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Real-Time Audio Spectrum Analyzer to Analyze Loudspeaker

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Abstract. In this essay, the author uses an audio spectrum analyzer application to display the loudspeaker's frequency response in real-time. The construction of the Fast Fourier Transform (FFT) function, which determines the amplitude value of the recorded audio sound, is the first step in this application. Also, the highest amplitude value of each spectrum should be selected throughout the equalisation and normalising processes to make the spectrum easier to study. The Matlab Guide User Interface (GUI) function was utilised in the creation of this Spectrum Analyzer programme. Inputs are processed in the form of sound signals captured by an RTA microphone and then processed by an external soundcard and displayed in the software. From the test results and comparison ofthe Audio Spectrum Analyzer application, it can be concluded that this device can also show theexact location of the spectrum.

1. Introduction

The development of technology in the 21st century, especially in the field of electronics is required us to adapt quickly in every change which occurs. One of the development changes is in the field of digital signal processing. The field of digital signal processing addresses many sub-fields including frequency spectrum analysis devices. Spectrum analysis is one way of signal analysis techniques which translates the time domain into the frequency domain, which is usually implemented in industry and scientific research [1].

Spectrum analyzer needs are still in need of further development and depth. The audio field, this analyzer is used to carry out loudspeaker technical data or analyze loudspeakers. Besides, it is also used as a device to determine the frequency response in a loudspeaker [2]. Whereas, in the field of education, for example, audio spectrum analyzer devices are very necessary for the physics and electronics laboratory [3].

In general, Audio spectrum analyzer is currently paid. Thus, it is not easy to obtain. Besides the high prices offered, the audio spectrum analyzer is needed by audio engineering to analyze loudspeakers. Generally, audio technicians currently only use ear hearing. However, every human hearing is different, there will be different views from the analysis of a loudspeaker that is heard [2].

For one of the alternatives to overcome the problem, it is designed a spectrum analyzer audio software in Real-Time combined with hardware of external soundcard and RTA microphone. The software will be implemented using Matlab to generate functions from the audio spectrum analyzer. In the software built, it will be applied the fast Fourier transform algorithm method used to quickly and efficiently convert signals to the frequency domain [4].

2. Research Method

System Analysis

A system built in this research was a device which could analyze spectrum analyzer. The input from the audio spectrum analyzer was an audio signal, and the output was a real-time frequency spectrum. The design of this device consisted of a hardware and software design. The design of the hardware used to integrate with the software made included a Real-Time Analyzer (RTA) microphone, an external soundcard, and a loudspeaker as the audio source to be analyzed. Whereas software design was developed using Matlab by utilizing the Guide User Interface (GUI) feature by applying the Fast Fourier Transform (FFT) algorithm to convert the signal into a spectrum.

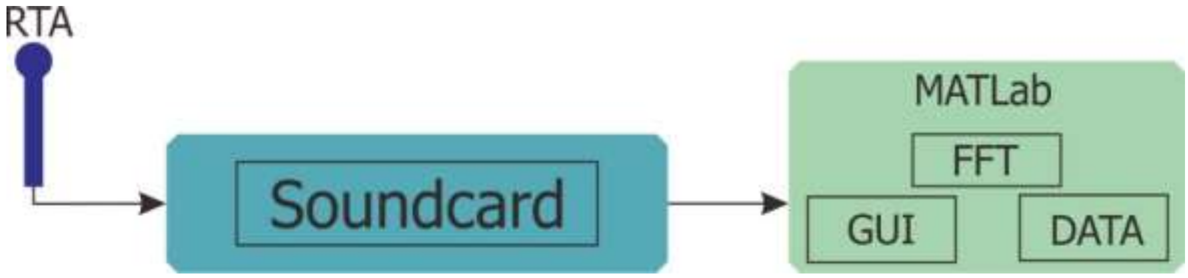


Figure 1. System Block Diagram

Figure 1 shows all system design diagram of the developed spectrum analyzer audio device. The explanation of parts from a diagram in figure 1 are as follow:

a. RTA Microphone
   A device used to receive audio wave signal emitted by the loudspeaker would be analyzed. RTA is a device that measures the amount of sound energy produced by a loudspeaker. RTA only captures sound pressure at certain frequencies and is only limited to its magnitude at the microphone location point [5].
b. External Soundcard
   A device used to process data was audio or sound.
c. Matlab Software
   1) Data
      Data which would be processed into spectrum was audio signal data. This data was obtained from the RTA microphone connected to the soundcard.
   2) FFT (Fast Fourier Transform)
      It was a method used to change signal into the spectrum. FFT Method consisted of some processes such as repairing bits of data taken.
   3) Matlab Guide User Interface (GUI)
      It was a software display consisted of a spectrum display and program menu. In an electronic device to implement FFT, one of which is Matlab. Matlab supports programming that can define sound in the form of FFT [6]. By using Matlab FFT, calculations will be simpler [7], [8].

The system design in figure 1 explains that between devices are integrated with the available ports and USB. After all, devices were connected properly and it could perform their work functions. Furthermore, it is the audio spectrum analyzer software. The software was created by applying the FFT algorithm, the data processed as a digital signal, and the appearance was in the form of a GUI. Fast Fourier Transform was the source of a mathematical algorithm to calculate Discrete Fourier Transform (DFT) quickly and efficiently. Complex calculations from FFT use equation (N/2) log2N for each multiplication and N log2N for complex addition[9]. Audio Spectrum Analyzer software was developed with three main components, such as the FFT calculation section, equalizer, and normalization. The overall design of the audio spectrum analyzer can be shown in Figure 2.

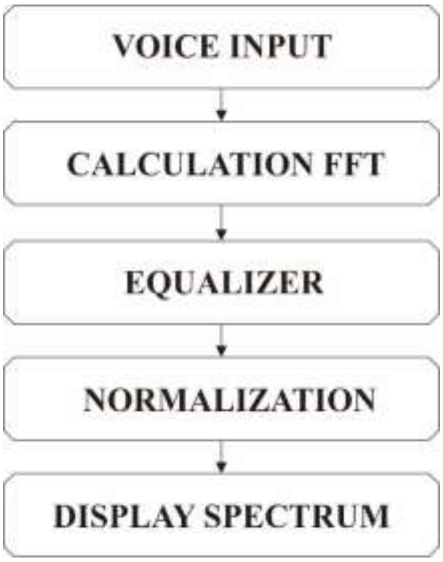


Figure 2. Diagram of the Audio Spectrum Analyzer

Process of FFT calculation implemented in the development of Spectrum Analyzer Audio used method of FFT Butterfly Radix-2 [10]. FFT calculation process was divided into several parts, as follow (1) sorting data, and (2) calculating complex multiplication, in which the results of the multiplication processed were complex number data in the frequency domain [2]. Furthermore, the calculation process in the FFT algorithm would always produce a frequency that has a different amplitude level power, even in certain conditions there can be a large-amplitude between frequencies. As a result, changes occurred at each change in frequency would be very difficult to detect [11]. Steps to overcome this problem the author would apply the equalizer method, the equalizer method was used to create a balance between the frequency levels that occur with existing frequencies [2]. The equalizer can be formulated as follow:

$$X^{"}[n] = [n] * [n] \qquad (1)$$

In which X[N[as data source of frequency and F[n] is response from Equalizer.

In each snippet of real-time sound caught would be FFT calculation. spectrum will be obtained with different amplitude [2]. The thing that needed to be conducted was to equalize every amplitude that occurs on each spectrum. Equalization of amplitude values on each spectrum used normalization procedures [11]. The process of stages of normalization can be seen in Figure 3.

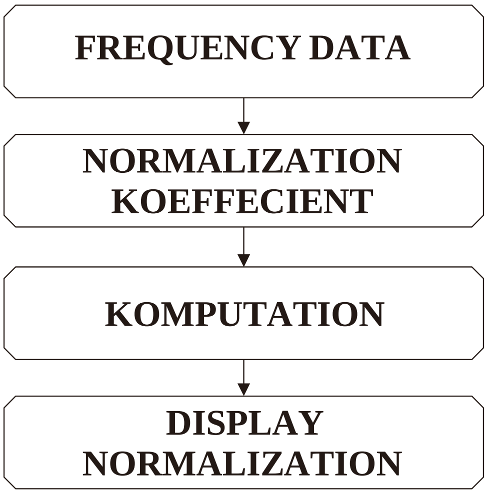


Figure 3. Diagram of Normalization Process

Process of normalization stages conducted was to implementation of algorithm from software of spectrum analyzer audio. Those processes were conducted some stages [2] suh as (1) conducting the highest frequency searching from as spectrum; and (2) conducting the research of normalization coefficient.

$$K_n = 255/\ X_{/01/est} \quad (2)$$

In which K_n is value from normalization coefficient and $X_{highest}$ is the highest data value from normalization coefficient.

After conducting the previous stage, it then conducted transfer of all data from the spectrum taken with normalization coefficients. Search for normalization values is found with the following formula.

$$X_{norm}[n] = \ K_n \,.[n] \quad (3)$$

In which X_{norm} is spectrum data which has been normalized and X is spectrum data.

Each calculation process conducted, the result of spectrum data obtained from the normalization process was then configured as an array. The last step after all the data processes were stored, all the data would be displayed in graphical form on the audio spectrum analyzer software.

System Implementation

System implementation of the entire assembly and configuration of the tools used was to realize an audio spectrum analyzer. The figure shows the overall implementation of the hardware after being assembled. After all devices could work, the next step was to create a program which could have the performance of audio spectrum analyzer software using Matlab by utilizing the Guide User Interface (GUI) feature. Whereas the hardware components were external soundcard, Real-Time Analyzer (RTA) microphone and loudspeaker.

Figure 4. Implementation of the Whole System

Figure 4 shows program implementation of spectrum analyzer audio which had been designed. The main interface of the program interface designed would display several frequency spectrum with additional features. The features contained in the audio spectrum analyzer developed by the diagram are as follow:

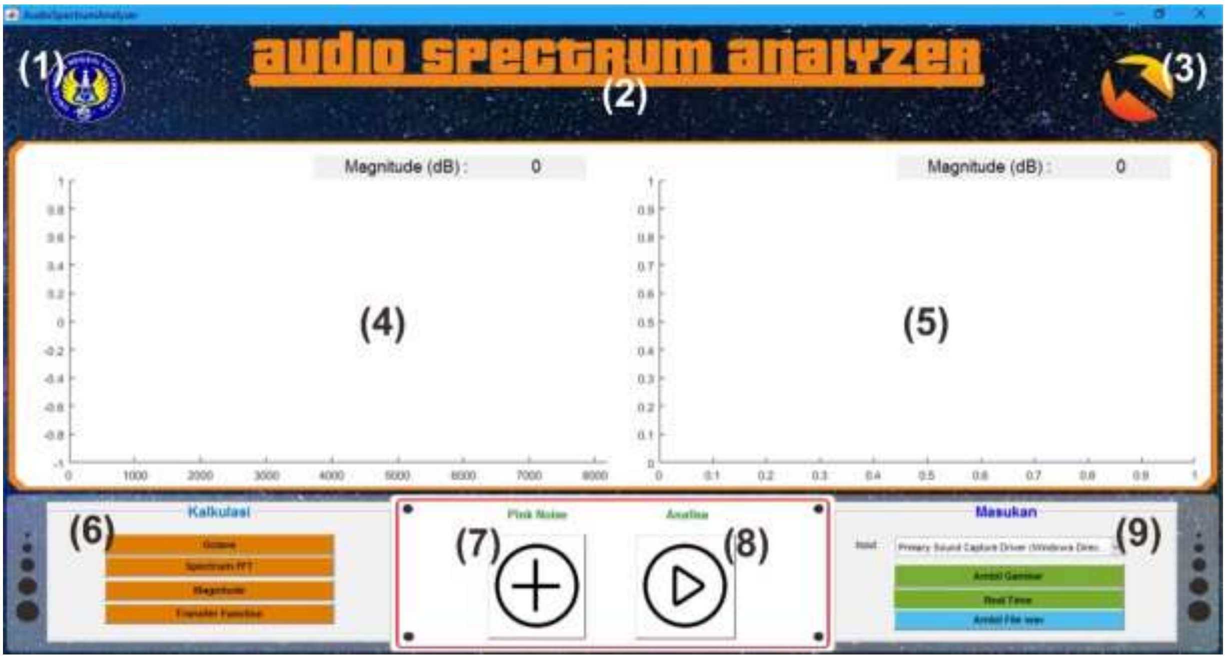


Figure 5. Main/Home Page Display

Table 1. Features of Audio Spectrum Analyzer

No	Information
1	Logo of Yogyakarta State University
2	Software Name
3	Software Logo
4	Display of one channel spectrum
5	Display of two channel spectrum
6	Calculation: a. Octave b. Magnitude c. Transfer Function
7	Pinknoise button
8	Start Analysis button
9	Input: a. Display of External Device Interface b. Real-Time c. Open file from .Wav

3. Results and Discussion

One of the function of spectrum analyzer audio is to be able to communicate with external soundcard. Therefore, to test ability of audio spectrum analyzer software which had been created, it was necessary to test to communicate with hardware. The output obtained from this test was that there was an audio spectrum analyzer software which could communicate with hardware with the appearance of the name of the hardware in the audio spectrum analyzer software.

Table 2. Hardware External Soundcard Communication Test

No	Device	Test
1	EDIROL UA 25	Detected
2	Behringer U-Phoria um2	Detected
3	Focusrite Scarlett 2i2	Detected
4	Edirol FA-66	Detected

Test result in table proves that software audio of spectrum analyzer built can demonstrate being able to communicate with external soundcard hardware from various brands in the market. Further test was conducted by comparing spectrum resulted by application. This would be compared to the results of the smaart audio spectrum analyzer spectrum from Rational Acoustic. The purpose of the measurement was to determine the level of sensitivity of the system built on the audio signals captured by the RTA microphone. The type of audio spectrum used to compare was smaart from Rational Acoustic.The objective of this test was to compare the spectrum form produced by software developed with paid applications.

One method of testing used pink noise.In general, method used was Laudspeaker given signal of Pink Noise input.Pink Noise input is signal sound source which was generally used to analyze loudspeakers/retrieval of loudspeaker technical data. RTA is a device used to analyze the sound energy captured by the microphone used. If it analyzed a loudspeaker by using a music sound source, the results obtained were the sound energy contained in the sound of the music.In analyzing/taking data of laudspeaker, we want to give an input signal in the form of flat/ flat energy at all frequencies. Thus, we can see how influential the change in the loudspeaker is.

Pink noise has the same energy content in each octave and this is closely related to how our ears map frequencies[9]. In terms of retrieving loudspeaker data, pink noise has more important roles and many methods are commonly used [5]. Pink noise is a type of noise with a spectrum which is inversely proportional to the frequency component. Tests were carried out on the monitor speaker Recording Tech RT-5. Tests are compared at frequencies in octave form. An example of a comparison of measurements from an octave spectrum from the results of the development and smaart application is shown in the figure.

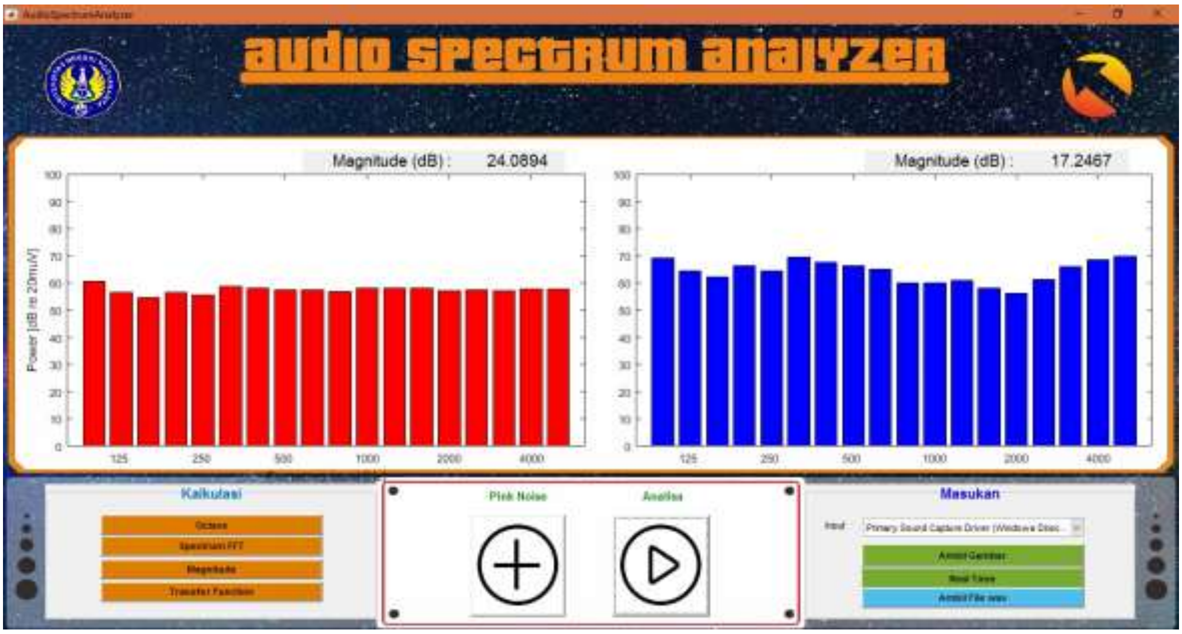
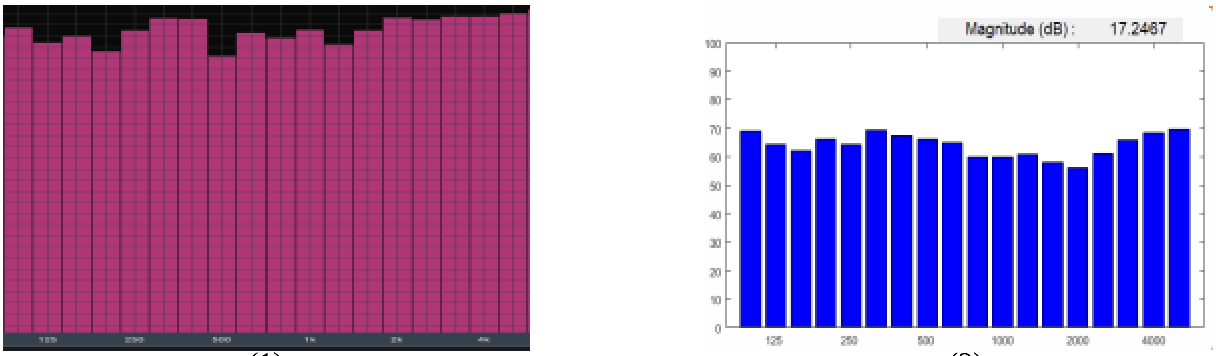


Figure 6. Testing of Audio Spectrum Analyzer



(1) (2)

Figure 7. Comparison of Smaart v.7 (1) and Development Results (2)

Figure 7 shows visualization of spectrum from audio signal of pink noise caught from microphone from a loudspeaker. The form of the spectrum produced by the software developed has similarities, it can be said that the results of the spectrum produced by audio spectrum analyzer software approach the test results with smaart devices. The form of the spectrum produced by having a similar resemblance to the frequency response displayed, thus this result can be categorized as close to the spectrum results of the test equipment with the paid application smaart.v7.

4. Conclusion

The results of the combination made by audio spectrum analyzer software paired with hardware in the form of external soundcards and Real-Time Analyzer (RTA) microphones can be inferred from the results and the debate that was held. The results of the testing show that software can communicate with hardware with various brands in the market. Furthermore, the results of the comparison of measurements using the smart v7 audio spectrum analyzer indicate that the system can show the exact location of the audio frequency spectrum.

5. References

[1] C.-P. Chuang, M. Jou, Y.-T. Lin dan C. T. Lu, "Development of a situated spectrum analyzer learning platform for enhancing student technical skills," *Interactive Learning Environments,* 2013.

[2] L. W. Santoso dan R. Sulistio, "Application of Spectrum Analyzer to Analyze Loudspeakers," dalam *Proceedings of the National Seminar on Informatics Engineering*, Surabaya, 2012.

[3] A. N. A. Thohari dan A. E. Putro, "Build a Spectrum Analyzer Using Fast Fourier Transform on the Sigle Computer Board," *IJEIS,* pp. 71-82, 2017.

[4] J. W. Cooley dan J. W. Tukey, "An Algoritm for The Machine Calculation of Complex Fourier Series," *Mathematics Of Computation Journal,* pp. 297-301, 2000.

[5] H. S. Kristianto, Practical Way of Collecting and Interpreting Technical Data of a Loudspeaker, Purwokerto: Hadi Sumoro, 2012.

[6] A. Saxena, A. K. Sinha, S. Chakrawarti dan S. Charu, "Speech Recognition Using MATLAB," *International Journal In Computer Science and Cloud Computing,* pp. 26-30, 2013.

[7] N. Sharma dan S. Sardana, "Designing a Real Time Speech Recognition System using MATLAB," *International Journal of Computer Applications,* pp. 0975-8887, 2016.

[8] K. Sieczkowski dan T. Sondej, "A Method for Real-Time Data Acquisition Using Matlab Software," *International Journal, Mixed Design of Integrated Circuit and Systems,* 2016.

[9] R. G. Lyons, Understanding Digital Signal Processing, United States: Prentice Hall, 2012.

[10] J. G. Prolakis, Pemrosesan Signal Digital, PT Prenhallindo, 1995.

[11] C. L. Phillips, J. Parr dan E. Riskin, Signal, Systems and Transforms 4th ED, Prentice HALL, 2007.