(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 755 205 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention
of the grant of the patent:
11.12.2019 Bulletin 2019/50

(51) Int Cl.:
G10L 25/18 $^{(2013.01)}$ *G10L 21/0208* $^{(2013.01)}$
G10L 19/02 $^{(2013.01)}$

(21) Application number: **14157074.7**

(22) Date of filing: **24.01.2011**

(54) **Sub-band processing complexity reduction**

Subband-Verarbeitung zur Komplexitätsverringerung

Réduction de la complexité de traitement de sous-bande

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **29.01.2010 US 696533**

(43) Date of publication of application:
16.07.2014 Bulletin 2014/29

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
11151856.9 / 2 355 094

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Printed by Jouve, 75001 PARIS (FR)

Description

BACKGROUND OF THE INVENTION

1. Priority Claim.

[0001] This application claims the benefit of priority from U.S. Patent Application No. 12/696,533, filed January 29,2010.

2. Technical Field.

[0002] This disclosure relates to sub-band processing, and more particularly to systems that reduce computational complexity and memory requirements.

3. Related Art.

[0003] Wideband networks receive and transmit data through radio frequency signals through inbound and outbound transmissions. The networks may transmit data, voice, and video simultaneously through multiple channels that may be distinguished in frequency. Some wideband networks are capable of high speed operations and may have a considerably higher throughput than some narrowband networks. The increased bandwidth of these networks may increase the processing loads and memory requirements of other applications.

[0004] Frequency domain based adaptive filtering, for example, may be computationally intensive because it translates a time domain signal into multiple frequency components that are separately processed. Translating a time domain signal into multiple frequency components increases the computational complexity and memory usage of some systems when a signal's bandwidth increases. As the number of frequency components increase with bandwidth, the computational load and the required memory increase.

[0005] The publication A. Miksic, B. Horvat: "Subband echo cancellation in automatic speech dialog systems", Eurospeech '97, p. 2579-2582, discloses subband echo cancellation on a sparse signal spectrum, thereby reducing computational complexity.

SUMMARY

[0006] A sub-band processing system that reduces computational complexity and memory requirements includes a processor and a local or a distributed memory. Logic stored in the memory partitions a frequency spectrum of bins into sub-bands. The logic enables a lossy compression by designating a magnitude and a designated or derived phase of each bin in the frequency spectrum as representative. The logic renders a lossless compression by decompressing the lossy compressed data and providing lost data based on original spectral relationships contained within the frequency spectrum.

[0007] Other systems, methods, features and advantages will be, or will become, apparent to one with skill in the art upon examination of the following figures and detailed description. It is intended that all such additional systems, methods, features and advantages be included within this description, be within the scope of the invention, and be protected by the following claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The system may be better understood with reference to the following drawings and description. The components in the figures are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention. Moreover, in the figures, like referenced numerals designate corresponding parts throughout the different views.

Figure 1 is a non-overlapping frequency compression of an uncompressed frame.
Figure 2 is a band-like overlapping frequency compression of an uncompressed frame.
Figure 3 is non-overlapping compression showing a phase selection.
Figure 4 is an uncompressed spectrum.
Figure 5 is an exemplary rotation of bin 5 to the phase of bin 4.
Figure 6 is an exemplary illustration of band 3.
Figure 7 is an exemplary illustration of a processed band 3
Figure 8 is an exemplary restoration of bins from the exemplary processed band 3.
Figure 9 is an exemplary sub-band processing system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0009] Due to improvements in transmission rates and device resolutions, networks are providing multi-media, multipoint, and multiple transmission rates for a variety of services. To reduce computational loads and memory requirements, a sub-band processing system processes data such that, after it is compressed and decompressed it is restored to its original format. The system may compress video, sound, text, code, and/or numeric data such that little or no data is lost after a bin or file is decompressed. While the data may contain more information than may be heard or seen (e.g., perceived by a user), some systems preserve the original data (or a representative data set) while compressing and decompressing operating data through a lossy compression. After further (optional) processing (by an ancillary device or system) the sub-band processing system reconstructs and restores the data. The restored data may maintain the relative magnitude and phase of the original data. The restored data may match the original relationships (e.g., relative magnitudes and phases) frequency-for-frequency.

[0010] The sub-band processing system analysis may occur on frequency domain characteristics. To derive frequency domain properties, the signal may be broken into intervals though a multiplier function (retained in a local or a distributed computer readable medium) or multiplier device that multiplies the signal by a "window" function or a "frame" of fixed duration. To minimize spectral distortion, smooth window functions (such as Hann, Hamming, etc. retained in the local or the distributed computer readable medium) or a window filter may be used for the short-time spectral analysis. A time-to-frequency transform device, a Discrete Fourier Transform (DFT) device, or a Fast Fourier Transform (FFT) device may transform (or decompose) the short-time based signals into a complex spectrum. The spectrum may be separated into bins of magnitude and phase data or substantially equivalent complex (e.g. real and imaginary) data. A sub-band (or band) may be represented by a single bin of magnitude and phase spectra, or a collection of consecutive or successive bins represented by a common or single magnitude and phase spectra. Table 1 shows representative characteristics of an exemplary FFT device.

Table 1 Parameters

Sample rate (kHz)	8	11.025	16	22.05	32	44.1
FFT length (*N*)	256	256	512	512	1024	1024
Number of useful output bins (*R*)	129	129	257	257	513	513
Hz / bin	31.25	43.07	31.25	43.07	31.25	43.07

[0011] At a sample rate of about 8 kHz, an FFT device may transform the time domain signal into about 256 bins. Due to the complex symmetry, the FFT device may yield about 129 useful bins (e.g., 256/2 + 1). Each bin may represent a frequency resolution of about 31.25 Hz (e.g., 8 kHz/256). The frequency resolution of other sample rates (e.g., 16 kHz and 32 kHz) may be maintained by changing the FFT length. For example, at 16 kHz, the FFT length may be about double the FFT length of the 8 kHz sample rate. At 32 kHz, the FFT length may be about double the FFT length of the 16 kHz sample rate.

[0012] In some systems, the magnitude and phase spectra may be obtained from one or more signal processors that execute a Discrete Fourier Transform (DFT) stored in a local or a distributed memory. The output of the DFT may be represented by *X(k).*

$$X(k) = \sum_{n=0}^{N-1} x(n) e^{j\frac{2\pi nk}{N}} \qquad (1)$$

for *k* = 0 ... *N*-1, where

k is the frequency index for each bin
n is the time index for each sample
N is the length of the DFT (or FFT)

[0013] The bins (*R*) of the FFT (or DFT) device may partitioned into a fewer (or smaller *R* >= *M*) number of sub-bands (*M*). In some applications, the sub-band processing system may reduce M to a lowest possible integer that does not affect the performance or quality of a later process. In these applications, the system may generate a number of sub-bands that minimize perceptual error. The applications may exploit the sensitivity of the human auditory system or other systems that do not detect or process certain frequencies or are affected by certain signal distortions.

[0014] A lossy compression may compress the data such that some data is lost when the data is compressed into the sub-bands. Some sub-band processing systems compress 2^q bins (q is an integer) into individual sub-bands. Other systems apply a perceptual scale (through a processor or controller, for example) where the bins are grouped into sub-bands that match the frequency selectivity of the human auditory system. The sub-bands may comprise non-overlapping or overlapping frequency regions that account for a selected or critical band (e.g., a frequency bandwidth that may model an auditory filter) or apply a perceptual scale like a single or multiple stage rectangular-like bandwidth filter or filter bank, logarithmic spacing filter or filter bank, Bark filter or filter bank, Mel or Mel-like filters or filter bank. Figures 1 and 2, respectively, describe exemplary non-overlapping and band-like overlapping compressions. In each figure the uncompressed bins are shown above the corresponding compressed sub-bands. The compressions divide a variable sequence of uncompressed bins into a substantially equal sequence of compressed sub-bands. A substantially equal gain or a variable gain may be applied to render compressed sub-bands that are substantially flat across the frequency spectrum. Perceptual distortions may be minimized by applying lower compression ratios at lower frequencies while applying higher compression ratios at higher frequencies.

[0015] Table 2 describes an exemplary non-overlapping compression scheme in which each sub-band represents 2^q bins.

Approximate freq range (kHz)	Input bin numbers	Compression ratio	Output sub-bands #s
0 - 1	0 .. 31	1:1	0 .. 31
1 - 2	32 .. 63	2:1	32 .. 47
2 - 4	64 .. 127	4:1	48 .. 63
4 - Nyquist	128 .. M	8:1	64 .. xx

Other systems may apply a more perceptually based scheme that partitions the frequency spectrum into non-overlapping regions. In this alternative, the compression may be based on an auditory filter estimate. Each sub-band may be approximately equal to a first predetermined frequency band such as ½ ERB (Equivalent Rectangular Bandwidth) for frequencies below about 4 kHz, and a second predetermined frequency band such as 1 ERB for frequencies above about 4 kHz. More aggressive compression schemes may be applied when the level of distortion or artifacts do not affect (or have little affect on) the performance of other systems.

[0016] Some systems, such as a system that may divide fifteen bins of the spectrum into five sub-bands (e.g., as shown in Figure 3) may group sub-bands such that each sub-band is about 0.4 ERB (at a low compression) to about 0.875 (at a high compression) ERB. When there is less processor execution speed the sub-bands may be increased. If there is a need to reduce a processors speed by a millions of instructions per second (MIPS), for example, some systems increase the sub-bands to larger ERB values (e.g., each sub-band may be about 1.25 ERB)

[0017] While many lossy compression schemes may be used, the sub-band processing system may select or designate a representative phase for each sub-band. Some sub-band processing system "preserve" or select the phase of a bin within the sub-band that has the lowest frequency (as shown in Figure 3) within that sub-band. Other systems may select bins near or at the center of the sub-band, and others may select a phase based on other structural, functional, or qualitative measures. An alterative sub-band processing system may derive phase through an average or weighted average (e.g., an averaging filter, a programmable dynamic weighting filter, a perceptual weighting filter, etc.). An average may comprise a logical operation stored in a local or remote central or distributed memory such as an arithmetic mean of the phases within each sub-band. The weights of a weighted average may be based on the phase correlations common to one or all of the bins that comprise one or more sub-bands.

[0018] The selected magnitudes, an average magnitude (e.g., an average of bins that makeup a band), peaks in the magnitude spectrum, or a function or algorithm that selects or synthesizes a magnitude of each sub-band may be designated as representative. When a maximum magnitude system is used and a maximum magnitude is detected, the bin containing that magnitude is indexed, stored in memory, and the magnitude is rotated or shifted (e.g., through a phase shifter) to attain the selected or designated phase. A resulting sub-band value may be transformed to a maximum magnitude selected from its constituent bins and the phase of the "preserved" or selected bin (through a rotation through or shift by a phase differential, e.g., $\text{beta}_{\text{sub-band1}}$, $\text{beta}_{\text{sub-band2}}$, etc.). In the sub-band processing system, the magnitude, $|SBX(m)|$, and phase, $\arg(SBX(m))$, for each sub-band may be:

$$SBX(m) = |SBX(m)|, \arg(SBX(m)) \qquad (2)$$

where

$$|SBX(m)| = \max(|X(j_m)|, |X(j_m+1)|, \ldots, |X(j_m+D_m-1)|) \qquad (3)$$

$$\arg(SBX(m)) = \arg(X(j_m)) \qquad (4)$$

$$h_m = \arg\max(|X(j_m)|, |X(j_m+1)|, \ldots, |X(j_m+D_m-1)|) \qquad (5)$$

for $m = 0 \ldots M\text{-}1$ and

m	is the index for each sub-band
j_m	is the starting (uncompressed frequency bin) index for sub-band m, and also the index of the bin whose phase is preserved for sub-band m
D_m	is the number of uncompressed bins that are "compressed" into sub-band m
h_m	is the uncompressed frequency index of the bin that has the maximum magnitude for sub-band m

[0019] In some systems, common bins may be selected from the divided spectrum to preserve the phase of the sub-bands relative to each processed frame. In these systems j_m and D_m may be constant (e.g., temporally invariant) while h_m may change (e.g., time variant) from one aural or sound frame (or video, sound, text, code, and/or numeric data) to the next. Such systems may preserve the phase of the same bin within a sub-band on a frame-by-frame basis such as for example, always the first bin of a sub-band in each frame or a common bin of a sub-band in each frame.

[0020] Figure 4 is an uncompressed spectrum of complex vectors representing bins 4, 5, 6 and 7 that comprise an exemplary sub-band 3. In sub-band 3, bin 5 has the largest magnitude and is therefore designated as representative (e.g., through a peak magnitude detector). Through a pre-selection or a derivation through a device such as a phase detector, the phase of bin 4 is the designated phase. To preserve that phase, the vector representing bin 5 is rotated counterclockwise or otherwise adjusted to substantially match the phase of bin 4 while maintaining its original maximum magnitude (as shown in Figure 5). The rotated or adjusted version of bin 5 represents sub-band 3, which effectively attenuates the remaining spectrum within the sub-band (e.g., effectively setting the remaining spectrum to substantially to zero) as shown in Figure 6. The magnitudes and phases of the sparse spectrum (e.g., the adjusted sub-band spectrum) may be further processed before the spectrum is reconstructed.

[0021] By maintaining magnitude and phase spectra through the sparse spectrum, the spectrum may be further processed in the frequency domain (or other domains). Adaptive filtering techniques or devices used by an acoustic echo canceller, noise cancellation, or a beam-former, for example, may process a consistent phase that does not change abruptly from frame to frame. Abrupt phase changes that may be a characteristic of other systems may be identified as an impulse response that causes an acoustic echo canceller to diverge. When divergence occurs, a sub-optimal, reduced, or no echo cancellation may occur due to the mismatch between the filter coefficients and the echo path characteristics. When a divergence is declared, an adaptive filter may require time to achieve a convergence.

[0022] When reconstructing the processed spectrum, the original spectral data (or a representative data set or a data set of relative measures) is processed so that little or no data is lost when the decompression is complete. By processing the original spectral data (or the representative data or relative measure data set), the sub-band processing system may achieve a lossless or nearly lossless compression. Some systems may preserve almost the entire original spectrum to avoid generating perceivable artifacts when the spectrum is reconstructed.

[0023] An overlap-add synthesis may partially reconstruct the spectrum from the processed sparse spectrum. An overlap-add synthesis may avoid discontinuities in the reconstructed spectrum. For each sub-band, the system rotates the processed sub-band to its original relative phase (or a substantially original relative phase), which is relative to the preserved bin (e.g., through a counter rotation through the phase differential, e.g., $\text{beta}_{\text{sub-band1}}$, $\text{beta}_{\text{sub-band2}}$, etc.). For example, if a bin containing the largest magnitude was rotated beta degrees in one direction, then the system rotates the processed sub-band by beta degrees in the opposite direction to restore the peak magnitude bin. With the bin restored, the remaining bins that made up the sub-band are reconstructed by maintaining relative magnitudes and phases of the original spectrum (or representative data or relative measure data set). The magnitude and phase of the remaining reconstructed bins maintain the same relative magnitude and phase relationship with the restored peak magnitude bin, as the original spectral bins had with the original peak magnitude bin. In some alternative systems, frequency-criteria may affect phase reconstruction. In one exemplary system, sub-bands that exceed a predetermined value (e.g., over about 4 kHz), may not maintain relative phase relationships.

[0024] Because further processing (e.g., echo cancellation, noise reduction, beam former, signal attenuators, amplifiers, signal modifier, etc.) may alter the magnitude and phase of each sub-band, quantitatively each *SBX(m)* has been transformed into *SBY(m)*. Equations 6-10 describe how the magnitude and phase for each sub-band may be expanded to its constituent bins. Equation (7) establishes that the magnitude of the restored peak magnitude bin is equal (or may be substantially equal) to the magnitude of the processed sub-band. Equation (8) establishes that the phase of the restored peak magnitude bin maintains substantially the same relative phase relationship measured during the partitioning process. Equations (9) and (10), respectively, establish how the remaining bins may be reconstructed. Once the complex spectrum is restored,

$$SBY(m) = |SBY(m)|, \arg(SBY(m)) \tag{6}$$

$$|Y(h_m)| = |SBY(m)| \tag{7}$$

$$\arg(Y(h_m)) = \arg(SBY(m)) - \arg(X(j_m)) + \arg(X(h_m)) \tag{8}$$

$$|Y(p)| = |Y(h_m)| \cdot \frac{|X(p)|}{|X(h_m)|} \tag{9}$$

$$\arg(Y(p)) = \arg(Y(h_m)) - \arg(X(h_m)) + \arg(X(p)) \tag{10}$$

for m = 0...*M*-1 and

m	is the index for each sub-band
j_m	is the starting (uncompressed frequency bin) index for sub-band *m*, and also the index of the bin whose phase is preserved for sub-band *m*
D_m	is the number of uncompressed bins that are "compressed" into sub-band *m*
h_m	is the uncompressed frequency index of the bin that has the maximum magnitude for sub-band *m*
p	are the indexes in the range $[j_m, j_m + D_m - 1]$ that do not equal h_m

a time domain signal may be generated by an Inverse Fourier Transform device (or function stored in a local or a distributed memory). If windows were used during system analysis, an overlap-add function may be used for synthesis.

[0025] Assuming original sub-band 3 (of Figure 6) contained echo and was processed to eliminate or minimize the unwanted or undesired additions (echo), processed sub-band 3 may be somewhat attenuated and rotated as shown in Figure 7. For example, since bin 5 was designated as representative, it may be restored by rotating sub-band 3 clockwise by beta degrees to maintain the original relative phase to bin 4. The restored bin 5 maintains a new attenuated (or adjusted) magnitude. The remaining bins are then scaled and rotated to maintain their original relative phase and magnitude relationships to the restored bin as shown in Figure 8.

[0026] Until the spectrum is restored, the original spectrum (or the representative data set) may be retained in a computer readable medium or memory so that the original relative magnitude and phase relationships may be maintained or restored in the decompressed spectrum. This retention potentially reduces audible artifacts that may be introduced by a compression scheme.

[0027] The system, methods, and descriptions described may be programmed in one or more controllers, devices, processors (e.g., signal processors). The processors may comprise one or more central processing units that supervise the sequence of micro-operations that execute the instruction code and data coming from memory (e.g., computer readable medium) that generate, support, and/or complete an operation, compression, or signal modifications. The dedicated applications may support and define the functions of the special purpose processor or general purpose processor that is customized by instruction code (and in some applications may be resident to vehicles). In some systems, a front-end processor may perform the complementary tasks of gathering data for a processor or program to work with, and for making the data and results available to other processors, controllers, or devices.

[0028] The systems, methods, and descriptions may program one or more signal processors or may be encoded in a signal bearing storage medium, a computer-readable medium, or may comprise logic 902 stored in a memory that may be accessible through an interface and is executable by one or more processors 904 as shown in Figure 9 (in Figure 9, N comprises an integer). Some signal-bearing storage medium or computer-readable medium comprise a memory that is unitary or separate (e.g., local or remote) from a device, programmed within a device, such as one or more integrated circuits, or retained in memory and/or processed by a controller or a computer. If the descriptions or methods are performed by software, the software or logic may reside in a memory resident to or interfaced to one or more processors, devices, or controllers that may support a tangible or visual communication interface (e.g., to a display), wireless communication interface, or a wireless system.

[0029] The memory may retain an ordered listing of executable instructions in a processor, device, or controller accessible medium for implementing logical functions. A logical function may be implemented through digital circuitry, through source code, or through analog circuitry. The software may be embodied in any computer-readable medium or signal-bearing medium, for use by, or in connection with, an instruction executable system, apparatus, and device, resident to system that may maintain persistent or non-persistent connections. Such a system may include a computer system, a processor-based system, or another system that includes an input and output interface that may communicate with a publicly accessible or privately accessible distributed network through a wireless or tangible communication bus through a public and/or proprietary protocol.

[0030] A "computer-readable storage medium," "machine-readable medium," "propagated-signal" medium, and/or "signal-bearing medium" may comprise a medium that stores, communicates, propagates, or transports software or data for use by or in connection with an instruction executable system, apparatus, or device. The machine-readable medium may selectively be, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, device, or propagation medium. A non-exhaustive list of examples of a machine-readable medium would include: an electrical connection having one or more wires, a portable magnetic or optical disk, a volatile memory, such as a Random Access Memory (RAM), a Read-Only Memory (ROM), an Erasable Programmable Read-Only Memory (EPROM or Flash memory), or an optical fiber. A machine-readable medium may also include a tangible medium, as the software may be electronically stored as an image or in another format (e.g., through an optical scan), then compiled, and/or interpreted or otherwise processed. The processed medium may then be stored in a computer and/or machine memory.

[0031] While various embodiments of the invention have been described, it will be apparent to those of ordinary skill in the art that many more embodiments and implementations are possible within the scope of the invention. Accordingly, the invention is not to be restricted except in light of the attached claims.

Claims

1. A sub-band processing method, comprising:

transforming an audio signal into a plurality of frequency bins each having a phase value;
partitioning the plurality of frequency bins into a smaller number of bands;
defining a first band to include multiple bins of the plurality of frequency bins;
determining a representative phase value for the first band by a processor programmed to determine the representative phase value based on the phase value of at least one of the multiple bins within the first band;
determining a representative magnitude for the first band; and
processing the first band using the representative phase and magnitude value, based on original spectral relationships between the representative phase and magnitude value and the bins in the first band.

2. The method of claim 1, where the step of determining the representative phase value comprises selecting, as the representative phase value, the phase value of a bin within the first band that has a lowest frequency within the first band.

3. The method of claim 1, where the step of determining the representative phase value comprises selecting, as the representative phase value, the phase value of a bin within the first band that is at a center of the first band.

4. The method of claim 1, where the step of determining the representative phase value comprises averaging multiple phase values associated with the multiple bins within the first band to derive the representative phase value, and where the step of averaging multiple phase values comprises applying a weighted average with weights set based on phase correlations common to one or more of the multiple bins within the first band.

5. The method of claim 1, the method further comprising determining a representative magnitude value for the first band by a processor programmed to determine the representative magnitude value based on the magnitude value of at least one of the multiple bins within the first band.

6. The method of claim 5, where the step of determining the representative magnitude value comprises selecting a largest magnitude value of the multiple bins within the first band as the representative magnitude value.

7. The method of claim 5, where the representative phase value is preserved from a first bin within the first band, and where the representative magnitude value is preserved from a second bin within the first band that is different than the first bin;
the method further comprising rotating a vector associated with the representative magnitude value based on the representative phase value so that a phase of the vector matches the representative phase value;
the further comprising performing a lossy compression on the signal to generate a compressed version of the signal, where the representative magnitude value and the representative phase value are preserved in the compressed version of the signal to represent the first band, and where other magnitude and phase data from the multiple bins of the first band are not maintained in the compressed version of the signal.

8. The method of claim 1, where the step of processing comprises transforming the first band of the signal by processing the first band at an adaptive filter, an acoustic echo canceller, a noise canceller, or a beam-former.

9. A computer readable medium comprising instructions for implementing the method of any of claims 1 to 8.

10. A sub-band processing system, comprising:

a computer memory that stores sub-band processing logic;
a processor coupled with the computer memory and configured to execute the sub-band processing logic stored in the computer memory, where execution of the sub-band processing logic causes the processor to implement the method of any of claims 1 to 8.

Patentansprüche

1. Teilbandverarbeitungsverfahren, umfassend:

Umwandeln eines Audiosignals in eine Vielzahl von Frequenz-Bins, die jeweils einen Phasenwert aufweisen;
Partitionieren der Vielzahl von Frequenz-Bins in eine kleinere Anzahl von Bändern;
Definieren eines ersten Bands, um mehrere Bins der Vielzahl von Frequenz-Bins zu enthalten;
Bestimmen eines repräsentativen Phasenwerts für das erste Band durch einen Prozessor, der dazu programmiert ist, den repräsentativen Phasenwert auf der Basis des Phasenwerts von mindestens einer der mehreren Bins innerhalb des ersten Bands zu bestimmen;
Bestimmen einer repräsentativen Größenordnung für das erste Band und
Verarbeiten des ersten Bands unter Verwendung des repräsentativen Phasen- und Größenordnungswerts auf der Basis von ursprünglichen spektralen Beziehungen zwischen dem repräsentativen Phasen- und Größenordnungswert und den Bins in dem ersten Band.

2. Verfahren nach Anspruch 1, wobei der Schritt des Bestimmens des repräsentativen Phasenwerts ein Auswählen des Phasenwerts einer Bin innerhalb des ersten Bands, die die niedrigste Frequenz innerhalb des ersten Bands aufweist, als den repräsentativen Phasenwert umfasst.

3. Verfahren nach Anspruch 1, wobei der Schritt des Bestimmens des repräsentativen Phasenwerts ein Auswählen des Phasenwerts einer Bin innerhalb des ersten Bands, die an einer Mitte des ersten Bands ist, als den repräsentativen Phasenwert umfasst.

4. Verfahren nach Anspruch 1, wobei der Schritt des Bestimmens des repräsentativen Phasenwerts ein Mitteln von mehreren Phasenwerten, die mit den mehreren Bins innerhalb des ersten Bands assoziiert sind, um den repräsentativen Phasenwert abzuleiten, umfasst und wobei der Schritt des Mittelns von mehreren Phasenwerten ein Anwenden eines gewichteten Mittels mit Gewichten, die auf der Basis von Phasenkorrelationen festgelegt werden, die für eine oder mehrere der mehreren Bins innerhalb des ersten Bands üblich sind, umfasst.

5. Verfahren nach Anspruch 1, wobei das Verfahren weiterhin ein Bestimmen eines repräsentativen Größenordnungswerts für das erste Band durch einen Prozessor umfasst, der dazu programmiert ist, den repräsentativen Größenordnungswert auf der Basis des Größenordnungswerts von mindestens einer der mehreren Bins innerhalb des ersten Bands zu bestimmen.

6. Verfahren nach Anspruch 5, wobei der Schritt des Bestimmens des repräsentativen Größenordnungswerts ein Auswählen eines größten Größenordnungswerts der mehreren Bins innerhalb des ersten Bands als den repräsentativen Größenordnungswert umfasst.

7. Verfahren nach Anspruch 5, wobei der repräsentative Phasenwert aus einer ersten Bin innerhalb des ersten Bands bewahrt wird und wobei der repräsentative Größenordnungswert aus einer zweiten Bin innerhalb des ersten Bands, die sich von der ersten Bin unterscheidet, bewahrt wird;
das Verfahren weiterhin ein Drehen eines Vektors, der mit dem repräsentativen Größenordnungswert assoziiert ist, auf der Basis des repräsentativen Phasenwerts umfasst, so dass eine Phase des Vektors mit dem repräsentativen Phasenwert übereinstimmt;
das Verfahren weiterhin ein Durchführen einer verlustbehafteten Kompression an dem Signal umfasst, um eine komprimierte Version des Signals zu erzeugen, wobei der repräsentative Größenordnungswert und der repräsentative Phasenwert in der komprimierten Version des Signals bewahrt werden, um das erste Band zu repräsentieren, und wobei andere Größenordnungs- und Phasendaten aus den mehreren Bins des ersten Bands nicht in der komprimierten Version des Signals aufrechterhalten werden.

8. Verfahren nach Anspruch 1, wobei der Schritt des Verarbeitens ein Umwandeln des ersten Bands des Signals durch Verarbeiten des ersten Bands an einem adaptiven Filter, einem akustischen Echokompensator, einem Rauschunterdrücker oder einem Strahlformer umfasst.

9. Computerlesbares Medium, das Anweisungen zum Implementieren des Verfahrens nach einem der Ansprüche 1 bis 8 umfasst.

10. Teilbandverarbeitungssystem, umfassend:

    einen Computerspeicher, der Teilbandverarbeitungslogik speichert;
    einen Prozessor, der mit dem Computerspeicher gekoppelt ist und dazu konfiguriert ist, die in dem Computerspeicher gespeicherte Teilbandverarbeitungslogik auszuführen, wobei die Ausführung der Teilbandverarbeitungslogik bewirkt, dass der Prozessor das Verfahren nach einem der Ansprüche 1 bis 8 implementiert.

Revendications

1. Procédé de traitement de sous-bande, comprenant :

    transformer un signal audio en une pluralité de segments de fréquence ayant chacun une valeur de phase ;
    partitionner la pluralité de segments de fréquence en un nombre plus petit de bandes ;
    définir une première bande pour inclure de multiples segments de la pluralité de segments de fréquence ;
    déterminer une valeur de phase représentative pour la première bande par un processeur programmé pour déterminer la valeur de phase représentative sur la base de la valeur de phase d'au moins l'un des multiples segments à l'intérieur de la première bande ;
    déterminer une amplitude représentative pour la première bande ; et
    traiter la première bande en utilisant la valeur de phase et d'amplitude représentative, sur la base de relations spectrales d'origine entre la valeur de phase et d'amplitude représentative et les segments dans la première bande.

2. Procédé selon la revendication 1, dans lequel l'étape de détermination de la valeur de phase représentative comprend la sélection, en tant que valeur de phase représentative, de la valeur de phase d'un segment à l'intérieur de la première bande qui a une fréquence la plus basse à l'intérieur de la première bande.

3. Procédé selon la revendication 1, dans lequel l'étape de détermination de la valeur de phase représentative comprend la sélection, en tant que valeur de phase représentative, de la valeur de phase d'un segment à l'intérieur de la première bande qui est au centre de la première bande.

4. Procédé selon la revendication 1, dans lequel l'étape de détermination de la valeur de phase représentative comprend le calcul de la moyenne de multiples valeurs de phase associées aux multiples segments à l'intérieur de la première

bande pour déduire la valeur de phase représentative, et dans lequel l'étape de calcul de la moyenne de multiples valeurs de phase comprend l'application d'une moyenne pondérée avec des poids définis sur la base de corrélations de phase communes à un ou plusieurs des multiples segments à l'intérieur de la première bande.

5. Procédé selon la revendication 1, le procédé comprenant en outre la détermination d'une valeur d'amplitude représentative pour la première bande par un processeur programmé pour déterminer la valeur d'amplitude représentative sur la base de la valeur d'amplitude d'au moins l'un des multiples segments à l'intérieur de la première bande.

6. Procédé selon la revendication 5, dans lequel l'étape de détermination de la valeur d'amplitude représentative comprend la sélection de la valeur d'amplitude la plus grande des multiples segments à l'intérieur de la première bande en tant que valeur d'amplitude représentative.

7. Procédé selon la revendication 5, dans lequel la valeur de phase représentative est conservée à partir d'un premier segment à l'intérieur de la première bande, et dans lequel la valeur d'amplitude représentative est conservée à partir d'un second segment à l'intérieur de la première bande qui est différent du premier segment ;
le procédé comprenant en outre la rotation d'un vecteur associé à la valeur d'amplitude représentative sur la base de la valeur de phase représentative de telle sorte qu'une phase du vecteur correspond à la valeur de phase représentative ;
le procédé comprenant en outre la réalisation d'une compression avec perte sur le signal pour générer une version compressée du signal, la valeur d'amplitude représentative et la valeur de phase représentative étant conservées dans la version compressée du signal pour représenter la première bande, et d'autres données de phase et d'amplitude provenant des multiples segments de la première bande n'étant pas maintenues dans la version compressée du signal.

8. Procédé selon la revendication 1, dans lequel l'étape de traitement comprend la transformation de la première bande du signal par traitement de la première bande au niveau d'un filtre adaptatif, d'un dispositif de suppression d'écho acoustique, d'un dispositif de suppression de bruit ou d'un dispositif de formation de faisceau.

9. Support lisible par ordinateur comprenant des instructions pour mettre en œuvre le procédé selon l'une quelconque des revendications 1 à 8.

10. Système de traitement de sous-bande, comprenant :

une mémoire informatique qui stocke une logique de traitement de sous-bande ;
un processeur couplé à la mémoire informatique et configuré pour exécuter la logique de traitement de sous-bande stockée dans la mémoire informatique, l'exécution de la logique de traitement de sous-bande amenant le processeur à mettre en œuvre le procédé selon l'une quelconque des revendications 1 à 8.

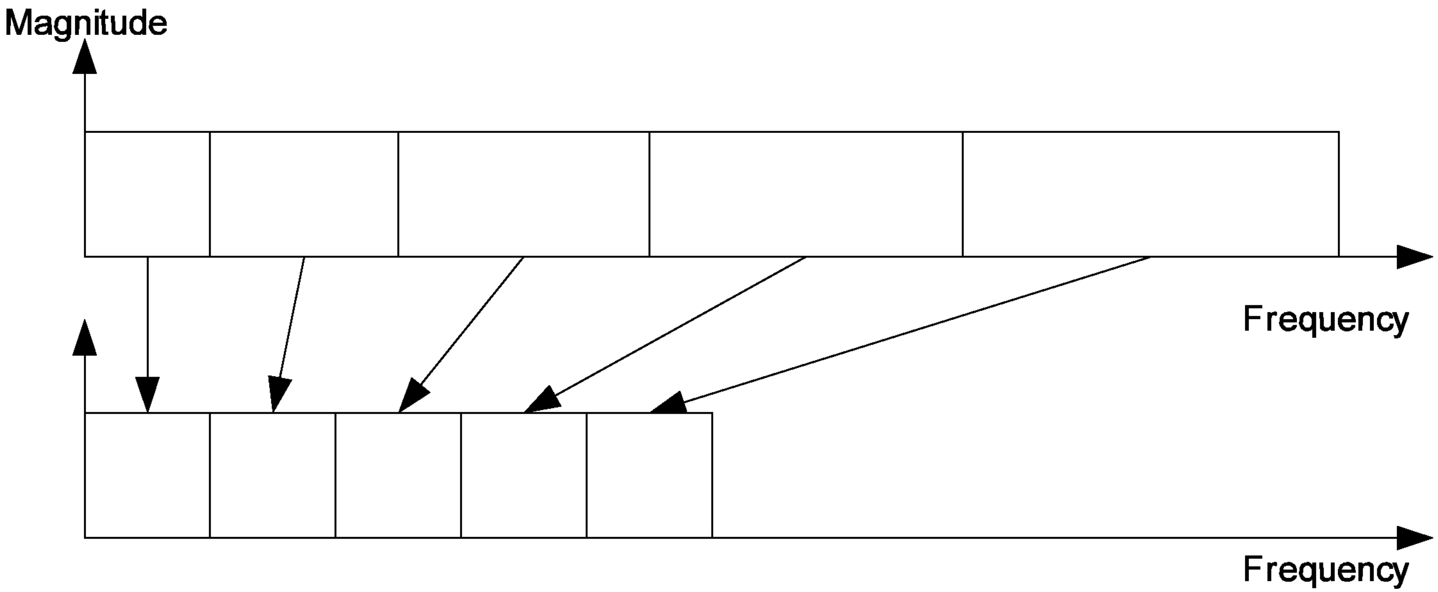

FIGURE 1

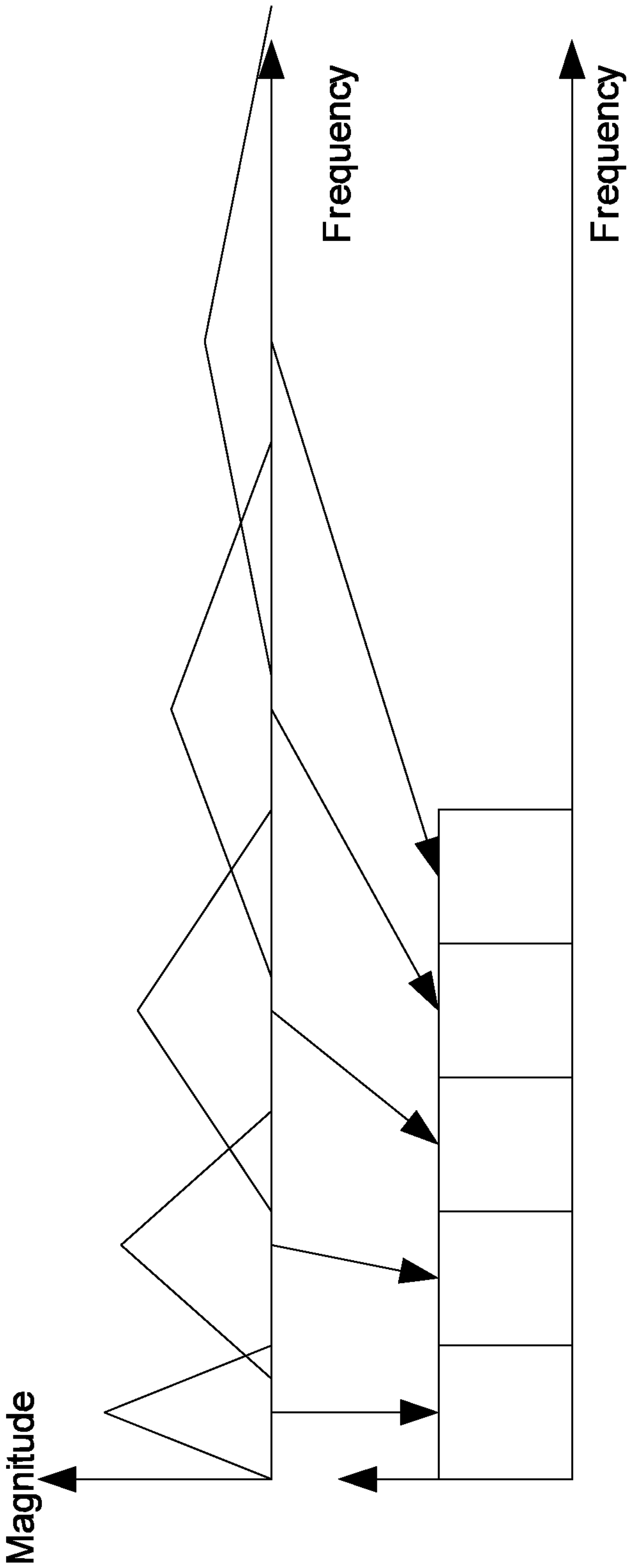

FIGURE 2

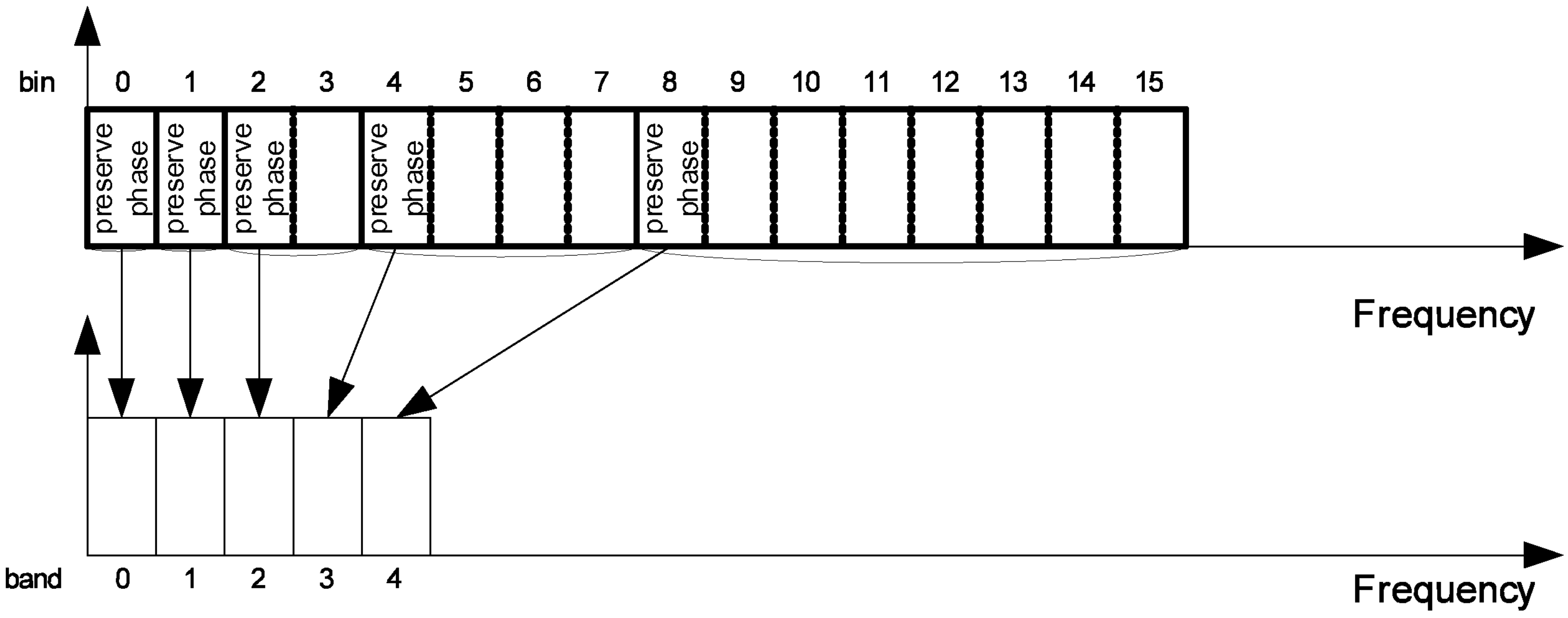
bin
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
preserve phase
preserve phase
preserve phase
preserve phase
preserve phase
Frequency
band
0
1
2
3
4
Frequency

FIGURE 3

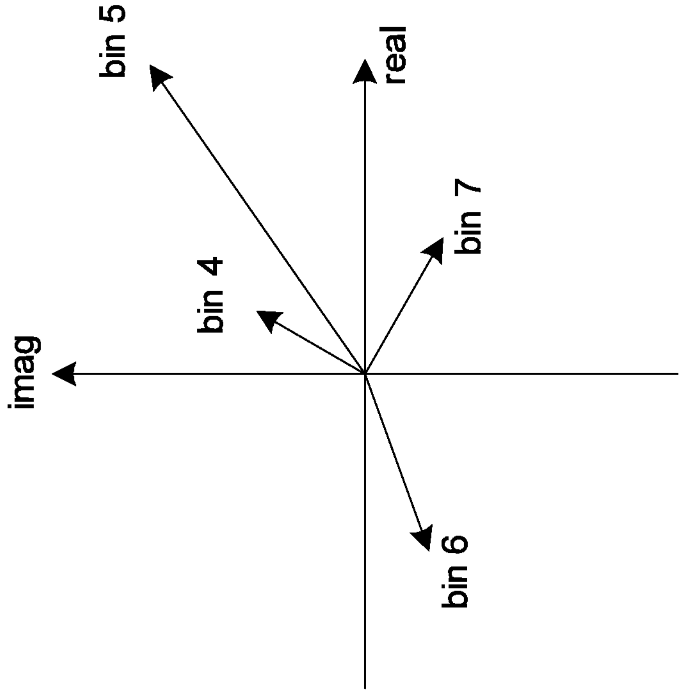

FIGURE 4

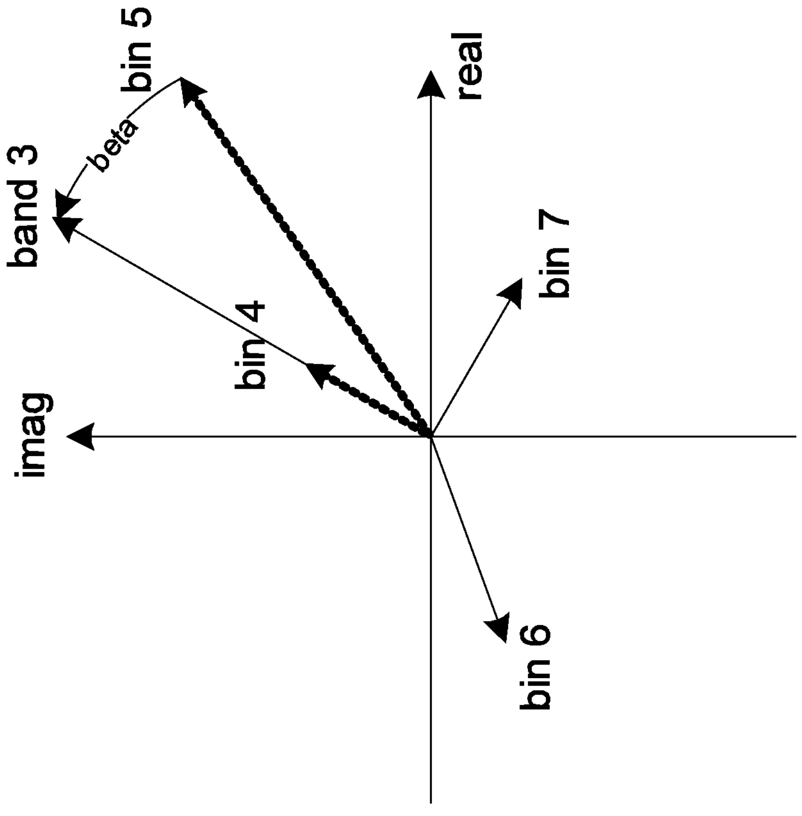

FIGURE 5

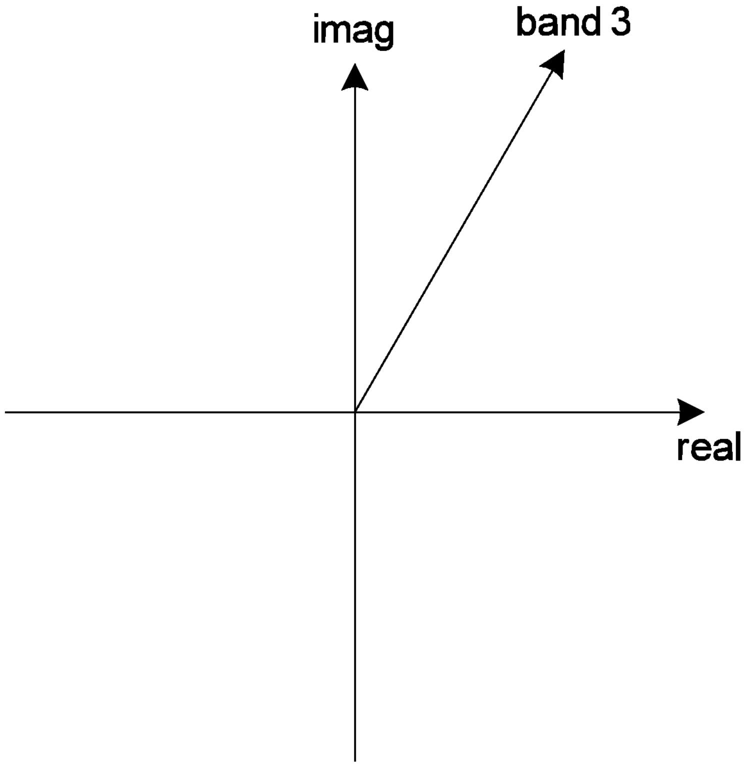

FIGURE 6

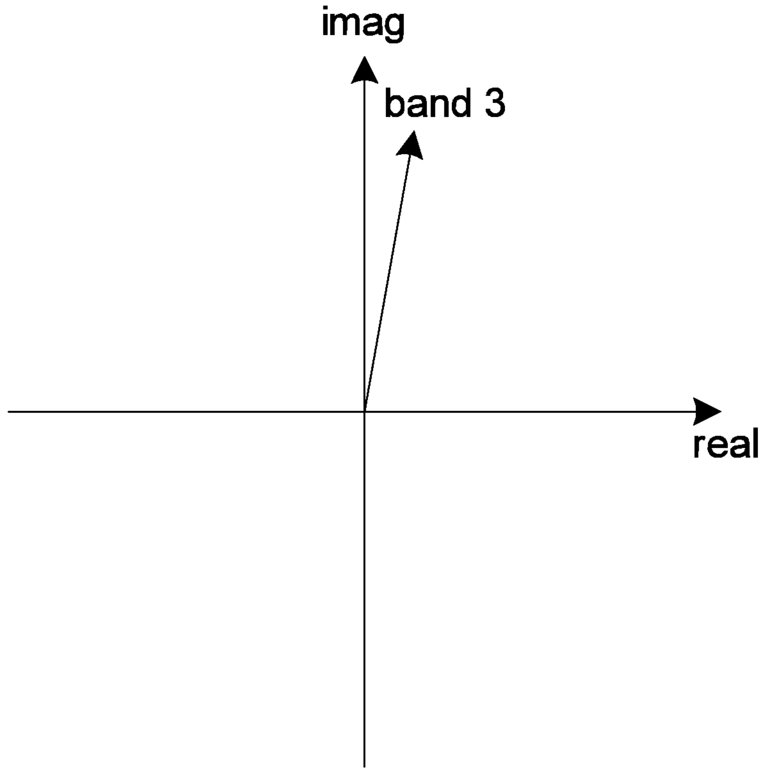

FIGURE 7

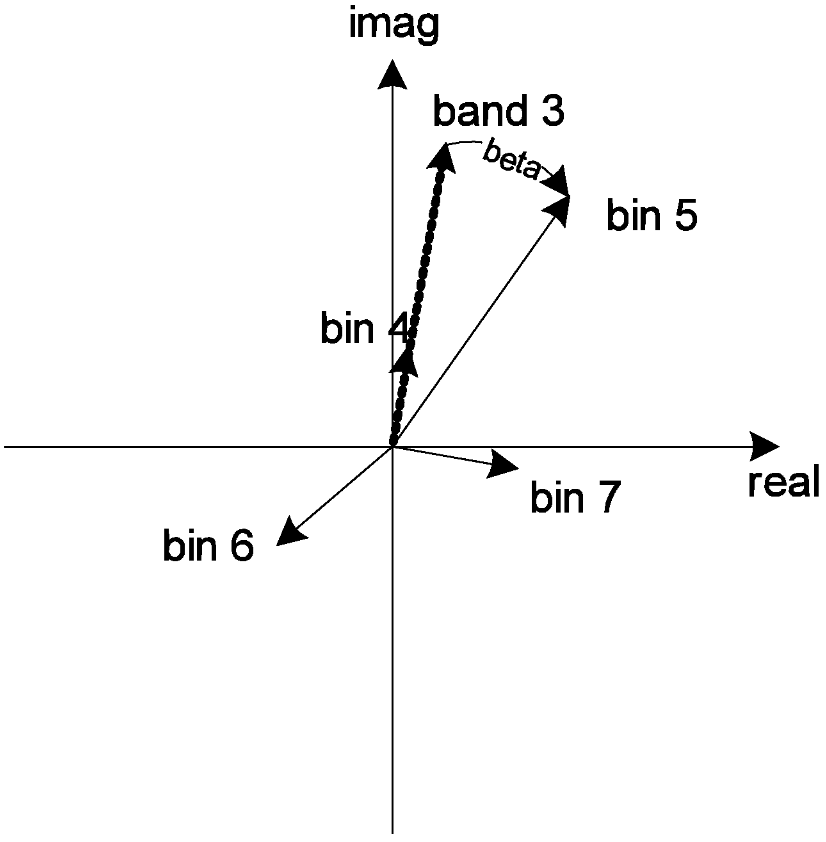

FIGURE 8

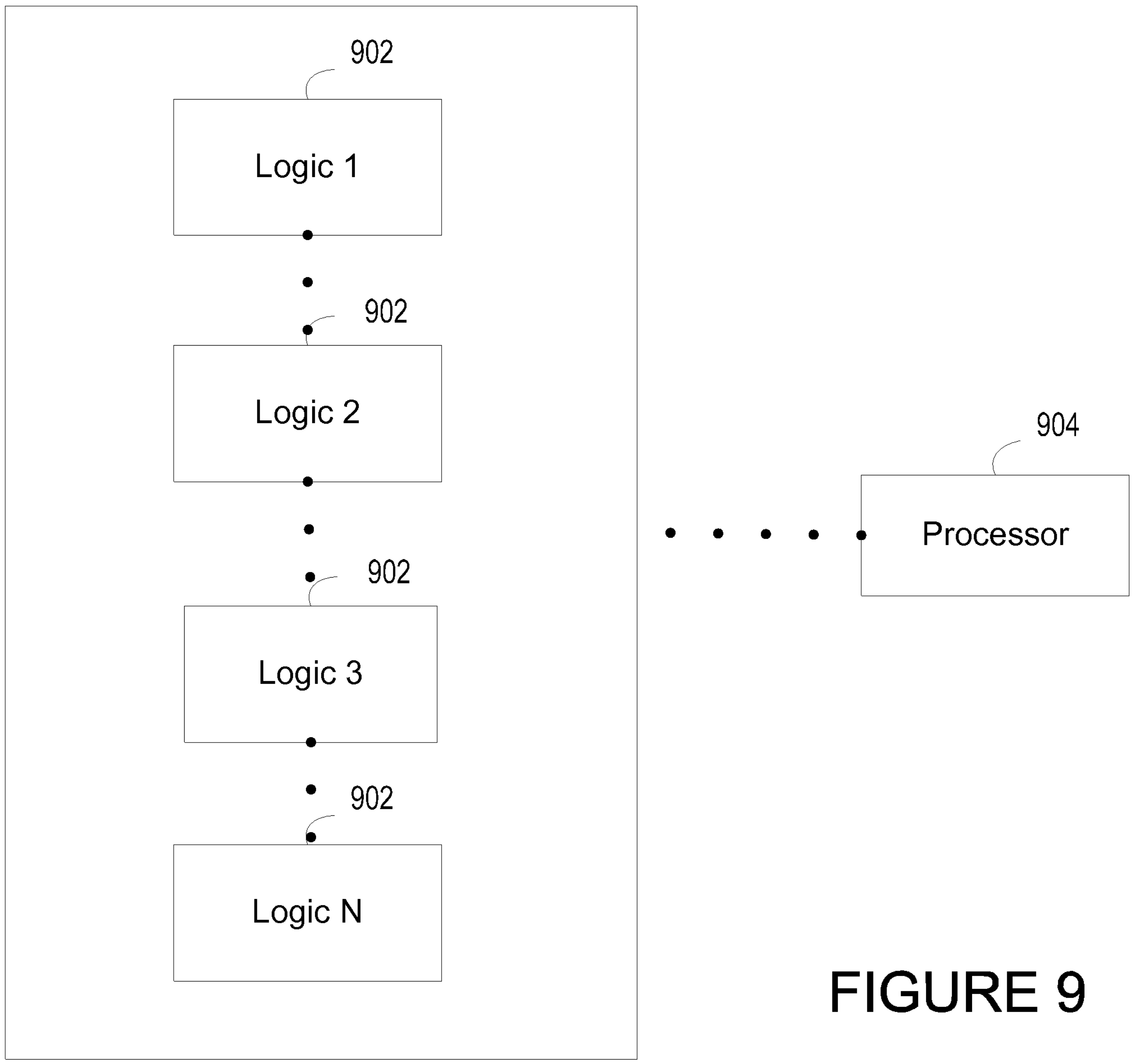

FIGURE 9

REFERENCES CITED IN THE DESCRIPTION

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