Designing Application Programs Sheet Music Using Fast Fourier Transform Method

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Abstract— **A good singer is demanded not only for singing well, but he/she also must be able to master the song soulfully. Unfortunately, most of musical creations are written in music block notations. This is quite troublesome for Indonesian singers because students are used to use sheet music written in cipher notations or numbered musical notations.**
Therefore, authors intend to make an application program that can solve this problem. There are many methods which can be used in making the voice-related applications. The method used by author is the Fast Fourier Transform method which will transform digital signals into analog signals. Application program created by author is expected to help singers to master the songs, specially in terms of tone and pitch intervals.

Index Terms— **block notation, Fast Fourier Transform, sheet music, tone**

I. INTRODUCTION

TODAY'S modern world requires everyone to be able to have a special ability and uniqueness in order to survive in it. The powerlessness of a person to follow the changing times will make the person excluded from this world movement. One sign of changing times is the development of information technology. Progress in information technology has demonstrated its influence on other fields. In this modern-paced era, all things can be done more efficiently and effectively thanks to the intervention of information technology. But unfortunately, there are still areas that have not been touched by the sophistication of information technology, including the field of music, especially in the choral world. Knowledge about information technology and its relation to the music world seems to have not known by most musicians, especially in Indonesia. Unfortunately, some people can not do it because they still have a conventional mindset, which does not want to learn the ease of which can be provided by information technology. In addition, the expensive price to pay to enjoy the sophistication of information technology has also become one of the barriers for these musicians. The purpose of this paper is to design an application program to create a sheet music and read and play

it so it can be heard. While the benefits of this paper is to find out how a song sung at the sheet music (played). Tone can be interpreted as a sign used in music to show the duration and pitch of voice. Generally, the notes in music can be written in seven pieces of letters, namely A, B, C, D, E, F and G. The same letter can have different frequencies (either half, twice, or multiplication). This is called the octave. The tones are then experiencing signs of modifications to the granting of sharps (#) to raise as much as a half-tone pitch (semitones) and signs of moles (b) to lower the pitch as much as half tones. Silence is a sign of symbols used to mark the time to stay inside a piece of music. Put the dot next to the tone or silent signal will extend the duration as much as half of the value of the tone. In the musical notation, the stave represents the unity of five horizontal lines and four spaces between the lines. Tone is located higher than the other tones have a higher pitch and vice versa. While the tone of which is located on the left played first before ringing in his right. Pitch of each tone is determined by the key tones are placed at the far left side of a stave. Is a music notation sheet music printed or handwritten form used to document or as a tool to display a piece of music. Changes in the digital signal into an analog signal, in principle, constitute a change of the numbers is limited (finite numbers), usually in the form of binary numbers, a continuous variable that varies, usually in the form of an analog electrical voltage. Fourier transformation is an integral transformation of a function to restate in the form of sine-based functions, namely a sum or integral of the sine function multiplied by a coefficient. DFT was introduced as a numerical approximation method for doing Fourier transform function. Fast Fourier Transform (FFT) algorithm is very efficient in implementing the DFT. To determine the odd and even-numbered component in the FFT, is a process of solving the so-called bit reversal, ie by exchanging the binary bits of decimal digits in reverse.

II. FAST FOURIER TRANSFORM (FFT)

Fourier Transform (FFT) algorithm is very efficient in implementing the DFT. During its development, there are various kinds of FFT algorithms developed for this, but that will be used is a radix-2 FFT algorithm. Radix-2 FFT algorithm is used to compute the DFT with the size limitation of powers of 2 (N = 2k). The number of calculations required to process a number of N-point FFT is (N / 2) log2 N From the equation on the N-point DFT, ie

$$X(m) = \sum_{n=0}^{N-1} x(n) \, e^{-j2\pi nm/N} \qquad (1)$$

FFT separates the input data x (n) into two parts, the elements of odd and even-numbered elements, so that equation (1) becomes

$$X(m) = \sum_{n=0}^{(N/2)-1} x(2n) \; e^{-j2\pi(2n)m/N} + \sum_{n=0}^{(N/2)-1} x(2n+1) \; e^{-j2\pi(2n+1)m/N} \quad (2)$$

By issuing a constant phase angle of the sum

$$X(m) = \sum_{n=0}^{(N/2)-1} x(2n) \; e^{-j2\pi(2n)m/N} + e^{-j2\pi m/N} \sum_{n=0}^{(N/2)-1} x(2n+1) \; e^{-j2\pi(2n)m/N} \quad (3)$$

With the new standard notation, namely WN = e-j2π / N, then the equation (3) transformed into

$$X(m) = \sum_{n=0}^{(N/2)-1} x(2n) \; W_N^{2nm} + W_N^m \sum_{n=0}^{(N/2)-1} x(2n+1) \; W_N^{2nm} \quad (4)$$

Because $W_N^2 = e^{-j2\pi 2/(N)} = e^{-j2\pi/(N/2)}$, so it can be replaced with W2N   WN / 2 so that equation (4) changed to

$$X(m) = \sum_{n=0}^{(N/2)-1} x(2n) W_{N/2}^{nm} \; + \; W_N^m \sum_{n=0}^{(N/2)-1} x(2n+1) W_{N/2}^{nm} \quad (5)$$

If the value of m replaced by m + N / 2, then

$$X(m+N/2) = \sum_{n=0}^{(N/2)-1} x(2n) W_{N/2}^{n(m+N/2)} \; + \; W_N^{(m+N/2)} \sum_{n=0}^{(N/2)-1} x(2n+1) W_{N/2}^{n(m+N/2)} \quad (6)$$

If $W_{N/2}^{n(m+N/2)} = W_{N/2}^{nm} \; W_{N/2}^{nN/2} = W_{N/2}^{nm} \; (e^{-j2\pi n 2N/2N} = W_{N/2}^{nm}(1) = W_{N/2}^{nm}$ (7)

Then $W_N^{(m+N/2)} = W_N^m \; W_N^{N/2} = W_N^m (e^{-j2\pi N/2N}) = W_N^m(-1) = -W_N^m$ (8)

So that equation (5) will be

$$X(m) = \sum_{n=0}^{(N/2)-1} x(2n) W_{N/2}^{nm} + W_N^m \sum_{n=0}^{(N/2)-1} x(2n+1) W_{N/2}^{nm} \quad (9)$$

By using equation (5) and (9), we only need m N / 2 ranging from 0 to (N / 2) - one to get all the value of output. To determine the odd and even components, a splitting process called bit reversal is done by exchanging the binary bits of decimal number in reverse, as shown in Table 1.

TABLE I
BIT REVERSAL

Number in the normal sequence		Number after the bit reversal	
Decimal	Binary	Binary	Decimal
0	0000	0000	0
1	0001	1000	8
2	0010	0100	4
3	0011	1100	12
4	0100	0010	2
5	0101	1010	10
6	0110	0110	6
7	0111	1110	14
8	1000	0001	1
9	1001	1001	9
10	1010	0101	5
11	1011	1101	13
12	1100	0011	3
13	1101	1011	11
14	1110	0111	7
15	1111	1111	15

FFT calculation can be implemented into a flow diagram form the so-called butterfly pattern, which can be seen in Figure 1 below.
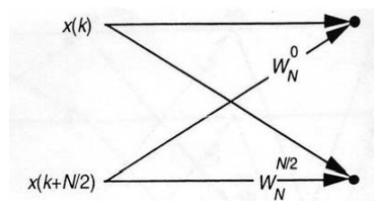

Fig. 1. FFT Butterfly with 2 point DFT

To implement the required application program into the algorithm, namely step-by-step instruction so that achieved the desired results. The algorithm used in the application to read sheet music is as follows:

1) Data sheet music used is sheet music which only consisted of a tone ladder.
2) On the data input provided a stave that can be used by the user to enter the desired tones.
3) Users press section on the stave, which is in accordance with the desired tone.
4) Then the user selects the desired tone value.
5) If you want to enter a silent signal, then the user presses the inside of the stave in a place that you want, then select the desired value of silence marks.
6) After the user finished entering data, the data is stored and by calculation using Fast Fourier Transform, the data converted into a format file. MIDI.
7) User opens the Open & Play to listen to the results of these inputs and open files that have been formed earlier.
8) For viewing the score or sheet music that has been saved previously, user should open the Open & Show submenu and choose the desired file.

The process that occurs in programs designed this can be explained by the following flowchart :
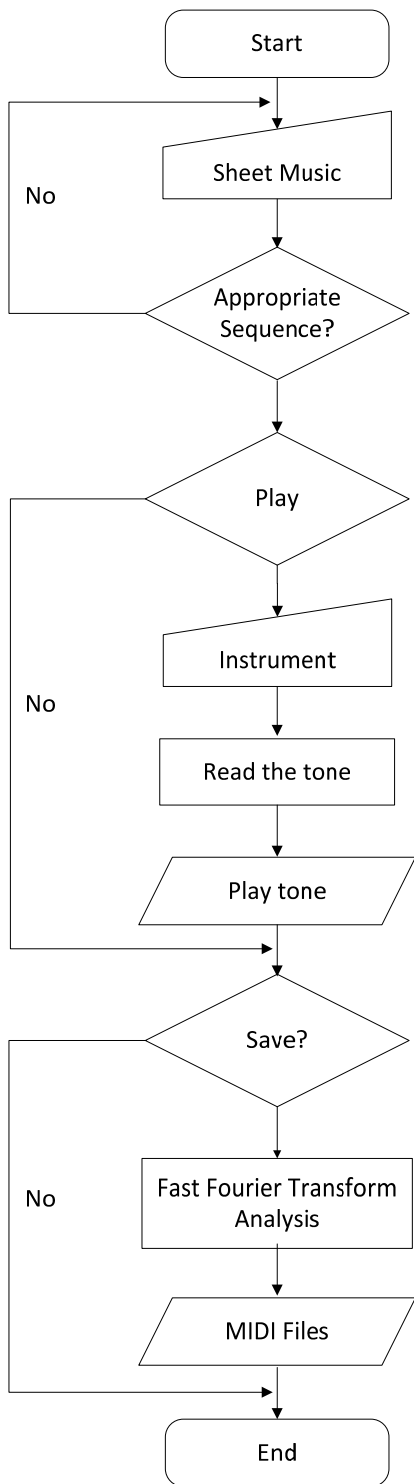
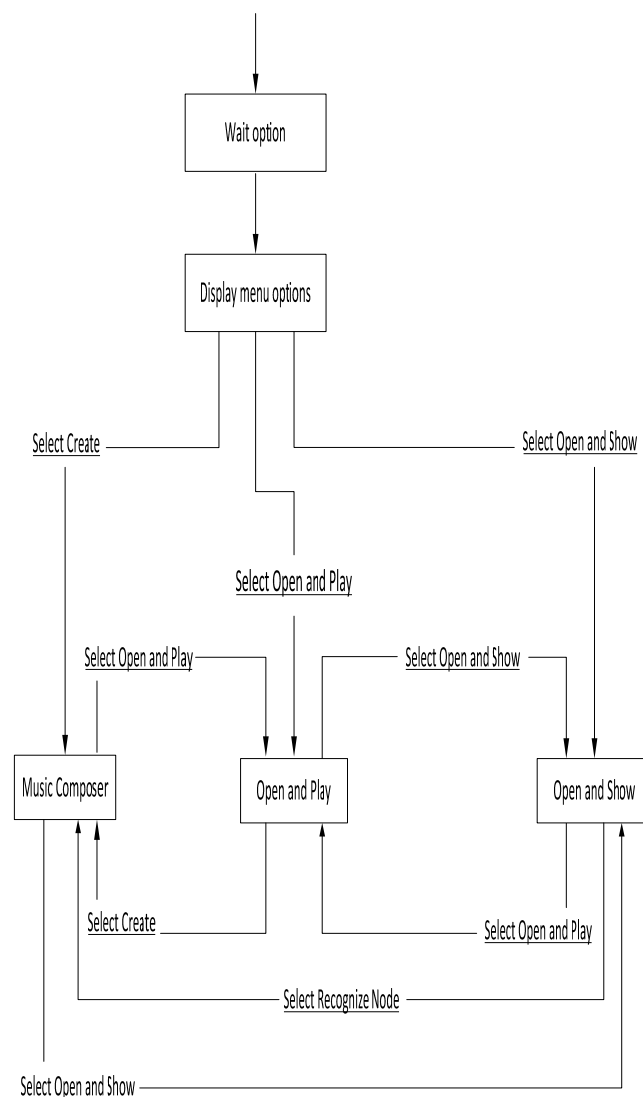The menu design on this program is explained through Figure 2 as follows:

Fig. 2. Menu of Program

III. IMPLEMENTATION AND EVALUATION

In the test application program Sheet Music Composer and this Reader, samples taken in the form of excerpts from four songs, namely Lesson 1 and Lesson 3 from the book of collected works of Giuseppe Concone (sample taken from the vocals and played with the basic tone of C major), 'Gimmewicks and Glimmerricks' works of Joseph Gentry Stephens (sample taken from the vocal Alto), and 'Temali Uta' by Makoto Shinohara (sample taken from the vocal Alto). This test uses only a little part of each song because of the restrictions contained in the application program. In this test, the evaluation focused only on the accuracy of tone and precision beats.

On testing the first song ('Lesson 1' by G. Concone), the input is entered into the application can be seen in Figure 4. The results of this test reached 85% success rate.
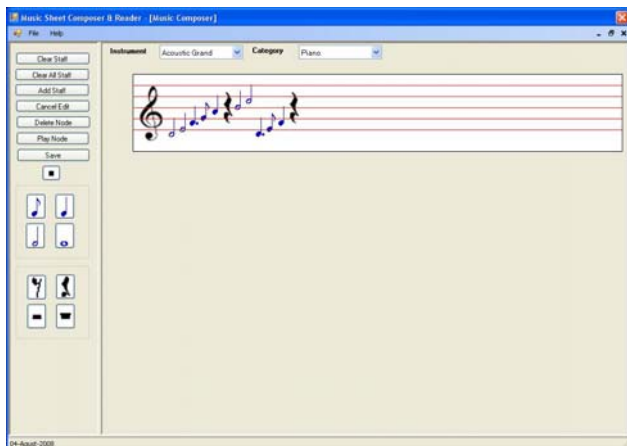
Fig. 3. Input song 'Lesson 1' by G. Concone

In testing the second song ('Lesson 3' by G. Concone), the input is entered into the application can be seen in Figure 4. The results of this test reached 85% success rate.
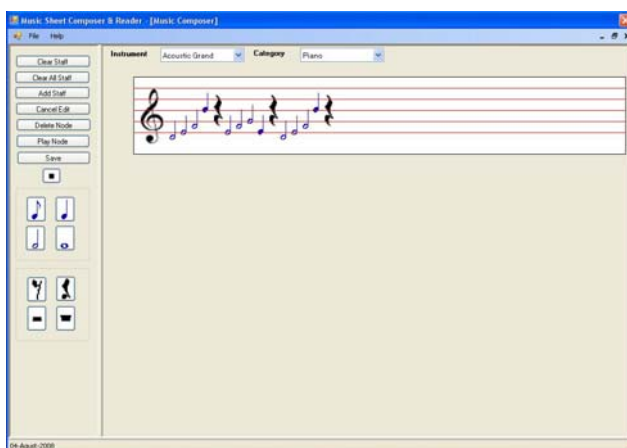

Fig. 4. Input song 'Lesson 3' by G. Concone

In testing the third song ('Gimmewicks and Glimmerricks') input is entered into the application can be seen in Figure 5. The results of this test reached 80% success rate.
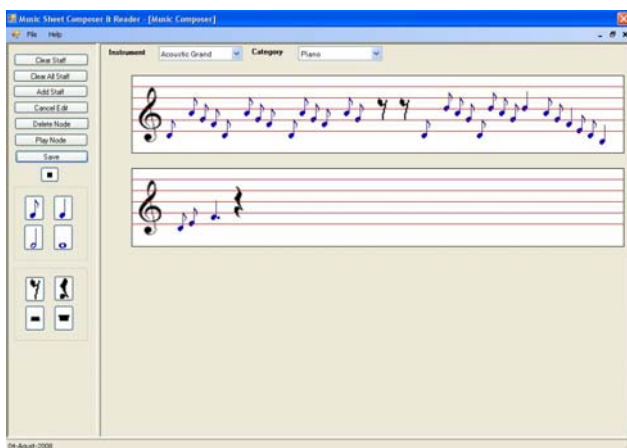

Fig. 5. Added Song 'Gimmewicks and Glimmerricks'

In testing the fourth song ('Temali Uta'), the input is entered into the application can be seen in Figure 6. The results of this test reached 85% success rate.
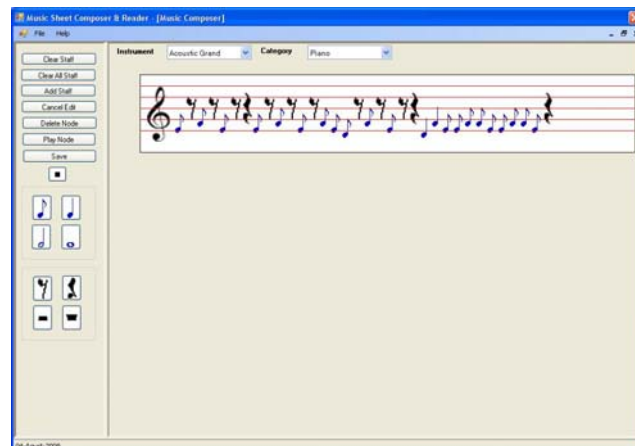

Fig. 6. Added Song 'Temali Uta'

From the evaluation results, the average success rate of application programs Sheet Music Composer and Reader amounted to 83.75%.

IV. CONCLUSION

The conclusion is as follows,

1) The application program can create sheet music in accordance with input by the user.
2) This application program can play the sheet music which is inputted by user and play the song following the tones that can be heard by user.
3) The application program can only accept input in the form of ringing tone with a range of C4 to C5 tone.
4) The application program can not receive any form of input tones with sharp sign (#) as well as signs of moles (b).
5) This application program can help someone who had difficulty in reading the notation of the beam

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