

Subjective Assessment of Audio Watermarked Quran

Adamu Abubakar¹ & Akram M. Zeki
International Islamic University Malaysia

Abstract

Audio Quran is now accessible in many websites free of charge. People can listen online or download any verse or the complete Quran verses. The genuineness of the sound content in those online audio Quran by principle should remain intact. Any intentional or non-intentional alteration to the content creates a big problem. There are reports on circulating fake sound output of online audio Quran intended to alter with the original message the Quran delivers and eventually create confusion. We use different audio watermarking technique for the protection of the originality of online audio Quran content. In this case a watermark is embedded into the bit-stream of audio Quran. This will help in verifying any suspicious fake audio Quran in internet. Unfortunately, there is a concern regarding this method, because the watermark may alter with the contents of the Quran sound, this might create more harm than good. As a result this paper aimed at watermarking some selected short surah of audio Quran and investigates the watermarked conditions by extensive subjective listening test. Furthermore, a model suitable for watermarking and verifying authentic audio Quran is proposed. The result is the combination of good watermarking technique suitable for protecting the integrity of audio Quran and a model for verifying contains of the audio Quran.

Keywords: audio Quran, watermarked audio Quran, subjective listening test

INTRODUCTION

Quran in digital format can exist as text; audio and video files, its content, context and originality still remain the same. The success of Da‘wah (Call towards Allah) is to spread the message of the Quran to mankind.

“Whoever directs someone to do good will gain the same reward as the one who does good”

(Muslim, Kitab Iftah al-Da`wah, Juz III: #4665)

¹ Corresponding author: Adamu Abu Bakar, International Islamic University Malaysia, e-mail : adamu@kict.iium.edu.my

In another report by Sahih Muslim (Muslim, Kitab Iftah al-Da`wah, Juz IV: #6470, says:

“Whoever calls to guidance will receive the same reward as the one who follows him without any decrease in the reward of (the follower)”.

It means it's a responsibility of every Muslims to ensure that the message being delivered for call towards Allah is correct and genuine. Audio Quran files in different formats, just as any other digital file is obviously attributed to simple noise-free transmission over general-purpose channels, accurate ability to be copied, simple to edit and compact storage. Thus the use of audio Quran nowadays accelerated over the Internet mostly with the aimed to disseminate call towards Allah.

Unfortunately, in some cases reports indicates that the contents of audio Quran might be intentional or non-intentional altered or people might intentionally circulate false Quranic audios with wrong sound output, and invalid interpretation in order to create confusion and deceive the public, or sometimes just for the sake of changing the originality of the Quranic content. Therefore the responsibilities of protecting the content of the audio Quran lies within communities in concern.

Digital audio watermarking is a technique that is generally used to protect the authenticity of audio against duplications and copyright (Akhaee et al., 2010; Kumar et al., 2008). In this case, it can be use to ensure the authenticity of audio Quran by embedding a watermark as an identifier into the bit-stream of audio Quran, so that any suspicious audio Quran found can be verified by detecting/extracting the inserted watermark. Unfortunately, there is a concern regarding this approach based on the fact that the watermark may alter with the contents of the Quran sound; this might create more harm than good. As a result, this paper intend to watermarked some selected shorts surah of audio Quran using the four basic audio watermarking approach which includes; embedding in a least significant bit, embedding on audio signal echo, phase coding audio watermarking, and embedding on spread spectrum of audio signal. Thereafter, we investigate watermarked audio Quran status by extensive subjective listening test in order to create a suitable model for audio Quran watermarking and verifying the authenticity audio Quran.

Following this section, section 2 present audio watermarking techniques. Section 3 present research methodologies and section 4 presents the results, finally section 5 present the conclusion of the work.

AUDIO QURAN ACOUSTIC MODEL AND SPEECH RECOGNITION

There are many audio Quran in the internet from different recitations. By principle audio Quran content should be the same with the textual Quran. On the other hand they should be recognized as the transcripts of the textual Quran, where all forms of elisions, pronunciations, expression words, grammar, nonverbal sounds, sighs and background sign are expressed (Hassan et al., 2007). In general audio Quran represent the verbal art of “tajweed” that is the rules governing the pronunciation of the content of the Quran during recitation (Hassan et al., 2007). Quran is said to been revealed in seven ahurf and despite it is in Arabic, its recitation is not as quiet as the normal reading of Arabic text. (Habash, 1986). Tajweed as applied to audio Quran dwells on giving every letter its rights and dues of characteristics during recitation. This implies that the sound outputs are guided by rules that apply to each letter of the Quran in different situations. Allah says in the Quran that:

“And recite the Quran (aloud) in a (slow and melodious) style (tarteela)’

(Surah Muzzammil, Ayah 4)

Ali ibn Abi Talib (RA) said in the explanation of this aayah: “at-Tarteel is Tajweed of the letters and knowing where to stop (correctly)”.[An-Nashr of Ibn Al-Jazaree 209:1] And of the rights of reciting correctly is reciting it the way it was revealed. There are various Ahadeeth also showing us the importance of Tajweed. Umm Salamah was asked about the recitation of the Prophet (SAW) and she described it as a recitation ‘clearly distinguished letter by letter’. [Tirmidhi] Sa’eed bin Mansoor relates in his Sunan that a man was reciting the Quran to Abdullah bin Mas’ood and he recited “Innamas sadaqaatu lil fuqara-i wal masaakeen”, so Ibn mas’ood said: “This was not how the Messenger of Allah (SAW) recited it to me!” So the man asked, “How did he read it to you oh Aba Abdir-Rahman?” So he said “Lil Fuqaraaaa-i wal masaakeen”, he elongated the word Fuqaraa and the knowledge of the different lengths of elongation (mudood) is also from the rules of Tajweed. Ibn al-Jazari (may Allaah have mercy on him) said: Whoever is able to read the words of Allah with correct Arabic pronunciation but he deliberately pronounces it incorrectly like a non-Arab, out of arrogance, stubbornness and complacency, or because he is too proud to go to a scholar who could help him to correct his pronunciation, is undoubtedly falling short and sinning and being dishonest. The Messenger of Allaah (pbuh) said: “Religion is sincerity: to Allah, to His Book, to His Messenger, and to the leaders of the Muslims and their common folk.” It is not permissible for anyone to deliberately change any letter of it when he is able to pronounce it correctly. This is a kind of mistake which is a sin. If a person finds it difficult to pronounce the letters

correctly, the choice is he/she have to try to learn the correct pronunciation, but if they are unable to master it then they are excused, but their example should not be followed, and they should be called upon to strive their hardest to learn and correct their pronunciation. And none of them should lead the prayer, unless he is leading others like him who cannot pronounce well either.

AUDIO WATERMARKING TECHNIQUES

Audio watermarking technique present a watermarking technique that utilizes audio file as the host (Bender et al.1996; Karthigaikuma et al., 2011), which is ready to host additional bits without altering being altered or damage and also the state and condition of additional bits remains intact. At any time the additional bits can be detected or extracted by authorized persons. This will maintain the originality of the audio at wherever it's found (Petitcolas et al. 1999).

The embedding of bits in audio takes place by utilizing its frequency or time domain. Therefore the audio stream and watermark bits needs to be transformed to binary format and using either discrete Fourier transform (DFT), discrete cosine transform (DCT) or discrete wavelet transform (DWT). Both the audio and watermark that will be inserted in the audio stream needs to be segmented where necessary (Lei et al. 2010), depending on the type of algorithm used for embedding and detection/extraction. Some of the basic algorithm used for embedding and extraction falls within the following techniques (Ballesteros and Moreno, 2012; Chen et al. 2010):

- i. Audio Watermarking Based on Least Significant Bit,
- ii. Embedding an Audio on Signal Echo
- iii. Phase Coding Audio Watermarking
- iv. Embedding on Spread Spectrum of Audio signal

Least significant bit (LSB) watermarking for audio utilize the LSB of audio signal embeds a watermark into it by substitution (Bender et al.1996). An echo hiding watermarking technique embeds a watermark into a host audio signal by utilizing the echo in those streams that cannot be perceptible by human's auditory system (Liang et al. 2010). Phase coding audio watermarking technique uses the phase difference of the audio segment to embed a watermark (Bender et al.1996). Spread spectrum (SS) utilized a large band signal of the audio to embed narrow band signal of the watermark (Bender et al.1996).

The strength of audio watermarking technique in general is measured by its robustness and watermark capacity (Chen et al., 2013). The fact here still remains that an embedded watermark into audio data is a noise. This noise might bring to some degree a modification of the audio bits streams.

Eventual it might lead to degradation of audio auditory quality of the audio (Zhang et al., 2013). The degradation might be imperceptible for human auditory system (HAS), but in case of an audio Quran, it already altered with the bits that by principle it shouldn't. On the other hand the embedded watermark signal might not be perceived by HAS, this means that despite adding bits to the content of the audio, yet it still show no sign of noise degradation by both HAS and a performance metric called peak signal to noise ratio (PSNR) (Li et al., 2006). In a difference situation where the audio that was embedded with the watermark undergoes some signal processing process like compression reassembling, re-quantization, echo addition and etc this might lead to the lost or destruction of the embedded watermark signal depending on the technique used. However, for protecting the sound of audio Quran, such circumstance will affect the identifier that is the watermark. Therefore, a watermarking technique suitable for audio Quran should possess strong robustness against any signal degradation process and ensure that the embedded bits do not alter with the audio bit stream in any way. Previous researches on audio watermarking have shown that there are mainly two broad categories of audio watermarking: (Bhat et al., 2011) temporal domain techniques and transform domain techniques which involve Discrete Cosine Transform (DCT), Discrete Fourier Transform (DFT), and Discrete Wavelet Transform (DWT). Temporal domain techniques provide simple and effective schemes for embedding the watermark into an audio unfortunately there are not robust. Whereas transform domain techniques is robust (Xu et al., 2007; Wang and Sun, 2001).

In general audio watermarking embedding follows the same pattern. If $f(x)$ is the watermark bits stream, where $x \in \{-1, +1\}$, and $g(x)$ is the original audio bits stream, the embedding of the watermark to the original audio stream involves direct insertion (addition) or substitution (replacement) of bits of the original audio in its time/spatial or transform domain (Zhang et al., 2013). Time/Spatial domain of the audio signal is manipulated directly, whereas in the transform domain, it needs to be changed into a transform representation (Yang et al., 2013).

METHODOLOGY

The entire Surahs of the audio Quran which were believed to be un-watermarked audio Quran were downloaded from the internet from the following links:

- i. <http://quranicaudio.com/>
- ii. <http://www.mp3quran.net/eng/>
- iii. <http://www.assabile.com/>
- iv. <http://www.hamariweb.com/islam/online-audio-quran.aspx>
- v. <http://quran.com/>

- vi. http://www.islamicacademy.org/html/audio/Qirat/Qirat_Arb.htm
- vii. <http://quran-e-majeed.com/quran-audio/>
- viii. <http://www.audioquran.net/>
- ix. <http://www.listen2quran.com/>
- x. <https://www.youtube.com/>

Four short surah of the audio Quran are selected to be used as the host files (see Figure 1 to 4) and an Image file (see Table 1) was used as the watermark file which will going to be embedded on the four audio files.

Table 1: Host files and watermark file

Host Files (.wav)	File size	Watermark file (14.4kb)
Ayat Al-Kursi	60.1 MB	
Surah Al-Falak	5.34 MB	
Surah Al-Fatihah	10.9 MB	
Surah Al-Nas	6.80 MB	

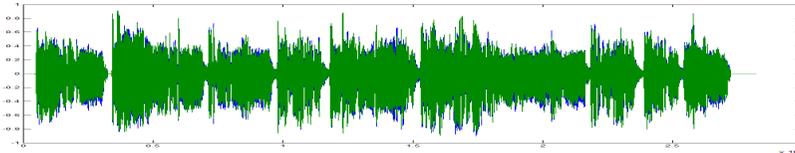


Figure 1. Ayat Al-Kursi

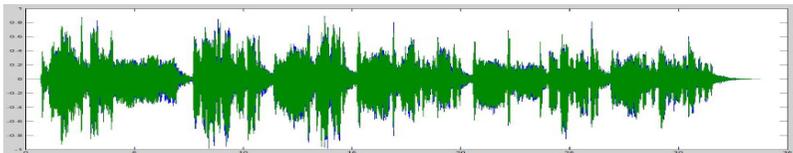


Figure 2. Surah Al-Falak

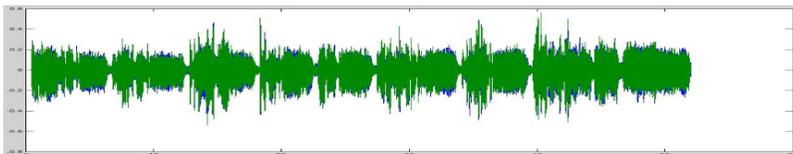


Figure 3. Surah Al-Fatihah

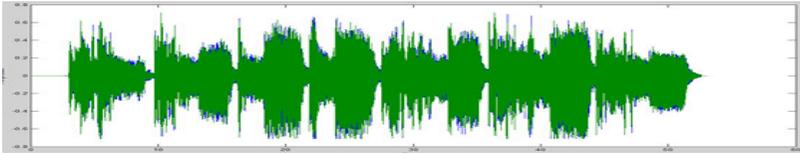


Figure 4. Surah Al-Nas

The first watermarking was undertaken with the least significant bit (LSB) audio-base watermarking technique. The watermark bits were embedded on the four audio files. The resulting watermarked files were saved separately and applied some watermarking attacks that involve the following:

- i. Re-quantization of a 16-bit watermarked audio signal to 8-bit and back to 16-bit
- ii. Echo addition which involves the addition of an echo signal with a delay of 98 ms and a decay of 41% was added to the watermarked audio signal.
- iii. MP3 compression by 64 kbps and 32 kbps were used in order to compress at a bit rate of 64 kbps and 32 kbps respectively, and then decompressed back to WAVE format.
- iv. Pitch shifting was applied by shifting one degree higher and one degree lower.
- v. Additive white noise with 10% of the power of the audio signal is added up to signal to noise ratio of 20 dB

The watermark file was then extracted and saved separately. Thereafter a correlation calculation was used between the watermark file before embedding and the watermark file after embedding in each case of the four cases. As a result four different files were saved (the original audio file, the watermark file, the watermarked file and the extracted watermarked). LSB embedding does direct substitution of LSB at each audio data sampling point by a watermark coded binary string; the substitution operation hides the bits to substitute the original (Yang et al., 2013; Zeki et al., 2012). The next embedding was undertaken by embedding the watermark on the four audio signal echo. The same procedure as applied to the first technique used was also used here. The other technique used is embedding the watermark through utilizing the phase difference of the audio segment, that is, the short-term phase of the signal over a small time interval. Thereafter the final technique which involves embedding on spread spectrum of audio signal was used. The four files chosen for subjective assessment test are based on the robustness of the techniques used. The technique with the best robustness was found to be the technique used by spread spectrum watermarking. Therefore the watermarked files from the spread spectrum technique are the watermarked files that will be used for the subjective listening test.

The justification for carrying out subject assessment test that differs from the conventional subjective assessment test used in most watermarking technique is based on a single fact. That is Quran is a revelation from Allah, and its content is untouchable in whatever case. As a result our subjective listening test is intended for audio Quran in order to understand watermarking techniques that will be suitable for it. Therefore the original un-watermarked audio files and the watermarked audio files are used for the subjective listening test.

Subjective Listening Test

The subjective listening test is carried out with 20 participants. During the subjective listening tests, the participants are asked to compare the perceptual quality of the watermarked audio Quran with the un-watermarked audio Quran. The evaluations follow the evaluations guide of International telecommunication union recommendations (ITU-R) by grading the perceptual quality to a five-graded impairment scale defined in ITU-R BS.1284 (see Table 2) (Zhang et al., 1998).

Table 2: ITU-R BS.1284 Standard audio quality grading scale.

Numerical rating	Perceived quality level
1	Perceived distortion in processed signal is very annoying
2	Perceived distortion in the processed signal is annoying
3	Perceived distortion in processed signal is slightly annoying
4	Distortion is perceptible, but not annoying
5	No perceivable difference between processed and unprocessed signal

For this research, we let the participants analyzed the waveform of each audio file while listening to it.

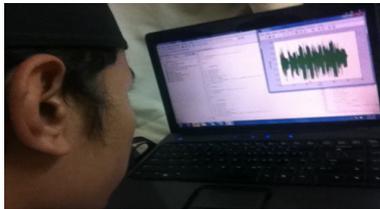
Participants

The key requirement for this particular subjective listening test is “Experts”. Therefore the sampling technique used for this evaluation is a convenient sampling technique. 20 participants voluntarily accept our request for this evaluation. All of them are male. In terms of the age group, approximately 13 of them were in the age group of 15 to 39 years, while the remaining are within the age group of 40 years and above. Considering the educational background, 13 of them are currently undergoing their Bachelor’s degrees while the rest are PhD degrees holders. All the participants by no examination

certified themselves in the categories of those that understand the “Tajweed” and applied it day-by-day and they memorized Quran.

Experimental Procedure

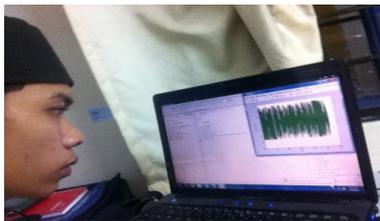
The four short surah of the watermarked and un-watermarked audio Quran were played with audio player. There are different audio players but for this analysis we use Matlab in order to read the audio signal and to listen to the audio Quran. This will allow for analyzing both the sound and the wave form signal of each audio file. MATLAB is a software package for carrying out numerical computations and analyses. It uses blocks of data called matrices (MATLAB stands for matrix laboratory). MATLAB is probably the most commonly used scientific and engineering numerical software (Eric et al., 2000; Lie Lu and Hanjalic, 2008), it can be use to analyze sound in the form of frequency and time domain. The analysis consists of observing the waveform, time and amplitude of the sound while listening audio is made easier with a Matlab. The eight audio files were analyzed by the participant separately at their own time. Some captured scenarios of the experimental task are represented in Figure 1 through figure 5.



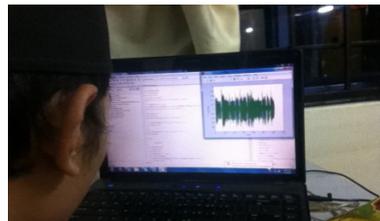
Listening to Surah An Nas and analyzing the waveform



Listening to Surah Al Falaq and analyzing the waveform



Listening to Surah Al Fatihah and analyzing the waveform

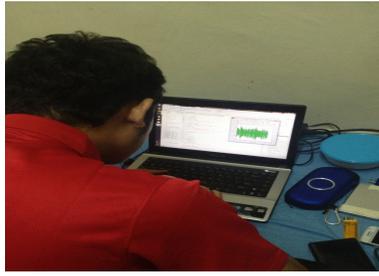


Listening to Ayat Kursi and analyzing the waveform

Figure 1: Listening test for the watermarked audio Quran by participant 1



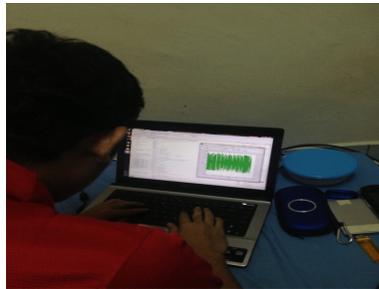
Listening to Surah Al Falaq and analyzing the waveform



Listening to Ayat Kursi and analyzing the waveform



Listening to Surah An -naas and analyzing the waveform



Listening to Surah Al - Fathiha and analyzing the waveform

Figure 2. Listening test for the watermarked audio Quran by Participant 2



Figure 3. Listening test for the watermarked audio Quran by Participant 3



Figure 4. Listening test for the watermarked audio Quran by Participant 2

RESULT

The entire 20 participants responded well and carried out all the exercises. Each participant listens to the eight audio Quran and graded the perceptual quality questions. Thereafter each participant was asked about his view regarding the perceptual quality of the audios. Some of the elected responses on the perceptual quality of the audios are presented below:

Participant 1 reports that the differences between the watermarked and un-watermarked audio are as follows:

Watermarked audio Quran wave form:

- i. Ayat Al-Kursi - the differences of frequency can be seen at 10s and 40s
- ii. Surah Al-Fatihah - the differences of frequency can be seen clearly at all times
- iii. Surah Al-Falak - the differences of frequency can be seen clearly at all times
- iv. Surah Al-Nas - the differences of frequency can be seen at the beginning and at 30s and above

Un-Watermarked audio Quran:

- i. Ayat Al-Kursi - 0, sounded clear and without echo
- ii. Surah Al-Fatihah - 0, sounded clear and without echo
- iii. Surah Al-Falak - 0, sounded clear and without echo
- iv. Surah Al-Nas - 0, sounded clear and without echo

Analysis based on the sound of Downloaded audio Quran from the Internet:

- i. Ayat Al-Kursi - 1, because of the noise (buzzing sound)
- ii. Surah Al-Fatihah - 1, because of the noise (buzzing sound)
- iii. Surah Al-Falak - 1, because of the little noise (buzzing sound) and little echo effect
- iv. Surah Al-Nas - 1, because of the little noise (buzzing sound) and little echo effect

Participant 2 reports that the differences between the watermarked and un-watermarked audio are as follows:

- i. Average waveform in un-watermark is bigger compare to waveform (Watermarked).
- ii. Time taken ayat Al-kursi in (watermarked) is 64s while ayat Al-kursi in (un-watermarked) is 55s.
- iii. Ayat Al-kursi (Watermarked) has the highest amplitude which is 0.92.
- iv. Time taken Al-falaq in (Watermarked) is 34s while ayat Al-falaq in (un-Watermarked) is 28s.
- v. Average waveform in Al-falaq (Watermarked) is bigger compare to waveform in (un-Watermarked).
- vi. Surah Al-falaq in (Watermarked) has the highest amplitude which is 0.91.
- vii. Average waveform in Al-fatiha (Watermarked) is bigger compare to waveform in (Watermarked).
- viii. Time taken Al-fatiha in (Watermarked) is 56s while ayat Al-kursi in (un-Watermarked) is 53s.
- ix. Al-fatiha in (un-Watermarked) has the highest amplitude which is 0.99.
- x. Time taken An-nas in (Watermarked) is 55s while ayat An-nas in (un-Watermarked) is 37s.
- xi. Average waveform in Surah An-Nas (Watermarked) is bigger compare to waveform in (un-Watermarked).
- xii. Surah An-nas in (Watermarked) has the highest amplitude which is 0.73.

Participant 3 reports that the differences between the watermarked and un-watermarked audio are as follows:

- i. Surah An-Nas audio (Watermarked) is longer and its range of amplitude (min and max) is greater compared to audio from (un-Watermarked)
- ii. Surah An-Nas audio (Watermarked) is 53 seconds while audio from (un-Watermarked) is 30 seconds.
- iii. Maximum amplitude of audio from Surah An-Nas (Watermarked) is 0.710 while for the audio from (Watermarked) is 0.298
- iv. Surah Al-Falaq audio (Watermarked) is longer and its range of amplitude is also greater compared to audio from (un-Watermarked)
- v. Surah Al-Falaq audio (Watermarked) is 33 seconds while audio from internet is 25 seconds.
- vi. Maximum amplitude of audio from (Watermarked) is 0.89 while for the audio from (un-Watermarked) is 0.37
- vii. Surah Al-Fatiha audio (Watermarked) is longer but the audio from internet has greater range of amplitude between lowest and highest compared to the audio from (un-Watermarked)
- viii. Surah Al-Fatiha audio (Watermarked) is 55 seconds while audio from (un-Watermarked) is 38 seconds.
- ix. Maximum amplitude of audio Surah Al-Fatiha (Watermarked) is 0.53 while for the audio from (Watermarked) is 0.64
- x. Ayat Kursi audio (Watermarked) is longer and its range of amplitude is also greater compared to audio from (un-Watermarked)
- xi. Ayat Kursi audio (Watermarked) is 64 seconds while audio from (un-Watermarked) is 54 seconds.
- xii. Ayat Kursi Maximum amplitude of audio (Watermarked) is 0.90 while for the audio from (un-Watermarked) is 0.76.

These results were further treated qualitatively in an attempt to give a special evaluation of audio Quran. Three variables are used for this qualitative evaluation. They are accuracy, reliability and trust. This comes as a result of some skepticism by some of the participants on the watermarked and un-watermarked audio Quran during the subjective analysis. The brief interview with them on these three variables yielded an important result. It's find out that some participants despite not being able to detect any abnormality from the recitation of the watermarked and un-watermarked audio Quran; they still don't trust some of the online contents. Some of the participants do not trust the authenticity of the entire online audio Quran whereas; despite they believed that contents are not altered. This finding indicates that "trust" remain major issues regarding the circulation of the audio Quran online. Another important issue is "accuracy". This has been the major variable that is accepted by most of the participants considering the output of the sound by both the watermarked and un-watermarked audio Quran. The major reason behind this is that most of the online audio Quran are recited by the most

renowned Quranic reciters around the world. Their voices are already known. As a result even a slight distortion of the audio signal does not affect the audio output. The last variable is reliability. Most of the participants seek to know the online source of the audio Quran. This has been reveal to them. The ten websites used for this study are among the popular audio Quran websites. Unfortunately, the contact information (address, email, phone number) of the people that provide of the content of each audio Quran was not specified. This has questioned the reliability of the source. Furthermore, credits were not given to the source that content. As a result this indicate that despite the content of online audio Quran might be accurate, most people do not trust them and they were not regarded as reliable. Following this evaluation, this study conceptualized a subjective assessment of audio Quran to include a structured interview on the accuracy, reliability and trust of online audio Quran. Watermarking still serves as a protective means of ensuring the originality of audio Quran, because good audio watermarking technique do not altered with the sound of audio Quran.

CONCLUSION

Audio files contain what is commonly regarded as sound. However, Audio Quran is more than sound, the data contains in it by principle should not be altered in any way. This paper present some practices with audio Quran. It gives the practical implementation of working with audio Quran. Generally, audio players bears file extension standard, although some of the audio players that are compatible to any audio file format plays almost all sort of audio files, which may include .MID, ASF, .WMA, .CDA, .WAV. In this paper we use Matlab to analyze watermarked audio Quran compared to un-watermarked audio Quran. The result based on subjective analysis indicate that there are no significant different between the watermarked audio Quran and the non-watermarked audio Quran. We conceptualized that subjective assessment of watermarked audio Quran should follow a structured interview on the accuracy, reliability and trust of online audio Quran. Because there a lot of issues regarding the online audio Quran. We found out that watermarking ensures the originality of audio Quran, and good audio watermarking technique do not altered with the sound of audio Quran. Therefore watermarking audio Quran will not altered with contains, but rather protect it from its originality. Further research should evaluate the three variables uncover in this research by quantitative survey.

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