US012383138B2

(12) **United States Patent**
Chang et al.

(10) **Patent No.: US 12,383,138 B2**
(45) **Date of Patent: Aug. 12, 2025**

(54) **PHYSIOLOGICAL INFORMATION MONITORING AND IDENTIFICATION METHOD, CHARACTERIZATION INFORMATION MONITORING AND IDENTIFICATION METHOD, AND PHYSIOLOGICAL INFORMATION MONITORING RADAR**

(71) Applicant: **Wistron Corporation**, New Taipei (TW)

(72) Inventors: **Yao-Tsung Chang**, New Taipei (TW); **Yin-Yu Chen**, New Taipei (TW); **Chuan-Yen Kao**, New Taipei (TW)

(73) Assignee: **WISTRON CORPORATION**, New Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 469 days.

(21) Appl. No.: **17/368,100**

(22) Filed: **Jul. 6, 2021**

(65) **Prior Publication Data**

US 2022/0296099 A1 Sep. 22, 2022

(30) **Foreign Application Priority Data**

Mar. 17, 2021 (TW) 110109487
Mar. 17, 2021 (TW) 110109639

(51) **Int. Cl.**
A61B 5/00 (2006.01)
G01S 7/35 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***A61B 5/0015*** (2013.01); ***A61B 5/0004*** (2013.01); ***A61B 5/7257*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC ... A61B 5/0015; A61B 5/0004; A61B 5/7257; G01S 7/356; G01S 7/412; G01S 13/584;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,155,087 A * 5/1979 Okrent G01S 13/78 714/824
4,292,637 A 9/1981 Johnson
(Continued)

FOREIGN PATENT DOCUMENTS

CN 108700645 A 10/2018
CN 111932826 A 11/2020
(Continued)

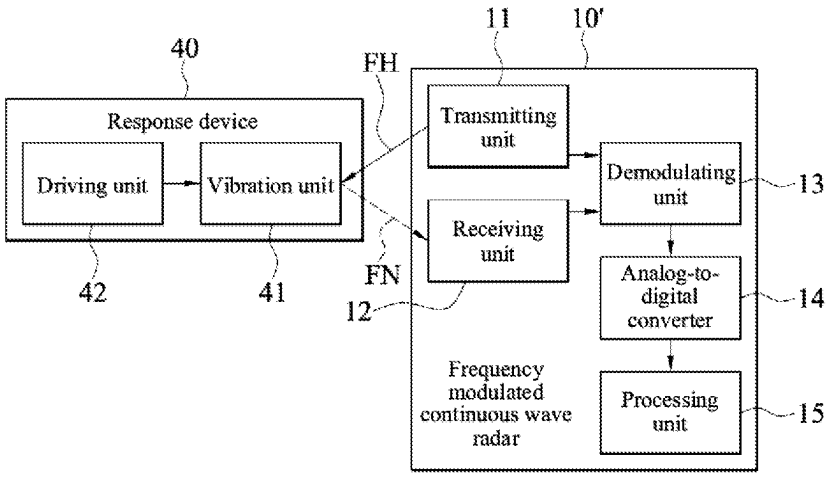
OTHER PUBLICATIONS

EESR dated Feb. 18, 2022, listed in related European patent application No. 21 190 299.4.
(Continued)

Primary Examiner — Olumide Ajibade Akonai
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

A monitoring radar and a monitoring and identification method therefor are provided. The monitoring radar may be a physiological information monitoring radar. The monitoring and identification method may be a physiological information monitoring and identification method. The physiological information monitoring radar processes at least one reflected radar signal to obtain a response characteristic and range information corresponding to each of a plurality of to-be-monitored objects and distinguishes the response characteristic of each of the to-be-monitored objects as identification information or physiological information. The physiological information monitoring radar then labels each
(Continued)



piece of physiological information according to the range information and the identification information.

26 Claims, 11 Drawing Sheets

(51) **Int. Cl.**
G01S 7/41 (2006.01)
G01S 13/58 (2006.01)
G01S 13/75 (2006.01)
G01S 13/82 (2006.01)

(52) **U.S. Cl.**
CPC ***G01S 7/356*** (2021.05); ***G01S 7/412*** (2013.01); ***G01S 13/584*** (2013.01); ***G01S 13/756*** (2013.01); ***G01S 13/825*** (2013.01)

(58) **Field of Classification Search**
CPC G01S 13/756; G01S 13/825; G01S 13/753; G01S 13/767; G01S 13/876; G01S 13/88; G01S 13/32; G01S 13/36; G01S 7/415; G01S 13/56; G01S 13/58; G01S 13/582; G01S 13/723; G01S 7/417; G06K 7/10009
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,567,200	B1	7/2009	Osterweil	
7,884,753	B2	2/2011	Peczalski et al.	
9,833,200	B2 *	12/2017	Lin	H04L 27/2273
11,169,254	B2 *	11/2021	Tsai	G01S 13/723
2008/0074307	A1	3/2008	Boric-Lubecke et al.	
2010/0231410	A1	9/2010	Seisenberger et al.	
2012/0022348	A1 *	1/2012	Droitcour	A61B 5/0816 600/407
2012/0268308	A1	10/2012	Tuttle et al.	
2014/0184447	A1	7/2014	Zhou et al.	
2016/0363648	A1	12/2016	Mindell et al.	
2018/0172813	A1 *	6/2018	Rao	G01S 13/343
2018/0301945	A1	10/2018	Ishida et al.	
2019/0094350	A1 *	3/2019	Baheti	G01S 7/415
2020/0165934	A1	5/2020	Schleif et al.	
2020/0200892	A1 *	6/2020	Rajab	G01S 13/753
2020/0237252	A1	7/2020	Lane et al.	
2020/0389770	A1	12/2020	Marschalkowski et al.	

FOREIGN PATENT DOCUMENTS

EP	0853245	A2	7/1998
EP	3477335	A1	5/2019
JP	3675741	B2	7/2005
JP	2019092726	A	6/2019
JP	2020118598	A	8/2020
WO	2018/206934	A1	11/2018
WO	2020128150	A1	6/2020

OTHER PUBLICATIONS

EESR dated Feb. 16, 2022, listed in related European patent application No. 21 190 277.0.
Rao, S.; "Introduction to mmwave Sensing: FMCW Radars;" Texas Instruments; pp. 1-70.
Office Action dated Mar. 7, 2023, listed in related U.S. Appl. No. 17/353,797 (copy not provided).
Office action dated Aug. 4, 2023, listed in related U.S. Appl. No. 17/353,797 (copy not provided).
Office action dated Mar. 22, 2024, listed in related European patent application No. 21 190 299.4.
Strobel, A., et al.; "A Millimeter-Wave Low-Power Active Backscatter Tag for FMCW Radar Systems;" IEEE Transactions on Microwave Theory and Techniques, vol. 61, No. 5, May 2013; pp. 1964-1972.
Lazaro, A., et al.; "Backscatter Transponder Based on Frequency Selective Surface for FMCW Radar Applications;" RadioEngineering, vol. 23, No. 2, Jun. 2014; pp. 632-641.

* cited by examiner

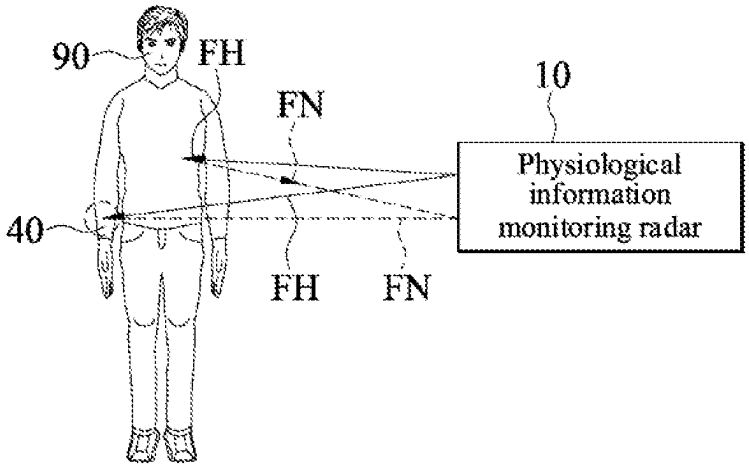

90
FH
FN
10
Physiological information monitoring radar
40
FH
FN

FIG. 1

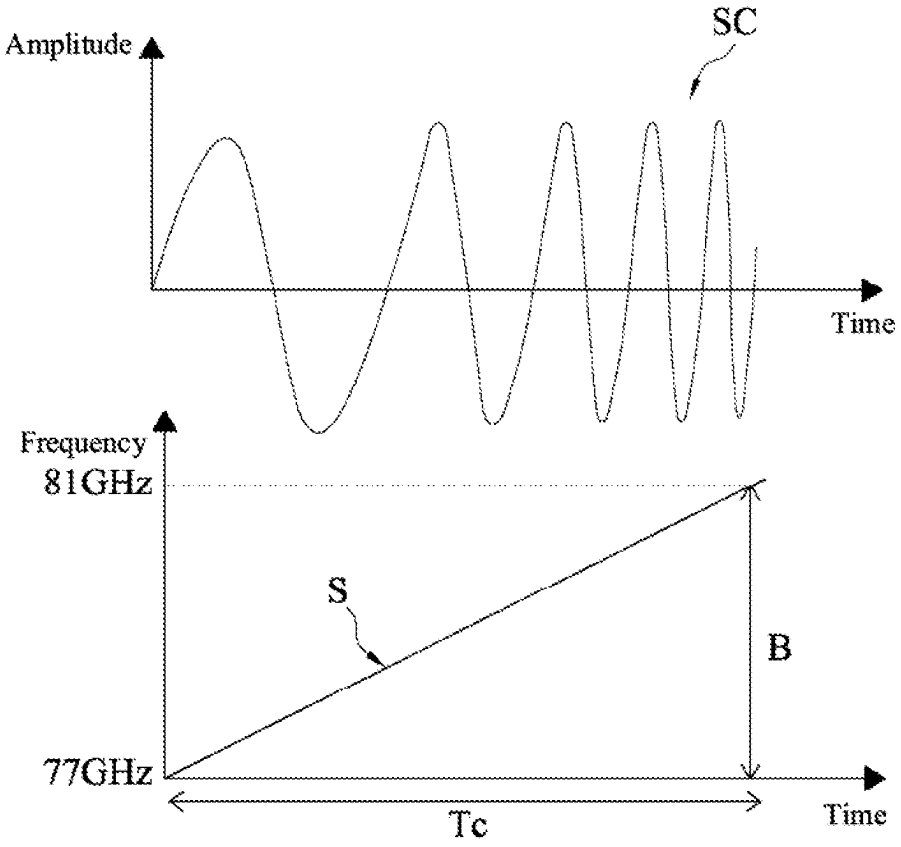

Amplitude
SC
Time
Frequency
81GHz
S
B
77GHz
Tc
Time

FIG. 2

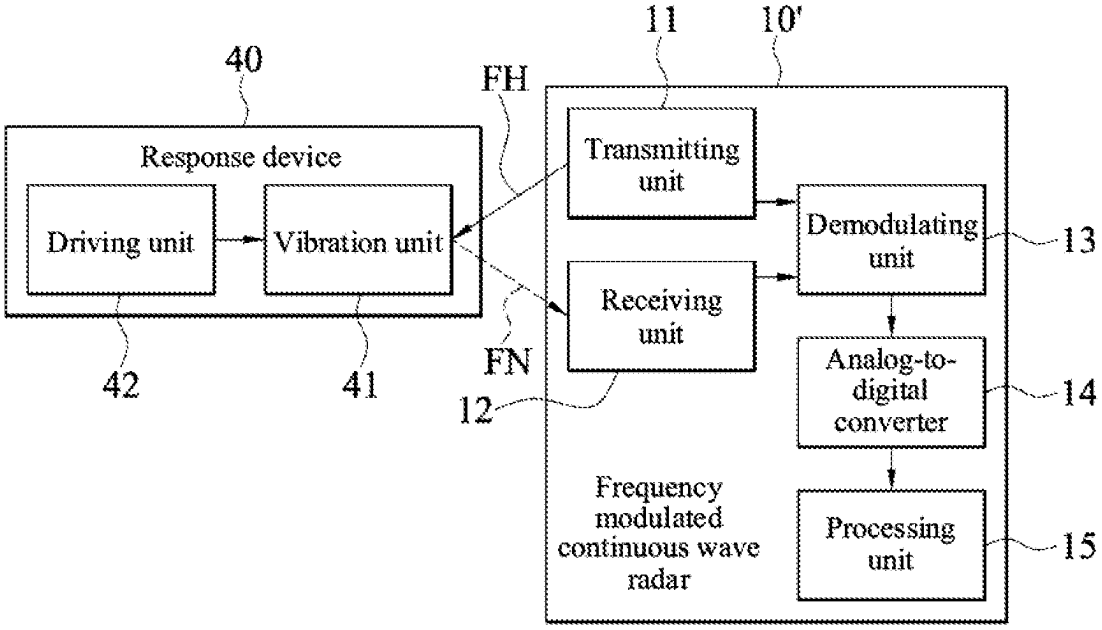

11
10'
40
FH
Response device
Transmitting unit
Demodulating unit
13
Driving unit
Vibration unit
Receiving unit
Analog-to-digital converter
14
42
41
FN
12
Frequency modulated continuous wave radar
Processing unit
15

FIG. 3

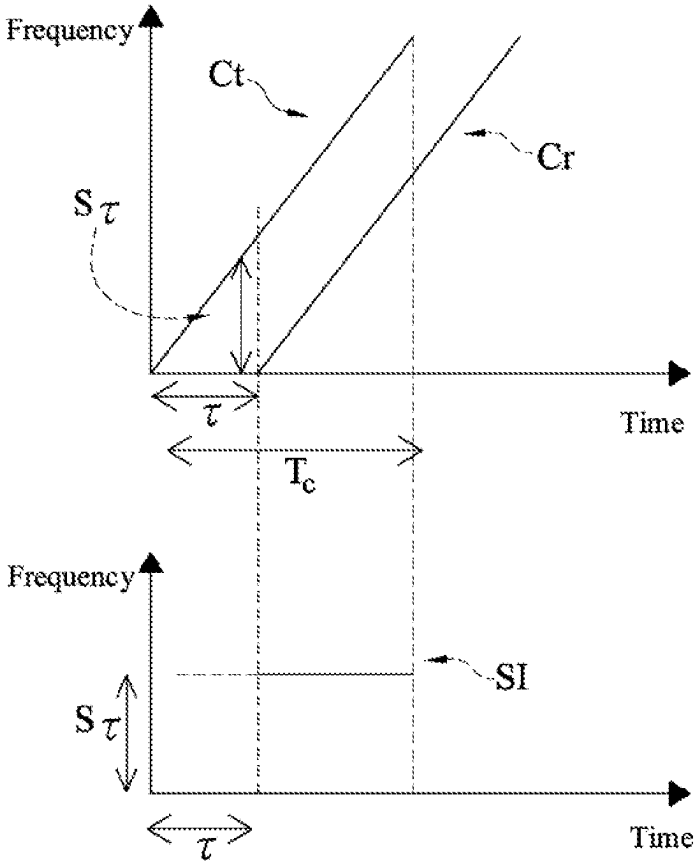

Frequency
Ct
Cr
Sτ
τ
Time
Tc
Frequency
SI
Sτ
τ
Time

FIG. 4

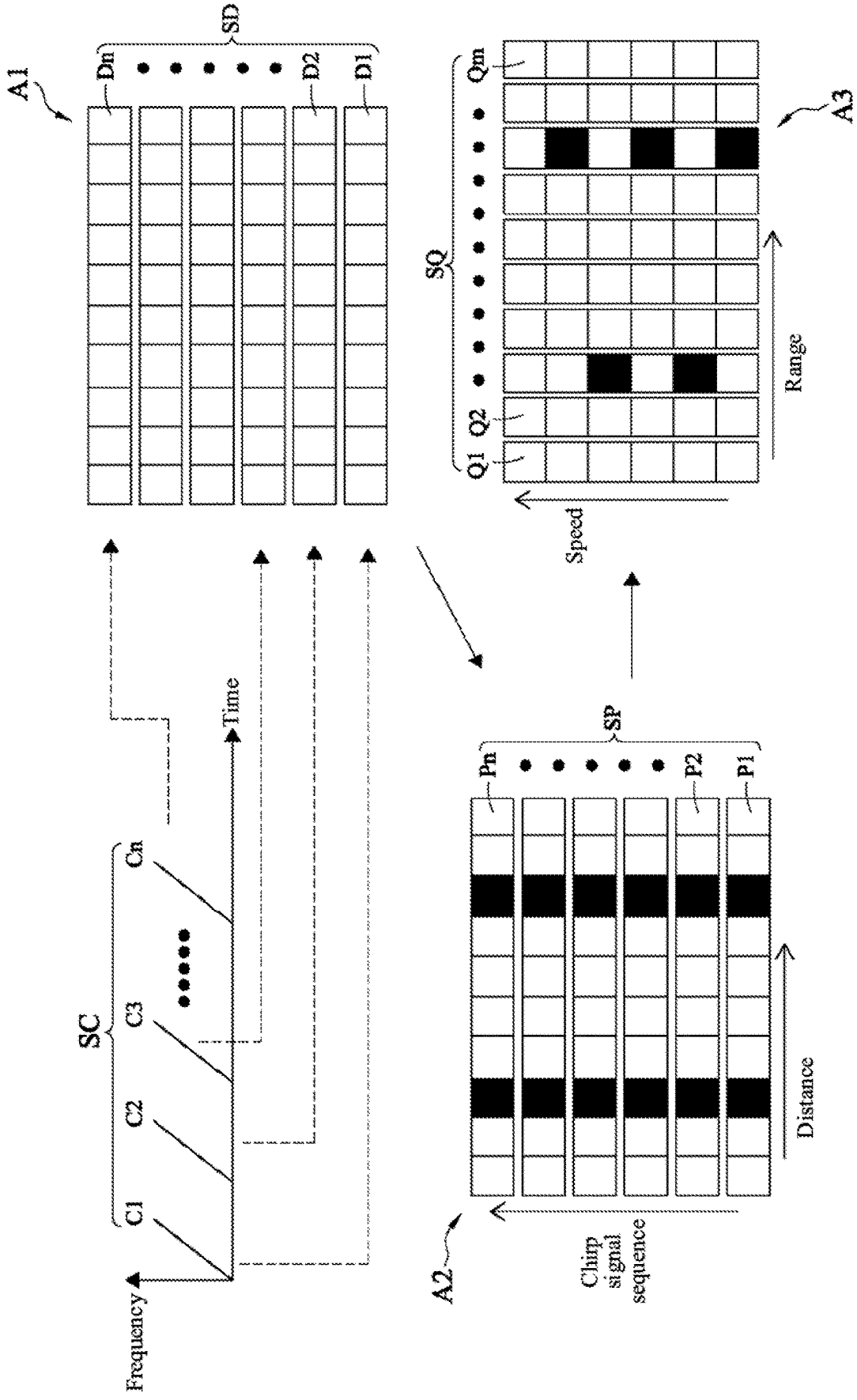

A1
SD
Dn
D2
D1
A3
SQ
Qm
Q2
Q1
Range
Speed
Time
SC
Cn
C3
C2
C1
Frequency
SP
Pn
P2
P1
Distance
A2
Chirp signal sequence

FIG. 5

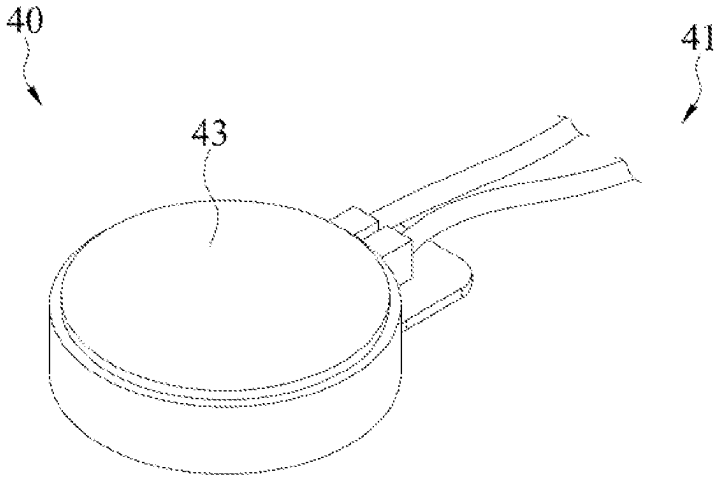


FIG. 6

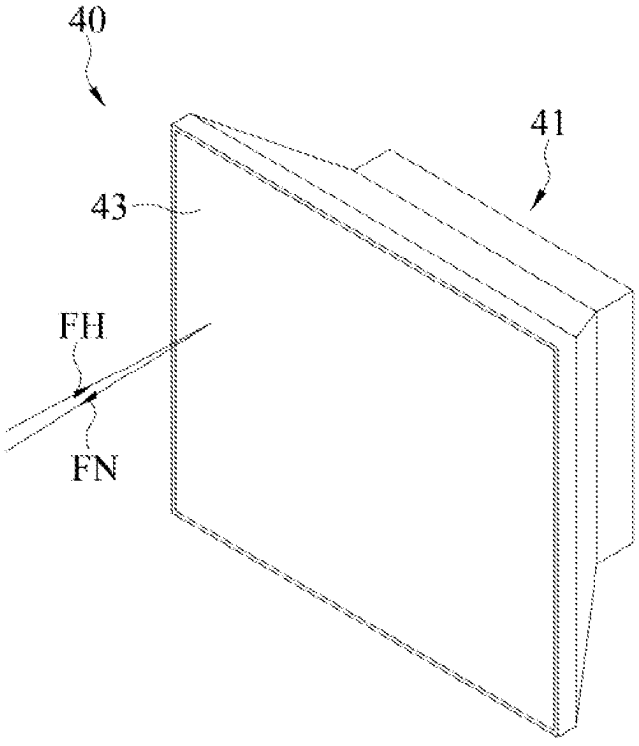


FIG. 7

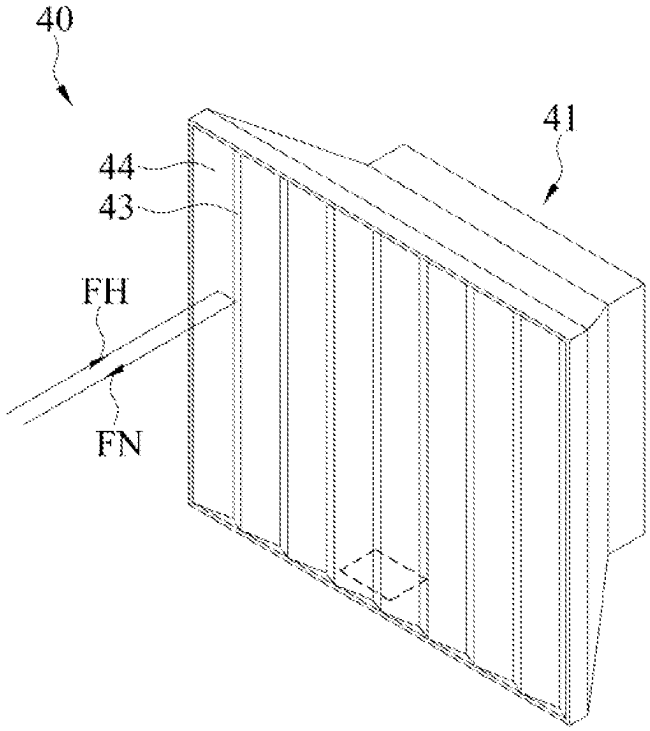


FIG. 8

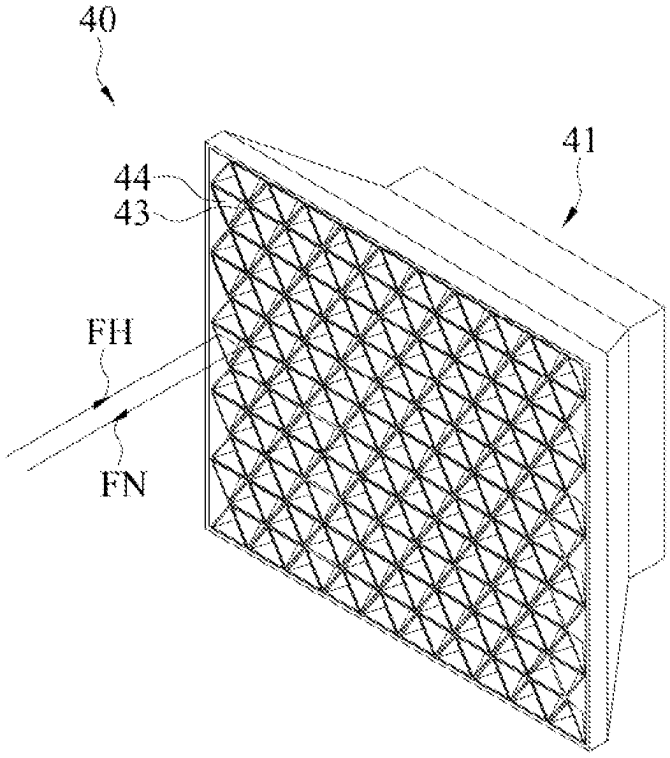


FIG. 9

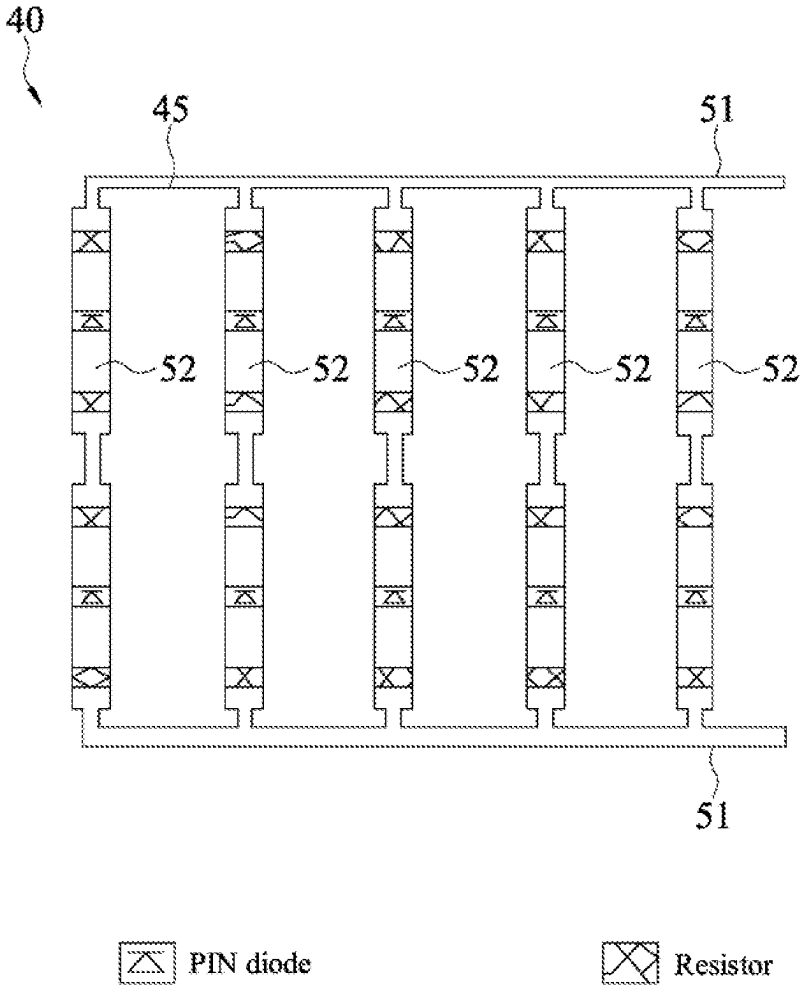


FIG. 10

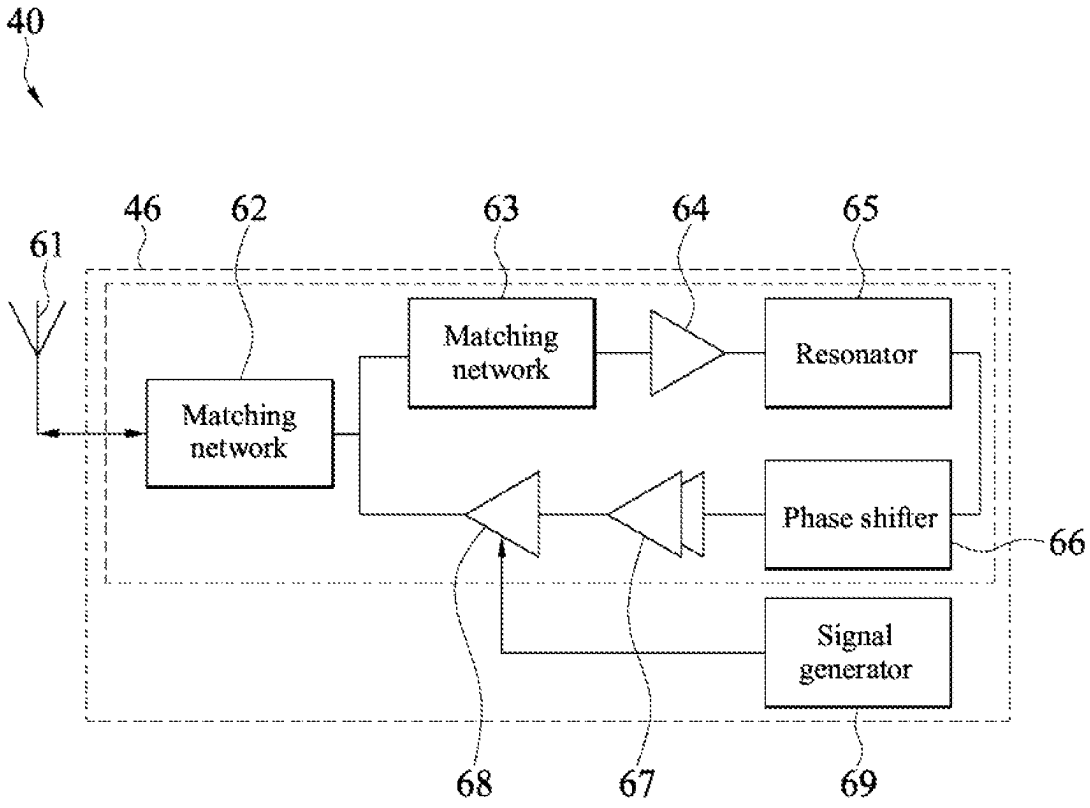

40
46
62
63
64
65
61
Matching network
Resonator
Matching network
Phase shifter
66
Signal generator
68
67
69

FIG. 11

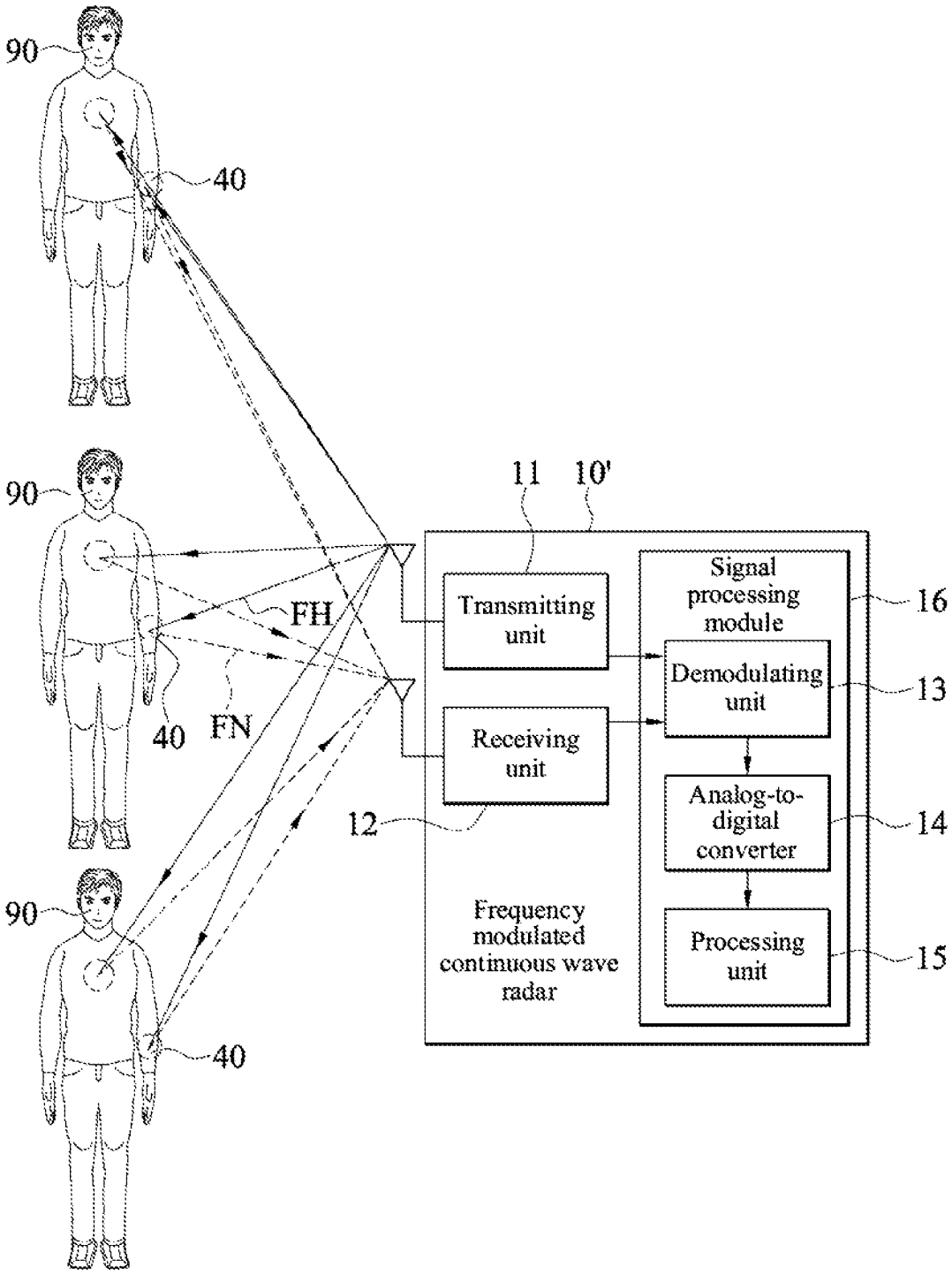

90
40
90
FH
40
FN
90
40
11
10'
Transmitting unit
Receiving unit
12
Signal processing module
Demodulating unit
Analog-to-digital converter
Processing unit
Frequency modulated continuous wave radar
16
13
14
15

FIG. 12

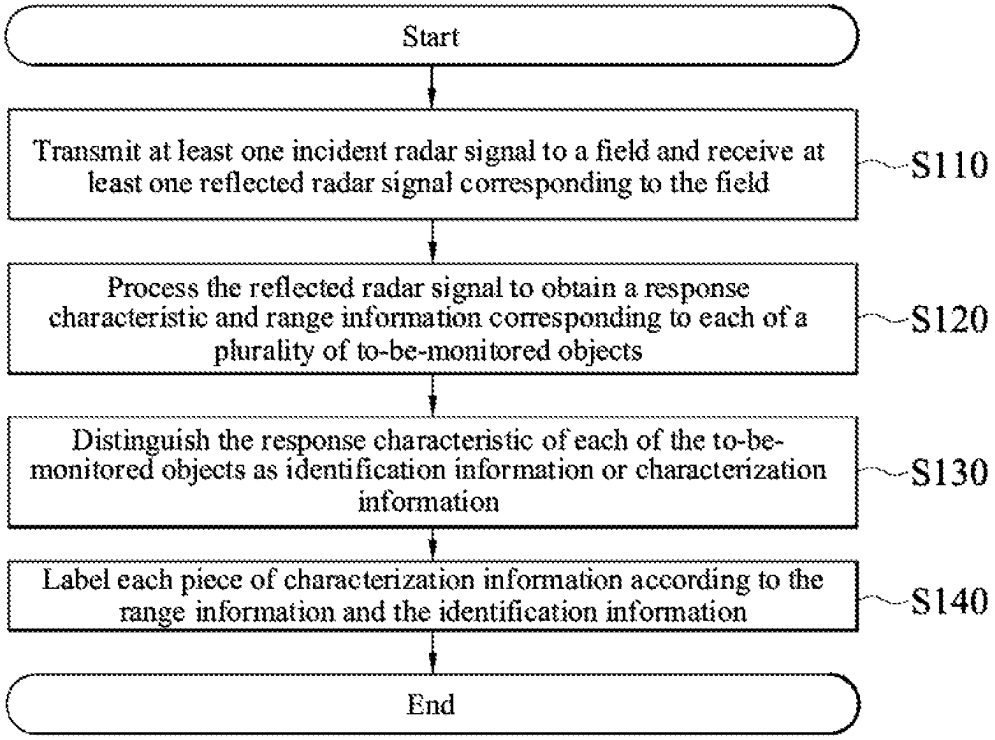

Start
Transmit at least one incident radar signal to a field and receive at least one reflected radar signal corresponding to the field
S110
Process the reflected radar signal to obtain a response characteristic and range information corresponding to each of a plurality of to-be-monitored objects
S120
Distinguish the response characteristic of each of the to-be-monitored objects as identification information or characterization information
S130
Label each piece of characterization information according to the range information and the identification information
S140
End

FIG. 13

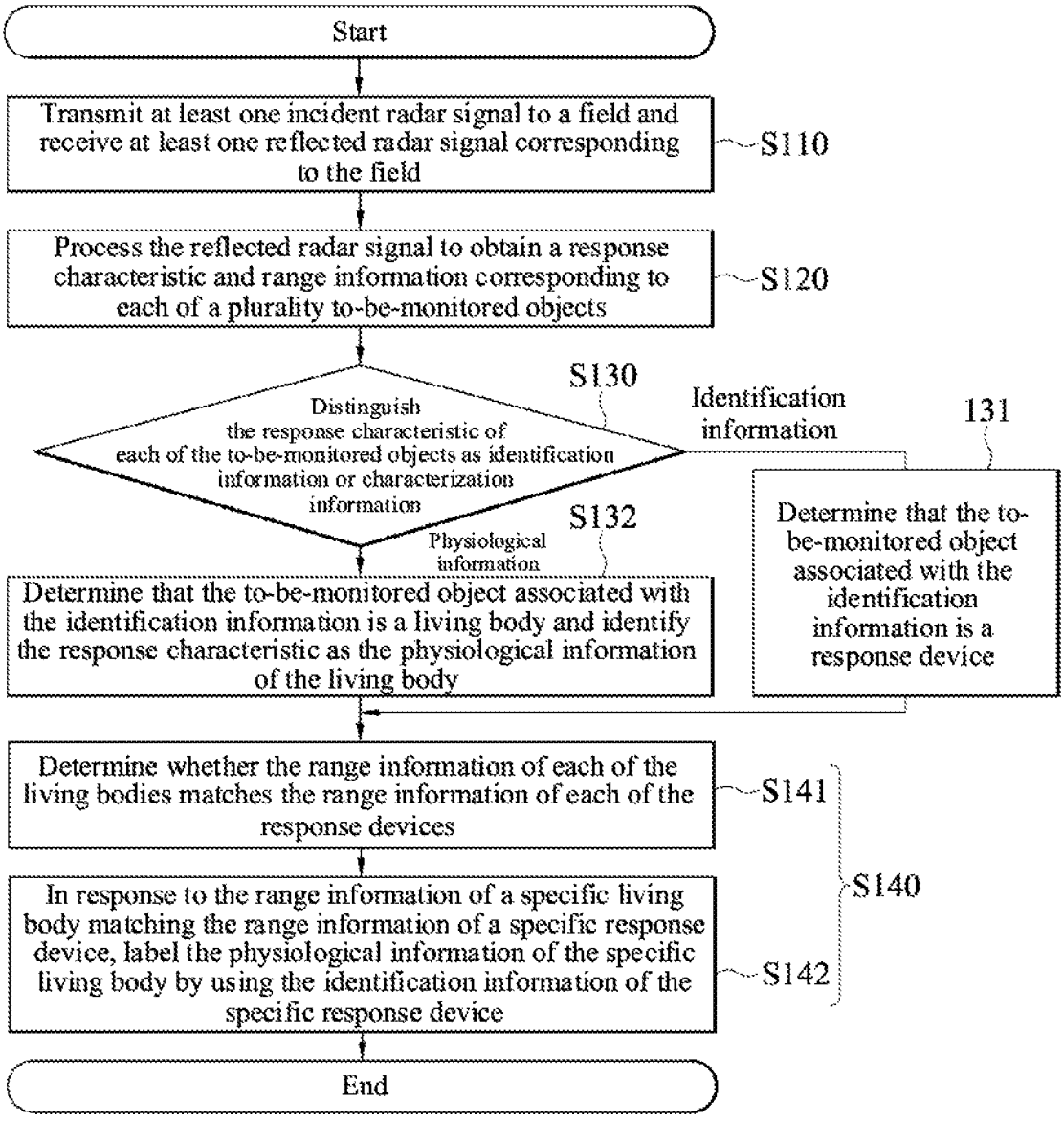

Start
Transmit at least one incident radar signal to a field and receive at least one reflected radar signal corresponding to the field
S110
Process the reflected radar signal to obtain a response characteristic and range information corresponding to each of a plurality to-be-monitored objects
S120
S130
Distinguish the response characteristic of each of the to-be-monitored objects as identification information or characterization information
Identification information
131
Determine that the to-be-monitored object associated with the identification information is a response device
S132
Physiological information
Determine that the to-be-monitored object associated with the identification information is a living body and identify the response characteristic as the physiological information of the living body
Determine whether the range information of each of the living bodies matches the range information of each of the response devices
S141
In response to the range information of a specific living body matching the range information of a specific response device, label the physiological information of the specific living body by using the identification information of the specific response device
S142
S140
End

FIG. 14

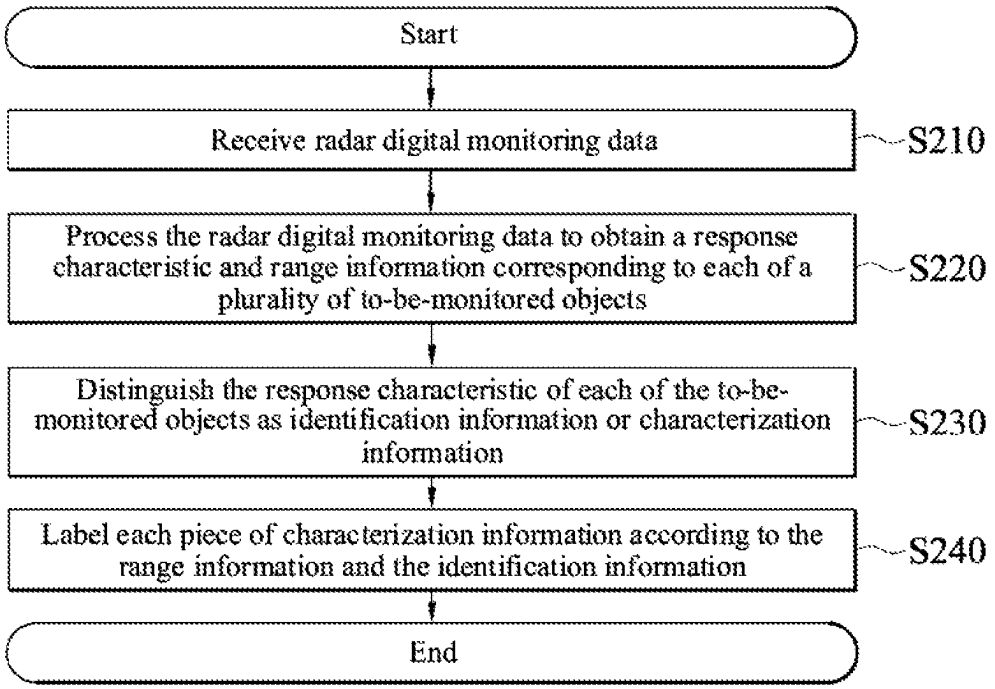

Start
Receive radar digital monitoring data
S210
Process the radar digital monitoring data to obtain a response characteristic and range information corresponding to each of a plurality of to-be-monitored objects
S220
Distinguish the response characteristic of each of the to-be-monitored objects as identification information or characterization information
S230
Label each piece of characterization information according to the range information and the identification information
S240
End

FIG. 15

PHYSIOLOGICAL INFORMATION MONITORING AND IDENTIFICATION METHOD, CHARACTERIZATION INFORMATION MONITORING AND IDENTIFICATION METHOD, AND PHYSIOLOGICAL INFORMATION MONITORING RADAR

CROSS-REFERENCES TO RELATED APPLICATIONS

This non-provisional application claims priority under 35 U.S.C. § 119(a) to Patent Application No. 110109639 filed in Taiwan, R.O.C. on Mar. 17, 2021 and Patent Application No. 110109487 filed in Taiwan, R.O.C. on Mar. 17, 2021, the entire contents of which are hereby incorporated by reference.

BACKGROUND

Technical Field

The present invention relates to radar technologies, and in particular, to a characterization information monitoring and identification method by using a reflected radar signal identification and response device and a monitoring radar system applying the method.

Related Art

A radar technology may be applied to various purposes such as distance measurement. However, during measurement of a plurality of objects, an object to which measured information belongs cannot be identified.

SUMMARY

In view of the above, according to some embodiments, a physiological information monitoring and identification method includes: transmitting at least one incident radar signal to a field; receiving at least one reflected radar signal corresponding to the field; processing the reflected radar signal to obtain a response characteristic and range information corresponding to each of a plurality of to-be-monitored objects; distinguishing the response characteristic of each of the plurality of to-be-monitored objects as identification information or physiological information; and labelling each piece of physiological information according to the range information and the identification information.

According to some embodiments, a radar signal processing method for monitoring and identifying characterization information includes: receiving at least one piece of radar digital monitoring data; processing the radar digital monitoring data to obtain a response characteristic and range information corresponding to each of the plurality of to-be-monitored objects; distinguishing the response characteristic of each of the plurality of to-be-monitored objects as identification information or characterization information; and labelling each piece of characterization information according to the range information and the identification information.

According to some embodiments, a physiological information monitoring radar includes a transceiver and a signal processing module. The transceiver is configured to transmit at least one incident radar signal to a field and receive at least one reflected radar signal corresponding to the field. The signal processing module is configured to process the reflected radar signal to obtain a response characteristic and range information corresponding to each of a plurality of to-be-monitored objects, distinguish the response characteristic of each of the plurality of to-be-monitored objects as identification information or physiological information, and label each piece of physiological information according to the range information and the identification information.

According to some embodiments, the range information includes distance information or orientation information.

According to some embodiments, in response to the response characteristic being the identification information, it is determined that the to-be-monitored object associated with the identification information is a response device.

According to some embodiments, the identification information is a vibration frequency of the response device or a change in a radar cross section of the response device.

According to some embodiments, in response to the response characteristic being the physiological information, it is determined that the to-be-monitored object associated with the physiological information is a living body, and the response characteristic is identified as the physiological information of the living body. According to some embodiments, in response to the response characteristic being speed information, it is determined that the to-be-monitored object associated with the speed information is a moving object, and the response characteristic is identified as the speed information of the moving body.

According to some embodiments, the step of labelling each piece of physiological information according to the range information and the identification information includes: in response to the range information of a specific living body matching the range information of a specific response device, labelling the physiological information of the specific living body by using the identification information of the specific response device.

According to some embodiments, the physiological information monitoring radar is a frequency modulated continuous wave radar, and the incident radar signal is a frequency modulated radar signal.

In conclusion, according to the physiological information monitoring radar and the physiological information monitoring and identification method in some embodiments, physiological information of a subject may be measured, and the physiological information is labelled through identification information of an identification and response device of the radar, so as to learn an identity of the subject.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram of a use state of a radar system according to some embodiments;

FIG. **2** is a schematic diagram illustrating a radar signal;

FIG. **3** is a schematic block diagram of a radar system according to some embodiments;

FIG. **4** is a schematic diagram illustrating an incident radar signal and a reflected radar signal;

FIG. **5** is a schematic diagram of signal processing according to some embodiments;

FIG. **6** is a perspective view of a first variation of a response device according to some embodiments;

FIG. **7** is a perspective view of a second variation of the response device according to some embodiments;

FIG. **8** is a perspective view of a third variation of the response device according to some embodiments;

FIG. **9** is a perspective view of a fourth variation of the response device according to some embodiments;

FIG. **10** is a schematic diagram of a fifth variation of the response device according to some embodiments;

FIG. **11** is a schematic block diagram of a sixth variation of the response device according to some embodiments;

FIG. **12** is a schematic diagram of a use state of a radar system according to some embodiments;

FIG. **13** is a flowchart of a radar signal processing method according to some embodiments;

FIG. **14** is a detailed flowchart of a physiological information monitoring and identification method according to some embodiments; and

FIG. **15** is another flowchart of the radar signal processing method according to some embodiments.

DETAILED DESCRIPTION

The term "connect" used herein means that two or more elements are directly in physical or electrical contact with each other or are indirectly in physical or electrical contact with each other.

FIG. **1** is a schematic diagram of a use state of a radar system according to some embodiments. The radar system includes a physiological information monitoring radar **10** and at least one response device **40**. One response device **40** is exemplified herein. The response device **40** may be disposed at a specified point (such as a resting position of a subject **90**) or carried on the subject **90**. The physiological information monitoring radar **10** transmits a radar signal (which is referred to as an "incident radar signal FH" below). The incident radar signal FH transmitted to a to-be-monitored object is modulated under a movement of the to-be-monitored object (such as the subject **90** and the response device **40**) and is reflected back to the physiological information monitoring radar **10**. The reflected radar signal is referred to as a "reflected radar signal FN" below. Therefore, one or more types of information of the to-be-monitored object may be monitored by analyzing the reflected radar signal FN. The information may be, for example, a speed, a distance, an orientation, a movement in a small range (such as a vibration frequency, physiological information (such as a heartbeat or a breath)), etc.

In some embodiments, the physiological information monitoring radar **10** may be a frequency modulated continuous wave (FMCW) radar, a continuous wave (CW) radar, or an ultra-wideband (UWB) radar. The frequency modulated continuous wave radar is exemplified below for description.

Referring to FIG. **2**, FIG. **2** is a schematic diagram illustrating a radar signal. An upper half presents a change of an amplitude of the incident radar signal FH over time, and a lower half presents a change of a frequency of the incident radar signal FH over time. The incident radar signal FH includes a plurality of chirp pulses SC. For clarity of the diagram, FIG. **2** presents only one chirp pulse SC. The chirp pulse SC is a linear frequency modulated pulse signal herein, which is a sine wave whose frequency increases linearly over time. In some embodiments, the frequency of the chirp pulse SC increases non-linearly. For ease of description, a linear way is exemplified below for description. As shown in FIG. **2**, within a duration Tc (for example, 40 microseconds), the chirp pulse SC linearly increases from a start frequency (for example, 77 GHz) to a stop frequency (for example, 81 GHz) according to a slope S. The start frequency and the stop frequency may be selected from the millimeter wave band (that is, 30 GHz to 300 GHz). A difference between the start frequency and the stop frequency is a pulse bandwidth B.

FIG. **3** is a schematic block diagram of a radar system according to some embodiments. In some embodiments, the response device **40** includes a vibration unit **41** and a driving unit **42**. The vibration unit **41** has a reflecting surface serving as a radar cross section (RCS). The driving unit **42** drives the vibration unit **41** to vibrate at a vibration frequency, so that the incident radar signal FH is modulated under a movement of the reflecting surface. In other embodiments, the response device **40** includes a backscatter transponder. The incident radar signal FH is reflected through the reflecting surface. A frequency modulated continuous wave radar **10'** receives the reflected radar signal FN and demodulates the reflected radar signal FN to obtain a vibration frequency, a modulation frequency, or a change in a radar cross section of the response device **40**. Therefore, for response devices **40** having different vibration frequencies, modulation frequencies, or changes in a radar cross section, the frequency modulated continuous wave radar **10'** may identify a specific response device **40** by using the different vibration frequencies, modulation frequencies, or changes in the radar cross section as identification information. Approximate response devices **40** and subjects **90** can be determined through comparison by using distance information and orientation information (which are collectively referred to as range information), and a subject **90** to which monitored physiological information or speed information (which is collectively referred to characterization information) belongs can be determined. How to calculate the information is described below.

Refer to FIG. **3** and FIG. **4** together. FIG. **4** is a schematic diagram illustrating an incident radar signal FH and a reflected radar signal FN. The frequency modulated continuous wave radar **10'** includes a transmitting unit **11**, a receiving unit **12**, a demodulating unit **13**, an analog-to-digital converter **14**, and a processing unit **15**. The transmitting unit **11** is configured to transmit an incident radar signal FH, and includes a transmitting antenna and a signal synthesizer. The signal synthesizer is configured to generate an incident radar signal FH including a chirp pulse Ct, and transmit the incident radar signal through the transmitting antenna. The receiving unit **12** includes a receiving antenna configured to receive a reflected radar signal FN including a chirp pulse Cr. The chirp pulse Cr may be considered as a delayed chirp pulse Ct. The demodulating unit **13** is connected to the transmitting unit **11** and the receiving unit **12**, and includes a mixer and a low-pass filter. The mixer couples the chirp pulse Ct of the incident radar signal FH with the chirp pulse Cr of the reflected radar signal FN to generate two coupled signals which are respectively a sum of frequencies of the two chirp pulses Ct and Cr and a difference between the frequencies. The low-pass filter performs low-pass filtering on the coupled signal to remove high-frequency components, to obtain a coupled signal which is the difference between the frequencies of the two chirp pulses Ct and Cr, which is referred to as an "intermediate frequency signal SI" below. The analog-to-digital converter **14** converts the intermediate frequency signal SI to a digital signal. The processing unit **15** performs digital signal processing on the digital signal. The processing unit **15** may be, for example, a central processing unit (CPU), a graphics processing unit (GPU), or other programmable general-purpose or special-purpose microprocessors, a digital signal processor (DSP), a programmable controller, an application specific integrated circuit (ASIC), a programmable logic device (PLD), or other similar devices, chips, integrated circuits, and a combination thereof.

Referring to FIG. **4**, a frequency f_0 of the intermediate frequency signal SI may be expressed as equation 1. S is a slope, and τ is a delay time between transmission of the incident radar signal FH and reception of the reflected radar signal FN. Therefore, τ may be expressed as equation 2. d is a distance between a radar transmitting antenna and the to-be-monitored object, and c is the speed of light. Equation 3 may be obtained by substituting equation 2 into equation 1. It can be learned from equation 3 that the frequency f_0 of the intermediate frequency signal SI implicitly contains distance information (that is, a distance between the frequency modulated continuous wave radar **10'** and the to-be-monitored object).

$$f_0 = S \cdot \tau \quad \text{Equation 1}$$

$$\tau = 2d/c \quad \text{Equation 2}$$

$$f_0 = 2Sd/c \quad \text{Equation 3}$$

FIG. **5** is a schematic diagram of signal processing according to some embodiments. Chirp pulses SC are sequentially numbered as C**1**, C**2**, C**3**, . . . , Cn herein, where n is a positive integer. The analog-to-digital converter **14** converts received intermediate frequency signals SI corresponding to the chirp pulses C**1** to Cn to digital signals SD (which are respectively expressed as D**1**, D**2**, . . . , Dn, where n is a positive integer). A value of each of the digital signals SD may be expressed as a one-dimensional array (a row matrix). The row matrices are arranged longitudinally in sequence to form a two-dimensional array A**1**. It may be understood that the digital signals SD may also be arranged into column matrices and arranged horizontally in sequence to form a two-dimensional array. A value of the two-dimensional array A**1** represents a signal strength (an amplitude). Index values of the columns of the two-dimensional array A**1** correspond to the sequence of the chirp pulses SC (the digital signals SD). An index value of the row of the two-dimensional array A**1** has a time implication, that is, the row matrix of the two-dimensional array A**1** is a time-domain signal.

The processing unit **15** performs Fast Fourier transform (FFT) (which is referred to as "range Fast Fourier transform, range FFT" below) on each of the row matrices of the two-dimensional array A**1** (that is, the digital signal SD) to obtain frequency-domain signals SP (which are respectively expressed as P**1**, P**2**, . . . , Pn, where n is a positive integer), that is, the two-dimensional array A**2**. Therefore, the row matrices of the two-dimensional array A**2** are equivalent to spectral distribution. As described above, the frequency of the intermediate frequency signal SI implicitly contains the distance information. In other words, the index value of the row of the two-dimensional array A**2** has a distance implication. The values of the two-dimensional array A**2** represent strengths of frequencies on a spectrum, which can present strengths of radar signals reflected at different distances from the frequency modulated continuous wave radar **10'**. As shown in FIG. **5**, a colored box in the two-dimensional array A**2** is a peak value (that is, a value exceeding a threshold), indicating that there is a to-be-monitored object at a distance corresponding to the frequency. The distance between the frequency modulated continuous wave radar **10'** and the to-be-monitored object may be calculated based on the peak frequency. Further, movement information (such as an average speed) within a wide range may be calculated according to calculated distance changes of a specific to-be-monitored object at different time points.

A time interval between the chirp pulses SC is very short (for example, tens of microseconds). Relatively speaking, a position of the same to-be-monitored object that reflects the chirp pulses SC is substantially unchanged. Therefore, each frequency-domain signal SP has a colored box corresponding to the same distance, presenting a column of colored boxes. As shown in FIG. **5**, two columns of colored boxes are exemplified herein. Since the frequency-domain signals SP has a peak in the same column, a slight movement change cannot be embodied in the frequency, However, a phase component is significantly affected. The index values of the columns of the two-dimensional array A**2** correspond to the sequence of the frequency-domain signals SP (the chirp pulses SC), which mean a time sequence. Therefore, each column matrix of the two-dimensional array A**2** may be considered as a time-domain signal. The processing unit **15** performs Fast Fourier transform (which is referred to as "Doppler Fast Fourier transform, Doppler FFT" below) on each column matrix of the two-dimensional array A**2** to obtain phase frequency-domain signals SQ (which are respectively expressed as Q**1**, Q**2**, . . . , Qm, where m is a positive integer), that is, a two-dimensional array A**3**. Therefore, the column matrices of the two-dimensional array A**3** are equivalent to phase spectrum distribution. A phase ϕ_0 of the intermediate frequency signal SI may be expressed as equation 4. By substituting equation 2 into equation 4, equation 5 can be obtained. λ is a wavelength. According to equation 5, equation 6 can be derived. v is a speed, $\Delta\phi$ is a phase difference between two adjacent chirp pulses (Cn−1 and Cn), and Δt is a time difference between two adjacent chirp pulses SC. It can be learned from equation 6 that a phase of the intermediate frequency signal SI implicitly contains movement information (a speed). Therefore, an index value of the column of the two-dimensional array A**3** has a speed implication. A moving speed or a cyclic movement frequency of the to-be-monitored object may be calculated based on the phase frequency-domain signal SQ, so that movement information (such as speed information) and physiological information (such as a breathing rate and a heartbeat frequency) of the subject **90** and the vibration frequency, the modulation frequency, or the change in the radar cross section of the response device **40** can be obtained. In the two-dimensional array A**3** shown in FIG. **5**, two columns respectively have two colored boxes (peak values exceeding a threshold) and three colored boxes (peak values exceeding a threshold), indicating that there are at least two to-be-monitored objects at two different distances from the frequency modulated continuous wave radar **10'**. A speed (a frequency) corresponding to each of the colored boxes is small-range movement information (such as a speed), physiological information, a vibration frequency, a modulation frequency, or a change in a radar cross section corresponding to at least one of the to-be-monitored objects.

$$\phi_0 = 2\pi f_0 \tau \quad \text{Equation 4}$$

$$\phi_0 = \frac{4\pi d}{\lambda} \quad \text{Equation 5}$$

$$v = \frac{\lambda \Delta\phi}{4\pi \Delta t} \quad \text{Equation 6}$$

In some embodiments, the processing unit **15** may not perform the Fast Fourier transform on the entire two-dimensional array A**2**, but perform the Fast Fourier transform on only the same peak values of the frequency-domain

signals SP (which are two column matrices represented by colored boxes), to reduce an amount of calculation and a calculation time.

It may be understood from the above description that, after the intermediate frequency signal SI undergoes analog-to-digital conversion, the processing unit **15** performs digital signal processing on the intermediate frequency signal, so that the movement information and the physiological information (such as the breathing rate and the heartbeat frequency) of the subject **90** and the vibration frequency, the modulation frequency, or the change in the radar cross section of the response device **40** can be obtained.

In the above description, the transmitting unit **11** is exemplified as having one transmitting antenna and the receiving unit **12** as having one receiving antenna. However, in some embodiments, the transmitting unit **11** has a plurality of transmitting antennas for transmit a plurality of incident radar signals FH. The receiving unit **12** has one receiving antenna, and the receiving antenna receives a plurality of reflected radar signals FN corresponding to the incident radar signals FH. The reflected radar signals FN are demodulated into a plurality of intermediate frequency signals SI by the demodulating unit **13**. The analog-to-digital converter **14** converts the intermediate frequency signals SI to digital signals. The processing unit **15** performs digital signal processing on the digital signals, and obtains a direction (orientation information) of the to-be-monitored object (such as the subject **90** or the response device **40**) by using an angle of departure (AOD) direction-finding function. However, the present disclosure is not limited thereto. In some other embodiments, the frequency modulated continuous wave radar **10'** obtains the direction (the orientation information) of the to-be-monitored object (such as the subject **90** or the response device **40**) through a multiple signal classification (MUSIC) algorithm. In other embodiments, the frequency modulated continuous wave radar **10'** obtains the direction (the orientation information) of the to-be-monitored object (such as the subject **90** or the response device **40**) through a Capon algorithm.

In some embodiments, the transmitting unit **11** has one transmitting antenna for transmitting one incident radar signal FH. The receiving unit **12** has a plurality of receiving antennas for receiving reflected radar signals FN. The reflected radar signals FN are demodulated into a plurality of intermediate frequency signals SI by the demodulating unit **13**. The analog-to-digital converter **14** converts the intermediate frequency signals SI to digital signals. The processing unit **15** performs digital signal processing on the digital signals, and obtains a direction (orientation information) of the to-be-monitored object (such as the subject **90** or the response device **40**) by using an angle of arrival (AOA) direction-finding function.

FIG. **6** is a partial perspective view of a first variation of the response device according to some embodiments. In the embodiments, the response device **40** includes a vibration unit **41**. The vibration unit **41** may be a vibrator, and an upper surface thereof serves as a reflecting surface **43**. The response device **40** further includes a driving unit **42**. The driving unit **42** has a driving circuit and is connected to the vibration unit **41** for controlling the vibrator to vibrate at a vibration frequency.

FIG. **7** is a perspective view of a second variation of the response device according to some embodiments. In the embodiments, the response device **40** includes a vibration unit **41**. The vibration unit **41** may be a speaker driver, such as a moving-coil speaker driver or a flat panel speaker driver. As shown in FIG. **3**, the response device **40** further includes a driving unit **42**. In these embodiments, the driving unit **42** has an oscillation control circuit for driving the speaker driver and controlling a vibration frequency of a diaphragm of the speaker driver. The diaphragm serves as the reflecting surface **43** herein, and the reflecting surface **43** may have a metal reflecting layer to enhance a reflection effect.

FIG. **8** is a perspective view of a third variation of the response device according to some embodiments. In the embodiments, the response device **40** includes a vibration unit **41**. A difference from FIG. **7** is that the diaphragm (that is, the reflecting surface **43**) includes a plurality of corner reflectors **44** arranged adjacent to each other. Each of the corner reflectors **44** is a dihedral corner reflector herein, which is composed of two surfaces perpendicular to each other. In this way, the incident radar signal FH and the reflected radar signal FN can be parallel to each other, and the reflection effect can be enhanced, helping the frequency modulated continuous wave radar **10'** receive the reflected radar signal FN.

FIG. **9** is a perspective view of a fourth variation of the response device according to some embodiments. In the embodiments, the response device **40** includes a vibration unit **41**. A difference from FIG. **8** is that the corner reflector **44** is a trihedral corner reflector, which is composed of three surfaces perpendicular to each other. Similarly, the incident radar signal FH and the reflected radar signal FN can be parallel to each other, and the reflection effect can be enhanced, helping the frequency modulated continuous wave radar **10'** receive the reflected radar signal FN.

FIG. **10** is a schematic diagram of a fifth variation of the response device **40** according to some embodiments. In the embodiments, the response device **40** includes a backscatter transponder **45**. The backscatter transponder **45** includes two main lines **51** and a plurality of branch lines **52** side by side. The main line **51** is configured to receive a bias voltage. The branch lines **52** are connected between the two main lines. The branch lines **52** each are provided with a phase shift switch diode (PIN diode) and a matching resistor. Biasing of the phase shift switch diode may cause the formation of a frequency selective surface (FSS) for frequency modulation. A backscatter response to the incident radar signal FH may be modulated by using a radar cross section (RCS) of the frequency selective surface. Therefore, the reflected radar signal FN will have a modulation frequency of the backscatter transponder **45**. In this way, the frequency modulated continuous wave radar **10'** can obtain the modulation frequency (the change in the radar cross section) of the backscatter transponder **45** through the above signal processing, so as to identify the response device **40**.

FIG. **11** is a schematic block diagram of a sixth variation of the response device **40** according to some embodiments. In the embodiments, the response device **40** includes an active backscatter transponder **46** for modulating the incident radar signal FH according to a modulation frequency. The active backscatter transponder **46** includes an antenna **61**, matching networks **62** and **63**, a low noise amplifier **64**, a resonator **65**, a phase shifter **66**, a power amplifier driver **67**, a power amplifier **68**, and a signal generator **69**. The antenna **61** receives the incident radar signal FH. The matching networks **62** and **63** are used for impedance matching. The incident radar signal FH is processed by the low noise amplifier **64** to resonate with the resonator **65**, and is then amplified through the power amplifier driver **67** and the power amplifier **68** after phase compensation by the phase shifter **66**. The signal generator **69** generates a control signal for switching the power amplifier **68** at a modulation frequency, so as to transmit the signal amplified by the

power amplifier **68** through the antenna **61**. Therefore, the reflected radar signal FN will have the modulation frequency of the backscatter transponder **45**. In this way, the frequency modulated continuous wave radar **10'** can obtain the modulation frequency (the change in the radar cross section) of the backscatter transponder **45** through the above signal processing, so as to identify the response device **40**. More specifically, the frequency modulated continuous wave radar **10'** may first find two distance frequencies corresponding to the modulation frequency (an identity frequency) of the active backscatter transponder **46** after performing signal processing (range FFT), and then add up and average the two distance frequencies to obtain an actual distance frequency, and subtract and average the two distance frequencies to obtain the modulation frequency (the identity frequency).

In the above description, the vibration frequency, the modulation frequency, or the change in the radar cross section of the response device **40** is exemplified as a single frequency. As shown in Table 1, the vibration frequency, the modulation frequency, or the change in the radar cross section of each response device **40** in any time period remains constant. However, in some embodiments, the vibration frequency, the modulation frequency, or the change in the radar cross section of the response device **40** is a time-varying frequency. In other words, the vibration frequency, the modulation frequency, or the change in the radar cross section of the response device is changed in different time periods. As shown in Table 2, each response device **40** has a different frequency combination. In this way, digital encoding achieved by using frequency changes can be formed. By setting different codes for different response devices **40**, the frequency modulated continuous wave radar **10'** can identify the response devices **40**. Table 3 presents another encoding manner. No-response (for example, stop oscillating) (marked as NA) within some time periods may also be used as a coding form. Table 4 presents still another encoding manner. The vibration frequency, the modulation frequency, or the change in the radar cross section may be set to a fixed single frequency, and different response devices **40** are set to respond in different time period combinations.

TABLE 1

	First time period	Second time period	Third time period	Fourth time period	Fifth time period
Response device A	F1	F1	F1	F1	F1
Response device B	F2	F2	F2	F2	F2
Response device C	F3	F3	F3	F3	F3

TABLE 2

	First time period	Second time period	Third time period	Fourth time period	Fifth time period
Response device A	F1	F2	F1	F1	F3
Response device B	F2	F3	F2	F2	F3
Response device C	F3	F2	F1	F1	F1

TABLE 3

	First time period	Second time period	Third time period	Fourth time period	Fifth time period
Response device A	F1	F2	NA	F1	F3
Response device B	F2	F3	NA	F3	NA
Response device C	F3	NA	F2	F1	F3

TABLE 4

	First time period	Second time period	Third time period	Fourth time period	Fifth time period
Response device A	F1	NA	NA	F1	NA
Response device B	F1	F1	NA	F1	F1
Response device C	F1	NA	F1	NA	NA

FIG. **12** is a schematic diagram of a use state of a radar system according to some embodiments. Elements and signals with similar functions are represented by using the same symbol herein for simplicity, and the above demodulating unit **13**, analog-to-digital converter **14**, and processing unit **15** are collectively referred to as a signal processing module **16**, and the transmitting unit **11** and the receiving unit **12** are collectively referred to as a transceiver.

In another embodiment of the present disclosure, the frequency modulated continuous wave radar **10'** further includes a transmitting module connected to the signal processing module **16**. The transmitting module is configured to transmit a result obtained through digital signal processing by the signal processing module **16** to an edge device or a cloud server at the other end.

In another embodiment of the present disclosure, the signal processing module **16** of the frequency modulated continuous wave radar **10'** only processes some of the digital signals SD from the analog-to-digital converter **14**, and processing results of some of the digital signals are transmitted to the edge device or the cloud server at the other end through a transmitting module of the frequency modulated continuous wave radar **10'** for subsequent digital signal processing and calculation.

In another embodiment of the present disclosure, the signal processing module **16** of the frequency modulated continuous wave radar **10'** does not process the digital signals SD from the analog-to-digital converter **14**. Instead, the digital signals SD from the analog-to-digital converter **14** are transmitted to the edge device or the cloud server at the other end through a transmitting module of the frequency modulated continuous wave radar **10'** for digital signal processing and calculation.

Refer to FIG. **12** and FIG. **13** together. FIG. **13** is a flowchart of a radar signal processing method for monitoring and identifying characterization information of the plurality of to-be-monitored objects according to some embodiments. In step **S110**, the transmitting unit **11** transmits at least one incident radar signal FH to a field, and the above receiving unit receives at least one reflected radar signal FN corresponding to the field. The field has the above to-be-monitored object (that is, one or more subjects **90** and respective response devices **40**). In step **S120**, the signal processing module **16** processes the reflected radar signals FN to obtain a response characteristic corresponding to each of the plurality of to-be-monitored objects (that is, the above physiological information of the subject **90** or the above vibration frequency, modulation frequency, or change in a radar cross

section of the response device **40**) and range information (that is, the above distance information and/or the orientation information). In other embodiments, if the to-be-monitored subject is the above subject **90**, the above subject **90** may further correspond to a plurality of response characteristics (for example, a plurality of pieces of characterization information of the same subject **90**, such as breathing information, heartbeat information, and speed information).

In some embodiments, the signal processing module **16** converts the reflected radar signals FN (the chirp pulses C**1** to Cn) to a plurality of intermediate frequency signals SI, converts the intermediate frequency signals SI corresponding to the chirp pulses C**1** to Cn to a plurality of digital signals SD, performs range FFT on the digital signals SD, and finds a specific frequency (a peak frequency) exceeding a set strength from a frequency domain obtained through the range FFT. The signal processing module **16** then calculates range of the to-be-monitored object (such as the subject **90** or the response device **40**) based on a time difference between chirps corresponding to specific frequencies. The signal processing module **16** then performs Doppler FFT on data of specific frequencies that exceed the set strength, and calculates at least one peak value of a corresponding phase frequency. The at least one peak value is a corresponding vibration characteristic of the to-be-monitored object (including a breath and a heartbeat, the vibration frequency, the modulation frequency, or the radar cross section of the response device, or a movement mode of the to-be-monitored object, etc.). In some embodiments, the signal processing module **16** performs digital signal processing on the digital signals, and obtains a direction (orientation information) of the to-be-monitored object (such as the subject **90** or the response device **40**) by using an angle of arrival (AOA) direction-finding function.

In step S**130**, the signal processing module **16** may distinguish the response characteristic of each of the plurality of to-be-monitored objects as identification information or physiological information according to a frequency value. For example, the breathing rate is generally 12-20 times per minute, and the heartbeat frequency is generally 60-100 times per minute. The vibration frequency, the modulation frequency, or the change in the radar cross section of the response device **40** may be set to a frequency value (for example, a frequency value of a plurality of orders of magnitudes) completely different from the breathing rate and the heartbeat frequency. In step S**140**, the signal processing module **16** labels each piece of physiological information according to the range information and the identification information. In this way, a subject **90** to which the obtained physiological information corresponds can be learned according to the label. In this embodiment, the response device **40** is disposed on the subject **90**.

In some embodiments, the signal processing module **16** distinguishes the response characteristic of each of the plurality of to-be-monitored objects as identification information or characterization information (such as physiological information and speed information). The signal processing module **16** labels each piece of characterization information according to the range information and the identification information. In this way, a subject **90** to which the obtained physiological information corresponds can be learned and a moving object to which the obtained speed information corresponds can be learned according to the label. The moving object may be an object or a living body that is moving.

In some embodiments, the response device **40** is disposed adjacent to the subject **90**, including but not limited to, at a specific sickbed in a multi-person room, a specific position in the field, or a specific orientation in the field. In some embodiments, the response device **40** serves as a group tag for labelling a plurality of to-be-monitored objects corresponding to the same range information. The range information may be distance information and/or orientation information.

FIG. **14** is a detailed flowchart of a physiological information monitoring and identification method according to some embodiments. After the above step S**130**, if the response characteristic is the identification information, the signal processing module **16** determines that the to-be-monitored object associated with the identification information is a response device **40** (step S**131**). If the response characteristic is the physiological information, the signal processing module **16** determines that the to-be-monitored object associated with the identification information is a living body (that is, the above subject **90**), and identifies the response characteristic as the physiological information of the living body (step S**132**).

The above step S**140** includes step S**141** and step S**142**. In step S**141**, the signal processing module **16** determines whether the range information of each of the living bodies (a subject **90**) matches the range information of each of the response devices **40**. In other words, it is determined whether the subject **90** and the response device **40** are adjacent according to the range information of the subject **90** and the range information of the response device **40**. If they are adjacent, it is determined that the two pieces of range information match each other.

In step S**142**, in response to the range information of the specific living body (the subject **90**) matching the range information of the specific response device **40**, physiological information of the specific living body (the subject **90**) is labelled by using identification information of the specific response device **40**. In other embodiments, similarly, the above physiological information monitoring and identification method may be further applied to monitoring and identification of the characterization information (such as speed information) of a specific to-be-monitored object (which may be, but is not limited to, the subject **90**). Specifically, a moving speed of a moving object or a moving living body is monitored and identified.

FIG. **15** is another flowchart of the radar signal processing method according to some embodiments, which may be performed by the above radar system or by an edge device or a cloud server. In other words, after being converted to a digital signal SD (or referred to as radar digital monitoring data) by the signal processing module **16**, the above reflected radar signal FN continues to be processed by the signal processing module **16** or is transmitted to the edge device or the cloud server for processing. In step S**210**, the radar digital monitoring data is received. Step S**220** to step S**240** are processing performed according to the received radar digital monitoring data, and the processing steps are the same as the above step S**120** to step S**140**. Details are not repeated herein. It may be understood that, as shown in FIG. **14**, the method may specifically further include steps S**131**, S**132**, S**141**, and S**142**.

In conclusion, according to the radar system in some embodiments, the physiological information of the subject **90** may be measured, and the physiological information is labelled through identification information of an identification and response device **40** of the radar, so as to learn an identity of the subject **90**.

What is claimed is:

1. A physiological information monitoring and identification method, comprising:

transmitting a plurality of incident radar signals to a plurality of to-be-monitored objects of a field, wherein the to-be-monitored objects includes at least one response device and at least one living body;

receiving a first reflected radar signal corresponding to each of the response devices of the field and a second reflected radar signal corresponding to each of the living bodies of the field;

processing each of the first reflected radar signals, by performing a Doppler FFT process, as a first phase frequency-domain signal;

processing each of the second reflected radar signals, by performing the Doppler FFT process, as a second phase frequency-domain signal;

respectively obtaining a response characteristic from the first phase frequency-domain signal and the second phase frequency-domain signal;

processing each of the first reflected radar signals and each of the second reflected radar signals, by performing a range FFT process and a direction-finding process, to obtain range information corresponding to each of the plurality of to-be-monitored objects;

distinguishing the response characteristic of the first phase frequency-domain signal as an identification and distinguishing the response characteristic of the second phase frequency-domain signal as a physiological information; and

labelling each piece of physiological information according to the range information and identification information, wherein the identification information is a time-varying frequency.

2. The physiological information monitoring and identification method according to claim 1, wherein the range information comprises distance information or orientation information.

3. The physiological information monitoring and identification method according to claim 1, further comprising:

in response to the response characteristic being the identification information, determining that the to-be-monitored object associated with the identification information is the response device.

4. The physiological information monitoring and identification method according to claim 3, wherein the identification information is a vibration frequency of the response device or a change in a radar cross section of the response device.

5. The physiological information monitoring and identification method according to claim 1, further comprising:

in response to the response characteristic being the physiological information, determining that the to-be-monitored object associated with the physiological information is the living body, and identifying the response characteristic as the physiological information of the living body.

6. The physiological information monitoring and identification method according to claim 5, further comprising: in response to the response characteristic being the identification information, determining that the to-be-monitored object associated with the identification information is the response device; wherein

the step of labelling each piece of physiological information according to the range information and the identification information comprises:

determining whether the range information of each of the living bodies matches the range information of each of the response devices; and

in response to the range information of a specific living body matching the range information of a specific response device, labelling the physiological information of the specific living body by using the identification information of the specific response device.

7. The physiological information monitoring and identification method according to claim 1, wherein each of the incident radar signals is a frequency modulated radar signal.

8. The physiological information monitoring and identification method according to claim 1, wherein the response device includes a vibration unit and a driving unit, the driving unit controls the vibration unit to vibrate at a vibration frequency, the vibration unit has a reflecting surface, the reflecting surface includes a plurality of corner reflectors arranged adjacent to each other.

9. The physiological information monitoring and identification method according to claim 1, wherein the response device includes an active backscatter transponder, the backscatter transponder includes an antenna, matching networks, a low noise amplifier, a resonator, a phase shifter, a power amplifier driver, a power amplifier and a signal generator, the antenna receives each of the incident radar signals, the matching networks is for impedance matching, a received incident radar signal is processed by the low noise amplifier to resonate with the resonator, and is then amplified through the power amplifier driver and the power amplifier after phase compensation by the phase shifter, the signal generator generates a control signal for switching the power amplifier at a modulation frequency, so as to transmit the signal amplified by the power amplifier as the first reflected radar signal through the antenna.

10. A radar signal processing method for monitoring and identifying characterization information of a plurality of to-be-monitored objects, comprising:

receiving at least one piece of first radar digital monitoring data corresponding to at least one response device in a plurality of to-be-monitored objects, at least one piece of second radar digital monitoring data corresponding to at least one living body in the plurality of to-be-monitored objects and at least one piece of third radar digital monitoring data corresponding to at least one moving object in the plurality of to-be-monitored objects;

processing each piece of the first radar digital monitoring data, by performing a Doppler FFT process, as a first phase frequency phase-domain signal;

processing each piece of the second radar digital monitoring data, by performing the Doppler FFT process, as a second phase frequency phase-domain signal;

processing each piece of the third radar digital monitoring data, by performing the Doppler FFT process, as a third phase frequency phase-domain signal;

respectively obtaining a response characteristic from the first phase frequency-domain signal, the second phase frequency-domain signal and the third phase frequency-domain signal;

processing each piece of the first radar digital monitoring data, each piece of the second radar digital monitoring data and each piece of the third radar digital monitoring data, by performing a range FFT process and a direction-finding process, to obtain range information corresponding to each of the plurality of to-be-monitored objects;

distinguishing the response characteristic of the first phase frequency-domain signal as an identification and distinguishing the response characteristics of the second phase frequency-domain signal and the third phase frequency-domain signal as characterization information; and

labelling each piece of characterization information according to the range information and identification information, wherein the identification information is a time-varying frequency.

11. The radar signal processing method according to claim **10**, wherein the range information comprises distance information or orientation information.

12. The radar signal processing method according to claim **10**, further comprising:

in response to the response characteristic being the identification information, determining that the to-be-monitored object associated with the identification information is the response device.

13. The radar signal processing method according to claim **12**, wherein the identification information is a vibration frequency of the response device or a change in a radar cross section of the response device.

14. The radar signal processing method according to claim **10**, further comprising:

in response to the response characteristic being the characterization information, further distinguishing the characterization information of the second phase frequency-domain signal as physiological information; and

in response to the response characteristic being the physiological information, determining that the to-be-monitored object associated with the physiological information is the living body, and identifying the response characteristic as the physiological information of the living body.

15. The radar signal processing method according to claim **10**, further comprising:

in response to the response characteristic being the characterization information, further distinguishing the characterization information of the third phase frequency-domain signal as speed information; and

in response to the response characteristic being the speed information, determining that the to-be-monitored object associated with the speed information is the moving object and identifying the response characteristic as the speed information of the moving object.

16. The radar signal processing method according to claim **14**, further comprising: in response to the response characteristic being the identification information, determining that the to-be-monitored object associated with the identification information is the response device; wherein

the step of labelling each piece of characterization information according to the range information and the identification information comprises:

determining whether the range information of each of the living bodies matches the range information of each of the response devices; and

in response to the range information of a specific living body matching the range information of a specific response device, labelling the physiological information of the specific living body by using the identification information of the specific response device.

17. The radar signal processing method according to claim **10**, wherein the response device includes a vibration unit and a driving unit, the driving unit controls the vibration unit to vibrate at a vibration frequency, the vibration unit has a reflecting surface, the reflecting surface includes a plurality of corner reflectors arranged adjacent to each other.

18. The radar signal processing method according to claim **10**, wherein the response device includes an active backscatter transponder, the backscatter transponder includes an antenna, matching networks, a low noise amplifier, a resonator, a phase shifter, a power amplifier driver, a power amplifier and a signal generator, the antenna receives an incident radar signal, the matching networks is for impedance matching, the incident radar signal is processed by the low noise amplifier to resonate with the resonator, and is then amplified through the power amplifier driver and the power amplifier after phase compensation by the phase shifter, the signal generator generates a control signal for switching the power amplifier at a modulation frequency, so as to transmit the signal amplified by the power amplifier as the first radar digital monitoring data through the antenna.

19. A physiological information monitoring radar, comprising:

a transceiver configured to transmit a plurality of incident radar signals to a plurality of to-be-monitored objects of a field and receive a first reflected radar signal corresponding to each of the response devices of the field and a second reflected radar signal corresponding to each of the living bodies of the field, wherein the to-be-monitored objects includes at least one response device and at least one living body; and

a signal processing module configured to process each of the first reflected radar signals, by performing a Doppler FFT process, as a first phase frequency-domain signal, process each of the second reflected radar signals, by performing the Doppler FFT process, as a second phase frequency-domain signal, respectively obtain a response characteristic from the first phase frequency-domain signal and the second phase frequency-domain signal, process each of the first reflected radar signals and each of the second reflected radar signals, by performing a range FFT process and a direction-finding process, to obtain range information corresponding to each of the plurality of to-be-monitored objects, distinguish the response characteristic of the first phase frequency-domain signal as an identification, distinguish the response characteristic of the second phase frequency-domain signal as a physiological information, and label each piece of physiological information according to the range information and identification information, wherein the identification information is a time-varying frequency.

20. The physiological information monitoring radar according to claim **19**, wherein the range information comprises distance information or orientation information.

21. The physiological information monitoring radar according to claim **19**, wherein in response to the response characteristic being the identification information, the signal processing module determines that the to-be-monitored object associated with the identification information is the response device.

22. The physiological information monitoring radar according to claim **21**, wherein the identification information is a vibration frequency of the response device or a change in a radar cross section of the response device.

23. The physiological information monitoring radar according to claim **19**, wherein in response to the response characteristic being the physiological information, the signal processing module determines that the to-be-monitored object associated with the physiological information is the

living body, and identifies the response characteristic as the physiological information of the living body.

24. The physiological information monitoring radar according to claim **23**, wherein in response to the response characteristic being the identification information, the signal processing module determines that the to-be-monitored object associated with the identification information is the response device and determines whether the range information of each of the living bodies matches the range information of each of the response devices, and in response to the range information of a specific living body matching the range information of a specific response device, the signal processing module labels the physiological information of the specific living body by using the identification information of the specific response device.

25. The physiological information monitoring radar according to claim **19**, wherein the response device includes a vibration unit and a driving unit, the driving unit controls the vibration unit to vibrate at a vibration frequency, the vibration unit has a reflecting surface, the reflecting surface includes a plurality of corner reflectors arranged adjacent to each other.

26. The physiological information monitoring radar according to claim **19**, wherein the response device includes an active backscatter transponder, the backscatter transponder includes an antenna, matching networks, a low noise amplifier, a resonator, a phase shifter, a power amplifier driver, a power amplifier and a signal generator, the antenna receives each of the incident radar signals, the matching networks is for impedance matching, a received incident radar signal is processed by the low noise amplifier to resonate with the resonator, and is then amplified through the power amplifier driver and the power amplifier after phase compensation by the phase shifter, the signal generator generates a control signal for switching the power amplifier at a modulation frequency, so as to transmit the signal amplified by the power amplifier as the first reflected radar signal through the antenna.

* * * * *