

METHOD FOR GENERATING SONG FOR INDIVIDUAL SUFFERING FROM HIGH-FREQUENCY HEARING LOSS, DEVICE, AND MEDIUM

[0001] This application claims the priority to Chinese Patent Application No.
5 202311432570.3, titled "METHOD FOR GENERATING SONG FOR INDIVIDUAL
SUFFERING FROM HIGH-FREQUENCY HEARING LOSS, DEVICE, AND MEDIUM",
filed on October 30, 2023 with the China National Intellectual Property Administration, which
is incorporated herein by reference in its entirety.

10 FIELD

[0002] The present disclosure relates to the technical field of audio processing, and in
particular to a method for generating a song for individuals with high-frequency hearing loss, a
device and a medium.

15 BACKGROUND

[0003] Individuals with high-frequency hearing loss are not sensitive to high-frequency
sound components. When listening to music without wearing a hearing aid, the individuals with
high-frequency hearing loss can only hear the sound of the low-frequency components in the
music, and are unable to hear the sound of high-frequency components in the music. This results
20 in an intermittent and disjointed listening experience, causing the music to sound distorted and
degrading listening quality of the music for those with hearing loss. In the conventional
technology, above issues are addressed by manually adjusting a frequency, which results in
great wastage of manpower and time and is inefficient.

[0004] Therefore, a method for automatically generating a song for individuals with high-
25 frequency hearing loss is required.

SUMMARY

[0005] In view of the above, an objective of the present disclosure is to provide a method for
generating a song for individuals with high-frequency hearing loss, a device and a medium, to

facilitate meeting a requirement for feeling music of individuals with high frequency hearing loss and reduce manpower and time costs. The technical solutions are as follows.

[0006] According to a first aspect of the present disclosure, a method for generating a song for individuals with high-frequency hearing loss is provided. The method includes:

5 separating an original song into a vocal track and an accompaniment track;

 performing frequency reduction on the accompaniment track to adjust a frequency range of the accompaniment track to a target frequency range perceivable by the individuals with high-frequency hearing loss to obtain a frequency-reduced accompaniment track;

 mixing the vocal track and the frequency-reduced accompaniment track to obtain a mixed
10 song; and

 performing loudness control on the mixed song based on a preset loudness control mechanism to obtain a target song for the individuals with high-frequency hearing loss.

[0007] In an embodiment, the separating an original song into a vocal track and an accompaniment track includes:

15 determining a vocal-to-accompaniment ratio between the vocal track and the accompaniment track, and

 where the mixing the vocal track and the frequency-reduced accompaniment track to obtain a mixed song includes:

 mixing the vocal track and the frequency-reduced accompaniment track based on the
20 vocal-to-accompaniment ratio.

[0008] In an embodiment, the performing frequency reduction on the accompaniment track to adjust a frequency range of the accompaniment track to a target frequency range perceivable by the individuals with high-frequency hearing loss to obtain a frequency-reduced accompaniment track includes:

25 determining a current to-be-processed accompaniment track based on the accompaniment track;

 performing high-pass filtering on the current to-be-processed accompaniment track by using a first frequency divider to obtain a first high-frequency range accompaniment track, and performing low-pass filtering on the current to-be-processed accompaniment track by using the

first frequency divider to obtain a first low-frequency range accompaniment track, where a frequency range of the first low-frequency range accompaniment track is the target frequency range, and a cutoff frequency of the first frequency divider is an upper limit frequency of the target frequency range;

5 performing frequency reduction on the first high-frequency range accompaniment track based on a target method for frequency reduction to adjust a frequency range of the first high-frequency range accompaniment track to the target frequency range to obtain a frequency-reduced first high-frequency range accompaniment track; and

10 mixing the first low-frequency range accompaniment track and the frequency-reduced first high-frequency range accompaniment track to obtain the frequency-reduced accompaniment track.

[0009] In an embodiment, the determining a current to-be-processed accompaniment track based on the accompaniment track includes:

15 in a case that an upper limit frequency of the frequency range of the accompaniment track meets a first preset condition, directly determining the accompaniment track as the current to-be-processed accompaniment track.

[0010] In an embodiment, the determining a current to-be-processed accompaniment track based on the accompaniment track includes:

20 in a case that an upper limit frequency of the frequency range of the accompaniment track meets a second preset condition,

performing high-pass filtering on the accompaniment track by using a second frequency divider to obtain a second high-frequency range accompaniment track, and performing low-pass filtering on the accompaniment track by using the second frequency divider to obtain a second low-frequency range accompaniment track, where a cutoff frequency of the second frequency divider is an upper limit frequency of a frequency range of the second low-frequency range accompaniment track;

25 performing frequency reduction on the second high-frequency range accompaniment track based on the target method for frequency reduction to adjust a frequency range of the second high-frequency range accompaniment track to the frequency range of the second low-frequency range accompaniment track, to obtain a frequency-reduced second high-frequency range

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accompaniment track; and

mixing the second low-frequency range accompaniment track and the frequency-reduced second high-frequency range accompaniment track to obtain the current to-be-processed accompaniment track.

5 **[0011]** In an embodiment, both the first frequency divider and the second frequency divider are constructed based on a Butterworth filter.

[0012] In an embodiment, the performing loudness control on the mixed song based on a preset loudness control mechanism includes:

10 determining, among multiple preset input loudness sub-ranges, a target input loudness sub-range corresponding to a current input loudness of the mixed song;

 determining, among multiple preset loudness adjustment proportional coefficients, a target loudness adjustment proportional coefficient corresponding to the target input loudness sub-range; and

15 determining a product of the target loudness adjustment proportional coefficient and the current input loudness as a current output loudness.

[0013] In an embodiment, the method for generating the song for the individuals with high-frequency hearing loss further includes:

20 determining multiple input loudness values within a preset input loudness range as dividing points for the preset input loudness range, and dividing the preset input loudness range based on the dividing points to obtain the multiple preset input loudness sub-ranges; and

 configuring respective loudness adjustment proportional coefficients for the multiple preset input loudness sub-ranges to obtain the multiple preset loudness adjustment proportional coefficients,

25 where the loudness adjustment proportional coefficients corresponding to the multiple preset input loudness sub-ranges are inversely correlated with the multiple input loudness values corresponding to the dividing points.

[0014] According to a second aspect of the present disclosure, an electronic device is provided. The electronic device includes: a memory and a processor.

[0015] The memory is configured to store a computer program.

[0016] The processor is configured to execute the computer program to implement the method for generating the song for the individuals with high-frequency hearing loss described above.

[0017] According to a third aspect of the present disclosure, a computer-readable storage medium is provided. The computer-readable storage medium is configured to store a computer program. The computer program, when executed by a processor, implements the method for generating the song for the individuals with high-frequency hearing loss described above.

[0018] It can be seen that a method for generating a song for individuals with high-frequency hearing loss is provided according to the present disclosure. The method includes: separating an original song into a vocal track and an accompaniment track; performing frequency reduction on the accompaniment track to adjust a frequency range of the accompaniment track to a target frequency range perceivable by the individuals with high-frequency hearing loss to obtain a frequency-reduced accompaniment track; mixing the vocal track and the frequency-reduced accompaniment track to obtain a mixed song; and performing loudness control on the mixed song based on a preset loudness control mechanism to obtain a target song for the individuals with high-frequency hearing loss. In summary, according to the present disclosure, the vocal and the accompaniment of the original song are separated firstly, to obtain the vocal track and the accompaniment track. Since high-frequency components are primarily concentrated in the accompaniment track, frequency reduction is performed on the accompaniment track to adjust the frequency range of the accompaniment track to the target frequency range perceivable by the individuals with high-frequency hearing loss. Further, the present disclosure involves: mixing the vocal track and the accompaniment track to obtain a mixed song; and performing loudness control on the mixed song based on a preset loudness control mechanism, to improve the hearing comfort of individuals with hearing loss. That is, according to the present disclosure, a hearing-loss-friendly song, which is adapted to the target frequency range perceivable by the individuals with high-frequency hearing loss, is automatically produced, facilitating meeting a requirement for feeling music of individuals with high-frequency hearing loss, and greatly reduces the wastage of manpower and time costs caused by manual adjustment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] To clearly illustrate technical solutions in embodiments of the present disclosure or in the conventional technology, the drawings required in the description of the embodiments or the conventional technology are briefly described below. Apparently, the drawings in the following description are merely some embodiments of the present disclosure, and other drawings may be obtained by those skilled in the art based on the provided drawings without any creative effort.

[0020] FIG. 1 is a schematic diagram of a system framework applicable to a solution for generating a song for individuals with high-frequency hearing loss according to the present disclosure;

[0021] FIG. 2 is a flowchart of a method for generating a song for individuals with high-frequency hearing loss according to the present disclosure;

[0022] FIG. 3 is a flowchart of a method for generating a song for individuals with high-frequency hearing loss according to the present disclosure;

[0023] FIG. 4 is a schematic diagram of controlling loudness of a mixed song according to the present disclosure;

[0024] FIG. 5 is a flowchart of a method for generating a song for individuals with high-frequency hearing loss according to an embodiment of the present disclosure;

[0025] FIG. 6 is a flowchart of a method for frequency reduction according to an embodiment of the present disclosure;

[0026] FIG. 7 illustrates an audio spectrum of an original song according to the present disclosure;

[0027] FIG. 8 illustrates an audio spectrum for individuals with high-frequency hearing loss according to the present disclosure;

[0028] FIG. 9 is a schematic structural diagram of an apparatus for generating a song for individuals with high-frequency hearing loss according to the present disclosure; and

[0029] FIG. 10 is a structural diagram of an electronic device according to the present disclosure.

DETAILED DESCRIPTION

[0030] The technical solutions according to the embodiments of the present disclosure are described clearly and completely as follows in conjunction with the drawings in the embodiments of the present disclosure. Apparently, the described embodiments are only some
5 of the embodiments of the present disclosure, rather than all of the embodiments. All other embodiments obtained by those skilled in the art based on the embodiments in the present disclosure without any creative efforts fall within the protection scope of the present disclosure.

[0031] Individuals with high-frequency hearing loss are not sensitive to high-frequency sound components. Without wearing a hearing aid, the individuals with high-frequency hearing
10 loss can only hear the sound of the low-frequency components in the music, and are unable to hear the sound of high-frequency components in the music. This results in an intermittent and disjointed listening experience, causing the music to sound distorted and degrading listening quality of the music for those with hearing loss. In the conventional technology, above issues are addressed by manually adjusting a frequency, which results in great wastage of manpower
15 and time and is inefficient.

[0032] In view of the above, a solution for generating a song for individuals with high-frequency hearing loss is provided according to an embodiment of the present disclosure, which facilitates meeting a requirement for feeling music of individuals with high frequency hearing loss.

[0033] In the solution for generating a song for individuals with high-frequency hearing loss according to the present disclosure, a system framework employed may be referred to FIG. 1. In an embodiment, the system framework includes an original song database 01 and a song generation platform 02 for individuals with high-frequency hearing loss, and further includes a new media platform 03.

[0034] In an embodiment, the original song database 01 is configured to store an original song and transmit the original song to the song generation platform 02 for individuals with high-frequency hearing loss, to determine the original song as a song to be frequency-reduced. After the song to be frequency-reduced transmitted from the original song database 11 is acquired by the song generation platform 02 for individuals with high-frequency hearing loss,
25 frequency reduction is performed the song to be frequency-reduced based on the method for generating the song for the individuals with high-frequency hearing loss according to the
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present disclosure, to obtain a target song. In addition, upon user triggering or automatic triggering, the target song may be uploaded to the new media platform 03. After receiving the target song transmitted from the song generation platform 02 for individuals with high-frequency hearing loss, the new media platform 03 may display the target song. Upon receiving
5 a song listening request initiated by a user, the target song may be played through an audio player.

[0035] Multiple specific examples may be provided for the positional relationship among the original song database 01, the song generation platform 02 for individuals with high-frequency hearing loss, and the new media platform 03.

10 **[0036]** In a specific example, both the original song database 01 and the song generation platform 02 for individuals with high-frequency hearing loss are configured in a handheld terminal of individuals with hearing loss. When individuals with hearing loss play a song through the handheld terminal, the handheld terminal records the original song and stores it in the local original song database 01. Upon user triggering, the handheld terminal may input the
15 original song in the original song database 01 to the local song generation platform 02 for individuals with high-frequency hearing loss, to obtain the target song. In order to share a certain target song, the individuals with hearing loss remotely transmits the target song to the new media platform 03 through the handheld terminal, enabling the user of the new media platform 03 to hear the target song shared by the individuals with hearing loss.

20 **[0037]** In another specific example, the original song database 01 and the song generation platform 02 for individuals with high-frequency hearing loss are both configured in the same server. The server receives and stores original songs uploaded by various persons with hearing loss, and performs frequency reduction on the original songs through the local song generation platform 02 for individuals with high-frequency hearing loss to obtain the corresponding target
25 songs. Then the target songs are displayed through the new media platform 03 for sharing among users of the new media platform 03.

[0038] In another specific example, the original song database 01 is configured in a handheld terminal of a user or a server, and the song generation platform 02 for individuals with hearing loss and the new media platform 03 are configured in another server. In this case, the target
30 song, obtained by performing frequency reduction on the original song through the song generation platform 02 for individuals with hearing loss, is directly displayed through the local

new media platform 03 without remote data transmission. It is equivalent to integrating the song frequency reduction function for the new media platform 03.

[0039] In addition, the original song database 01, the song generation platform 02 for individuals with high-frequency hearing loss, and the new media platform 13 may be respectively configured in different servers, maintained and managed by different enterprises, and ultimately the target song is displayed through an audio client connected to the new media platform 03.

[0040] A method for generating a song for individuals with high-frequency hearing loss is provided according to an embodiment of the present disclosure. Referring to FIG. 2 and FIG. 3, the method includes steps S11 to S14.

[0041] In step S11, an original song is separated into a vocal track and an accompaniment track.

[0042] In this embodiment, vocal and accompaniment separation is performed on the original song, to obtain a vocal track and an accompaniment track.

[0043] In step S12, frequency reduction is performed on the accompaniment track to adjust a frequency range of the accompaniment track to a target frequency range perceivable by the individuals with high-frequency hearing loss, so as to obtain a frequency-reduced accompaniment track.

[0044] It should be noted that since high-frequency components of a song are mainly concentrated in the accompaniment track, frequency reduction is performed on the accompaniment track in this embodiment. The objective is to adjust the frequency range of the accompaniment track to a target frequency range perceivable by the individuals with high-frequency hearing loss, to obtain a frequency-reduced accompaniment track. For the target frequency range, for example, individuals with high-frequency hearing loss often can only hear sound signals within a frequency range below 4 kHz. Thus, the target frequency range is set to [0, 4 kHz].

[0045] In some embodiments, in a case that an upper limit frequency of a frequency range of an accompaniment track meets a first preset condition, the accompaniment track is directly determined as a current to-be-processed accompaniment track. High-pass filtering is performed on the current to-be-processed accompaniment track by using a first frequency divider to obtain

a first high-frequency range accompaniment track, and low-pass filtering is performed on the current to-be-processed accompaniment track by using the first frequency divider to obtain a first low-frequency range accompaniment track. A frequency range of the first low-frequency range accompaniment track is the target frequency range, and a cutoff frequency of the first frequency divider is an upper limit frequency of the target frequency range. Further, frequency reduction is performed on the first high-frequency range accompaniment track based on a target method for frequency reduction to adjust a frequency range of the first high-frequency range accompaniment track to the target frequency range, so as to obtain a frequency-reduced first high-frequency range accompaniment track. Then, the first low-frequency range accompaniment track and the frequency-reduced first high-frequency range accompaniment track are mixed to obtain the frequency-reduced accompaniment track.

[0046] The above steps are illustrated by taking an example that the target frequency range is [0, 4 kHz] and the first preset condition is the upper limit frequency of the frequency range of the accompaniment track being not greater than 8 kHz. In an embodiment, assuming that the upper limit frequency of the frequency range of the accompaniment track is 8 kHz, the accompaniment track is directly determined as the current to-be-processed accompaniment track. High-pass filtering is performed on the current to-be-processed accompaniment track by using a first frequency divider to obtain a first high-frequency range accompaniment track, and low-pass filtering is performed on the current to-be-processed accompaniment track by using the first frequency divider to obtain a first low-frequency range accompaniment track. The first frequency divider is constructed based on a Butterworth filter. The cutoff frequency of the first frequency divider is the upper limit frequency of the target frequency range, which is 4 kHz. In this case, the frequency range of the first high-frequency range accompaniment track is [4 kHz, 8 kHz], and a frequency range of the first low-frequency range accompaniment track is the target frequency [0, 4kHz]. Further, octave and pitch down processes are performed on the first high-frequency range accompaniment track based on a target method for frequency reduction (such as by using a phase vocoder, by the overlap-add method, or by using an open-source pitch-down tool) to adjust the frequency range of the first high-frequency range accompaniment track to the target frequency range [0, 4kHz], so as to obtain the frequency-reduced first high-frequency range accompaniment track. Then, the first low-frequency range accompaniment track and the frequency-reduced first high-frequency range accompaniment track are mixed to obtain the frequency-reduced accompaniment track.

[0047] In step S13, the vocal track and the frequency-reduced accompaniment track are mixed to obtain a mixed song.

[0048] It can be understood that after the vocal track and the frequency-reduced accompaniment track are obtained, the vocal track and the frequency-reduced accompaniment track are mixed to obtain a mixed song.

[0049] In an embodiment, to maintain the listening experience of the original song, a vocal-to-accompaniment ratio between the vocal track and the accompaniment track is acquired in this embodiment, and the vocal track and the frequency-reduced accompaniment track are mixed based on the vocal-to-accompaniment ratio. In this way, the vocal-to-accompaniment ratio (that is, an energy ratio) of the mixed song is consistent with an energy ratio of the original song, so that for individuals with high-frequency hearing loss, the listening experience of the mixed song is consistent with the listening experience of the original song. Thus, the listening experience for individuals with hearing loss is greatly improved. It should be noted that the vocal-to-accompaniment ratio is obtained when vocal and accompaniment separation is performed on the original song.

[0050] In step S14, loudness control is performed on the mixed song based on a preset loudness control mechanism to obtain a target song for the individuals with high-frequency hearing loss.

[0051] In this embodiment, to improve the hearing comfort of individuals with high-frequency hearing loss, loudness control is performed on the mixed song based on a preset loudness control mechanism (wide dynamic range compression), to obtain a target song for the individuals with high-frequency hearing loss.

[0052] In an embodiment, a target input loudness sub-range corresponding to a current input loudness of the mixed song is firstly determined among multiple preset input loudness sub-ranges. Then a target loudness adjustment proportional coefficient corresponding to the target input loudness sub-range is determined among multiple preset loudness adjustment proportional coefficients. Further, a product of the target loudness adjustment proportional coefficient and the current input loudness is determined as a current output loudness.

[0053] For example, reference is made to FIG. 4. In this embodiment, multiple input loudness values within a preset input loudness range [0, 110dB] are determined as dividing points for the

preset input loudness range. The preset input loudness range is divided based on the dividing points to obtain the multiple preset input loudness sub-ranges. For FIG. 4, input loudness values, that is, dividing points, are 35dB and 95dB. The preset input loudness range is divided into three preset input loudness sub-ranges of [0, 35dB], [35dB, 95dB] and [95dB, 110dB] by using the values 35dB and 95dB. Further, respective loudness adjustment proportional coefficients are configured for the preset input loudness sub-ranges to obtain the multiple preset loudness adjustment proportional coefficients. In an embodiment, a first loudness adjustment proportional coefficient is configured for [0, 35dB], a second loudness adjustment proportional coefficient is configured for [35dB, 95dB], and a third loudness adjustment proportional coefficient is configured for [95dB, 110dB]. The first loudness adjustment proportional coefficient is greater than the second loudness adjustment proportional coefficient, the second loudness adjustment proportional coefficient is greater than the third loudness adjustment proportional coefficient, and the third loudness adjustment proportional coefficient is 1. It can be seen that as the input loudness value increases, the loudness adjustment proportional coefficient corresponding to the preset input loudness sub-range decreases. In this embodiment, large proportion amplification is performed on low loudness, small proportion amplification is performed on high loudness, and even higher loudness is not amplified. This achieves an objective of ensuring clarity of the low loudness sound while preventing excessive harshness of the high loudness sound, thereby improving the hearing comfort of individuals with high-frequency hearing loss.

[0054] It can be seen that a method for generating a song for individuals with high-frequency hearing loss is provided according to the present disclosure. The method includes: separating an original song into a vocal track and an accompaniment track; performing frequency reduction on the accompaniment track to adjust a frequency range of the accompaniment track to a target frequency range perceivable by the individuals with high-frequency hearing loss to obtain a frequency-reduced accompaniment track; mixing the vocal track and the frequency-reduced accompaniment track to obtain a mixed song; and performing loudness control on the mixed song based on a preset loudness control mechanism to obtain a target song for the individuals with high-frequency hearing loss. In summary, according to the present disclosure, the vocal and the accompaniment of the original song are separated firstly, to obtain the vocal track and the accompaniment track. Since high-frequency components are primarily concentrated in the accompaniment track, frequency reduction is performed on the

accompaniment track to adjust the frequency range of the accompaniment track to the target frequency range perceivable by the individuals with high-frequency hearing loss. Further, the present disclosure involves: mixing the vocal track and the accompaniment track to obtain a mixed song; and performing loudness control on the mixed song based on a preset loudness control mechanism, to improve the hearing comfort of individuals with hearing loss. That is, according to the present disclosure, a hearing-loss-friendly song, which is adapted to the target frequency range perceivable by the individuals with high-frequency hearing loss, is automatically produced, facilitating meeting a requirement for feeling music of individuals with high-frequency hearing loss, and greatly reduces the wastage of manpower and time costs caused by manual adjustment.

[0055] A method for generating a song for individuals with high-frequency hearing loss is provided according to an embodiment of the present disclosure. Compared with the previous embodiment, the technical solution is further illustrated and optimized in this embodiment. Referring to FIG. 5, the method includes steps S121 to S123.

[0056] In step S121, in a case that an upper limit frequency of the frequency range of the accompaniment track meets a second preset condition, high-pass filtering is performed on the accompaniment track by using a second frequency divider to obtain a second high-frequency range accompaniment track, and low-pass filtering is performed on the accompaniment track by using the second frequency divider to obtain a second low-frequency range accompaniment track. A cutoff frequency of the second frequency divider is an upper limit frequency of a frequency range of the second low-frequency range accompaniment track.

[0057] Referring to FIG. 6, the above step is illustrated by taking an example that the target frequency range is $[0, 4 \text{ kHz}]$ and the second preset condition is the upper limit frequency of the frequency range of the accompaniment track being greater than 8 kHz. In an embodiment, assuming that the upper limit frequency of the frequency range of the accompaniment track is 16kHz, high-pass filtering is performed on the accompaniment track by using a second frequency divider to obtain a second high-frequency range accompaniment track, and low-pass filtering is performed on the accompaniment track by using the second frequency divider to obtain a second low-frequency range accompaniment track. The second frequency divider is constructed based on a Butterworth filter. The cutoff frequency of the second frequency divider is the upper limit frequency of the frequency range of the second low-frequency range

accompaniment track, which is 8 kHz. In this case, the frequency range of the second high-frequency range accompaniment track is [8 kHz, 16 kHz], and the frequency range of the second low-frequency range accompaniment track is the target frequency [4 KHz, 8 kHz].

[0058] In step S122, frequency reduction is performed on the second high-frequency range accompaniment track based on the target method for frequency reduction to adjust a frequency range of the second high-frequency range accompaniment track to the frequency range of the second low-frequency range accompaniment track, so as to obtain a frequency-reduced second high-frequency range accompaniment track.

[0059] Further, octave and pitch down processes are performed on the second high-frequency range accompaniment track based on a target method for frequency reduction (such as by using a phase vocoder, by the overlap-add method, or by using an open-source pitch-down tool) to adjust the frequency range of the second high-frequency range accompaniment track to the frequency range [4 kHz, 8 kHz] of the second low-frequency range accompaniment track, so as to obtain the frequency-reduced second high-frequency range accompaniment track.

[0060] In step S123, the second low-frequency range accompaniment track and the frequency-reduced second high-frequency range accompaniment track are mixed to obtain a current to-be-processed accompaniment track.

[0061] In this embodiment, the second low-frequency range accompaniment track and the frequency-reduced second high-frequency range accompaniment track are mixed to obtain the current to-be-processed accompaniment track. A frequency range of the current to-be-processed accompaniment track is [4 kHz, 8 kHz].

[0062] Further, based on the foregoing content, the step of performing high-pass filtering and low-pass filtering on the accompaniment track with the frequency range of [4 kHz, 8 kHz] is performed on the current to-be-processed accompaniment track to obtain a final frequency-reduced accompaniment track.

[0063] In summary, two high-pass filtering processes and two low-pass filtering processes are performed on the accompaniment track in this embodiment. That is, in this embodiment, a frequency divider is constructed by cascading two Butterworth filters. The two Butterworth filters connected in cascade constitute an L-R filter (Linkwitz-Riley filter). The L-R filter has a flat passband and exhibits rapid attenuation in a transition band. The Butterworth filter is

specifically expressed as: $[b, a] = \text{butter}(n, w_n)$, where, $n = 4$, indicating that the filter is a 4th order equation, a and b represent coefficients of the 4th order equation. A cutoff frequency f_c is set to 8 kHz when frequency division is performed at 8 kHz, and the cutoff frequency f_c is set to 4 kHz when the frequency division is performed at 4 kHz. The corresponding normalized cutoff frequency $w_n = f_c / (f_s/2)$, f_s represents a sampling rate, which is 32 kHz.

[0064] It should be noted that the present embodiment does not limit the quantity of the frequency divider, and in actual operation, the quantity of the frequency divider may be determined based on the frequency range of the accompaniment track to be frequency-reduced.

[0065] Referring to FIG. 7 and FIG. 8, FIG. 7 illustrates an original audio spectrum of the song "Luminous Moon Rising Over the Sea", and FIG. 8 illustrates an audio spectrum of the song "Luminous Moon Rising Over the Sea" processed based on the method for generating the song for the individuals with high-frequency hearing loss according to the present disclosure. In both FIG. 7 and FIG. 8, the horizontal axis represents time, and the vertical axis represents frequency. The denser the striations in the figures, the stronger the energy at that frequency, i.e., the greater the loudness. It can be seen from FIG. 8 that the loudness of the low-frequency components is greatly enhanced, thereby improving the hearing comfort of individuals with hearing loss. In summary, according to the present disclosure, by analyzing a common issue of mild high-frequency hearing loss among individuals with hearing loss, the accompaniment and the overall loudness of the original song are dynamically adjusted in conjunction with song separation technology, and the dynamics and colors of the song are presented to individuals with hearing loss to the greatest extent, which facilitates meeting a requirement of feeling music for individuals with high-frequency hearing loss, and greatly reduces the wastage of manpower and time costs caused by manual adjustment.

[0066] Accordingly, referring to FIG. 9, an apparatus for generating a song for individuals with high-frequency hearing loss is provided according to an embodiment of the present disclosure. The apparatus includes: a vocal and accompaniment separation module 11, a frequency reduction module 12, a mixing module 13, and a loudness control module 14.

[0067] The vocal and accompaniment separation module 11 is configured to separate an original song into a vocal track and an accompaniment track.

[0068] The frequency reduction module 12 is configured to perform frequency reduction on the accompaniment track to adjust a frequency range of the accompaniment track to a target

frequency range perceivable by the individuals with high-frequency hearing loss to obtain a frequency-reduced accompaniment track.

[0069] The mixing module 13 is configured to mix the vocal track and the frequency-reduced accompaniment track to obtain a mixed song.

5 **[0070]** The loudness control module 14 is configured to perform loudness control on the mixed song based on a preset loudness control mechanism to obtain a target song for the individuals with high-frequency hearing loss.

[0071] For a specific operation process of the above-described modules, reference may be made to the corresponding contents disclosed in the above-described embodiments, which is
10 not repeated here.

[0072] It can be seen that a method for generating a song for individuals with high-frequency hearing loss is provided according to the present disclosure. The method includes: separating an original song into a vocal track and an accompaniment track; performing frequency reduction on the accompaniment track to adjust a frequency range of the accompaniment track
15 to a target frequency range perceivable by the individuals with high-frequency hearing loss to obtain a frequency-reduced accompaniment track; mixing the vocal track and the frequency-reduced accompaniment track to obtain a mixed song; and performing loudness control on the mixed song based on a preset loudness control mechanism to obtain a target song for the individuals with high-frequency hearing loss. In summary, according to the present disclosure,
20 the vocal and the accompaniment of the original song are separated firstly, to obtain the vocal track and the accompaniment track. Since high-frequency components are primarily concentrated in the accompaniment track, frequency reduction is performed on the accompaniment track to adjust the frequency range of the accompaniment track to the target frequency range perceivable by the individuals with high-frequency hearing loss. Further, the
25 present disclosure involves: mixing the vocal track and the accompaniment track to obtain a mixed song; and performing loudness control on the mixed song based on a preset loudness control mechanism, to improve the hearing comfort of individuals with hearing loss. That is, according to the present disclosure, a hearing-loss-friendly song, which is adapted to the target frequency range perceivable by the individuals with high-frequency hearing loss, is
30 automatically produced, facilitating meeting a requirement for feeling music of individuals with high-frequency hearing loss, and greatly reduces the wastage of manpower and time costs

caused by manual adjustment.

[0073] In some embodiments, the vocal and accompaniment separation module 11 further includes a vocal-to-accompaniment ratio determination unit.

[0074] The vocal-to-accompaniment ratio determination unit is configured to determine a
5 vocal-to-accompaniment ratio between the vocal track and the accompaniment track.

[0075] Accordingly, the mixing module 13 is further configured to mix the vocal track and the frequency-reduced accompaniment track based on the vocal-to-accompaniment ratio.

[0076] In some embodiments, the frequency reduction module 12 further includes a to-be-processed accompaniment track determination unit, a filtering unit, a frequency reduction unit,
10 and a mixing unit.

[0077] The to-be-processed accompaniment track determination unit is configured to determine a current to-be-processed accompaniment track based on the accompaniment track.

[0078] The filtering unit is configured to perform high-pass filtering on the current to-be-processed accompaniment track by using a first frequency divider to obtain a first high-
15 frequency range accompaniment track, and perform low-pass filtering on the current to-be-processed accompaniment track by using the first frequency divider to obtain a first low-frequency range accompaniment track. A frequency range of the first low-frequency range accompaniment track is the target frequency range, and a cutoff frequency of the first frequency divider is an upper limit frequency of the target frequency range.

[0079] The frequency reduction unit is configured to perform frequency reduction on the first high-frequency range accompaniment track based on a target method for frequency reduction to adjust a frequency range of the first high-frequency range accompaniment track to the target frequency range to obtain a frequency-reduced first high-frequency range accompaniment track.

[0080] The mixing unit is configured to mix the first low-frequency range accompaniment
25 track and the frequency-reduced first high-frequency range accompaniment track to obtain the frequency-reduced accompaniment track.

[0081] In some embodiments, the to-be-processed accompaniment track determination unit is further configured to:

in a case that an upper limit frequency of the frequency range of the accompaniment track

meets a first preset condition, directly determine the accompaniment track as the current to-be-processed accompaniment track.

[0082] In some embodiments, the to-be-processed accompaniment track determination unit is further configured to:

5 in a case that an upper limit frequency of the frequency range of the accompaniment track meets a second preset condition, perform high-pass filtering on the accompaniment track by using a second frequency divider to obtain a second high-frequency range accompaniment track, and perform low-pass filtering on the accompaniment track by using the second frequency divider to obtain a second low-frequency range accompaniment track, where a cutoff frequency
10 of the second frequency divider is an upper limit frequency of a frequency range of the second low-frequency range accompaniment track;

perform frequency reduction on the second high-frequency range accompaniment track based on the target method for frequency reduction to adjust a frequency range of the second high-frequency range accompaniment track to the frequency range of the second low-frequency
15 range accompaniment track to obtain a frequency-reduced second high-frequency range accompaniment track; and

mix the second low-frequency range accompaniment track and the frequency-reduced second high-frequency range accompaniment track to obtain the current to-be-processed accompaniment track.

20 **[0083]** In some embodiments, both the first frequency divider and the second frequency divider are constructed based on a Butterworth filter.

[0084] In some embodiments, the loudness control module 14 further includes: a target input loudness sub-range determination unit, a target loudness adjustment proportional coefficient determination unit, and a current output loudness determination unit.

25 **[0085]** The target input loudness sub-range determination unit is configured to determine, among multiple preset input loudness sub-ranges, a target input loudness sub-range corresponding to a current input loudness of the mixed song.

[0086] The target loudness adjustment proportional coefficient determination unit is configured to determine, among multiple preset loudness adjustment proportional coefficients,
30 a target loudness adjustment proportional coefficient corresponding to the target input loudness

sub-range.

[0087] The current output loudness determination unit is configured to determine a product of the target loudness adjustment proportional coefficient and the current input loudness as a current output loudness.

5 **[0088]** In some embodiments, the apparatus for generating a song for individuals with high-frequency hearing loss further includes: a preset input loudness sub-range determination unit, and a preset loudness adjustment proportional coefficient determination unit.

[0089] The preset input loudness sub-ranges determination unit is configured to determine multiple input loudness values within a preset input loudness range as dividing points for the
10 preset input loudness range, and divide the preset input loudness range based on the dividing points to obtain the multiple preset input loudness sub-ranges.

[0090] The preset loudness adjustment proportional coefficient determination unit is configured to configure respective loudness adjustment proportional coefficients for the multiple preset input loudness sub-ranges to obtain the multiple preset loudness adjustment
15 proportional coefficients.

[0091] The loudness adjustment proportional coefficients corresponding to the multiple preset input loudness sub-ranges are inversely correlated with the multiple input loudness values corresponding to the dividing points.

[0092] Further, an electronic device is provided according to an embodiment of the present
20 disclosure. FIG. 10 is a structural diagram of an electronic device 20 according to an embodiment of the present disclosure, the content in which should not be considered as any limitation on a scope of the present disclosure.

[0093] FIG. 10 is a schematic structural diagram of an electronic device 20 according to an embodiment of the present disclosure. The electronic device 20 may include: at least one
25 processor 21, at least one memory 22, a display screen 23, an input/output interface 24, a communication interface 25, a power supply 26, and a communication bus 27. The memory 22 is configured to store a computer program. The computer program is loaded and executed by the processor 21 to implement the method for generating the song for the individuals with high-frequency hearing loss according to any foregoing embodiment. In addition, the electronic
30 device 20 in the present embodiment may be an electronic computer.

[0094] In this embodiment, the power supply 26 is configured to provide operating voltage for hardware components of the electronic device 20. The communication interface 25 is configured to create a data transmission channel between the electronic device 20 and external devices. The communication interface 25 uses a communication protocol applicable to the technical solution of the present disclosure, which is not specifically limited here. The input/output interface 24 is configured to acquire input data from the external or output data to the external. The interface type of the input/output interface 25 may be selected according to actual requirements, which is not specifically limited here.

[0095] In addition, the memory 22, as a resource storage carrier, may be a read-only memory, a random access memory, a magnetic disk or an optical disk, etc., and the resources stored thereon may include a computer program 221. The storage may be temporary storage or permanent storage. In addition to including a computer program for implementing the method for generating the song for the individuals with high-frequency hearing loss executed by the electronic device 20 according to any of the foregoing embodiments, the computer program 221 may further include a computer program for implementing other specific tasks.

[0096] Further, a computer-readable storage medium is provided according to an embodiment of the present disclosure. The computer-readable storage medium is configured to store a computer program. The computer program, when executed by a processor, implements the method for generating the song for the individuals with high-frequency hearing loss described above.

[0097] Specific steps of the method may refer to content disclosed in the foregoing embodiments, and are not repeated herein.

[0098] The above embodiments of the present disclosure are described in a progressive manner. Each embodiment is mainly focused on describing differences from other embodiments, and references may be made among these embodiments with respect to the same or similar parts. Since the apparatus disclosed in embodiments corresponds to the method disclosed in the embodiments, the description of the apparatus is simple, and reference may be made to the relevant part of the method.

[0099] Those skilled in the art may further realize that the units and algorithm steps of each example described in conjunction with the embodiments disclosed herein may be implemented by electronic hardware, computer software, or a combination of both. To clearly illustrate the

interchangeability of hardware and software, the composition and steps of each example have been generally described according to the function in the above description. Whether a function is to be implemented by hardware or software depends on a particular application of the technical solution and a design constraint. Those skilled in the art may use different methods to
5 implement the described functions for each particular application, and such implementation should not be regarded as departing from the scope of the present disclosure.

[0100] Steps of the method or algorithm described in conjunction with the embodiments of the present disclosure may be implemented by hardware, a software module executed by a processor, or a combination thereof. The software module may be located in a random-access
10 memory (RAM), an internal memory, a read only memory (ROM), an electrically programmable ROM, an electrically-erasable programmable ROM, a register, a hard disk, a removable disk drive, a CD-ROM, or any other storage medium known in the art.

[0101] Finally, it should also be noted that in the present disclosure, relational terms such as "first", "second" and the like are only used to distinguish one entity or operation from another,
15 and do not necessarily require or imply any such actual relationship or precedence order in these entities or operations. Furthermore, terms "include", "comprise" or any other variants thereof are intended to be non-exclusive. Therefore, a process, method, article or device including a series of elements includes not only the elements but also other elements that are not enumerated or other elements inherent to such process, method, article or device. Unless
20 expressively limited, the statement "including a..." does not exclude the case that other similar elements may exist in the process, method, article or device including the elements.

[0102] Described above is a method for generating a song for individuals with high-frequency hearing loss, a device, and a storage medium according to the present disclosure. Although the principles and implementations of the present disclosure are described by using
25 specific examples in the present disclosure, the descriptions of the foregoing embodiments are merely intended to facilitate understanding the method and the core concept of the method in the present disclosure. In addition, those skilled in the art may make modifications to the specific implementations and application range according to the concept of the present disclosure. In conclusion, the content of this specification is not to be construed as a limit on
30 the present disclosure.

CLAIMS

1. A method for generating a song for individuals with high-frequency hearing loss, comprising:

5 separating an original song into a vocal track and an accompaniment track;

performing frequency reduction on the accompaniment track to adjust a frequency range of the accompaniment track to a target frequency range perceivable by the individuals with high-frequency hearing loss to obtain a frequency-reduced accompaniment track;

10 mixing the vocal track and the frequency-reduced accompaniment track to obtain a mixed song; and

performing loudness control on the mixed song based on a preset loudness control mechanism to obtain a target song for the individuals with high-frequency hearing loss.

15 2. The method for generating the song for the individuals with high-frequency hearing loss according to claim 1, wherein the separating an original song into a vocal track and an accompaniment track comprises:

determining a vocal-to-accompaniment ratio between the vocal track and the accompaniment track, and

wherein the mixing the vocal track and the frequency-reduced accompaniment track to obtain a mixed song comprises:

20 mixing the vocal track and the frequency-reduced accompaniment track based on the vocal-to-accompaniment ratio.

25 3. The method for generating the song for the individuals with high-frequency hearing loss according to claim 1, wherein the performing frequency reduction on the accompaniment track to adjust a frequency range of the accompaniment track to a target frequency range perceivable by the individuals with high-frequency hearing loss to obtain a frequency-reduced accompaniment track comprises:

determining a current to-be-processed accompaniment track based on the accompaniment track;

performing high-pass filtering on the current to-be-processed accompaniment track by

using a first frequency divider to obtain a first high-frequency range accompaniment track, and performing low-pass filtering on the current to-be-processed accompaniment track by using the first frequency divider to obtain a first low-frequency range accompaniment track, wherein a frequency range of the first low-frequency range accompaniment track is the target frequency range, and a cutoff frequency of the first frequency divider is an upper limit frequency of the target frequency range;

performing frequency reduction on the first high-frequency range accompaniment track based on a target method for frequency reduction to adjust a frequency range of the first high-frequency range accompaniment track to the target frequency range to obtain a frequency-reduced first high-frequency range accompaniment track; and

mixing the first low-frequency range accompaniment track and the frequency-reduced first high-frequency range accompaniment track to obtain the frequency-reduced accompaniment track.

4. The method for generating the song for the individuals with high-frequency hearing loss according to claim 3, wherein the determining a current to-be-processed accompaniment track based on the accompaniment track comprises:

in a case that an upper limit frequency of the frequency range of the accompaniment track meets a first preset condition, directly determining the accompaniment track as the current to-be-processed accompaniment track.

5. The method for generating the song for the individuals with high-frequency hearing loss according to claim 3, wherein the determining a current to-be-processed accompaniment track based on the accompaniment track comprises:

in a case that an upper limit frequency of the frequency range of the accompaniment track meets a second preset condition,

performing high-pass filtering on the accompaniment track by using a second frequency divider to obtain a second high-frequency range accompaniment track, and performing low-pass filtering on the accompaniment track by using the second frequency divider to obtain a second low-frequency range accompaniment track, wherein a cutoff frequency of the second frequency divider is an upper limit frequency of a frequency range of the second low-frequency range accompaniment track;

performing frequency reduction on the second high-frequency range accompaniment track based on the target method for frequency reduction to adjust a frequency range of the second high-frequency range accompaniment track to the frequency range of the second low-frequency range accompaniment track, to obtain a frequency-reduced second high-frequency range accompaniment track; and

mixing the second low-frequency range accompaniment track and the frequency-reduced second high-frequency range accompaniment track to obtain the current to-be-processed accompaniment track.

6. The method for generating the song for the individuals with high-frequency hearing loss according to claim 5, wherein both the first frequency divider and the second frequency divider are constructed based on a Butterworth filter.

7. The method for generating the song for the individuals with high-frequency hearing loss according to any one of claims 1 to 6, wherein the performing loudness control on the mixed song based on a preset loudness control mechanism comprises:

determining, among a plurality of preset input loudness sub-ranges, a target input loudness sub-range corresponding to a current input loudness of the mixed song;

determining, among a plurality of preset loudness adjustment proportional coefficients, a target loudness adjustment proportional coefficient corresponding to the target input loudness sub-range; and

determining a product of the target loudness adjustment proportional coefficient and the current input loudness as a current output loudness.

8. The method for generating the song for the individuals with high-frequency hearing loss according to claim 7, further comprising:

determining a plurality of input loudness values within a preset input loudness range as dividing points for the preset input loudness range, and dividing the preset input loudness range based on the dividing points to obtain the plurality of preset input loudness sub-ranges; and

configuring respective loudness adjustment proportional coefficients for the plurality of preset input loudness sub-ranges to obtain the plurality of preset loudness adjustment proportional coefficients,

wherein the loudness adjustment proportional coefficients corresponding to the plurality of preset input loudness sub-ranges are inversely correlated with the plurality of input loudness values corresponding to the dividing points.

9. An electronic device, comprising:

5 a memory, configured to store a computer program; and

a processor, configured to execute the computer program to implement the method for generating the song for the individuals with high-frequency hearing loss according to any one of claims 1 to 8.

10 10. A computer-readable storage medium, storing a computer program, wherein the computer program, when executed by a processor, implements the method for generating the song for the individuals with high-frequency hearing loss according to any one of claims 1 to 8.