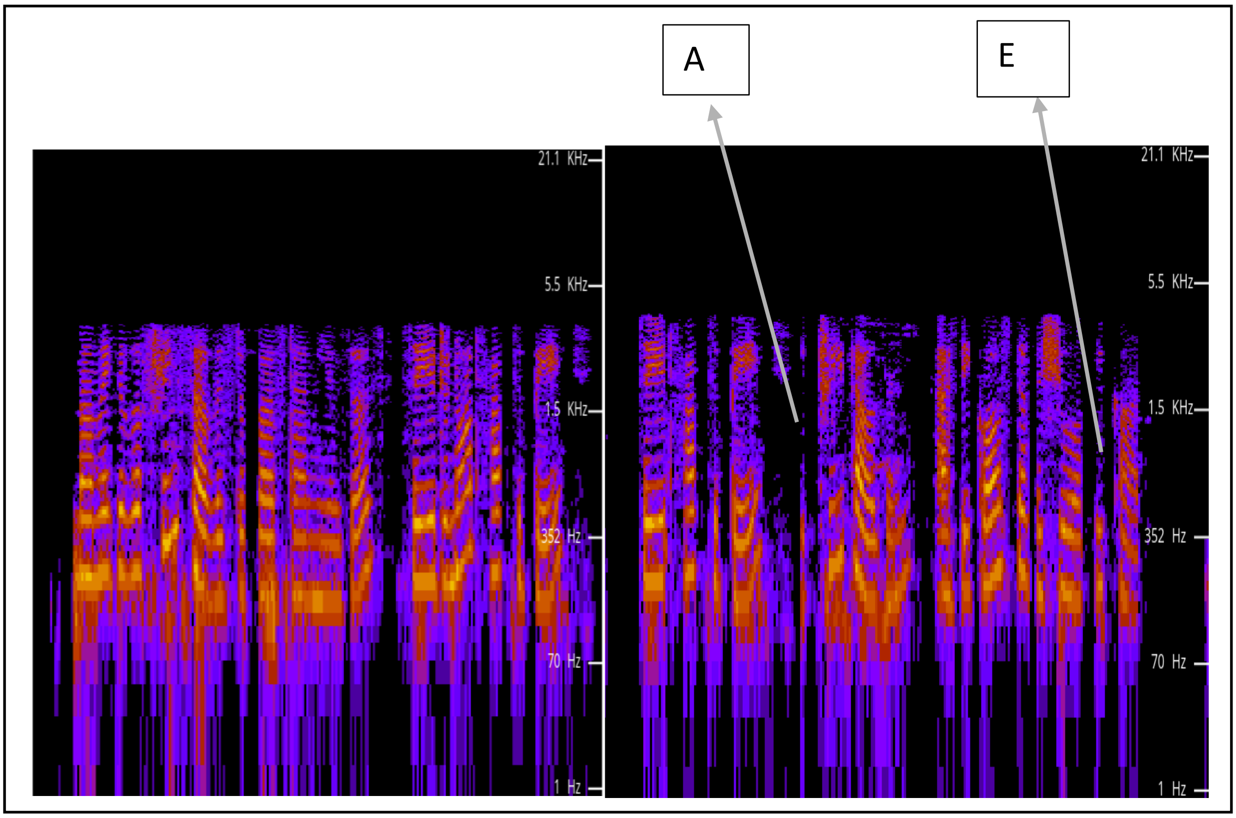

FIGURE 18 Image showing comparison between original(left) and edited(right) audio file between devices no.21 -22

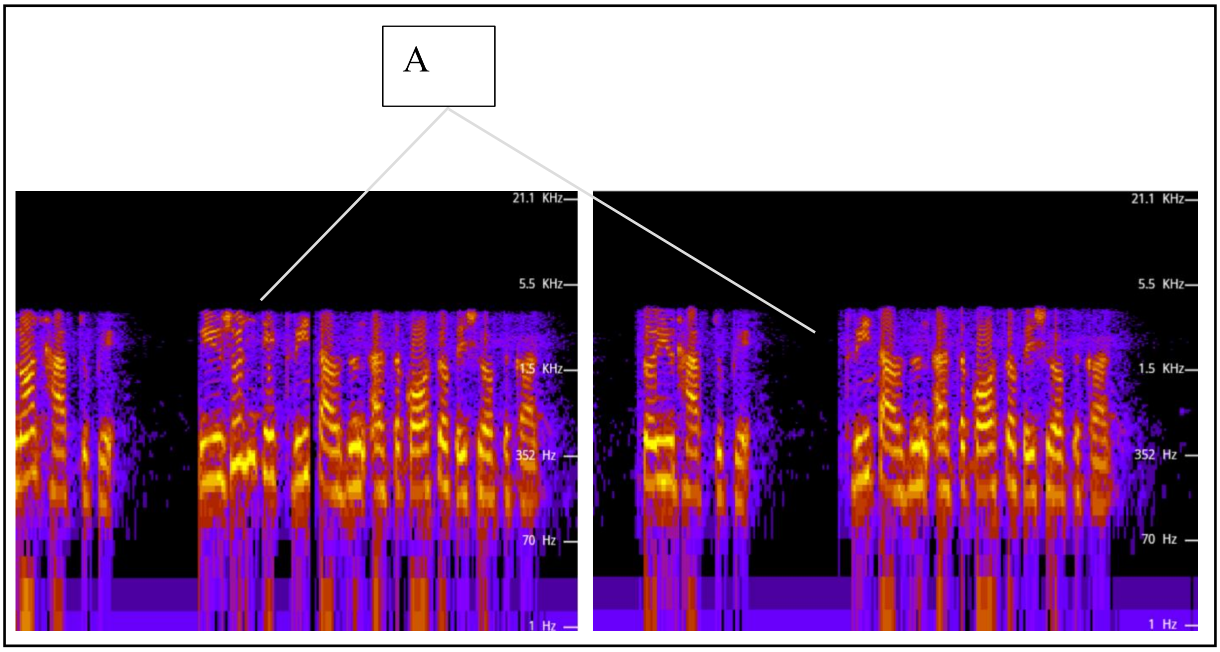

Figure 19: Image showing comparison between original(left) and edited(right) audio file between devices no. 45&46

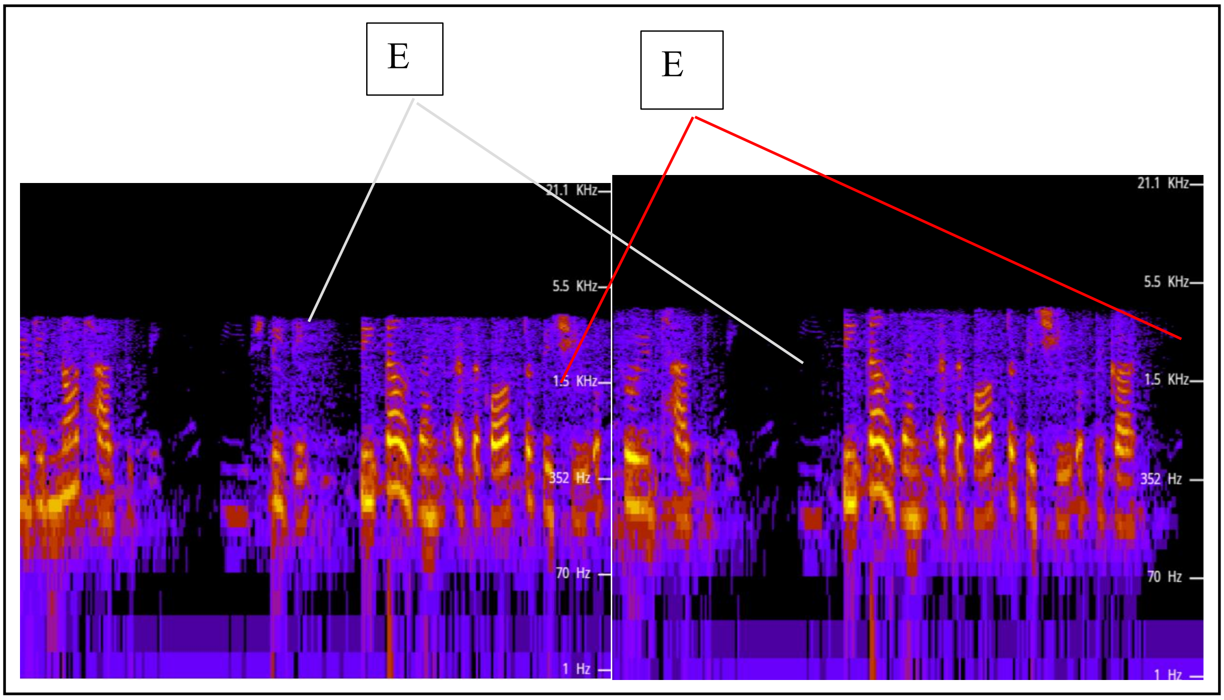

Figure20: Image showing comparison between original(left) and edited(right) audio file between devices no.. 39- 40.

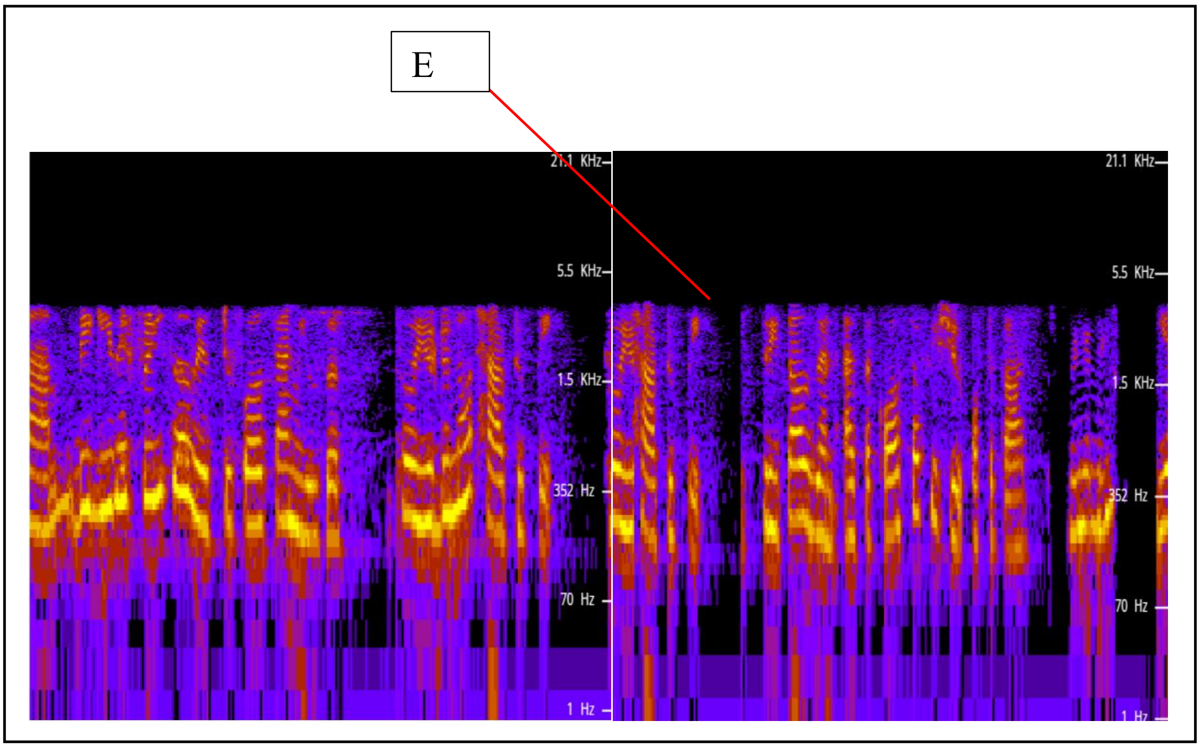

Figure 21: Image showing comparison between original(left) and edited(right) audio file between devices no. 49&50.

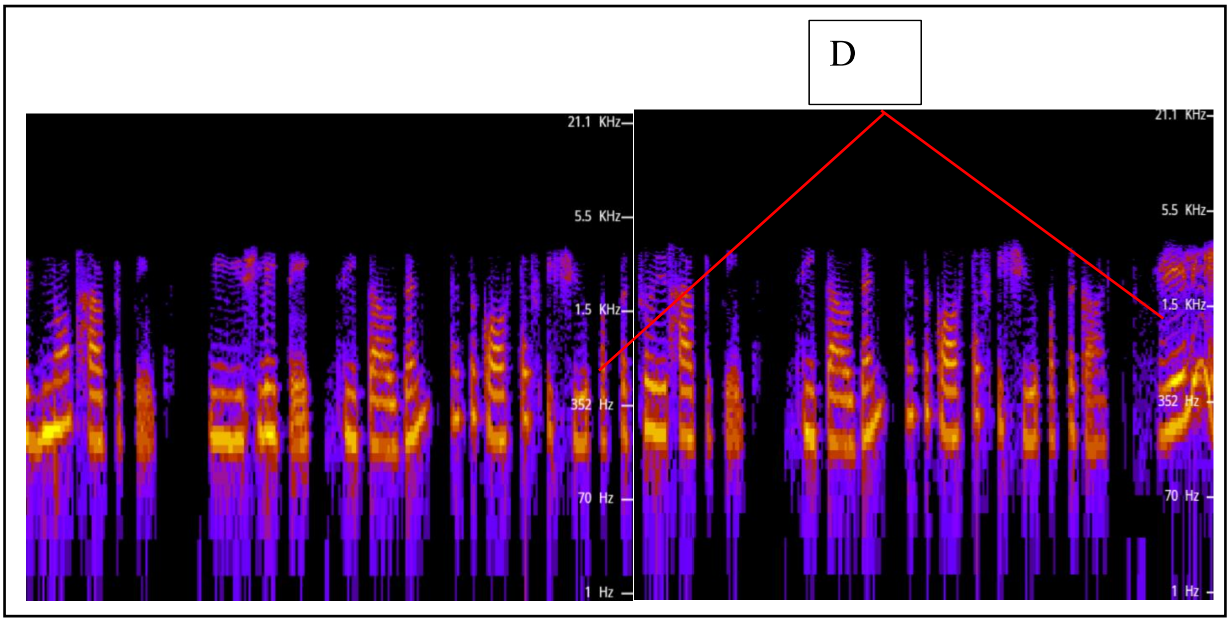

Figure 22: Image showing comparison between original(left) and edited(right) audio file between devices no. 41&42

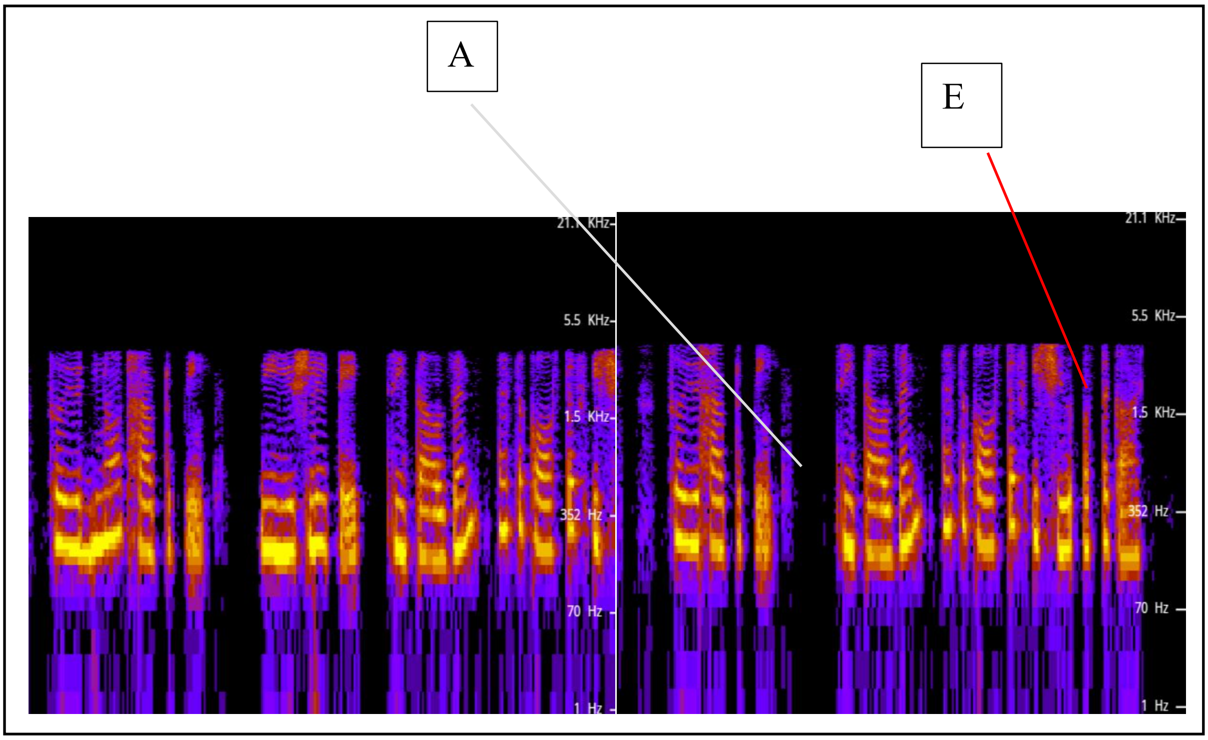

Figure 23: Image showing comparison between original(left) and edited(right) audio file between devices no. 43&44

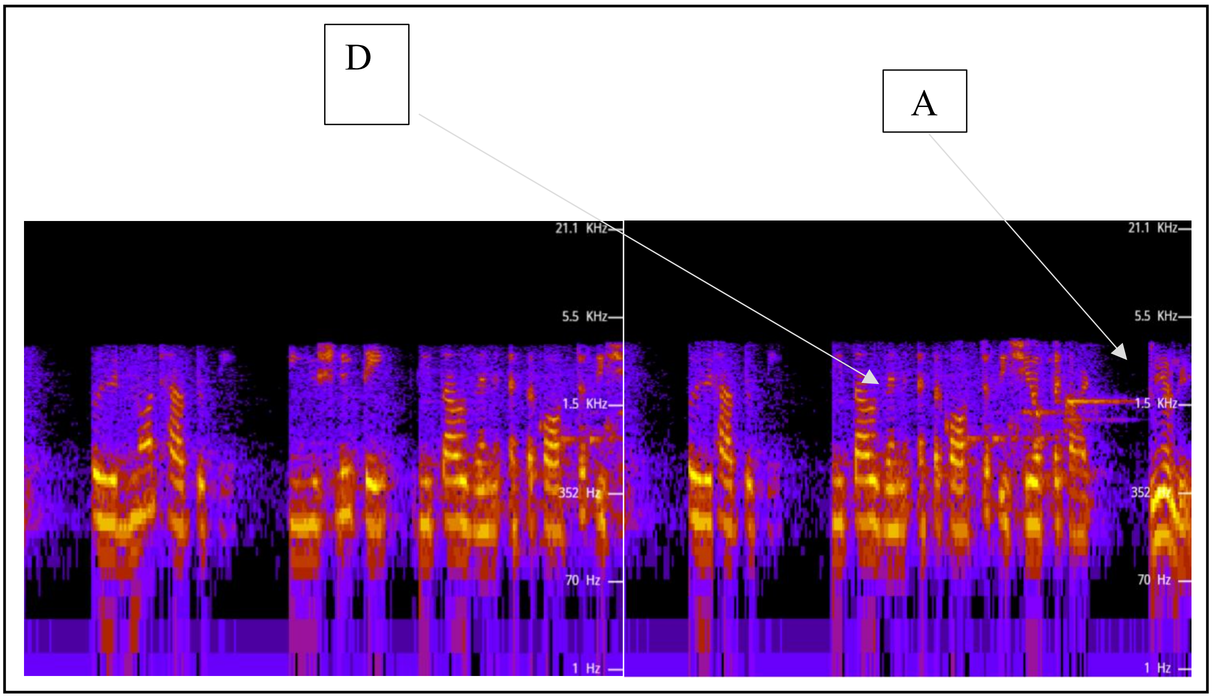

Figure 24: Image showing comparison between original(left) and edited(right) audio file between devices no. 47&48.

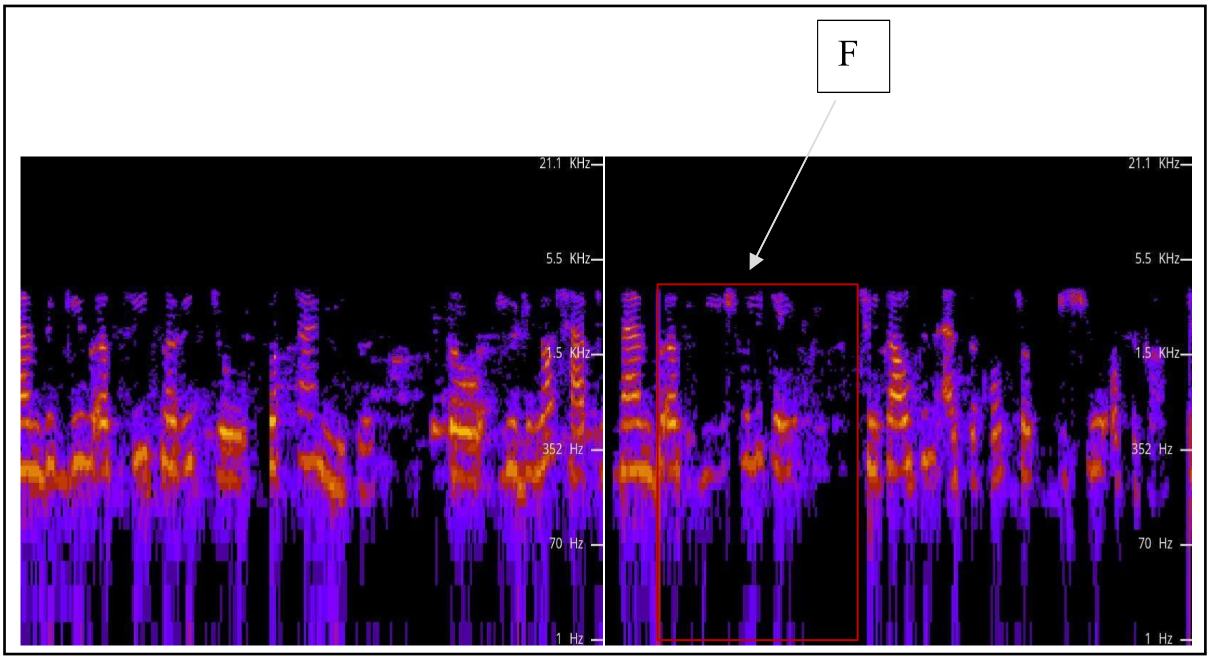

Figure 25: Image showing comparison between original(left) and edited(right) audio file between devices no. *51 and 52*

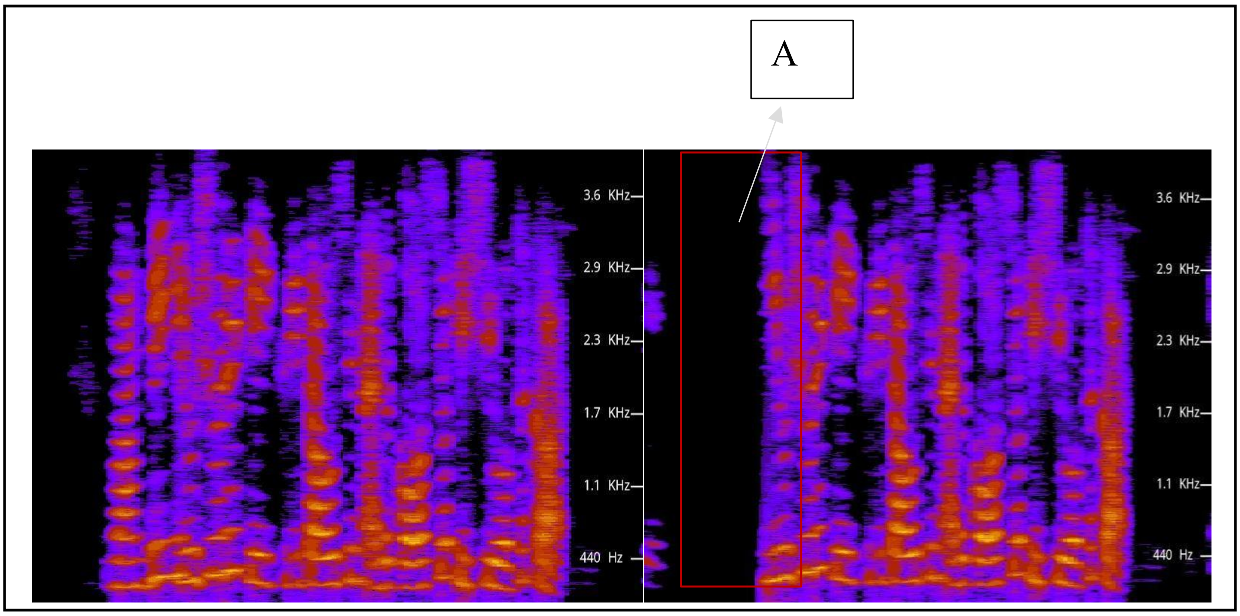

Figure 26: Image showing comparison between original(left) and edited(right) audio file between devices no. 57 and 58.

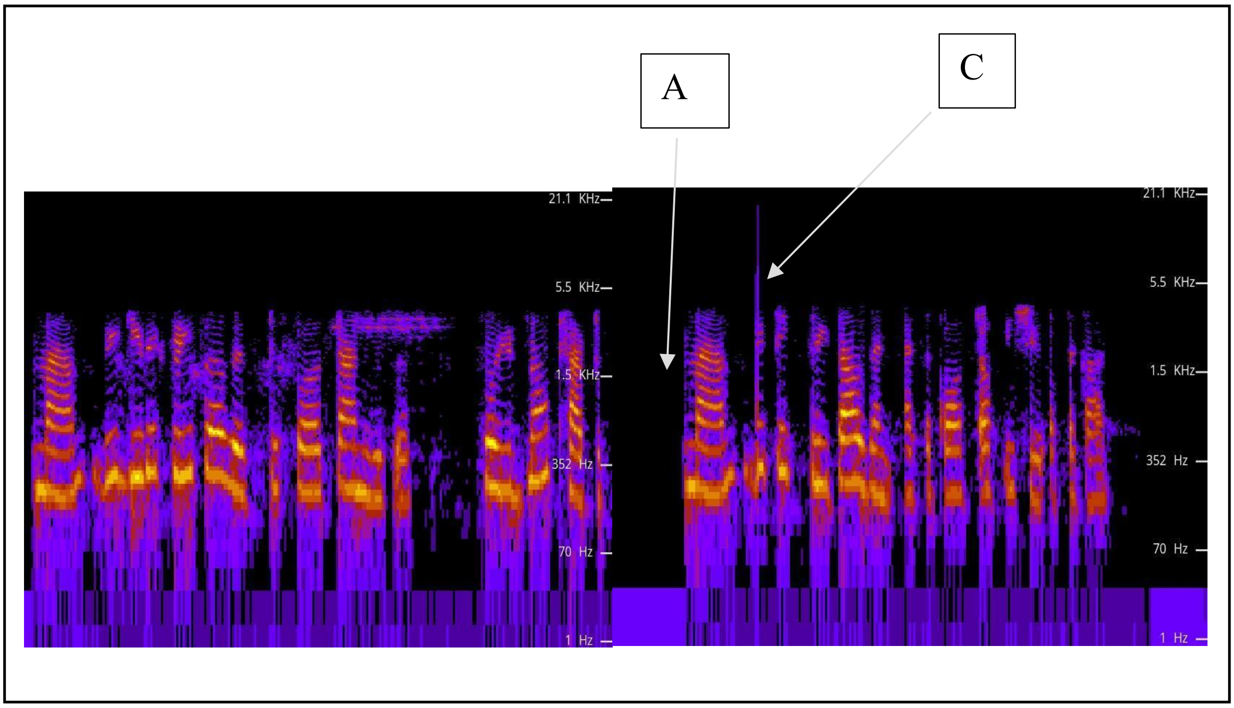

Figure 27: Image showing comparison between original(left) and edited(right) audio file between devices no.27-28

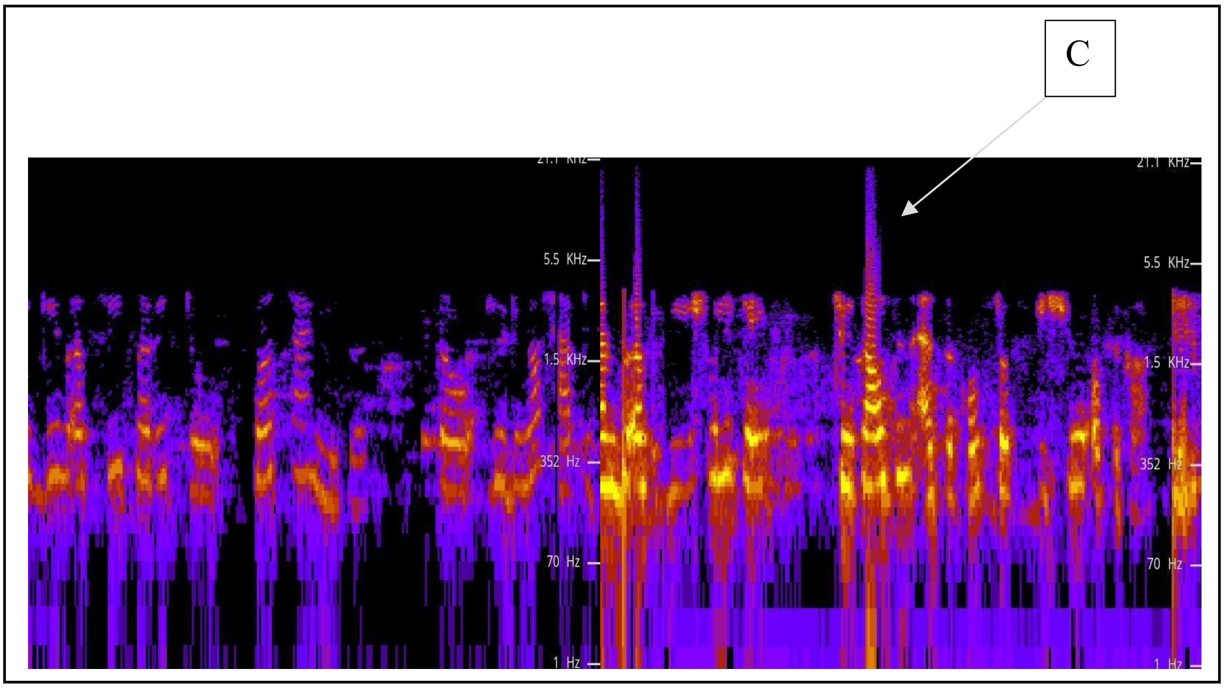

Figure 28: Image showing comparison between original(left) and edited(right) audio file between devices no. 55 and 56

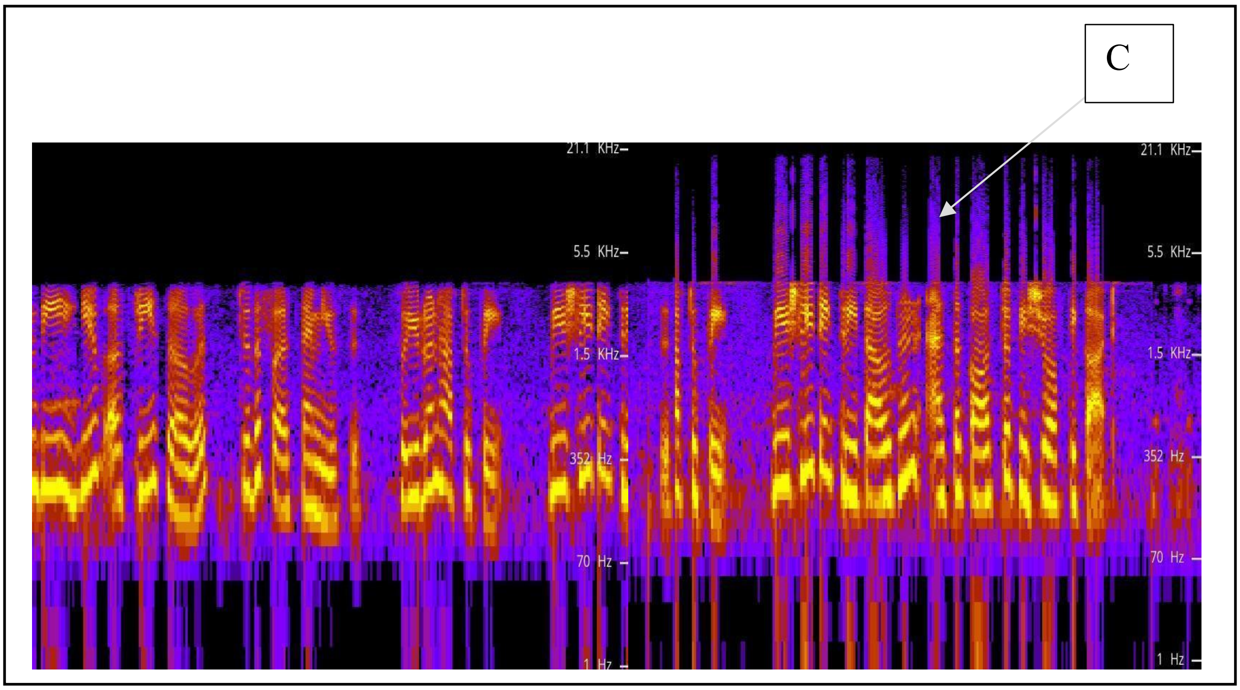

Figure 29: Image showing comparison between original(left) and edited(right) audio file between devices no. 53 and 54

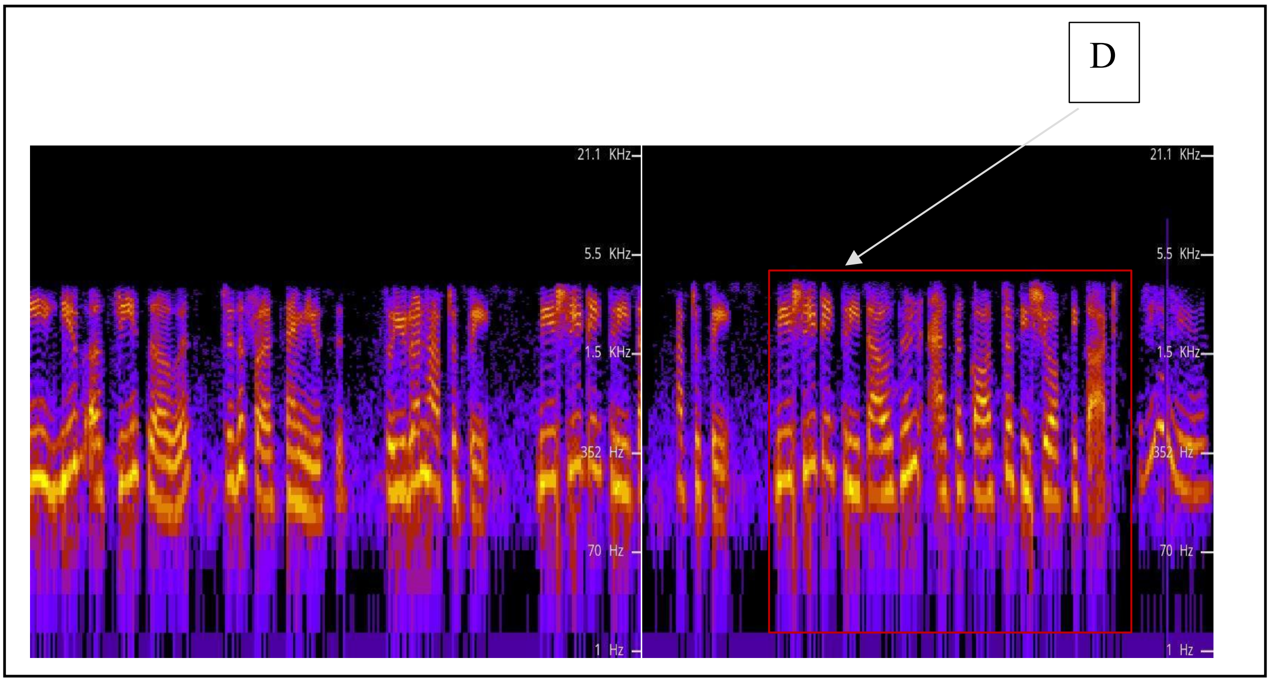

Figure30: Image showing comparison between original(left) and edited(right) audio file between devices no. 59- 60

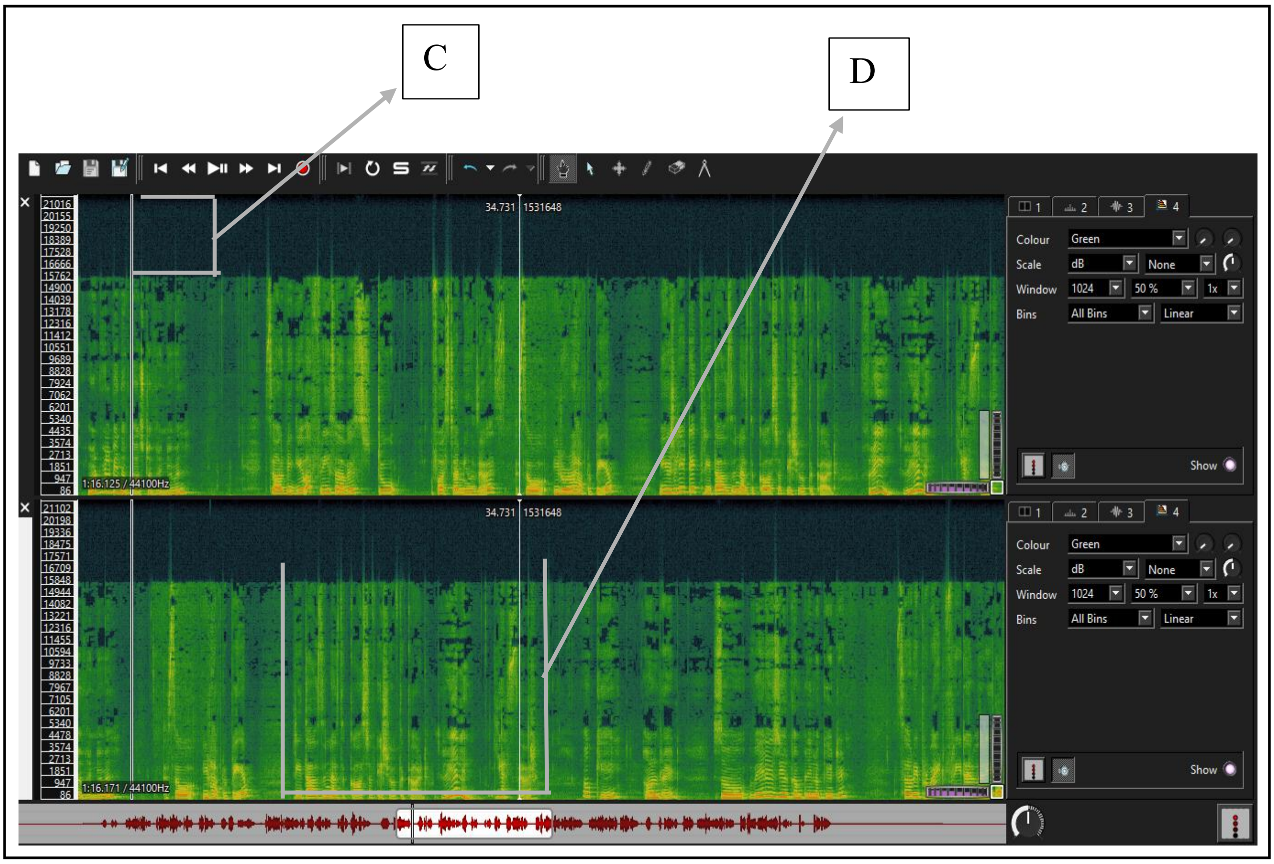

Figure 31: Image showing comparison between original(top) and edited(bottom) audio file between device no. 63.

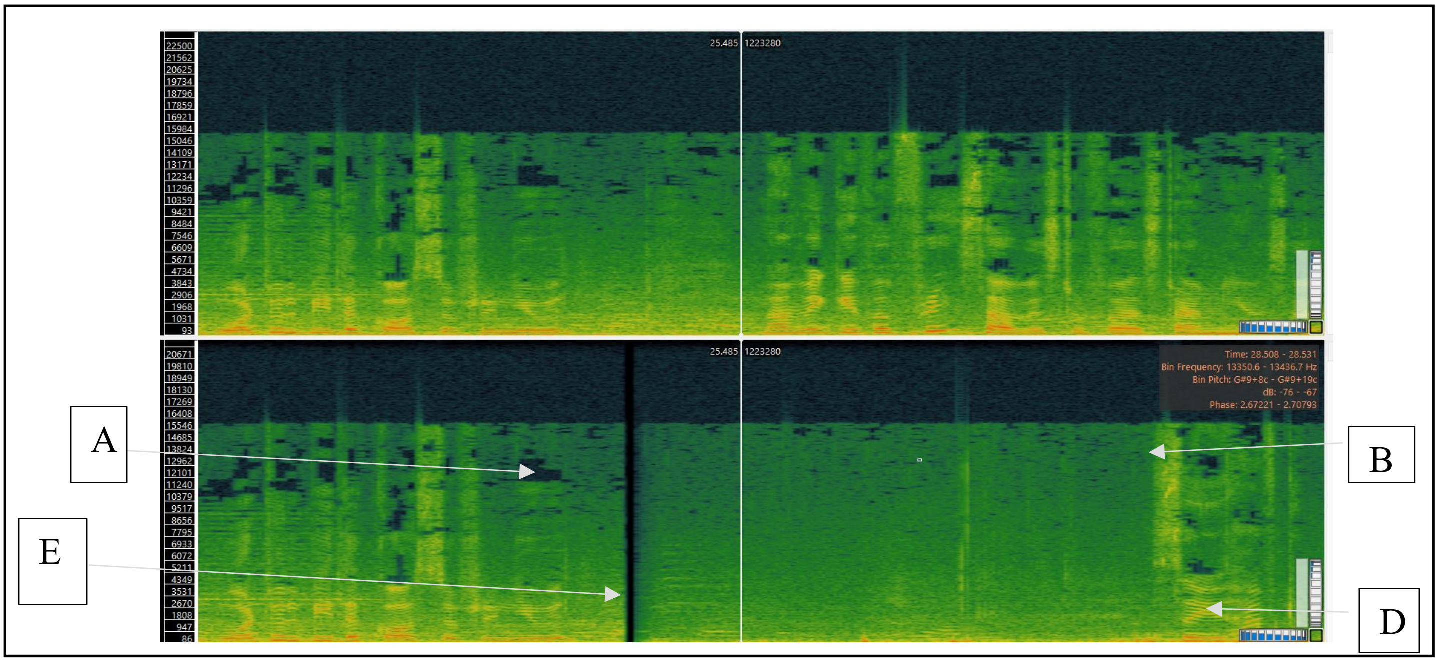

Figure 32: Image showing comparison between original(top) and edited(bottom) audio file between device no. 64.

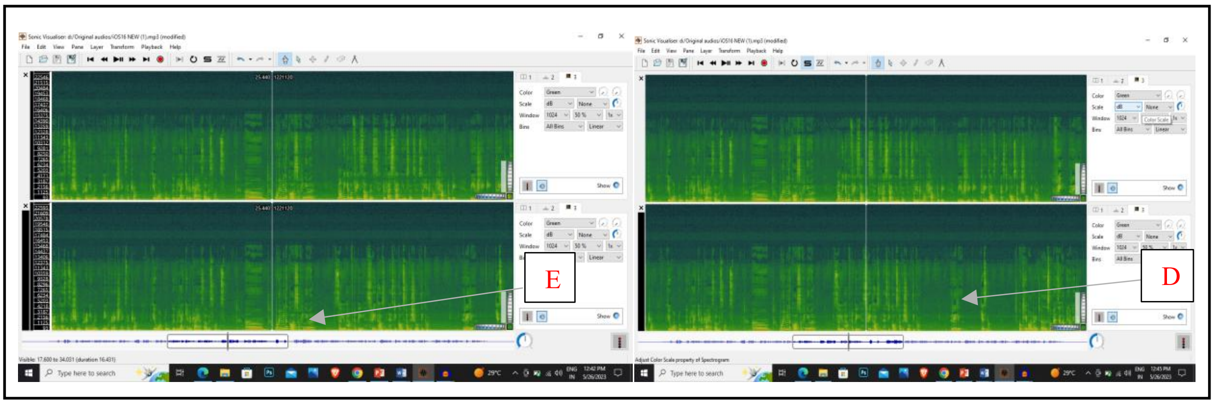

Figure 33 : Image showing comparison between original(left) and edited(right) audio file between device no. 65.

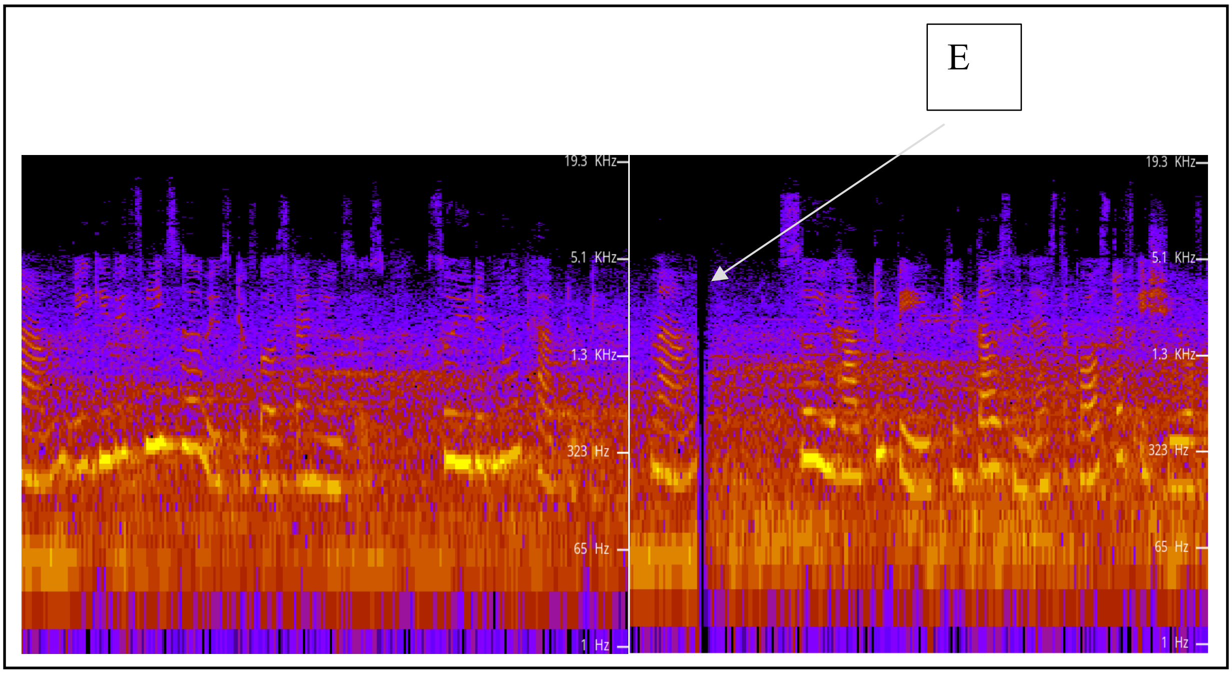

Figure 34: Image showing comparison between original(left) and edited(right) audio file between device no. 60

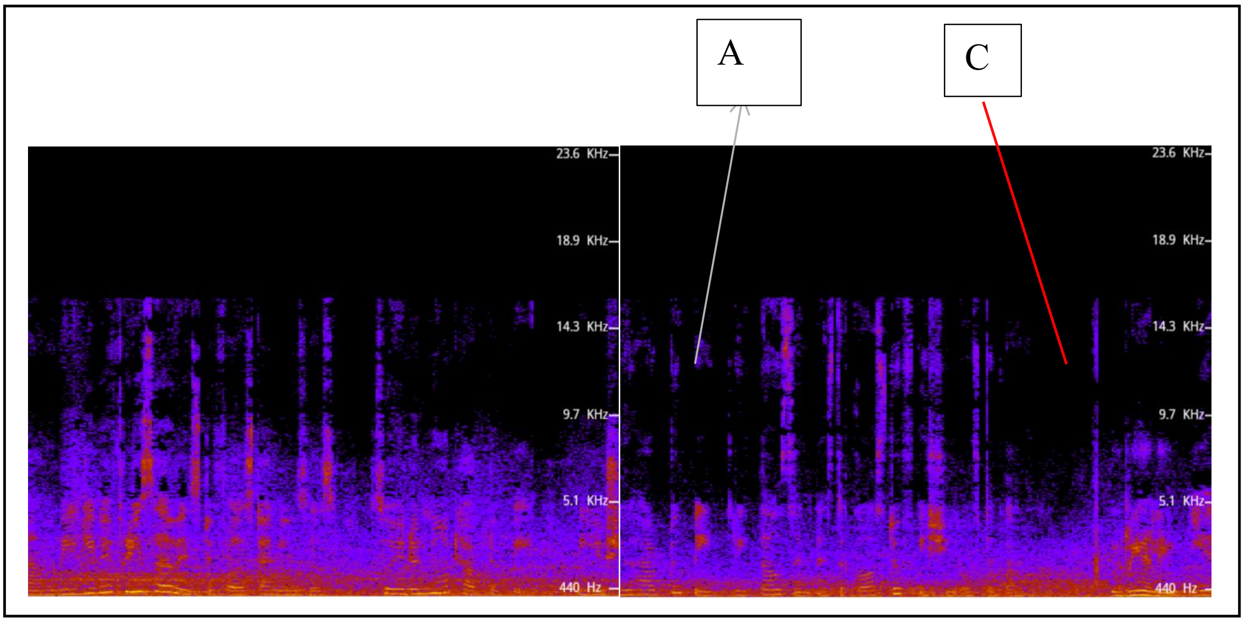

Figure 35: Image showing comparison between original(left) and edited(right) audio file between device no. 62.

PARAMETRS FOR SPECTOGRAM

A- Black Background in between the bands showing silence: The gap showing that the part has been edited. Which means Silence or Absence of Sound: A complete absence of sound or silence would result in a break in the spectrogram since there would be no frequency components present during that time.

B- Longest duration: A longer duration allows for better observation of longer-term patterns and trends in the audio band, while a shorter duration provides more localised or transient information.

C- Increase in frequency: change in source or event. If there is a transition from one sound source to another or a significant event occurs in the audio.

D- Compressed wide/narrow band spectrum

E- Signal Dropout: If there are gaps or missing portions in the audio bands due to errors, recording issues, or other factors, these gaps would be reflected as breaks in the spectrogram.

F- Change in spectrum pattern: differences in the distribution of frequency components.

G- Sudden Discontinuities: changes in the frequency content or intensity levels that don't match the origin.

While comparing the spectrograms of both original and edited audio files these were the 7 parameters that were been observed in the edited audio file.

DISCUSSION

DISCUSSION

Metadata analysis gives an overview of the file properties through which any unusual data found can be detected. It is helpful when an initial quick checking of the file is required. From the metadata analysis, once it is proved that there is some kind of alteration that is done to the file, further spectrographic analysis can help to visualize the whole spectrum of the audio and detect different parameter changes occurring in the spectrum.

For this study, we have performed both metadata and spectrograph analysis for the different audio recordings that were collected and have interpreted the results.

Metadata analysis provides significant information about an audio file's creation and modification history. Suspicious adjustments or discrepancies can be found by inspecting features such as file format, encoded date, bit depth, bitrate, sample size, file size, and producer. The efficacy of this strategy, however, is strongly dependent on the availability and correctness of metadata. It is essential to remember that metadata analysis may not be enough to identify complex alteration tactics. The audio content may be altered by skilled manipulators without leaving any evidence in the metadata. In these circumstances, relying only on metadata analysis might result in false negatives, when modified audio recordings go undetected. While it can assist in detecting fundamental manipulations, it may be incapable of detecting advanced tampering techniques that alter audio content without affecting metadata. To enhance the effectiveness of metadata analysis, it is advisable to combine it with other technique, such as spectrograph analysis. This additional technique can provide complementary information and increase the chances of accurately detecting manipulation.

In the analysis part of the spectrogram 35 audios were analysed in which it included 30 Android versions (10-13) and 5 IOS versions (16). The software's such Sonic Visualizer and Spectrum Analyser were used to analyse the spectrogram.
The spectrogram of the original and edited audio files was compared to detect any source of manipulation or alterations.
During the examination of the spectrogram different variations were observed in the edited audio file such **Silence, Longest duration, increase in frequency, compressed wide/narrow band spectrum, Signal dropout, change in spectrum pattern, sudden discontinuity.**
From the observation of both original and edited audio files there were manipulations which were noted in the edited audio files**.**
Some of the limitations of using a spectrogram include difficulty in interpreting complex sounds, inability to distinguish between sounds with similar frequency content, and the fact that it only provides a two-dimensional representation of a sound.

- **To determine which tool is better for spectrographic analysis of audio file.**

The spectrograph produced by the Sonic Visualiser and Spectrum Analyzer were observed to look for features which aid in producing better spectrograph which is better for analysis.

The sonic visualiser was found to be a better tool as compared to spectrum analyser for comprehensive analysis and interpretation as it allows for a wide range of audio visualization of the audio. It is more versatile and user friendly as compared to spectrum analyser as it consists of different options to view the audio in different forms for comparison.

The dropout, the pattern changes, the discontinuity and the transition of spectral pattern is clearly visible in sonic visualizer where spectrum Analyzer does not produce a clearer view of the spectrograph for analysis.

Overall, Sonic visualiser is found to be better for carrying out the spectrographic analysis of audio to detect manipulation by observing anomalies in the spectrograph and aid in authentication of the audio.

LIMITATION

- The determination of the better tool is subjective as it depends on the needs of the user.
- The effectiveness of the tool depends on the context of analysis.
- The effectiveness of the tool depends on the user's proficiency and familiarity with software.

- **To propose a technique to detect manipulated audio files.**

The evidence found in the scene of crime must undergo a plan of action through which information should be collected and documented without tampering with the evidence.

- Acquisition of audio files
  Details regarding the device or medium in which the audio material was recorded should be documented along with the physical condition the device(evidence), The digital device should be collected and handled with care so that the authenticity of the evidence is not compromised, and it is important to maintain the chain of custody.

- Imaging the file
  Before the audio file present in the device is extracted from the evidence it must undergo is imaged using a forensic imaging using forensic tool such as FTK imager, SluethKit, Encase, Autopsy etc,.

- Exporting the audio for analysis
  Once the imaging of the evidence is done and if suspected of any sort of alterations **metadata** and **spectrograph** analysis are performed to detect any type of malicious alterations in the audio file.
    The metadata analysis of the audio is performed using the software tool, MediaInfo which displays different properties such as the date of creation, date of modification, bit depth, bitrate, sampling rate, producer, and writing application and other parameters. If the audio (evidence) was of an **android** version phone and was undergone any sort of alteration using any software or application, the metadata shows it by giving the name of the producer (such as reaper in our study). In the case of **iPhone**, the metadata provides the details of the writing application which includes the Build and the application used for recording such as (Voice Memo). The **producer** parameter can be used to find out the tool used for editing the audio. The **writing application** gives information about the source/Recording device of the audio.

    The next step is spectrograph of the audio which is produced by using software such as **Sonic Visualizer** or **Spectrum Analyzer**. The spectrograph is examined to look for any gaps or signal dropouts, change in frequency, abrupt pattern change, and any discontinuity which indicates possible manipulation of the audio file.
    The audio file received as evidence can be examined using metadata and spectrograph analysis to determine if the audio has been Altered or manipulated.

This research is important because communication through phones is spreading worldwide, to add up on the other side, the manipulation of audio recordings is also misleading. This research is an alternative way to find the manipulated audios from a device. Anyone who has access to technology can analyse the audio to determine whether it is manipulated or authentic. The outcome of analysing audio recordings can prevent being a victim of fraud or scam calls. This analysis helped to detect and prevent the manipulation of audio recordings, which can have serious consequences in various fields, including journalism, law enforcement, and entertainment.

CONCLUSION

CONCLUSION

Audio authentication a useful and developing technology, which is important in many fields, namely security, forensics, and entertainment. To establish the accuracy and reliability of the recorded content, audio signals must be analysed and verified. Recent developments in digital signal processing, machine learning have dramatically advanced audio authentication approaches. These developments have made it possible to use more precise and trustworthy ways to check the validity of audio recordings.

Law enforcement and forensics are two areas where audio authentication is most used. It enables investigators to assess the reliability of audio evidence, such as phone recordings or taped conversations, which can be essential in criminal investigations and court cases. Audio authentication a useful and developing technology which can support and is trustworthy of the evidence by examining several aspects of the audio, such as speaker identity, voice recognition, and tamper detection.

Audio authentication also contributes to protecting the integrity of audio content in the digital age, in addition to forensic applications. Robust approaches to identify and stop audio forgeries are becoming more and more necessary with the rise of fake news and audio manipulation techniques. By identifying modified or synthetic sounds, audio authentication solutions can shield people and organisations against false information and hostile activity.

Nevertheless, audio authentication is not perfect and has some drawbacks. Even with modern audio editing software and methods, forgeries might be difficult to spot but still sound convincing. Researchers and professionals in audio authentication have difficulties as a result of the ways used to modify audio evolving along with technology.

To draw a thorough conclusion, audio authentication should be utilised in addition to other types of evidence and investigative strategies, despite the fact that it is a powerful tool. In order to remain ahead of new threats and increase the precision and dependability of audio authentication techniques, constant study and advancement are required.

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Annexure

Annexure

(Conversation between a fraud company executive and the victim)

Person1: (picks the call) Hello. Who is this?
Person2: Hi sir. I'm calling from SafeDrives Company. I have called to inform you that your driving licence is due for renewal. Sir when do you plan to renew it.
Person1: Yes.. I know. I have not thought about it yet.
Person2: Sir our company provides with all facilities like driving license issue, renewal, name correction, etc. If you want to, we would like you to try our service once.
Person1: Umm.. What will be the cost of renewal?
Person2: Sir we give a free service to first time users. **So you** do not **have to pay**. We usually take **3000 as the cost of issue of the card**.
Person1: Free? Really?
Person2: Yes sir
Person1: Okayy alright.. So where is your company located?
Person2: Sir we provide free delivery of services so you can be at the comfort of your house. You just have to send us your details through this number and we will go ahead with the renewal.
Person1: Alright but may I know who I am speaking to?
Person2: Sir I'm Sujata. If you have any queries or grievances you can contact in this number. Also we would appreciate if you could send us your email so that we can keep you updated.
Person1: Okay
Person2: Thank you sir. Have a great day ahead.