

**FREQUENCY ANALYZING METHOD AND
APPARATUS AND PLURAL PITCH
FREQUENCIES DETECTING METHOD AND
APPARATUS USING THE SAME**

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to frequency analyzing method and frequency analyzer and further, to method and apparatus for measuring a fundamental frequency (hereinafter, referred to as a pitch frequency or simply abbreviated to a pitch) of a complex distorted wave signal of a music signal or the like.

2. Description of the Related Arts

The realization of an apparatus for producing music data from playing pieces of music is demanded from composers and other musicians who treat musical notes, and persons who are engaged in the production of MIDI (Musical Instruments Digital Interface) data of a communication Karaoke system, and the like.

Many of music information signals consist of a complex sound component including a plurality of fundamental frequency components like a multi-chorus. In a conventional pitch detecting technique, although it is relatively easy to detect a pitch for a simple tone, it is difficult to detect each pitch for a complex sound from a viewpoint of accuracy or a construction to realize an accurate detection.

OBJECT AND SUMMARY OF THE INVENTION

The invention is made in consideration of the foregoing points and it is an object of the invention to provide frequency analyzing method and apparatus which can contribute to estimation of each correct fundamental frequency from a complex distorted wave signal such as a music signal or the like by a relatively simple construction and to provide complex sound separating method and apparatus using the frequency analyzing method and apparatus.

According to the invention, there is provided a frequency analyzing method of analyzing a frequency component of an original signal, comprising: a spectrum detecting step of detecting, from the original signal, energy levels of components of a predetermined number of orthogonal function waves which have waveforms each having same start position and end position in a predetermined time window and in which the number of occurrences of periods in the predetermined time window or frequencies are different from each other; and an orthogonal function wave changing step of changing at least one of the start position and the end position in the predetermined time window after completion of the spectrum detecting step, wherein the spectrum detecting step and the orthogonal function wave changing step are alternately repeated.

According to the invention, there is provided a frequency analyzing method of analyzing a frequency on the basis of energy levels of components of a plurality of orthogonal function waves detected from an original signal, comprising: an operation discriminating step of assuming that one of the orthogonal function waves is set to a fundamental wave, executing an operation to obtain the sum of the energy level of the component of the orthogonal function wave corresponding to the fundamental wave and the energy levels of components of a predetermined number of orthogonal function waves corresponding to harmonics of the fundamental wave and having waveforms each having the same start position and end position as those of the fundamental wave in a predetermined time window each time the orthogonal

function wave which is assumed as the fundamental wave is switched, and of discriminating one of the sums obtained by the operations which is regarded such that a ratio to a total level of the energy levels of the components of all of the orthogonal function waves having waveforms each having the same start position and end position as those of the orthogonal function wave corresponding to the presumed fundamental wave is largest; a repeating step of changing at least one of the start position and the end position within the predetermined time window and allowing the operation discriminating step to be executed; and an estimating step of selecting the largest sum among all of the sums discriminated by the operation discriminating step as a result of the repeating step and estimating a pitch frequency from a period or a frequency of the orthogonal function wave corresponding to the fundamental wave presumed in the operation by which the selected sum was obtained.

According to the invention, there is provided a plural pitch frequencies detecting method of detecting each pitch frequency of an original signal by using the above frequency analyzing method, further comprising: an eliminating step of eliminating from the original signal the component of the orthogonal function wave corresponding to the pitch frequency estimated by the estimating step and the component of the orthogonal function wave corresponding to harmonics of the fundamental wave corresponding to the estimated pitch frequency, wherein a residual component of the original signal which is obtained as a result of the eliminating step is set to a new original signal and each of the above steps is repeated.

According to the invention, there is provided a plural pitch frequencies detecting method of detecting each pitch frequency of an original signal, comprising: a spectrum detecting step of detecting, from the original signal, energy levels of components of a predetermined number of orthogonal function waves which have waveforms each having same start position and end position in a predetermined time window and in which the number of occurrences of periods in the predetermined time window or frequencies are different; an operation discriminating step of assuming that one of the orthogonal function waves regarding the energy level which is obtained by the spectrum detecting step is set to a fundamental wave, executing an operation to obtain the sum of the energy level of the component of the orthogonal function wave corresponding to the fundamental wave and energy levels of components of a predetermined number of orthogonal function waves corresponding to harmonics of the fundamental wave and having waveforms each having the same start position and end position as those of the fundamental wave in a predetermined time window each time the orthogonal function wave which is assumed as a fundamental wave is switched, and of discriminating one of the sums obtained by the operations which is regarded such that a ratio to a total level of the energy levels of the components of all of the orthogonal function waves having waveforms each having the same start position and end position as those of the orthogonal function wave corresponding to the presumed fundamental wave is largest; a repeating step of changing at least one of the start-position and the end position within the predetermined time window and allowing the spectrum detecting step and the operation discriminating step to be executed; an estimating step of selecting the largest sum among all of the sums discriminated by the operation discriminating step as a result of the repeating step and estimating a pitch frequency from a period or a frequency of the orthogonal function wave corresponding to the fundamental wave presumed in the