

# Application of Digital Forensics to Identify Human Voices Using the System Development Life Cycle (SDLC) Method

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**Abstract:** This study aims to identify digital audio forensics using the System Development Life Cycle (SLDC) method which is used as a reference in the audio forensic investigation process. The process of testing the application of the framework that was carried out succeeded in identifying audio evidence with the identification results that subject x sampling (known) was identical to recorded evidence (unknown) with the results obtained for more than 4 identical words and supporting the prosecution hypothesis. Also, the results of the feasibility test of a framework that has been developed as a reference standard for comparison of frameworks related to other audio forensics, show that the framework that has been developed has a more complete stage to be used in the audio forensic investigation process. The results of Spectrogram analysis and Pict analysis on values matrix cross similarity level of evidence with audio subject Nasri4Y has the highest similarity value 0.9575822. The results of reading the audio evidence matrix with audio subject Bakrim5Y have the lowest similarity value 0.48924464. The results of reading the matrix, audio subject- B with audio subject Bakrim3Y have the highest similarity value of 0.9287775 because it is a sample voice from the same person. The results of the reading of the matrix, Nasri2Y audio subject, and Nasri4Y audio subject have a similarity value of 0.9575822 because they are sound samples from the same person. The results of reading the matrix audio subject Nasri2Y with audio subject Nasri4Y have the highest similarity value of 0.9575822, from this result it can be said a significant value because the audio subject Nasri2Y and Nasri4Y have the most similar level of sound samples from other subjects because Nasri2Y and Nasri4Y are sound samples from the same person.

**Index Terms:** Framework, forensics, identification, audio, digital, SDLC, voice similarity.

## 1. Introduction

The development of multimedia technology has made it easy to produce sound recordings. An example is the features and applications on cellphones that can make it easy to perform various types of recordings, either in the form of telephone conversations or other personal recordings. This convenience on the one hand will help efforts to collect digital evidence. Therefore, it is not surprising that various cases handled by law enforcers at this time have involved voice recordings as an important piece of evidence for investigations and various case disclosures. In this case, a common problem faced in cases involving recorded evidence is how to ensure the originality of the voice of the perpetrator which is the key in case investigation and disclosure. Based on data from the [1]National Police-Criminal Investigation Unit, namely January-October the National Police in Indonesia handled 1,763 cybercrime cases. From this figure, the police have at least completed 835 cybercrime cases. In this data, the highest cybercrime is fraud. To tackle cyber cases besides security management which aims to prevent cyber cases, handling procedures are also needed if the incident has already occurred and has resulted in a violation of the law, where one of the procedures carried out is digital forensics.

The number of audio forensic frameworks and investigative guidance documents that are currently developing has not provided an answer to the need for a standard framework for audio forensic investigations. As research conducted by Zjalic, (2017) p.55, proposes a framework for the audio forensic enhancement process, the framework consists of 4 main stages with 18 sub- stages that can be done in the audio forensic enhancement process [2], then Huizen, et al (2016) ) p.2., which developed an audio forensic acquisition technique framework and produced 7 stages, namely

Checking the authenticity of recorded evidence, Acquisition of Evidence, Comparative Acquisition, Correction of Evidence, Improvement of Comparisons, Identification, and Identification Results [3]. Furthermore, research conducted by G. Wicaksono & Yudi Prayudi (2013) page 5, resulted in 4 stages in conducting forensic investigations on audio, namely Collection, Testing, Analysis, and Reports. Other studies related to the audio forensic framework are research conducted by Nuh Al-Azhar, (2012) p.202, with the Digital Forensic Analyst Team (DFAT) made 12 Standard Operating Procedure (SOP) for the process of checking digital evidence. Of the 12 SOPs made, one of them describes Audio forensics, which refers to the standard forensic document from the Good Practice Guide for Computer-Based Electronic Evidence published by the Association of Chief Police Officers and 7 safes in the UK. This standard procedure focuses on 4 stages in handling Audio evidence, namely acquisition, audio enhancement, decoding, and voice recognition [4]. From the research framework above, there is no standard that describes an audio forensic investigation framework that can accommodate all activities in audio forensic investigations from the start of reporting to the final process, namely securing post-analysis evidence. Therefore, we need an audio forensic framework that can accommodate all audio forensic stages from the initial handling process at the crime scene to the process of storing evidence that has been analyzed. Through this research, we propose a systems development life cycle (SDLC) framework for voices identifying. The advantages with the SDLC approach are efficient and easy to implement [5], highly secure framework [6], support with design and modeling [7] and quality oriented [8].

The problems above, authors need to examine how is the application of Digital Forensics for Digital Audio identification using the Systems Development Life Cycle (SDLC) method. The research will apply of Digital Forensics for Digital Audio identification using the Systems Development Life Cycle (SDLC) method. That application of this audio can produce an audio identification for audio forensic investigations, that research is needed to develop a pre-existing framework and combine several audio forensic investigation techniques. However, this research is only related to the development of the framework from the previous framework in the scope of audio forensic identification, and comparing voice recordings. This research will develop the framework of Huizen, et al (2016), which is combined with the audio forensic enhancement technique by Zjalic (2017), as well as the audio forensic technique conducted by Al-Azhar (2012), G. Wicaksono & Yudi Prayudi (2013), and A. Subki, et al (2018) use the Systems Development Life Cycle (SDLC) method so that it can be used as a standard that can be used by investigators in investigating audio forensics.

Based on the SDLC explanation, there is a problem in this research, how is the application of Digital Forensics for Digital Audio identification using the Systems Development Life Cycle (SDLC) method, with the aim that the application of Digital Forensics for Digital Audio identification uses the Systems Development Life Cycle (SDLC) method. Audio identification for audio forensic investigations, with the human voice identification framework that will be developed, this framework can make it easy for investigators to carry out investigations related to audio evidence, as a reference for further research related to the same research studies related to development. human voice identification framework and audio forensic investigation techniques.

## 2. Related Works

Several studies have been conducted previously became a reference in this research, including the Application of a System Development Life Cycle (SDLC) in Developing an Audio Forensic Framework, [9]. In this study, the analysis technique used is pictorial statistical analysis, formant analysis, and spectrogram analysis on three audio recording analyzes without manipulation of audio objects.

[10], Malukan research related to the evidentiary process efforts to support audio originality or the similarity of audio sources of evidence with suspects by using the pitch concept approach, statistical formant and bandwidth analysis, graphical distribution, and spectrograms.

In another study conducted by [11], this method has characteristics that can record the history of input, so it can be assumed that the method can see the previous digital forensic investigation framework (DFIF) sequence to form a new DFIF. Where this is meant is combining 6 types of frameworks and eliminating the same stages into one new framework with the sequential logic method.

[12], basic empathy steps in contacting Audio forensics. The goal is to combine four types of frameworks with the sequential Logic method.

In several studies above, no one has conducted an analysis related to audio recordings with different types of sound with different objects. So that this research is expected to be able to become a guide in the analysis of audio recordings, especially different audio recordings between objects.

## 3. Material and Method

Systems Development Life Cycle (SDLC) or the system development life cycle is basically a model and methodology that can be used to develop an existing system. According to [13] Systems Development Life Cycle (SDLC) has 5 stages such as planning, analysis, design, implementation, and maintenance (Rhodes, 2012) page 1.

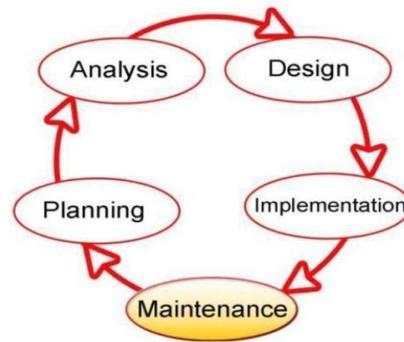


Fig.1. SDLC stages

Source: The Systems Development Life Cycle (SDLC) as a Standard: Beyond the Documentation (2012).

- 1) Planning or the planning stage aims to identify and prioritize the system being developed, and what it wants to achieve. Planning is also the initial stage of the process of developing a framework. Where aims to extract the stages in the framework and audio forensic investigation techniques and the targets to be achieved.
- 2) The analysis is the research phase of an existing system to design a new system or update an existing system. At this stage, literature study activities are carried out to determine a case that can be handled by the system, as well as to identify the previous system for system development. The analysis process is carried out on the evidence found which will later be used in identifying the crimes that occurred and then submitted to support the trial process.
- 3) The design or system design stage is the stage for determining the process stages or techniques for implementing a new system or a system developed from the previous system. The design process also requires an analysis of the function of each stage or the technique is built. Where this stage is the process of eliminating the same stages in the framework and the audio forensic investigation technique which is used as a reference for developing the framework.
- 4) Implementation or the implementation stage is the stage for implementing a design that is built to be developed and conducting trials on the system. At this stage, the framework development process will be carried out based on the stages of the framework and previous audio forensic investigation techniques. The framework development process will be made in the form of a state chart diagram using the Microsoft Visio program. The form of the framework development will be made sequentially based on the initial stages and sub-stages from the beginning to the final stage to form a complete framework so that it can be used for audio forensic investigations.
- 5) The maintenance stage is the process of maintaining the system during use to remain able to operate properly. In the process of developing a digital audio identification framework in this study using the Systems Development Life Cycle (SDLC) method, this method is used because at the time of framework development there will be several stages that will be added and eliminated or removed without maintaining the meaning or initial arrangement of the existing framework. This framework is expected to be able to meet the standards for forensic investigation and handling of audio evidence/sound recordings.

The Application of Digital Forensics identifies the human voice using SDLC.

Figure 2 explains that this research methodology was used based on a review of previous related studies. This research method aims to develop research that has existed before. In this research, can be used the application of Digital Forensics for Digital Audio identification using the Systems Development Life Cycle (SDLC) method. This research method includes 6 main stages, namely problem identification, literature study, development framework using SDLC, framework trial and framework feasibility test, and make conclusions with regard to the results of forensic audio framework development.

The explanations related to this research method are as follows:

#### 1. Problem Identification

That was the initial stage in research, this was done to obtain and found research topics that will be studied further to identify the problems needed for the application of digital forensics in identifying digital audio using the SDLC method.

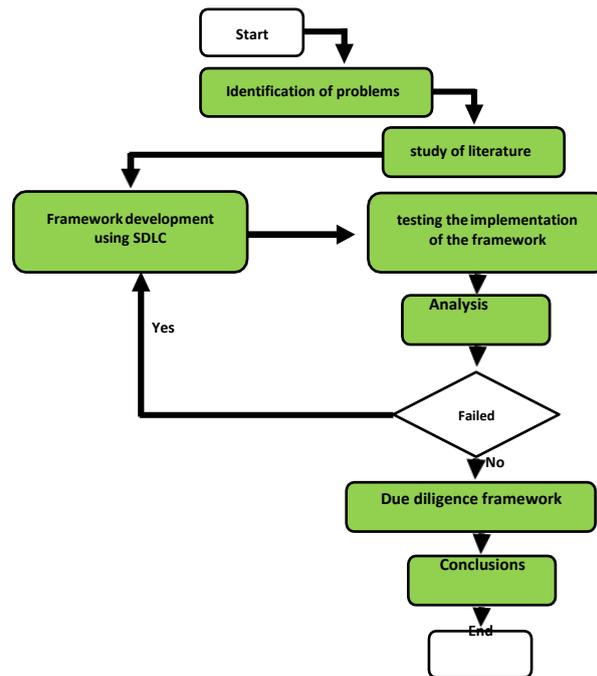


Fig.2. Research Methodology

## 2. Literature Study

Literature studies are used to collect reference materials related to research, either through books, articles, papers, journals, papers, and visiting several sites on the internet with existing problems so that they can support the final objective of the research carried out.

## 3. Framework Development Using SDLC

### a. Planning

Planning or the planning stage is the initial stage of the framework development process. The goal is to extract the stages in the framework and audio forensic investigation techniques and the goals to be achieved.

### b. Analysis

The analysis is a core stage in the investigative process. The analysis process is carried out on findings of evidence which will later be used in identifying crimes that have occurred and then submitted to support the trial process.

### c. Design or Design Stage

The design stage is the third stage in the process of developing an audio forensic investigation framework. Where this stage is the stage of the elimination process of the same stages in the framework and audio forensic investigation techniques which are used as a reference for developing the framework.

### d. Implementation

The implementation stage is the stage for implementing the design of each stage of the framework that has been developed.

### e. Maintenance

The maintenance or maintenance stage is an action taken so that the framework is maintained during its use.

## 4. Testing Framework Application

### 1) Case Scenarios

A case scenario is a step taken to create a case related to audio or voice recordings.

### 2) Hardware / Software

This stage is the main stage in carrying out the testing process which aims to determine the feasibility of the framework that has been developed from previous research.

### 3) *Testing the Framework*

This stage is the stage of conducting a framework trial based on the results of case simulations.

### 4) *Analysis Framework*

According to the trial results, it will be seen the performance of the framework being developed, the framework analysis process is a process of evaluating the developed framework.

### 5) *Report*

This stage contains reports on the results of the framework analysis by comparing the advantages and disadvantages of the framework developed and the previous one.

## 5. Analysis

### 1) *Pitch*

Pitch is the vibrating frequency of the vocal cords which is also called the fundamental (basic) frequency with the notation F0. Each person has a unique habitual pitch which is strongly influenced by the physiological aspects of the human larynx. In normal speech conditions, the habitual pitch level ranges from 50 to 250 Hz for men and 120 to 500 Hz for women. This frequency F0 changes constantly and provides a person's linguistic information such as differences in intonation and emotions.

### 2) *Formant*

Formant is the resonating frequencies of the filter, namely an articulator (vocal tract) that transmits and filters periodic sounds from the vibrations of the vocal cord into output sounds in the form of words that have meaning. In general, the formant frequencies are unlimited, but for the identification of a person's voice, at least 3 (three) formants were analyzed, namely Formant 1 (F1), Formant 2 (F2), and Formant 3 (F3) [14].

3) *Spectrogram is a time-varying spectral representation that shows the level of spectral density (energy intensity). In other words, a spectrogram is a form of visualization of each formant value that is equipped with an energy level that varies with time. This energy level is known as formant bandwidth.*

## 6. Diligence Framework Test

After the new framework has been built and tested, the next step is to test the feasibility of the framework that has been built.

## 7. Conclusion

At this stage, it is the stage of making conclusions, after the framework that has been analyzed has passed the test, the next step is an explanation of the conclusion of the successful access to the framework that has been developed.

## 4. Result and Discussion

In this study, there is a voice recording consisting of original voice recordings, the minimum spoken word is 4 words and a maximum of 23 words:

### 1) *Conversation audio evidence file*

- you are poor.
- you said you like natural girls.

### 2) *Conversation audio file subject 3*

- Many guys say they like natural girls, but if you see a girl wearing make-up, you glance at it. what to do with it?you should say that you cannot afford to buy me make-up. You are poor.

### 3) *Conversation audio file subject 5*

- yesterday I met my brother, he told me to change my clothes. he said do not wear like that.
- four kilometers is about to run out a hundred thousand.

## 1. Methode Generalized End-to-End Loss for Speaker Verification

Dibawah ini adalah gambar proses pembacaan sample audio, kemudian dilakukan preproses sample audio, dan sebelum dilakukan komputasi embed utterances dari setiap file audio yang akan menghasilkan matrix. Untuk selanjutnya dilakukan proses similarity matrix dan terakhir ditampilkan hasilnya.

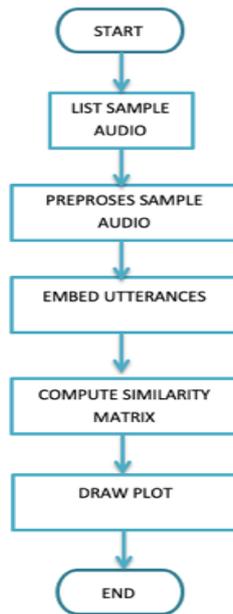


Fig. 3. Metode Generalized End-to-End Loss for Speaker Verification

2. Embed Utterances

Gambar dibawah menjelaskan bagaimana proses komputasi embedding untuk satu ucapan. Dimana ucapan yang dimaksud dibagi menjadi beberapa ucapan dan embedding serta dihitung untuk masing-masing ucapan. Penyematan ucapan lengkap adalah Rata-rata embedding L2-normed dari ucapan parsial. [15]

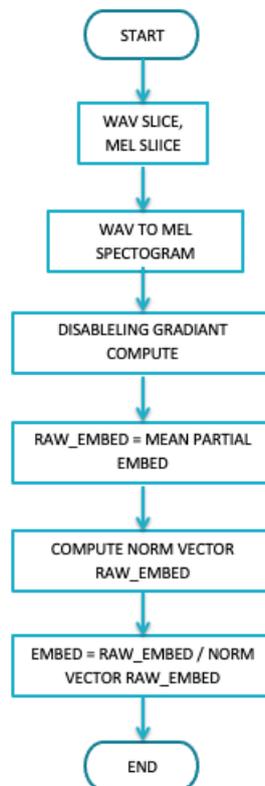


Fig.4. Embed Utterances

The sound recording evidence, it is found that the original recording of the audio matrix reading subject3-B with audio subject3-A has the highest similarity value of 0.957582 because it is a sound sample from the same person. The results of reading the matrix, audio evidence with audio subject1 have the highest similarity value = 0.882929.

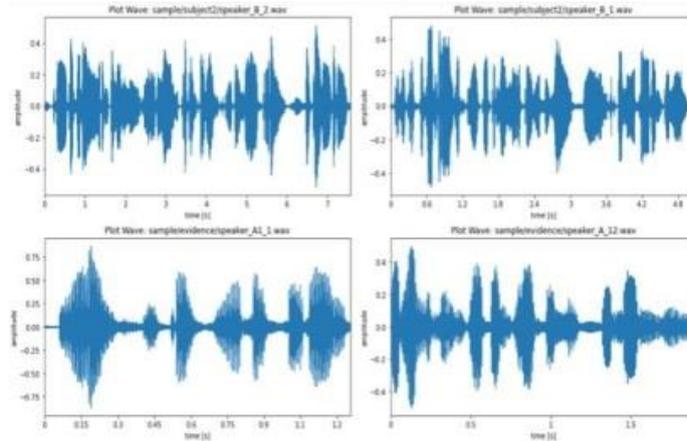


Fig.5. Sample Audio Recording

The results of the analysis show that the comparison between audio A, B, C, and the original sound recording is as follows:

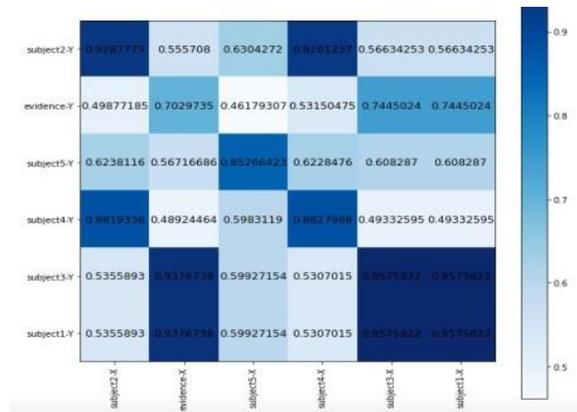


Fig.6. Flow Audio forensic Identification Framework

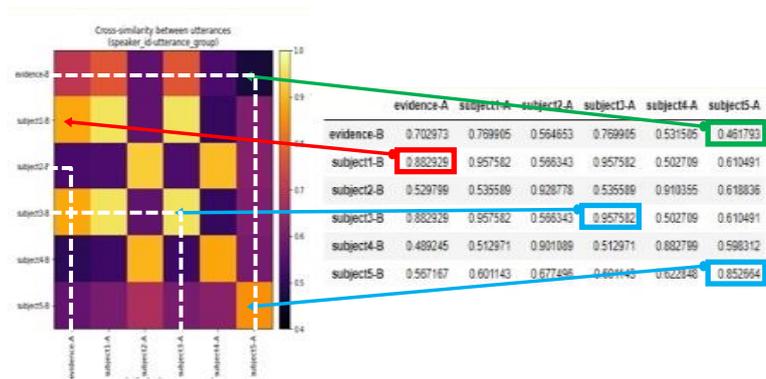


Fig.7. Audio forensic identification framework explanation flow

- The result of reading the matrix, audio evidence with audio subject1 has the highest similarity value = 0.882929
- The results of reading the matrix, audio evidence with audio subject5 have the lowest similarity value = 0.461793
- The result of reading the matrix, audio subject3-B with audio subject3-A has the highest similarity value = 0.957582 because it is a sound sample from the same person.

The result of reading the matrix, audio subject3-B with audio subject3-A has a similarity value = 0.852664 because it is a sound sample from the same person.

Table 1. Analysis results of all comparisons between original records and sampling records of subjects A1, A2, B1, B2, E1, E2, and X.

	Subject2-X	Evidence-X	Subject5-X	Subject4-X	Subject3-X	Subject1-X
Subject2-Y	0.928778	0.555708	0.630427	0.928124	0.566343	0.566343
Evidence-Y	0.498772	0.702973	0.461793	0.531505	0.744502	0.744502
Subject5-Y	0.623812	0.567167	0.852664	0.622848	0.608287	0.608287
Subject4-Y	0.881934	0.489245	0.598312	0.882799	0.493326	0.493326
Subject3-Y	0.535589	0.937674	0.599272	0.5300702	0.957582	0.957582
Subject1-Y	0.535589	0.937674	0.599272	0.530702	0.957582	0.957582

Table 1 is a display of the results of the analysis of all comparisons between the original recordings and the sampling records of subjects A1, A2, B1, B2, E1, E2, and X. of all comparisons of the results of the analysis of the pitch value in table 1 that of the 36 words analyzed in subject A only has 1 identical word, Subject B gets 10 identical words and subject X has 25 identical words, therefore it can be concluded that Subject X is IDENTIC with the original voice recording from the results of the pitch analysis.

## 5. Conclusions

Systems Development Life Cycle (SDLC) can be a reference for developing and building an audio forensic framework in a sound recording by collaborating on several frameworks related to audio forensics. This is because in the Systems Development Life Cycle (SDLC) there are stages that become references in the framework development process, namely planning, analysis, design, implementation, and maintenance. The framework developed produces 7 main stages and 33 sub- stages and 3 conditions, with a total of 40 stages that can support the audio forensic identification process.

The results of the Spectrogram analysis and Pitch analysis showed that the value of the matrix of cross similarity in the level of evidence with the audio subject Nasri4Y had the highest similarity value = 0.9575822. The results of reading the audio evidence matrix with the audio subject Bakrim5Y had the lowest similarity value = 0.48924464. Matrix reading, audio subject-B with audio Bakrim3Y subject has the highest similarity value = 0.9287775 because it is a sample of votes from the same person. The results of the reading of the matrix, Nasri2Y audio subject, and Nasri4Y audio subject have a similarity value = 0.9575822 because it is a sample of the voice of the same person. The results of reading the matrix audio subject Nasri2Y with audio subject Nasri4Y have the highest similarity value of 0.9575822, from this result it can be said a significant value because the audio subject Nasri2Y and Nasri4Y have the most similar level of sound samples from other subjects because Nasri2Y and Nasri4Y are sound samples from the same person.

Based on the results of testing the sound / audio recording framework that has been developed with samples of voice recordings made from case scenarios to test the performance of the developed framework, it has identified the sound recordings with the results of subject X IDENTIC with sound recordings on evidence that show more identical word numbers. From 4 words, this can be ascertained that the results of the framework that have been developed can become a standard for investigators in investigating sound recorded evidence. Also, the results of the feasibility test of a framework that has been developed as a reference standard for comparison of frameworks related to other audio forensics, show that the framework that has been developed has a more complete stage to be used in the audio forensic investigation process.

For further researchers, they can develop a voice identification framework by integrating several techniques that have not been carried out in the framework developed by the developers in this study. So that this framework will not only be applied to the manual method of analysis, but can be applied to the automatic method in the digital audio identification process.

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## Authors' Profiles



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In recent years Digital Forensics in identifying human voices has been actively scrutinized. Audio Comparison is a fundamental issue in the main research covering Framework.



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