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Analysis and Research of Instrument Timbre base on the Digital Virtual Instrument Model Constructed by the Computer Music Notation Software

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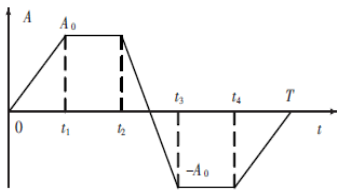
Abstract: **Timbre is a very important expression means in music, which is an auditory attributes to determine the difference between the two steady tones with the same loudness and pitch. When computer technology combined with music and produced computer music, it is undoubtedly very important that research of instrument timbre base on the Digital virtual instrument model constructed by the computer music notation software. In order to describe computer musical instrument timbre, build software instrument and to change the computer instrument timbre by adjusting the parameters, this paper set up a digital virtual instrument timbre model constructed by the computer music notation software, analysis the influence of parameter values to timbre in this model, so as to provide more space for the choice of timbre.**



Keywords: Computer software; Digital virtual instrument model; Instrument timbre

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1. Introduction

Hearing is a very important source of information, how to make the computer has the human's hearing sense is a very interesting question which has a broad application prospects. Music is a king of complex non-nature voice nature; it is the embodiment of human wisdom and emotional thinking. Many thoughts and feelings which cannot be accurately described by language can be expressed though music. Excellent music works often make people emotional resonance. Therefore, music is the universal language of mankind and the human culture for thousands years development. So study on music has a very important value. For music contains a large amount of different levels, the automatic analysis is difficult for music signal [1]. Human society has entered a digital age, entertainment industry and information industry is become more and more closely. How to search, analysis and management multimedia data quickly and efficiently has become a very important problem question, and the audio and music signal analysis is helpful for this problem.

As one of the four basic element of music, timbre is a very important expression means in music, which is an auditory attributes to determine the difference between the steady tones. It has the same loudness and pitch. When the computer is penetrated into the music field and produced the computer music, it is undoubtedly very important that research of instrument timbre base on the Digital virtual instrument model constructed by the computer music notation software. However, at present the research of computer musical instrument sound is very weak [2]. So the research of computer instrument has important practical significance. In order to describe computer musical instrument timbre and build software instrument to change the computer instrument timbre by adjusting the parameters, this paper established the digital virtual instrument timbre model constructed by the computer music notation software based on trapezoid wave.

At present, the computer timbre mostly through hardware to realize, the starting point of this paper is the construction software tone. Compared with timbre produced by hardware synthesizer, advantages of software method is that you can enjoy more creative and more rich sound, at the same time you don't need to speed a lot of money to buy hardware instruments. Most tradition instrument is design for a particular individual. In order to make the computer instruments produced more tone; we establish the timbre model based on trapezoidal wave, then under the condition that the parameters of amplitude envelope id determined, analysis the influence of each parameter value to timbre in the model. Diversity of parameters determines diversity of musical instruments, so as to provide more space to choice timbre [3].

2. The Establishment of the Trapezoidal Wave Timbre Model

Because of the computer instrument timbre depends on the characteristics of spectrum and amplitude envelope characteristics, Tone modeling is set up the vibration model and the amplitude envelope model, the former determines the frequency spectrum characteristics and the latter which determines the amplitude envelope characteristics [4].

2.1. Vibration sub-model

The vibration sub-model has shown in equation 2-1 and the curve of this model in a period time shown in

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figure 1.

$$A=\begin{cases} k_1 t;0\le t<t_1 \\ A_0;t_1\le t<t_2 \\ k_2 t-k_2 t/2;t_2\le t<t_3 \\ -A_0;t_3\le t<t_4 \\ k_1 t-k_1 T;t_4\le t\le T \end{cases}$$

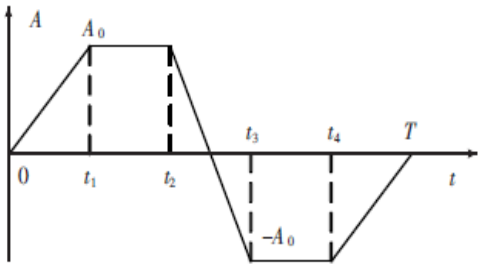

Figure 1. The curve of trapezoidal wave

In figure 1, this model is composed of two trapezoidal symmetrical, A_0 is digital amplitude peak, t_1-t_4 is time node, T is vibration period, which determines the frequency of vibration.

Define the following tone parameters:

(1) The time coefficient [5]:

$c_t_1=t_1/T;c_t_2=t_2/T$

(2) Non symmetry:

$c_i=(0.5-c_t_2)/c_t_1$

(3) Taper:

$c_l=(c_t_2-c_t_1)/0.5$

(4) The degree of triangle

In the above parameters, the coefficient is basic parameter, the basic parameters can derive to the other three parameters; if the ladder is a non isosceles trapezoid, non symmetry can be used to describe the difference about the two size degree; if the ladder is a isosceles trapezoid, taper can be used to describe the degree of difference between top and button; if the ladder is triangle, the degree of triangle can be used to describe the change of the right corner [6].

2.2. The Amplitude Envelope Model

The amplitude envelope model has shown in equation 2-2 and the curve of this model in an envelope period time shown in figure 2.

$$\text{c_A}=\begin{cases} \ln(\alpha_1 t+1);0\le t\le t_1 \\ kt-kt_2+c_A_2;t_1<t<t_2 \\ c_A_2\exp[-\alpha_2(t_1-t_2)];t\ge t_2 \end{cases} \quad (2\text{-}2)$$

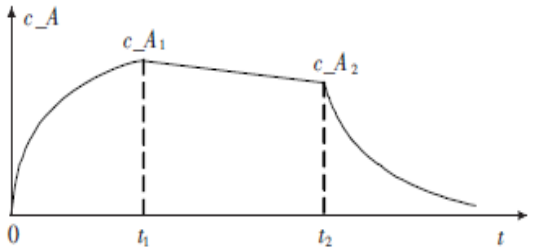

Figure 2. The curve of amplitude envelope wave

When determining the amplitude envelope coefficient, the influence of parameters to timbre in the vibration model is very important [7].

3. Experimental Results and Analysis

Due to the WINDOWS low level audio function can interacts with the audio driver and provides a divece independent interface, the contral is flexible. So we can use the low level audio function to achieve the operate of WAV audio data, software development tools for VC++, the sampling frequency for 44.1HZ, the number of quantization bits for 16 bit [8]. By using one-dimension discrete cosine transform (DCT) acquisit the spectrum, the number of sample is 2000.

3.1. Non-Isosceles Trapezoids

Condition to meet the non isosceles trapezoid:

$$c_t_1\ne c_t_2;c_i\ne 1 \quad (3\text{-}1)$$

Here we are focus on time coefficient difference:

$$c_t_2-c_t_1=0.1 \quad (3\text{-}2)$$

The non symmetry degree were the following four kinds of circumstance, the sound spectrum as shown in figure 3.

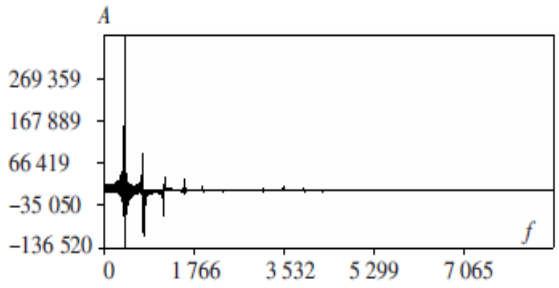

Figure 3. (a) *c_i* = 0.25

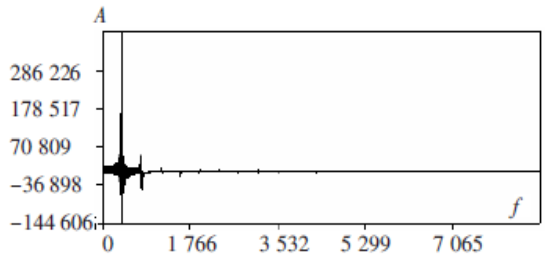

Figure 3. (b) c_i = 0.6

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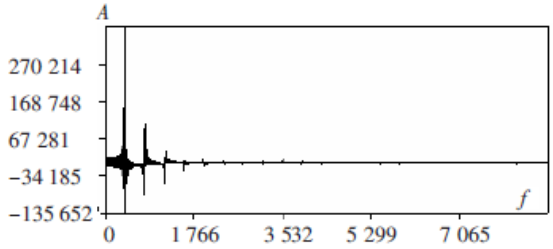

Figure 3. (c) c_i = 4

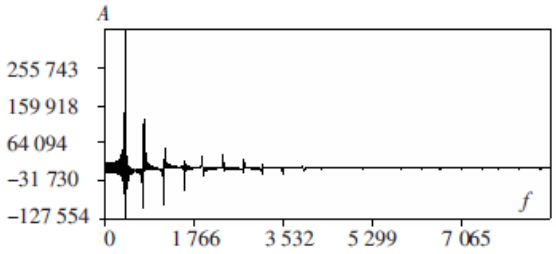

Figure 3. (d) c_i = 9

As can be seen in figure 3, when non symmetry *c_i* is less than 1, *c_i* smaller, the spectrun more abundant; when non symmetry *c_i* is more than 1, *c_i* more bigger, the spectrun more abundant; As can be seen in figure 3(a) and figure 3(c), when values of *c_i* are reciprocal, the specturm is basically same. In a word, the distance of values of *c_i* and 1 farther, the spectrun more abundant, the more high frequency compnents, sound more fullness.

3.2. Isosceles Trapezoids

Condition to meet the isosceles trapezoid:

$$c_t_1 \neq c_t_2; c_i = 1 \qquad (3\text{-}3)$$

Here we are focus on the taper were the following four kinds of circumstance, the sound spectrum as shown in figure 4.

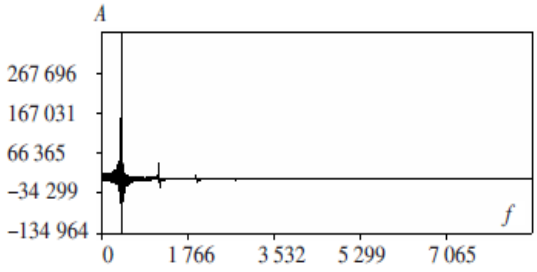

Figure 4. (a) *c_l* = 0.1

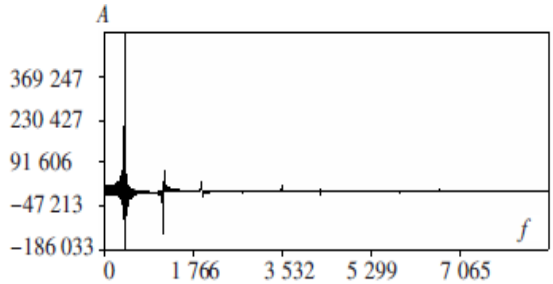

Figure 4. (b) c_l = 0.7

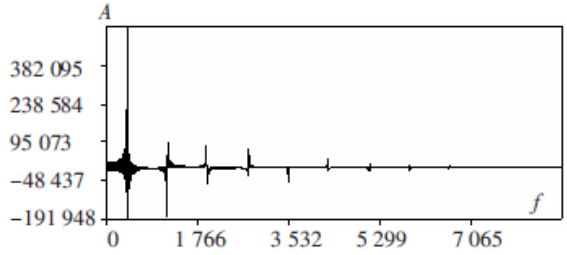

Figure 4. (c) c_l = 0.9

As can be seen in figure 4, in the value range (0,1) of taper, c_1 bigger, the spectrun more abundant and more high frequency compnents. Relative with isosceles trapeziod, there is no even harmonic in the harmonic components of isosceles trapezoid.

3.3. Triangle

Condition to meet the isosceles trapezoid:

$$c_t_1 = c_t_2 \qquad (3\text{-}4)$$

Here we are focus on the taper were the following four kinds of circumstance, the sound spectrum as shown in figure 5.

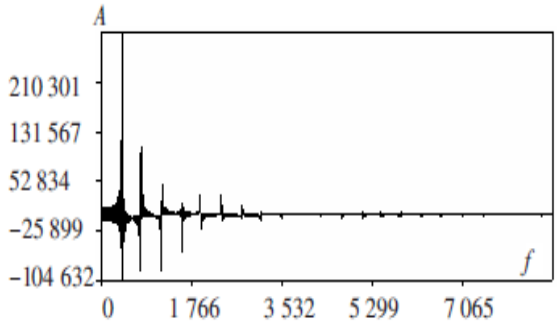

Figure 5. (a) *c_a* = 0.05

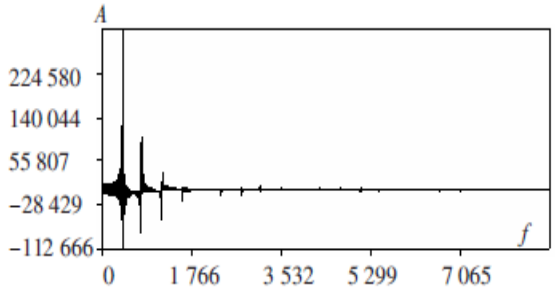

Figure 5. (a) c_a = 0.1

As can be seen in figure 5(a) and figure 5(b), when c_a is less than 0.25, c_1 smaller, the spectrun more abundant; As can be seen in figure 5(d) and figure 5(e), when non symmetry c_a is more than 0.25, c_1 bigger, the spectrun more abundant, the more high frequency compnents, sound more fullness. As can be seen in figure 5(c), there is only odd harmonics in the spectrum, no even harmonic. This is because when c_a=0.25, the triangle is isosceles triangle, it show the same nature and isosceles trapezoid, which is lack of even harmonic components.

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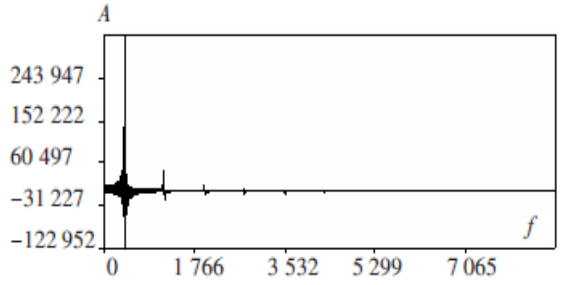

Figure 5. (a) c_a = 0.25

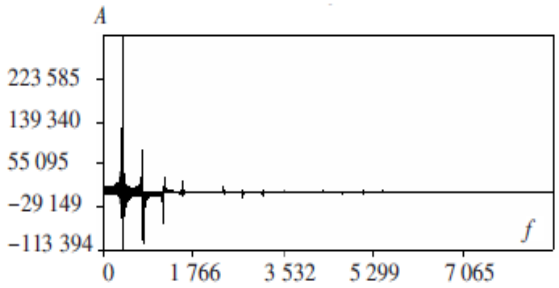

Figure 5. (a) c_a = 0.4

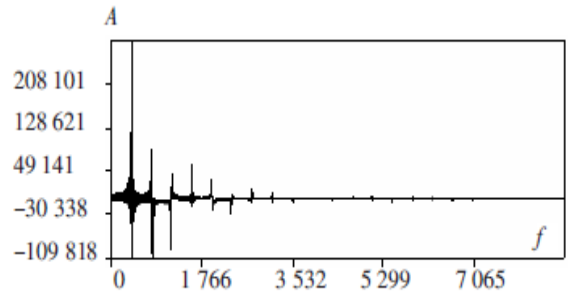

Figure 5. (a) c_a = 0.45

4 Conclusion

Through the analysis of trapezoid wave model, we know that: when the ladder is general non isosceles trapezoid, both add harmonic and even harmonic in spectrum. The distance of values of c_i and 1 farther, the spectrun more abundant, the more high frequency compnents, sound more fullness. When it is isosceles trapezoids, c_1 bigger, the spectrun more abundant and more high frequency compnents. Relative with isosceles trapeziod, there is no even harmonic in the harmonic components of isosceles trapezoid. When it is Triangle ,when non symmetry c_a is more than 0.25, c_1 bigger, the spectrum more abundant, the more high frequency components, sound more fullness. when non symmetry c_a is more than 0.25, c_1 bigger, the spectrum more abundant, the more high frequency components, sound more fullness.

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