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(71) Applicant: **Medison Co., Ltd.**
Kangwon-do 250-875 (KR)

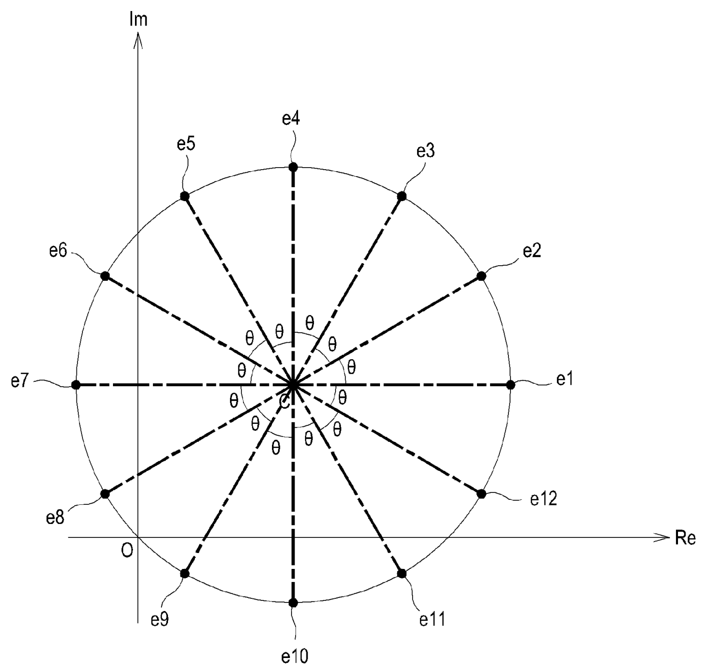
(72) Inventors:
- **Bae, Moo Ho**
  138-240, Seoul (KR)
- **Kim, Tae Yun**
  135-851, Seoul (KR)

(74) Representative: **Schmid, Wolfgang**
Lorenz & Kollegen
Patentanwälte Partnerschaftsgesellschaft
Alte Ulmer Strasse 2
89522 Heidenheim (DE)

(54) Ultrasound system and method for adaptively performing clutter filtering

(57) Embodiments of adaptively performing clutter filtering are disclosed. In one embodiment, by way of non-limiting example, an ultrasound system comprises: an ultrasound data acquisition unit configured to transmit and receive ultrasound signals to and from a target object to thereby output a plurality of ultrasound data for obtaining a color Doppler mode image, wherein the target object includes at least one of a tissue and a blood flow; and a processing unit placed in communication with the ultrasound data acquisition unit and being configured to locate the plurality of ultrasound data on a complex plane, the processing unit being further configured to perform a circle fitting upon the plurality of ultrasound data located on the complex plane and perform a downmixing and a clutter filtering upon the circle-fitted ultrasound data in consideration of speed of the tissue.

FIG. 6



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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority from Korean Patent Application Nos. 10-2009-0038060 (filed on April 30, 2009) and 10-2010-0034064 (filed on April 14, 2010), the entire subject matters of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure generally relates to ultrasound systems, and more particularly to an ultrasound system and method for adaptively performing clutter filtering.

BACKGROUND

[0003] An ultrasound system has become an important and popular diagnostic tool since it has a wide range of applications. Specifically, due to its non-invasive and non-destructive nature, the ultrasound system has been extensively used in the medical profession. Modem high-performance ultrasound systems and techniques are commonly used to produce two or three-dimensional diagnostic images of internal features of an object (e.g., human organs).

[0004] As is known in the art, the ultrasound system may provide ultrasound images of various modes including a brightness mode (B mode) image representing reflection coefficients of the ultrasound signals reflected from the target object with a 2D (two-dimensional) image, a Doppler mode (D mode) image representing speed of a moving object with spectral Doppler by using a Doppler effect, a color Doppler mode (C mode) image representing speed of a moving object with colors by using the Doppler effect, and an elastic mode (E mode) image representing mechanical characteristics of tissues object before and after applying a pressure thereto. In particular, the ultrasound system may transmit and receive ultrasound signals to and from the target object to thereby form Doppler signals. The ultrasound system may further form the C mode image representing the speed of the moving object with the colors based on the Doppler signals.

[0005] The Doppler signal may include a low frequency signal (so-called clutter signal) due to the motion of a tissue such as a blood vessel wall, a cardiac wall, a heart valve and the like. The clutter signal may have amplitude, which is over 100 times than that of a pure Doppler signal indicative of velocities of the blood flow. The clutter signal may be an obstacle to accurately detect speed of the blood flow. Thus, it is required to remove the clutter signal from the Doppler signal to accurately detect the speed of the blood flow.

[0006] A clutter downmixing has been used to remove the clutter signals. The downmixing may be carried out by estimating a center frequency of the clutter signals and by performing the downmixing (frequency shift), which shifts the center frequency of the clutter signals to 0, upon the Doppler signals based on the center frequency. Thereafter, the downmixed clutter signals, which are shifted to a DC component, may be removed by using the conventional clutter filtering methods.

[0007] The clutter signals may have a speed component when a tissue exists within the target object, wherein the tissue moves at a constant speed. However, the clutter signals may have two speed components when tissues exist within the target object, wherein the tissues comprise a tissue that does not move within the target object and a tissue that moves at the constant speed. Thus, it may be difficult to accurately perform the downmixing, which shifts the center of the clutter signals to 0, by using the conventional clutter downmixing methods. Further, the clutter signals may have a plurality of speed components when a tissue exists within the target object, wherein the tissue moves at a lower speed than a predetermined speed (e.g., minimum speed of blood flow). As such, it may be difficult to accurately perform the downmixing, which shifts the center of the clutter signals to 0, by using the conventional clutter downmixing methods.

SUMMARY

[0008] According to the present disclosure, there is disclosed an ultrasound system and method for adaptively performing a clutter filtering upon a plurality of ultrasound data in consideration of the speed of tissues (e.g., blood vessel wall) existing within a target object.

[0009] In one embodiment, by way of non-limiting example, an ultrasound system comprises: an ultrasound data acquisition unit configured to transmit and receive ultrasound signals to and from a target object to thereby output a plurality of ultrasound data for obtaining a color Doppler mode image, wherein the target object includes at least one of a tissue and a blood flow; and a processing unit placed in communication with the ultrasound data acquisition unit and being configured to locate the plurality of ultrasound data on a complex plane, the processing unit being further configured to perform a circle fitting upon the plurality of ultrasound data located on the complex plane and perform a downmixing and a clutter filtering upon the circle-fitted ultrasound data in consideration of speed of the tissue.

[0010] In another embodiment, there is provided a method of performing a clutter filtering, comprising: a) acquiring a plurality of ultrasound data corresponding to a target object including at least one of a tissue and a blood flow, wherein the plurality of ultrasound data are ultrasound data for obtaining a color Doppler mode image; b) locating each of the plurality of ultrasound data on a complex plane; c) performing a circle fitting on the plurality of ultrasound data located on the complex plane; and d) performing a downmixing and a clutter filtering on the circle-fitted ultrasound data in consideration of speed of the tissue.

[0011] The Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used in determining the scope of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Figure 1 is a block diagram showing an illustrative embodiment of an ultrasound system.

[0013] Figure 2 is a schematic diagram showing an example of a brightness mode image and a region of interest (ROI).

[0014] Figure 3 is a block diagram showing an illustrative embodiment of an ultrasound data acquisition unit.

[0015] Figure 4 is a block diagram showing an illustrative embodiment of a processing unit.

[0016] Figure 5 is a schematic diagram showing an example of locating the plurality of ultrasound data corresponding to a tissue on the complex plane, wherein the tissue moves at constant speed within the target objet.

[0017] Figure 6 is a schematic diagram showing an example of locating the plurality of ultrasound data corresponding to tissues on the complex plane, wherein the tissues comprise a tissue that does not move within the target object and a tissue that moves at constant speed within the target object.

[0018] Figure 7 is a schematic diagram showing an example of locating a plurality of ultrasound data corresponding to a tissue on the complex plane, wherein the tissue moves at a lower speed than a predetermined speed within the target object.

[0019] Figure 8 is a schematic diagram showing an example of locating the plurality of ultrasound data corresponding to the tissue and the blood flow on the complex plane, wherein the tissue moves at the constant speed within the target object.

[0020] Figure 9 is a schematic diagram showing an example of locating the plurality of ultrasound data corresponding to the tissues and the blood flow on the complex plane, wherein the tissues comprise the tissue that does not move within the target object and the tissue that moves at the constant speed.

[0021] Figure 10 is a schematic diagram showing an example of locating the plurality ultrasound data corresponding to the tissue and the blood flow, wherein the tissue moves at a low speed within the target object.

[0022] Figure 11 is a schematic diagram showing an example of performing a circle fitting upon the plurality of ultrasound data corresponding to the tissue and the blood flow, wherein the tissue moves at the constant speed within the target object.

[0023] Figure 12 is a schematic diagram showing an example of performing the circle fitting upon the plurality of ultrasound data corresponding to the tissues and the blood flow, wherein the tissues comprise the tissue that does not move within the target object and the tissue that moves at the constant speed within the target object.

[0024] Figure 13 is a schematic diagram showing an example of performing the circle fitting upon the plurality of ultrasound data corresponding to the tissue and the blood flow, wherein the tissue moves at the low speed within the target object.

[0025] Figure 14 is a schematic diagram showing an example of performing a downmixing upon the plurality of ultrasound data corresponding to the tissue and the blood flow, wherein the tissue moves at the constant speed.

[0026] Figure 15 is a schematic diagram showing an example of performing the downmixing upon the plurality of ultrasound data corresponding to the tissues and the blood flow, wherein the tissues comprise the tissue that does not move within the target object and the tissue that moves at the constant speed within the target object.

[0027] Figure 16 is a schematic diagram showing an example of performing the downmixing upon the plurality of ultrasound data corresponding to the tissue and the blood flow, wherein the tissue moves at the low speed within the target object.

DETAILED DESCRIPTION

[0028] A detailed description may be provided with reference to the accompanying drawings. One of ordinary skill in the art may realize that the following description is illustrative only and is not in any way limiting. Other embodiments of the present invention may readily suggest themselves to such skilled persons having the benefit of this disclosure. As used herein, the term "Doppler mode" comprises a color Doppler mode.

[0029] Figure 1 is a block diagram showing an illustrative embodiment of an ultrasound system. Referring to Figure 1, the ultrasound system 100 may include a user input unit 110, an ultrasound data acquisition unit 120, a processing unit 130, a storage unit 140 and a display unit 150.

[0030] The user input unit 110 may be configured to receive input information from a user. In one embodiment, the input information may include position and size information of a region of interest (ROI) 220, which may be set on a brightness mode image 210, as shown in Figure 2. The ROI 220 may include a color box. Also, at least one of scan-lines may be comprised within the ROI 220. The user input unit 110 may include a control panel, a keyboard, a mouse and the like.

[0031] The ultrasound data acquisition unit 120 may be configured to transmit and receive ultrasound signals to and from a target object to thereby acquire ultrasound data corresponding to the ROI (i.e., color box). The ultrasound data acquisition unit 120 will be described with reference to Figure 3.

[0032] Figure 3 is a block diagram showing an illustrative embodiment of the ultrasound data acquisition unit. Referring to Figure 3, the ultrasound data acquisition unit 120 may include a transmit (Tx) signal generating section 121, an ultrasound probe 122 comprising a plurality of transducer elements (not shown), a beam former 123 and an ultrasound data forming section 124.

[0033] The Tx signal generating section 121 may be configured to generate Tx signals in consideration of focal points and positions of the transducer elements. The Tx signals may be signals for acquiring a Doppler mode image. The Tx signal generating section 121 may generate a plurality of Tx signals based on a predetermined ensemble number. The ensemble number may represent the number of transmitting and receiving the ultrasound signals in order to acquire Doppler signals corresponding to a scan-line.

[0034] The ultrasound probe 122 may be configured to convert the Tx signals provided from the Tx signal generating section 121 into the ultrasound signals. The ultrasound probe 122 may further transmit the ultrasound signals into the target object, and receive ultrasound echo signals reflected from the target object to thereby form received signals, which may be analog signals. The ultrasound probe 122 may include a linear array probe, a convex array probe and the like.

[0035] The beam former 123 may be configured to convert the received signals provided from the ultrasound probe 122 into digital signals. The beam former 123 may further receive-focus the digital signals in consideration of the focal points and the positions of the transducer elements to thereby form receive-focused signals.

[0036] The ultrasound data forming section 124 may be configured to form the ultrasound data based on the receive-focused signals provided from the beam former 123. In one embodiment, the ultrasound data may include IQ (in-phase/quadrature) data (i.e., ensemble data) for acquiring the Doppler signals. The ultrasound data forming section 124 may form a plurality of ultrasound data corresponding to the ensemble number based on the receive-focused signals sequentially provided from the beam former 123.

[0037] Referring back to Figure 1, the processing unit 130 may be coupled to the user input unit 110 and the ultrasound data acquisition unit 120. The processing unit 130 may be configured to adaptively perform clutter filtering upon the ultrasound data provided from the ultrasound data acquisition unit 120. The processing unit 120 may further form the Doppler mode image based on the clutter-filtered ultrasound data. The processing unit 130 will be described in detail with reference to Figure 4.

[0038] Figure 4 is a block diagram showing an illustrative embodiment of the processing unit. Referring to Figure 4, the processing unit 130 may include a data processing section 131, a circle fitting section 132, a center point detecting section 133, a determining section 134, a filtering section 135 and an image forming section 136.

[0039] The data processing section 131 may be configured to analyze the plurality of ultrasound data (i.e., ensemble data) provided from the ultrasound data acquisition unit 120 to thereby locate each of the plurality of ultrasound data on a complex plane.

[0040] Generally, the ultrasound data (i.e., ensemble data) corresponding to the ROI may be located on the complex plane in various shapes according to speeds of a tissue (e.g., vessel wall), blood flow and the like, which exist within the target object.

[0041] Figure 5 is a schematic diagram showing an example of locating the plurality of ultrasound data corresponding to a tissue on the complex plane, wherein the tissue moves at a constant speed within the target objet. Referring to Figure 5, when the tissue moves at the constant speed within the target object, a plurality of ultrasound data e1 to e12 acquired from the tissue may be located on a circumference with a center point at an origin O of the complex plane. In addition, the plurality of ultrasound data e1 to e12 may be located on the circumference at constant interval θ.

[0042] Figure 6 is a schematic diagram showing an example of locating the plurality of ultrasound data corresponding to tissues on the complex plane, wherein the tissues comprise a tissue that does not move within the target object and another tissue that moves at constant speed within the target object. Referring to Figure 6, when the tissues comprise the tissue that does not move within the target object and the tissue that moves at the constant speed within the target object, a plurality of ultrasound data e1 to e12 acquired from the tissues may be located on a circumference with a speed component (i.e., DC component) of the tissue that does not move within the target object as a center point C apart from the origin O of the complex plane. In addition, the plurality of ultrasound data e1 to e12 may be located on the circumference at the constant interval θ.

[0043] Figure 7 is a schematic diagram showing an example of locating a plurality of ultrasound data corresponding to a tissue on the complex plane, wherein the tissue moves at a lower speed (hereinafter, "a low speed") than a predetermined speed within the target object. Referring to Figure 7, when the tissue moves at the low speed within the target object, the ultrasound data e1 to e3 acquired from the tissue may be located on a circumference CI1, the ultrasound data e4 to e6 acquired from the tissue may be located on a circumference CI2, the ultrasound data e7 to e9 acquired from the tissue may be located on a circumference CI3, and the ultrasound data e10 to e12 acquired from the tissue may be located on a circumference CI4. Center points C31 to C34 of the circumferences CI1 to CI4 may not be located on the origin O of the complex plane, and may move slowly.

[0044] Examples of locating the plurality of ultrasound data, which correspond to the tissue and the blood flow that exist within the target object, on the complex plane in consideration of speeds of the tissue and the blood flow will be described in view of Figures 8 to 10.

[0045] Figure 8 is a schematic diagram showing an example of locating the plurality of ultrasound data, which correspond to the tissue and the blood flow, on the complex plane, wherein the tissue moves at the constant speed within the target object. The data processing section 131 may be configured to analyze the plurality of ultrasound data e1 to e12 acquired from the tissue and the blood flow. The data processing section 131 may further locate the plurality of ultrasound data e1 to e12, which overlap speed components (shown by dotted lines) corresponding to the tissue with speed components (shown by lines) corresponding to the blood flow, on the complex plane as shown in Figure 8. The plurality of ultrasound data e1 to e12 may be located on the complex plane with the center point at the origin O of the complex plane. In one embodiment, the overlap may represent sum of phases.

[0046] Figure 9 is a schematic diagram showing an example of locating the plurality of ultrasound data corresponding to the tissues and the blood flow on the complex plane, wherein the tissues comprise the tissue that does not move within the target object and the tissue that moves at the constant speed. The data processing section 131 may be configured to analyze the plurality of ultrasound data e1 to e12 acquired from the tissues and the blood flow. The data processing section 131 may further locate the plurality of ultrasound data e1 to e12, which overlap speed components (shown by dotted lines) corresponding to the tissue with speed components (shown by lines) corresponding to the blood flow, on the complex plane as shown in Figure 9. The plurality of ultrasound data may be located on the complex plane with the speed component (i.e., DC component) of the tissue that does not move within the target object as the center point C apart from the origin O of the complex plane.

[0047] Figure 10 is a schematic diagram showing an example of locating the plurality ultrasound data corresponding to the tissue and the blood flow, wherein the tissue moves at a low speed within the target object. The data processing section 131 may be configured to analyze the plurality of ultrasound data e1 to e12 acquired from the tissue and the blood flow. The data processing section 131 may further locate the plurality of ultrasound data e1 to e12, which overlap speed components (shown by dotted lines) corresponding to the tissue with speed components (shown by lines) corresponding to the blood flow, on the complex plane with the center points C31 to C34 as shown in Figure 10.

[0048] Referring back to Figure 4, the circle fitting section 132 may be configured to form a plurality of ultrasound data group based on the plurality of ultrasound data located on the complex plane by the data processing section 131. Each of the ultrasound data groups may include a predetermined number of ultrasound data. The circle fitting section 132 may further perform a circle fitting upon each of the ultrasound data groups. The methods of performing the circle fitting are well known in the art. For example, the circle fitting may include RANSAC circle fitting, a least-square circle fitting, an S-parameter circle fitting and the like.

[0049] Examples of performing the circle fitting upon the plurality of ultrasound data located on the complex plane in consideration of the speeds of the tissue and the blood flow, which exist within the target object, will be described in view of Figures 11 to 13.

[0050] Figure 11 is a schematic diagram showing an example of performing the circle fitting upon the plurality of ultrasound data corresponding to the tissue and the blood flow, wherein the tissue moves at the constant speed within the target object. The circle fitting section 132 may be configured to group the plurality of ultrasound data e1 to e12 located on the complex plane as shown in Figure 8 into the plurality of ultrasound data group G11 to G14 as shown in Figure 11. Each of the ultrasound data group G11 to G14 may include three ultrasound data. That is, a first ultrasound data group G11 may include ultrasound data e1 to e3, a second ultrasound data group G12 may include ultrasound data e4 to e6, a third ultrasound data group G 13 may include ultrasound data e7 to e9 and a fourth ultrasound data group G14 may include ultrasound data e10 to e12. The circle fitting section 132 may further perform the circle fitting upon the ultrasound data corresponding to each of the ultrasound data group G11 to G14 to thereby set circumferences CF11 to CF14 corresponding to each of the ultrasound data group as shown in Figure 11.

[0051] Figure 12 is a schematic diagram showing an example of performing the circle fitting upon the plurality of ultrasound data corresponding to the tissues and the blood flow, wherein the tissues comprise the tissue that does not move within the target object and the tissue that moves at the constant speed within the target object. The circle fitting section 132 may be configured to group the plurality of ultrasound data e1 to e12 located on the complex plane as shown in Figure 9 into a plurality of ultrasound data groups G21 to G24 as shown in Figure 12. Each of the ultrasound data groups G21 to G24 may include three ultrasound data. That is, a first ultrasound data group G21 may include the ultrasound data e1 to e3, a second ultrasound data group G22 may include the ultrasound data e4 to e6, a third ultrasound data group G23 may include the ultrasound data e7 to e9, and the fourth ultrasound data group G24 may include the ultrasound data e10 to e12. The circle fitting section 132 may further perform the circle fitting upon the ultrasound data corresponding to each of the ultrasound data groups G21 to G24 to thereby set circumferences CF21 to CF24 corresponding to each of the ultrasound data groups G21 to G24 as shown in Figure 12.

[0052] Figure 13 is a schematic diagram showing an example of performing the circle fitting upon the plurality of ultrasound data corresponding to the tissue and the blood flow, wherein the tissue moves at the low speed within the target object. The circle fitting section 132 may be configured to group the plurality of ultrasound data e1 to e12 located on the complex plane as shown in Figure 10 into a plurality of ultrasound data groups G31 to G34 as shown in Figure 13. Each of the ultrasound data groups G31 to G34 may include three ultrasound data. That is, a first ultrasound data may include the ultrasound data e1 to e3, a second ultrasound data may include the ultrasound data e4 to e6, a third ultrasound data may include the ultrasound data e7 to e9, and a fourth ultrasound data may include the ultrasound data e10 to e12. The circle fitting section 132 may further perform the circle fitting upon the ultrasound data corresponding to each of the ultrasound data groups G31 to G34 to thereby set circumferences CF31 to CF34 corresponding to each of the ultrasound data groups G31 to G34 as shown in Figure 13.

[0053] Referring back to Figure 4, the center point detecting section 133 may be configured to detect center points of the circumferences corresponding to the plurality of ultrasound data groups based on the circumferences set by the circle fitting section 132. As one example, the center point detecting section 133 may detect center points C11 to C 14 of each of the circumferences CF11 to CF 14 corresponding to the plurality of ultrasound data groups G11 to G14 as shown in Figure 11. As another example, the center point detecting section 133 may detect center points C21 to C24 of each of the circumferences CF21 to CF24 corresponding to the plurality of ultrasound data groups G21 to G24 as shown in Figure 12. As yet another example, the center point detecting section 133 may detect center points C31 to C34 of each of the circumferences CF31 to CF34 corresponding to the plurality of ultrasound data groups G31 to G34 as shown in Figure 13. The methods of detecting the center points are well known in the art. Thus, they have not been described in detail so as not to unnecessarily obscure the present disclosure.

[0054] The determining section 134 may be configured to analyze the plurality of center points detected by the center point detecting section 133. The determining section 134 may further determine whether the plurality of the center points are located on the same position and whether located on the origin of the complex plane to thereby form determination information.

[0055] As one example, the determining section 134 may be configured to analyze the center points C 11 to C 14 corresponding to the plurality of circumferences CF 11 to CF14 as shown in Figure 11. The determining section 134 may further determine whether the plurality of center points C1 to C14 are located on the same position and whether located on the origin of the complex plane. If it is determined that the plurality of center points C11 to C14 are located on the same position and located on the origin of the complex plane, then the determining section 134 may form first determination information. The first determination information may be the information representing that the plurality of center points C11 to C 14 are located on the same position and located on the origin of the complex plane. That is, the first determination information may be information representing that the tissue and the blood flow exist within the target object, wherein the tissue moves at the constant speed.

[0056] As another example, the determining section 134 may be configured to analyze the center points C21 to C24 corresponding to the plurality of circumferences CF21 to CF24 as shown in Figure 12. The determining section 134 may further determine whether the plurality of center points C21 to C24 are located on the same position and whether located on the origin of the complex plane. If it is determined that the plurality of center points C21 to C24 are located on the same position but not located on the origin of the complex plane, then the determining section 134 may form second determination information. The second determination information may be the information representing that the plurality of center points C21 to C24 are located on the same position but not located on the origin of the complex plane. That is, the second determination information may be the information representing that the tissues and the blood flow exist within the target object, wherein the tissues comprise the tissue that does not move and the tissue that moves at the constant speed.

[0057] As yet another example, the determining section 134 may be configured to analyze the center points C31 to C34 corresponding to the plurality of the circumferences CF31 to CF34 shown in Figure 13. The determining section 134 may further determine whether the plurality of center points C31 to C34 are located on the same position and whether located on the origin of the complex plane. If it is determined that the plurality of center points C31 to C34 are neither located on the same position nor on the origin of the complex plane, then the determining section 134 may form third determination information. The third determination information may be the information representing that the plurality of center points C31 to C34 are neither located on the same position nor on the origin of the complex plane. That is, the third determination information may be the information representing that the tissue and the blood flow exist within the target object, wherein the tissue moves at the low speed.

[0058] The filtering section 135 may be configured to perform a downmixing and a clutter filtering upon the plurality of ultrasound data based on the determination information provided from the determining section 134.

[0059] Examples of performing the downmixing and the clutter filtering upon the plurality of ultrasound data will be described with reference to Figures 14 to 16.

[0060] Figure 14 is a schematic diagram showing an example of performing the downmixing upon the plurality of ultrasound data corresponding to the tissue and the blood flow, wherein the tissue moves at the constant speed. The filtering section 135 may be configured to perform the downmixing, which rotates each of the plurality of ultrasound data e1 to e12 into a real axis of the complex plane with the center point at the origin O of the complex plane based on the first determination information provided from the determining section 134, upon the plurality of ultrasound data e1 to e12 as shown in Figure

14. More particularly, the filtering section 135 may perform the downmixing, which performs a phase shift (0°) upon the ultrasound data e1 based on the first determination information. The filtering section 135 may further perform the downmixing, which performs a phase shift (-θ) upon the ultrasound data e2 based on the first determination information. The filtering section 135 may further perform the downmixing, which performs a phase shift (-2θ) upon the ultrasound data e3 based on the first determination information. The filtering section 135 may further perform the downmixing on the ultrasound data e4 to e12 as described above. As to performing the downmixing upon each of the plurality of ultrasound data, the speed components corresponding to clutter signals moves to DC component. The filtering section 135 may further perform the clutter filtering upon the downmixed ultrasound data to thereby filter the speed components (i.e., DC component) corresponding to the clutter signals from the downmixed ultrasound data.

[0061] Figure 15 is a schematic diagram showing an example of performing the downmixing upon the plurality of ultrasound data corresponding to the tissues and the blood flow, wherein the tissues comprise the tissue that does not move within the target object and the tissue that moves at the constant speed within the target object. The filtering section 135 may be configured to perform the downmixing upon each of the plurality of ultrasound data e1 to e12 based on the second determination information provided from the determining section 134 as shown in Figure 15. More particularly, the filtering section 135 may move the center points of the circumferences corresponding to the ultrasound data e1 to e12 to the origin O of the complex plane based on the second determination information. The filtering section 135 may further perform the downmixing, which rotates each of the plurality of ultrasound data e1 to e12 into the real axis based on the origin O of the complex plane as described above. That is, the filtering section 135 may perform the downmixing, which performs a phase shift (0°) on the ultrasound data e1 based on the second determination information. The filtering section 135 may further perform the downmixing, which performs a phase shift (-θ) on the ultrasound data e2 based on the second determination information. The filtering section 135 may further perform the downmixing, which performs a phase shift (-2θ) on the ultrasound data e3 based on the second determination information. The filtering section 135 may further perform the downmixing on the ultrasound data e4 to e12 as described above. As to performing the downmixing upon each of the plurality of ultrasound data, the speed components corresponding to clutter signals move to DC component. The filtering section 135 may further perform the clutter filtering upon the downmixed ultrasound data to thereby filter the speed components (i.e., DC component) corresponding to the clutter signals from the plurality of the ultrasound data.

[0062] It was explained in the above embodiment that the filtering section 135 may move the center points of the circumferences corresponding to the plurality of ultrasound data to the origin of the complex plane, and perform the downmixing on each of the ultrasound data. However, the filtering section 135 may further set any ultrasound data (e.g., first ultrasound data e1) among the plurality of ultrasound data e1 to e12 as a reference ultrasound data, perform the downmixing, which rotates each of the ultrasound data into the reference ultrasound data, upon the plurality of ultrasound data, and move the center points of the circumferences to the origin of the complex plane.

[0063] Figure 16 is a schematic diagram showing an example of performing the downmixing upon the plurality of ultrasound data corresponding to the tissue and the blood flow, wherein the tissue moves at the low speed within the target object. The filtering section 135 may be configured to perform the downmixing upon each of the ultrasound data e1 to e12 based on the third determination information provided from the determining section 134 as shown in Figure 16. More particularly, the filtering section 135 may move the center points of the plurality of circumferences corresponding to the plurality of ultrasound data e1 to e12 to the origin O of the complex plane based on the third determination information. The filtering section 135 may further perform the downmixing that rotates each of the ultrasound data e1 to e12 into the real axis of the complex plane based on the origin O of the complex plane as described above. As to performing the downmixing on each of the ultrasound data, the speed components corresponding to clutter signals move to the DC component. The filtering section 135 may further perform the clutter filtering on the plurality of ultrasound data to thereby filter the speed components (i.e., DC component) corresponding to the clutter signals from the plurality of the ultrasound data.

[0064] Referring back to Figure 4, the image forming section 136 may be configured to form a Doppler mode image based on the plurality of ultrasound image downmixed and clutter-filtered by the filtering section 135.

[0065] Referring back to Figure 1, the storage unit 140 may store the plurality of ultrasound data acquired from the ultrasound data acquisition unit 110. The storage unit 140 may further store the plurality of ultrasound data filtered by the processing unit 130. The display unit 150 may display the Doppler mode image formed by the processing unit 130.

[0066] Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this disclosure. More particularly, numerous variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

[0067] As an example, while only the processing unit 130 may perform the circle fitting, the downmixing and the clutter filtering upon the plurality of ultrasound data acquired from the ultrasound data acquisition unit 120, the processing unit 130 may further perform the circle fitting, the downmixing and the clutter filtering on a plurality of ultrasound data provided from external devices (e.g., a personal computer, a storage medium, etc.) which connect to the ultrasound system.

Claims

1. An ultrasound system, comprising:

    an ultrasound data acquisition unit configured to transmit and receive ultrasound signals to and from a target object to thereby output a plurality of ultrasound data for obtaining a color Doppler mode image, wherein the target object includes at least one of a tissue and a blood flow; and
    a processing unit placed in communication with the ultrasound data acquisition unit and being configured to locate the plurality of ultrasound data on a complex plane, the processing unit being further configured to perform a circle fitting upon the plurality of ultrasound data located on the complex plane and perform a downmixing and a clutter filtering upon the circle-fitted ultrasound data in consideration of speed of the tissue.

2. The ultrasound system of Claim 1, wherein the ultrasound data comprise IQ (in-phase/quadrature) data.

3. The ultrasound system of Claim 2, wherein the processing unit comprises:

    a data processing section configured to analyze the plurality of ultrasound data to thereby locate the plurality of ultrasound data on the complex plane;
    a circle fitting section configured to perform the circle fitting upon the plurality of ultrasound data to thereby set circumferences corresponding to the plurality of ultrasound data;
    a center point detecting section configured to detect center points of the circumferences;
    a determining section configured to analyze the detected center points and determine whether the detected center points are located on a same position and located on an origin of the complex plane to thereby form determination information; and
    a filtering section configured to perform the downmixing and the clutter filtering upon the plurality of ultrasound data based on the determination information.

4. The ultrasound system of Claim 3, wherein the circle fitting section is configured to:

    group the plurality of ultrasound data located on the complex plane into a plurality of ultrasound data group, wherein each of the plurality of ultrasound data group comprises a predetermined number of ultrasound data; and
    perform the circle fitting upon each of the plurality of ultrasound data group to thereby set the circumferences corresponding to the plurality of ultrasound data group.

5. The ultrasound system of Claim 4, wherein the center point detecting section is configured to detect the center points of the circumferences corresponding to the plurality of ultrasound data group.

6. The ultrasound system of Claim 3, wherein the determination information comprises:

    first determination information representing that the detected center points are located on the same position and located on the origin of the complex plane;
    second determination information representing that the detected center points are located on the same position but not located on the origin of the complex plane; and
    third determination information representing that the detected center points are neither located on the same position nor on the origin of the complex plane.

7. The ultrasound system of Claim 6, wherein the filtering section is configured to:

    perform the downmixing for rotating each of the plurality of ultrasound data into a real axis of the complex plane with the center point at the origin of the complex plane based on the first determination information; and
    perform the clutter filtering upon the downmixed ultrasound data.

8. The ultrasound system of Claim 6, wherein the filtering section is configured to:

    move the center points of the circumferences corresponding to the plurality of ultrasound data to the origin of the complex plane based on the second determination information;
    perform the downmixing for rotating each of the plurality of ultrasound data into a real axis of the complex plane based on the origin of the com-

plex plane; and
perform the clutter filtering on the downmixed ultrasound data.

9. The ultrasound system of Claim 6, wherein the filtering section is configured to:

set any ultrasound data among the plurality of ultrasound data as a reference ultrasound data based on the second determination information;
perform the downmixing for rotating each of the plurality of ultrasound data into the reference ultrasound data based on the center points of the circumferences; and
move the center points of the circumferences corresponding to the plurality of ultrasound data to the origin of the complex plane.

10. The ultrasound system of Claim 6, wherein the filtering section is configured to:

move the center points of the circumferences corresponding to the plurality of ultrasound data into the origin of the complex plane based on the third determination information;
perform the downmixing for rotating each of the plurality of ultrasound data into a real axis of the complex plane based on the origin of the complex plane; and
perform the clutter filtering upon the downmixed ultrasound data.

11. A method of performing a clutter filtering, comprising:

a) acquiring a plurality of ultrasound data corresponding to a target object including at least one of a tissue and a blood flow, wherein the plurality of ultrasound data are ultrasound data for obtaining a color Doppler mode image;
b) locating each of the plurality of ultrasound data on a complex plane;
c) performing a circle fitting on the plurality of ultrasound data located on the complex plane; and
d) performing a downmixing and a clutter filtering on the circle-fitted ultrasound data in consideration of speed of the tissue.

12. The method of Claim 11, wherein the ultrasound data comprise IQ (in-phase/quadrature) data.

13. The method of Claim 12, wherein the step c) comprises:

grouping the plurality of ultrasound data located on the complex plane into a plurality of ultrasound data group, wherein each of the plurality of ultrasound data group comprises a predetermined number of ultrasound data; and
performing the circle fitting upon each of the plurality of ultrasound data group to thereby set the circumferences corresponding to the plurality of ultrasound data group.

14. The method of Claim 13, wherein the step d) comprises:

d1) detecting the center points corresponding to the circumferences;
d2) analyzing the detected center points, determining whether the detected center points are located on a same position and located on origin of the complex plane to thereby form determination information; and
d3) performing the downmixing and the clutter filtering upon the plurality of ultrasound data based on the determination information.

15. The method of Claim 14, wherein the determination information comprises:

first determination information representing that the detected center points are located on the same position and located on the origin of the complex plane;
second determination information representing that the detected center points are located on the same position but not located on the origin of the complex plane; and
third determination information representing that the detected center points are neither located on the same position nor on the origin of the complex plane.

16. The method of Claim 15, wherein the step d3) comprises:

performing the downmixing for rotating each of the plurality of ultrasound data into a real axis of the complex plane with the center point at the origin of the complex plane based on the first determination information; and
performing the clutter filtering upon the downmixed ultrasound data.

17. The method of Claim 15, wherein the step d3) comprises:

moving the center points of the circumferences corresponding to the plurality of ultrasound data to the origin of the complex plane based on the second determination information;
performing the downmixing for rotating each of the plurality of ultrasound data into a real axis of the complex plane based on the origin of the complex plane; and

performing the clutter filtering upon the downmixed ultrasound data.

18. The method of Claim 15, wherein the step d3) comprises:

setting any ultrasound data among the plurality of ultrasound data as a reference ultrasound data based on the second determination information;
performing the downmixing for rotating each of the plurality of ultrasound data into the reference ultrasound data based on the center points of the circumferences; and
moving the center points of the circumferences corresponding to the plurality of ultrasound data to the origin of the complex plane.

19. The method of Claim 15, wherein the step d3) comprises:

moving the center points of the circumferences corresponding to the plurality of ultrasound data to the origin of the complex plane based on the third determination information;
performing the downmixing for rotating each of the plurality of ultrasound data into a real axis of the complex plane based on the origin of the complex plane; and
performing the clutter filtering on the downmixed ultrasound data.

FIG. 1

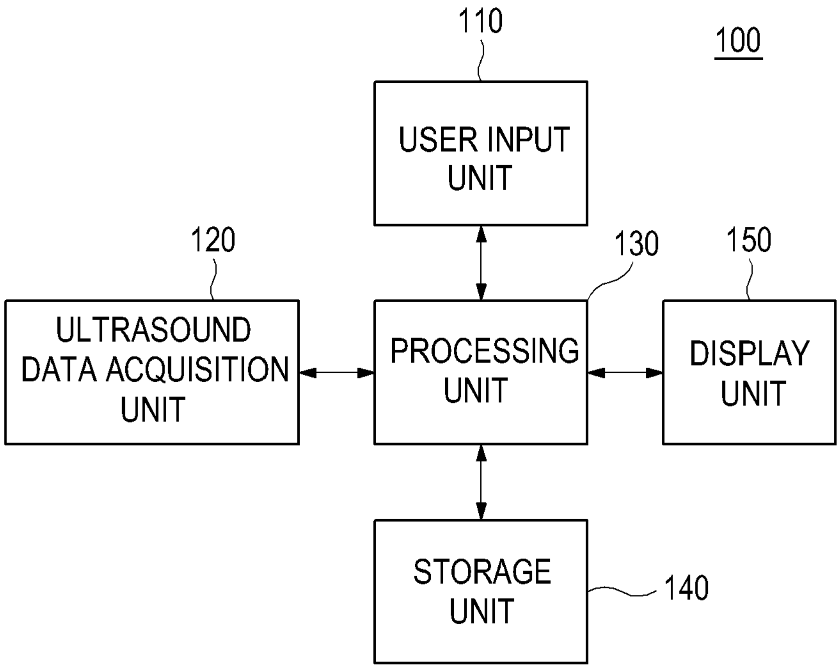
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FIG. 2

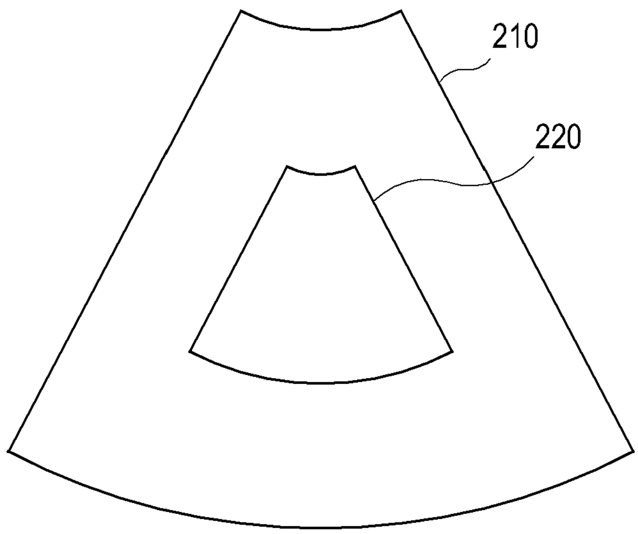
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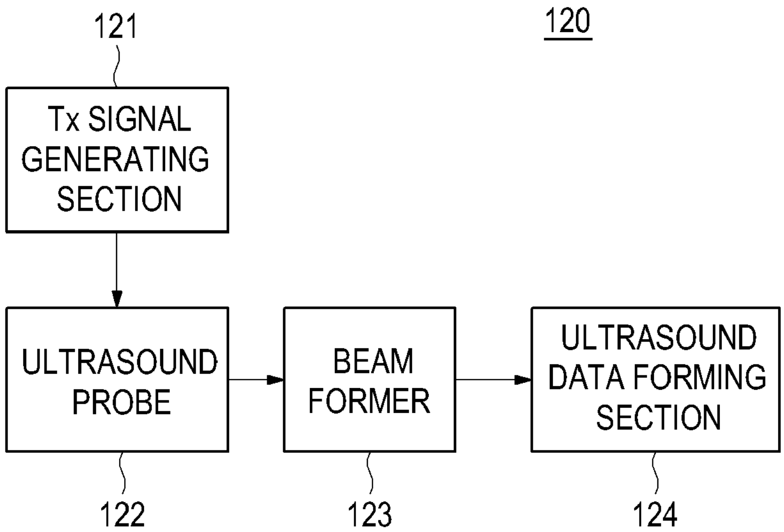
FIG. 3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BEAM FORMER
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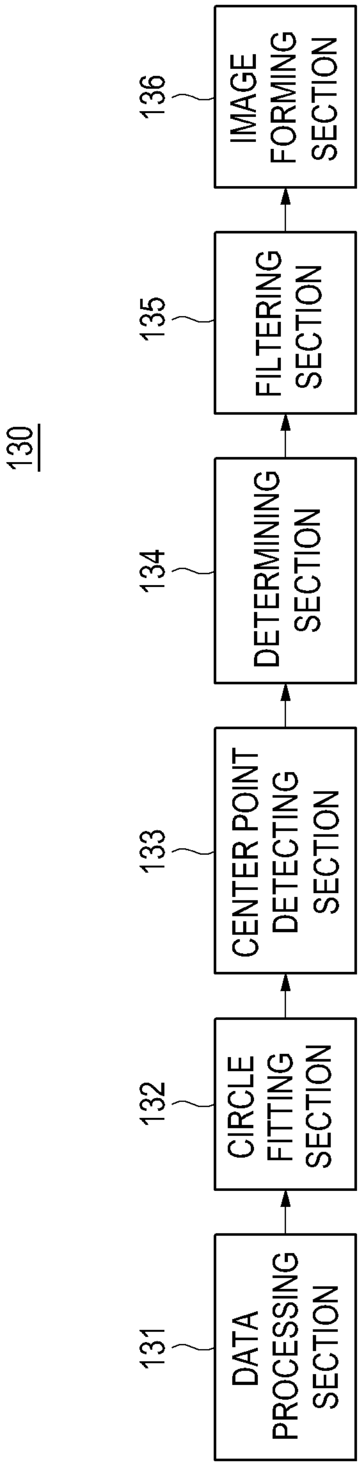
FIG. 4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CENTER POINT DETECTING SECTION
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DETERMINING SECTION
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FILTERING SECTION
136
IMAGE FORMING SECTION

FIG. 5

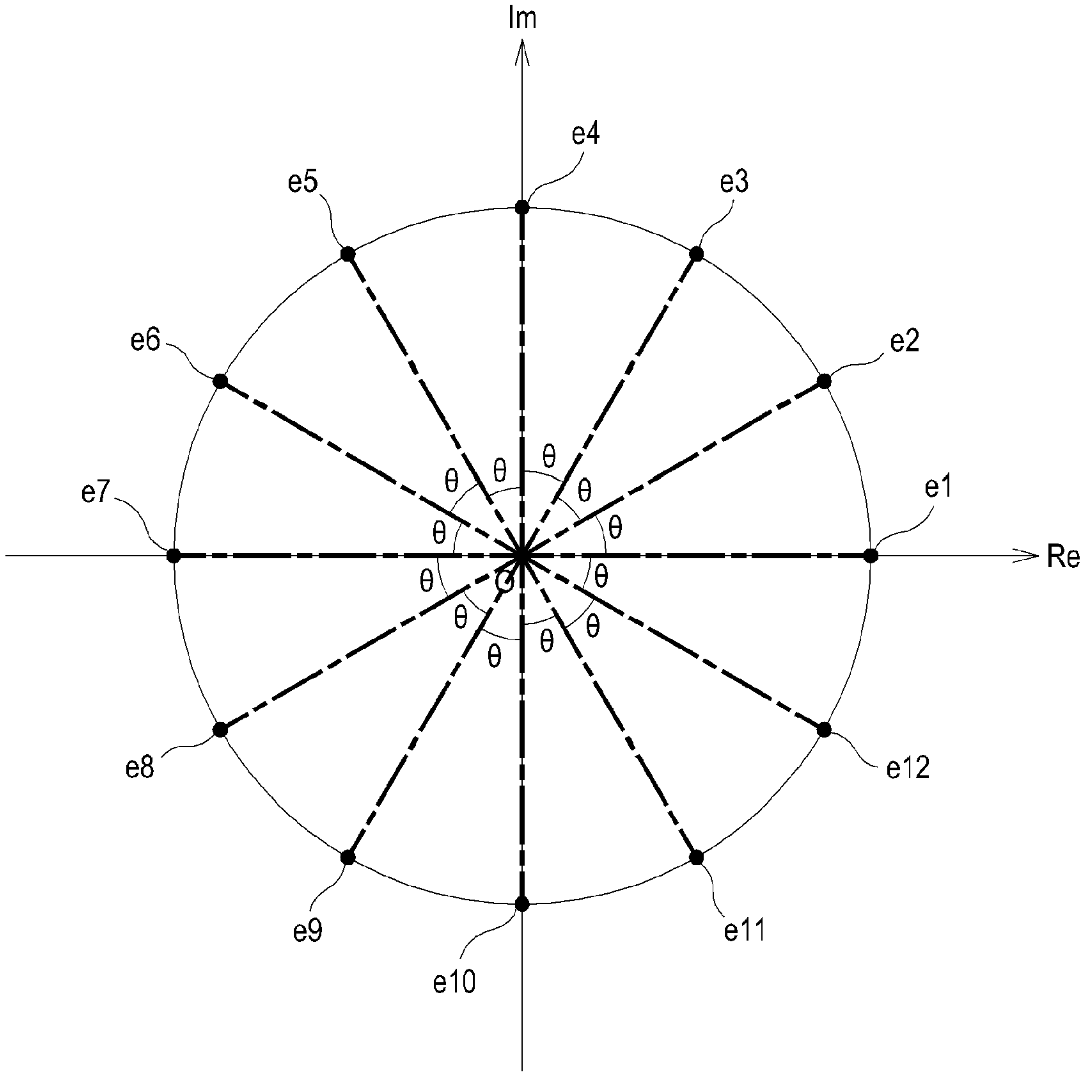


FIG. 6

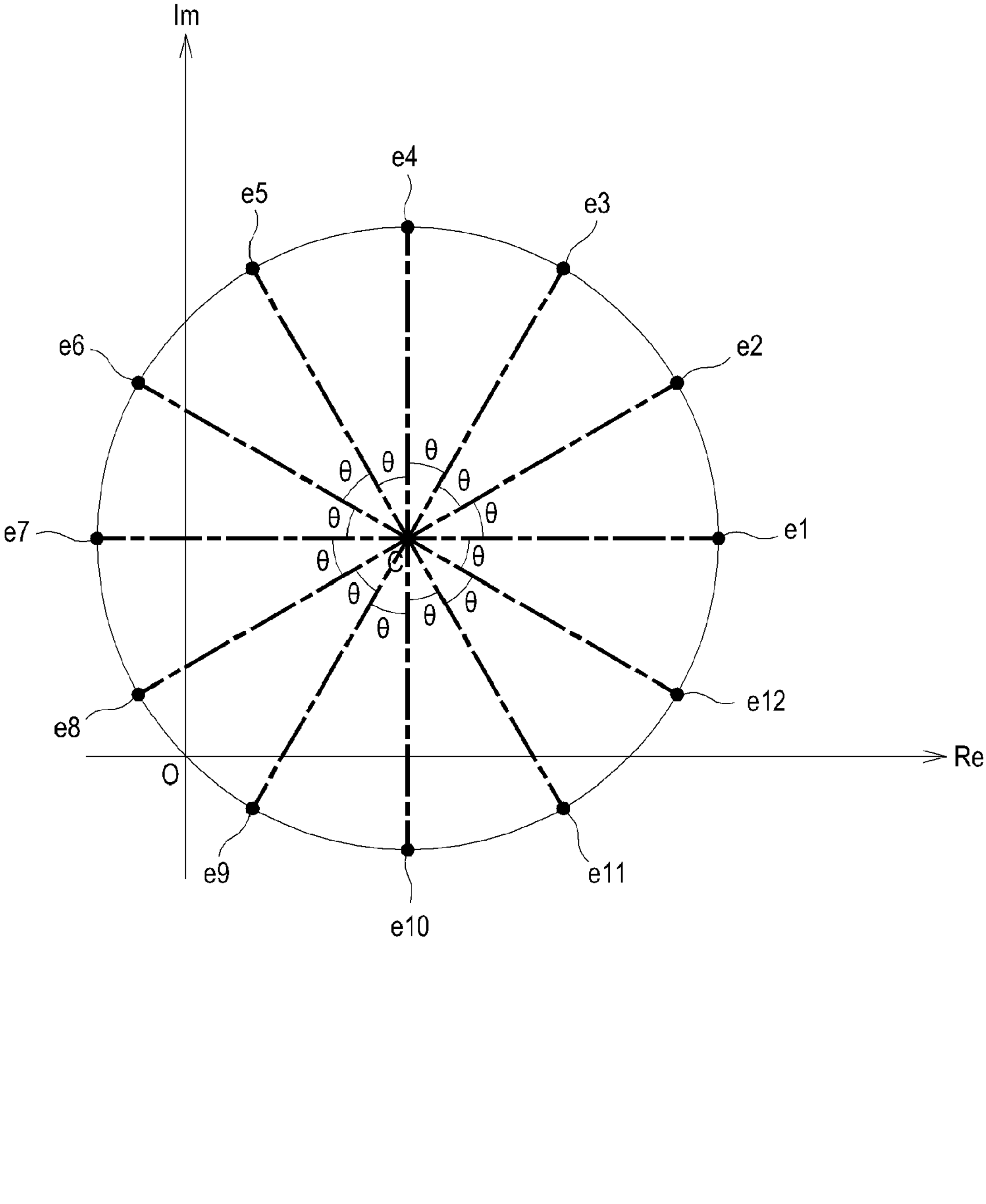
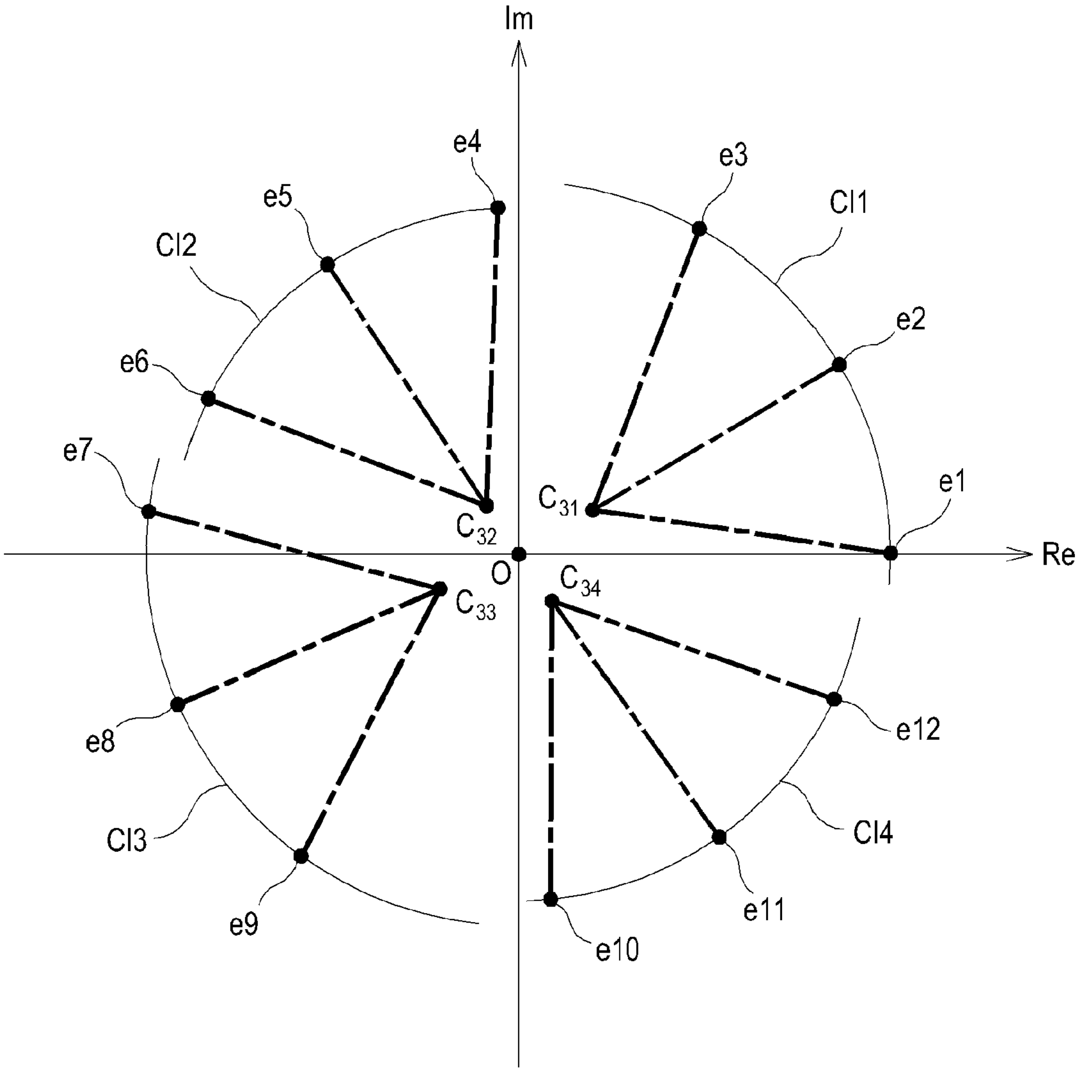


FIG. 7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C33
C34

FIG. 8

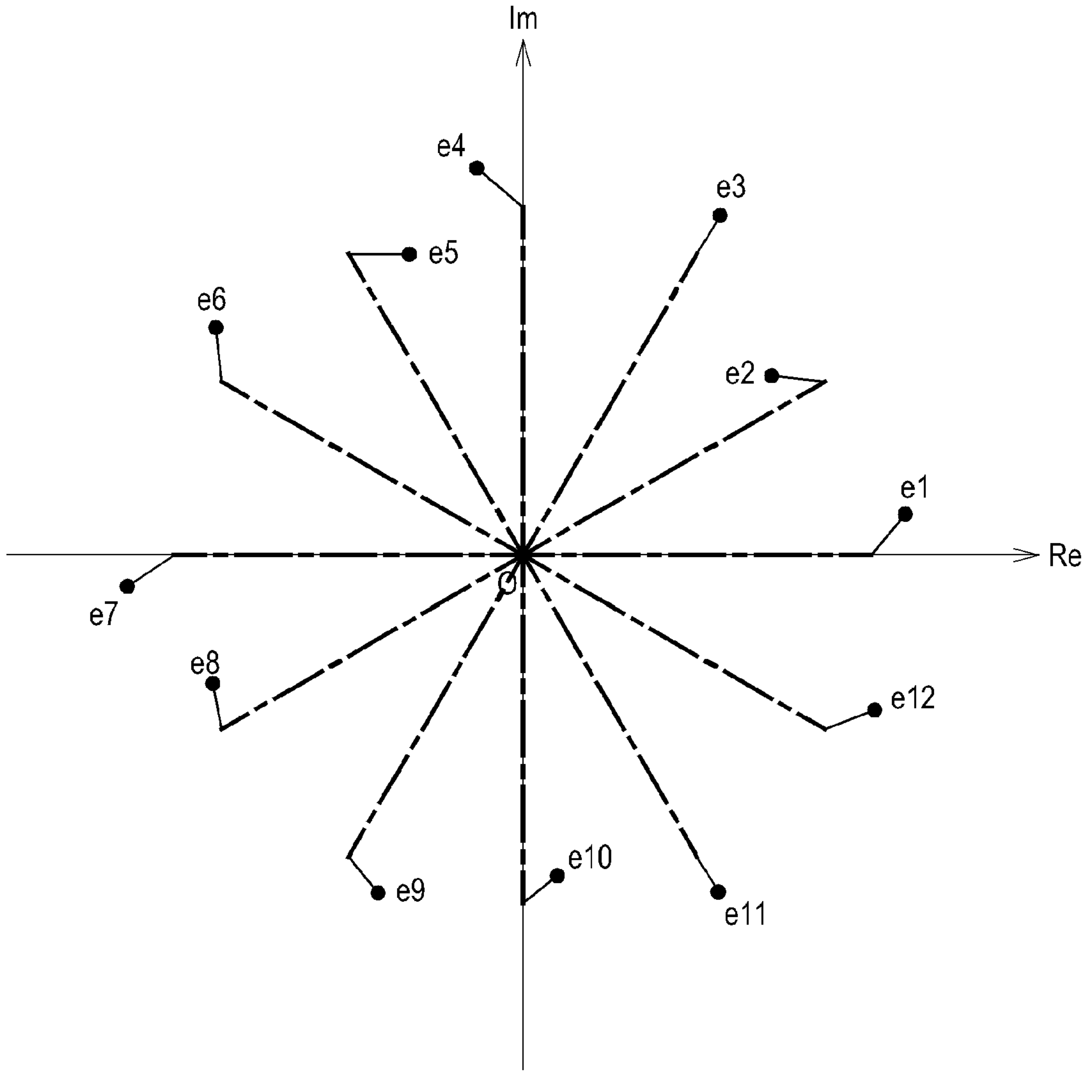

FIG. 9

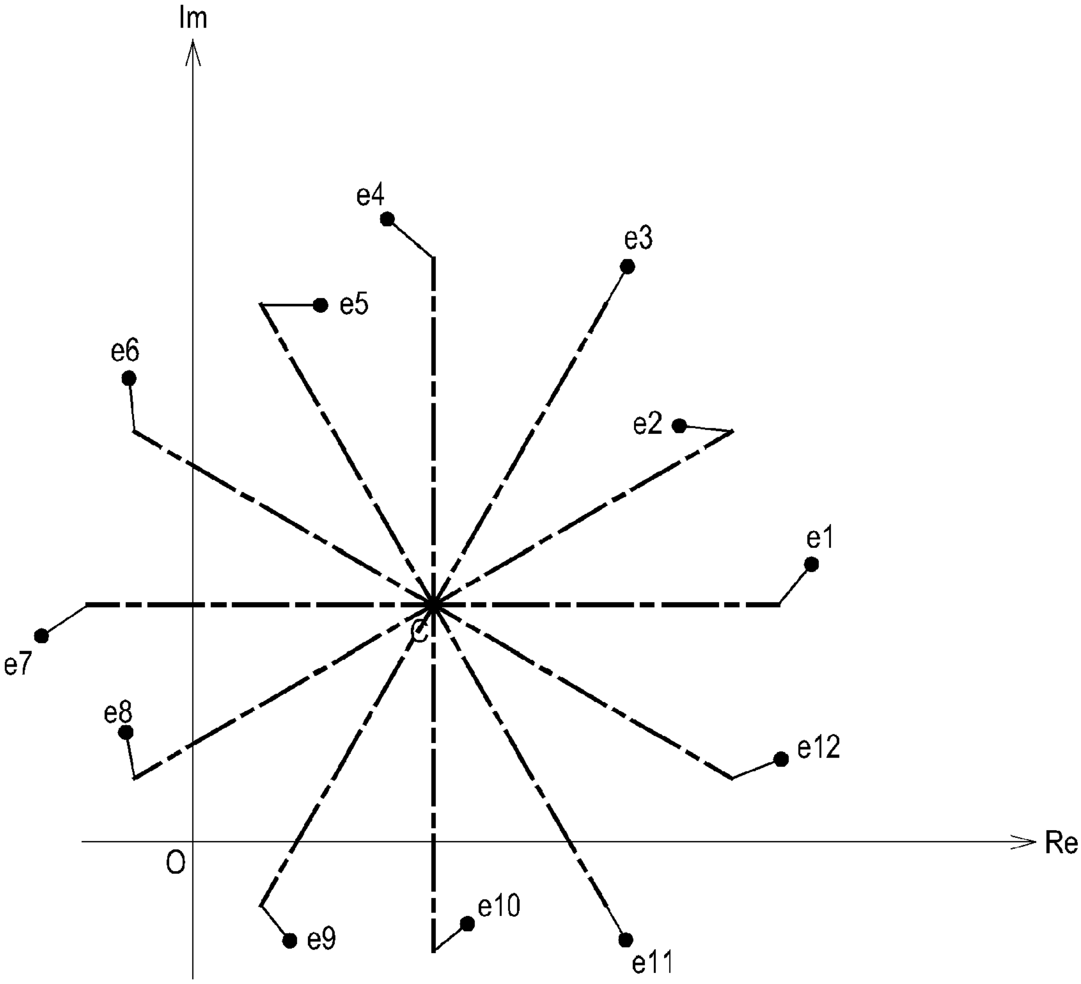

FIG. 10

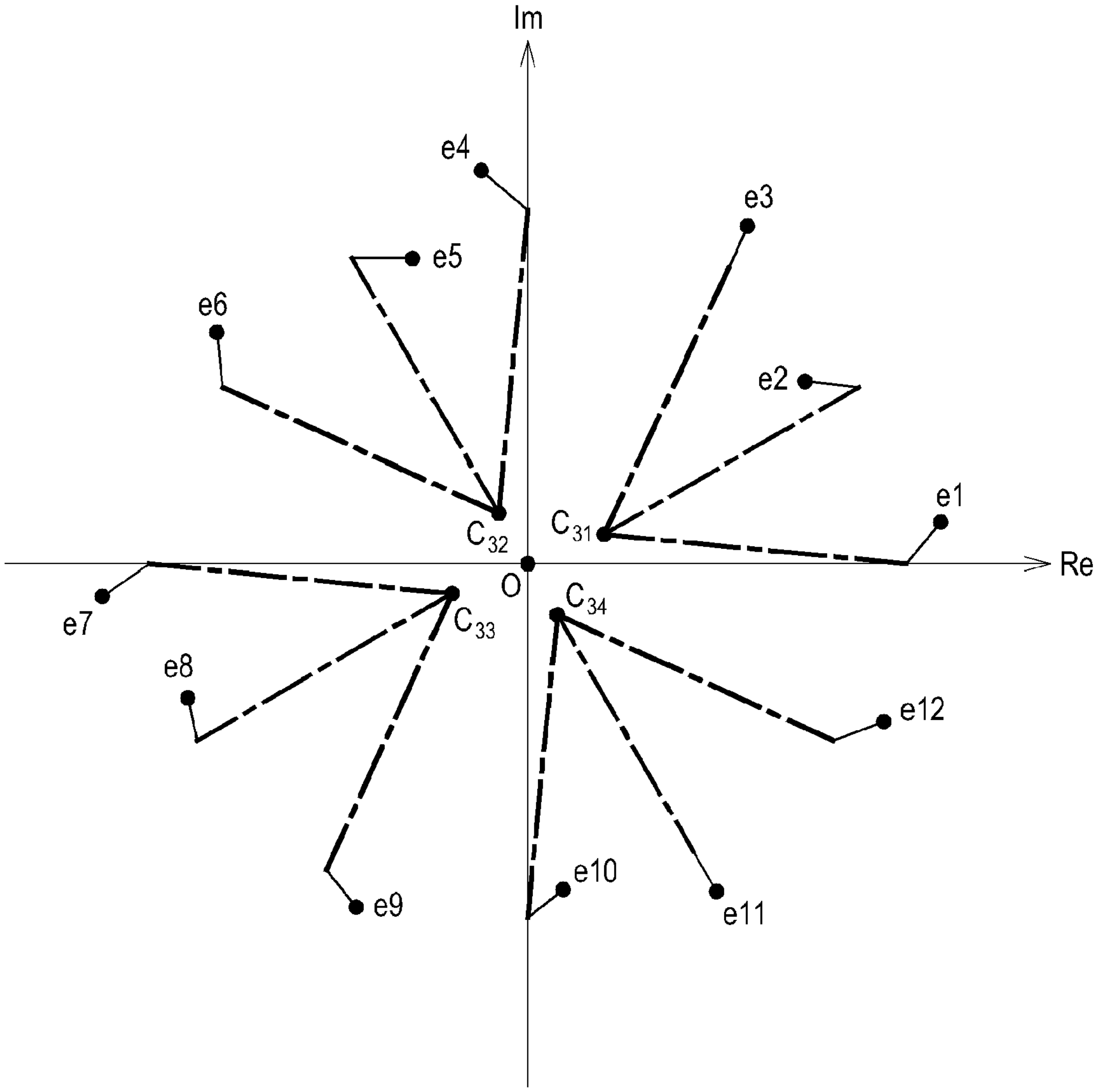

FIG. 11

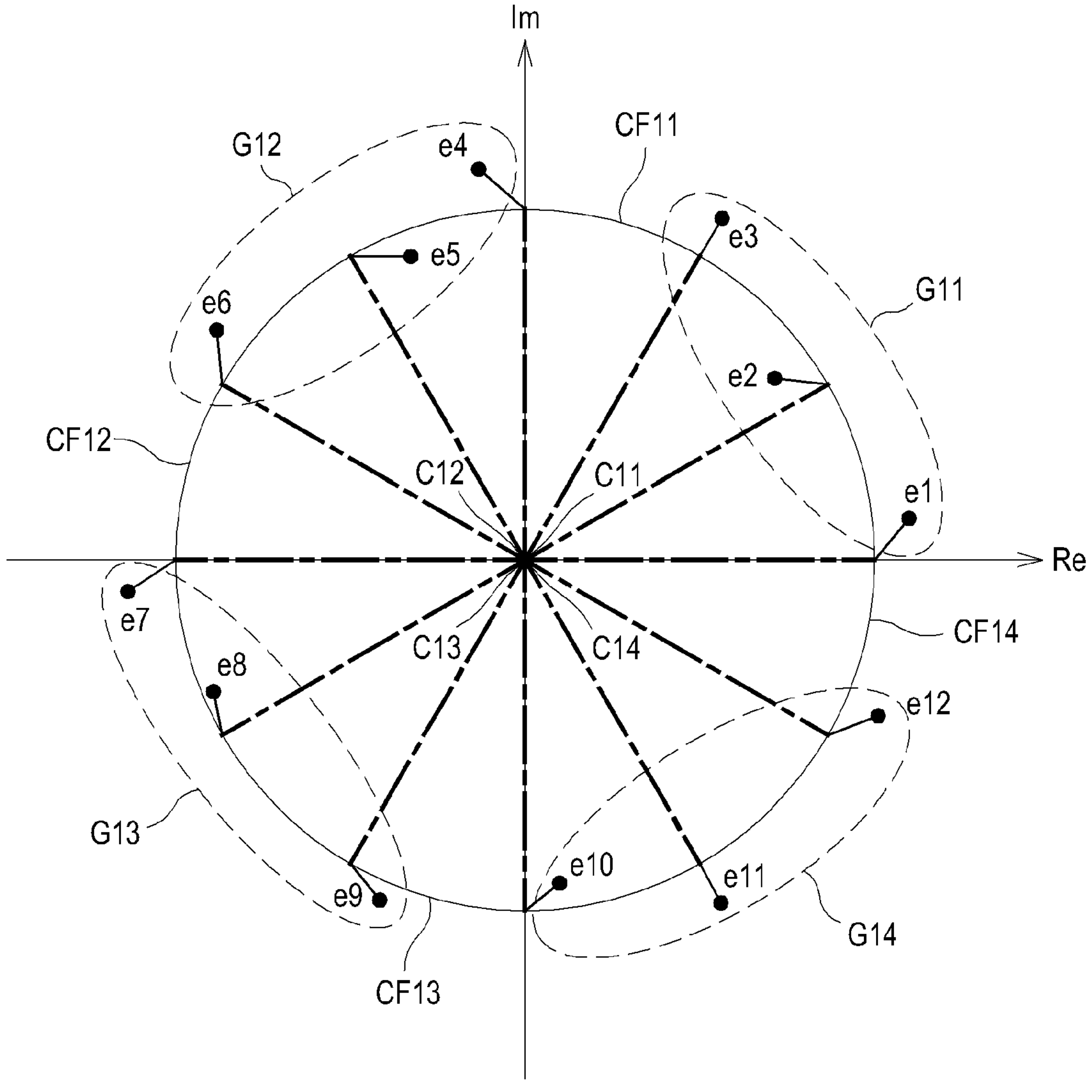
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FIG. 12

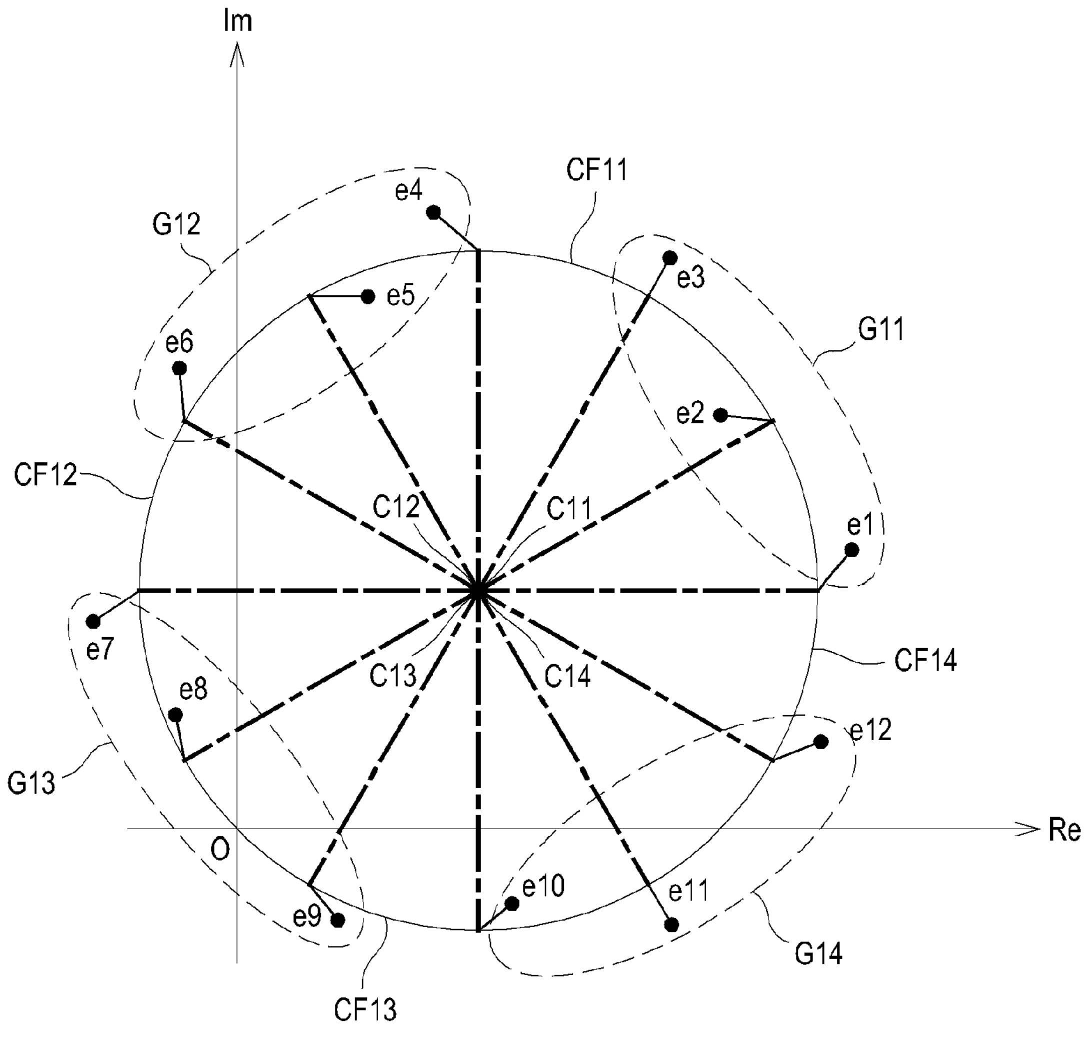
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FIG. 13

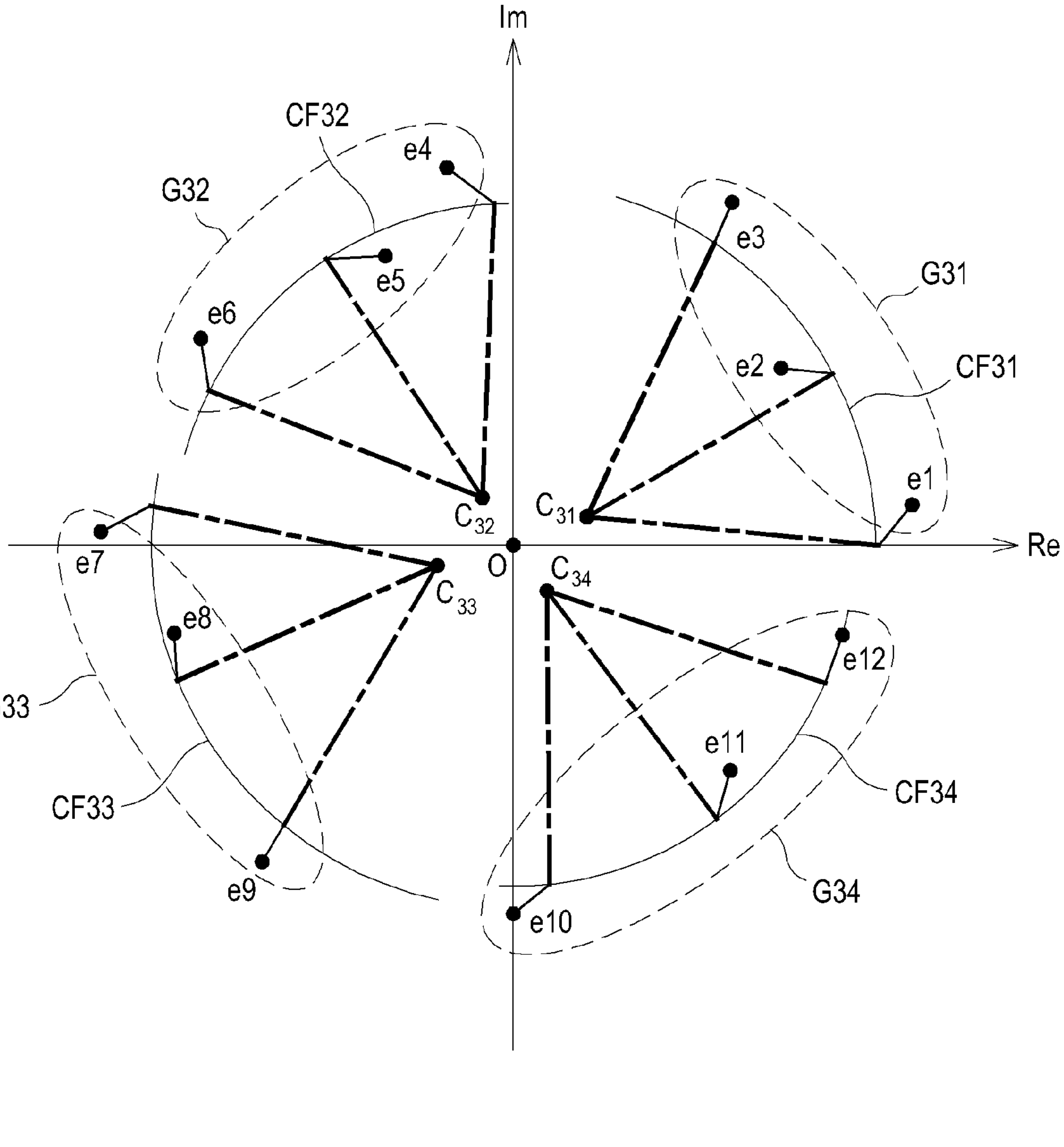
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FIG. 14

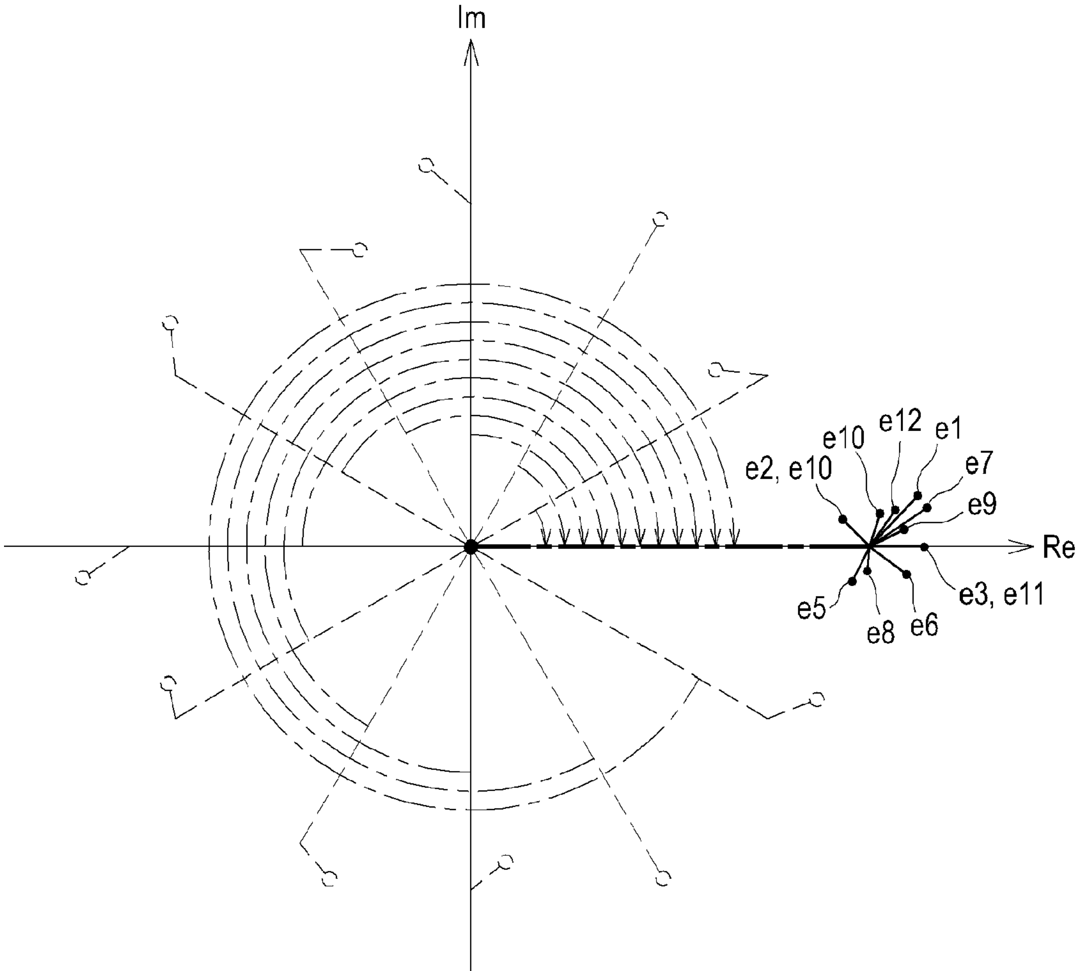


FIG. 15

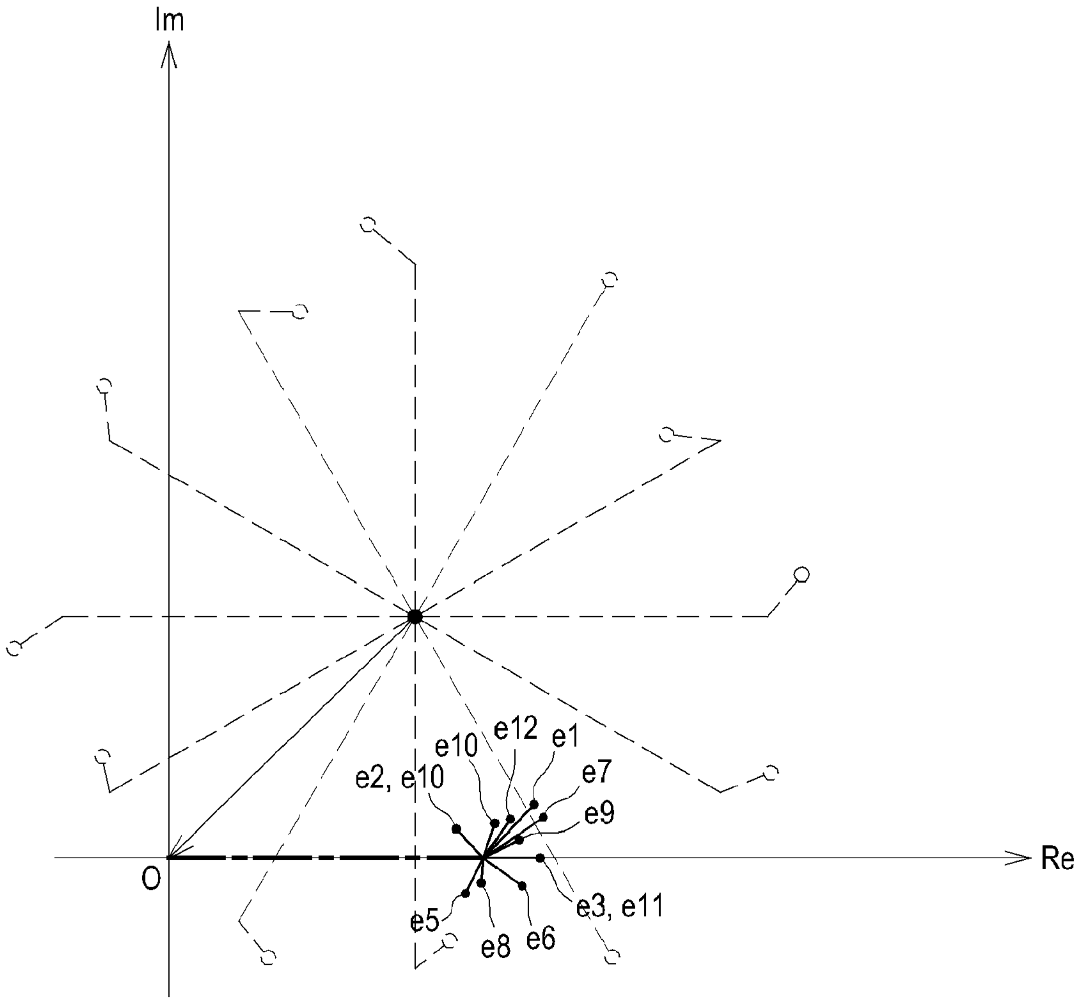
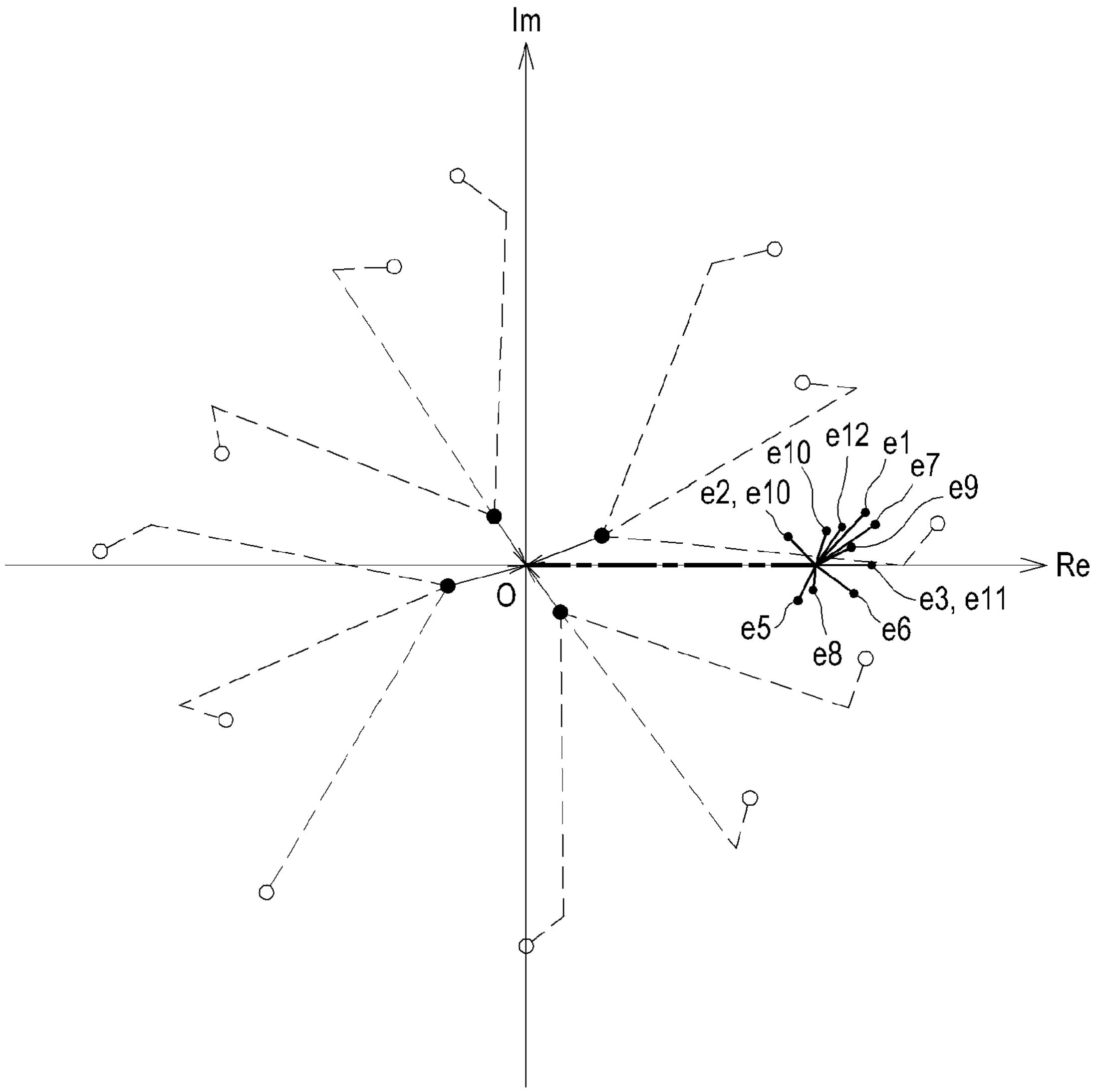


FIG. 16



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- KR 1020090038060 **[0001]**
- KR 1020100034064 **[0001]**

专利名称(译)	用于自适应地执行杂波滤波的超声系统和方法		
公开(公告)号	EP2248468A2	公开(公告)日	2010-11-10
申请号	EP2010160837	申请日	2010-04-23
申请(专利权)人(译)	MEDISON CO., LTD.		
当前申请(专利权)人(译)	三星MEDISON CO., LTD.		
[标]发明人	BAE MOO HO KIM TAE YUN		
发明人	BAE, MOO HO KIM, TAE YUN		
IPC分类号	A61B8/00 G01S15/89		
CPC分类号	G01S15/8981 A61B8/488		
代理机构(译)	SCHMID, WOLFGANG		
优先权	1020090038060 2009-04-30 KR 1020100034064 2010-04-14 KR		
其他公开文献	EP2248468A3 EP2248468B1		
外部链接	Espacenet		

摘要(译)

公开了自适应地执行杂波滤波的实施例。在一个实施例中，作为非限制性示例，超声系统包括：超声数据获取单元，被配置为向目标对象发送超声信号和从目标对象接收超声信号，从而输出多个超声数据以获得彩色多普勒模式图像，其中，目标物体包括组织和血流中的至少一种;处理单元，与超声数据采集单元通信，用于将多个超声数据定位在复平面上，处理单元还用于对位于复平面上的多个超声数据进行圆拟合并且考虑到组织的速度对圆拟合的超声数据执行缩混和杂波滤波。

FIG. 6