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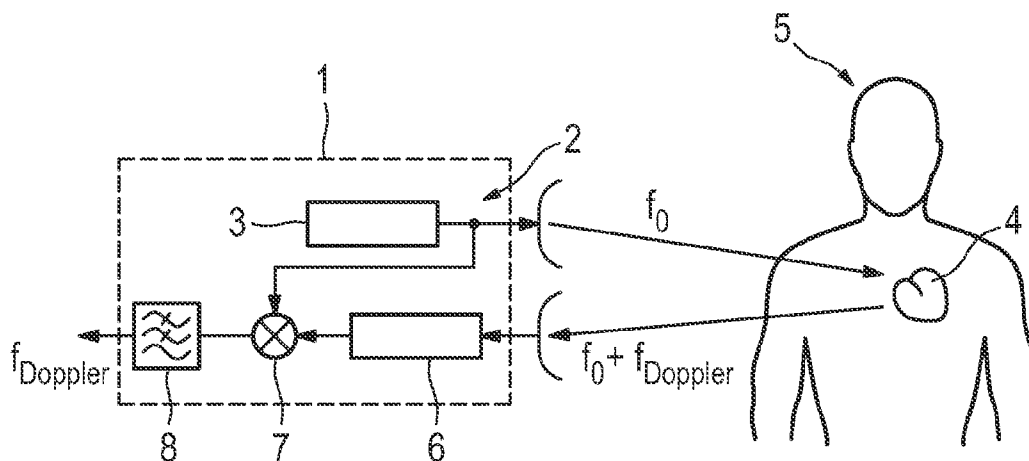


FIG. 1

(57) Abstract: The present invention relates to a method and system for identifying a subject (5). In order to provide biometric identification technology, which is highly accurate, non-invasive, simple to implement, and resistant to spoofing, a method is suggested, comprising the following steps: carrying out a Doppler radar measurement to obtain a Doppler radar signal (9) representing information on the mechanical activity of an inner part (4) of the subject's body, e.g. the subject's heart; determining the characteristics of said mechanical activity from said Doppler radar signal (9); and identifying that subject (5) using said characteristics.

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Method and system for identifying a subject

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The present invention relates to a method and system for identifying a subject.

During the last years more and more emphasis is placed on security at borders, airports, and workplaces. Furthermore, enterprises today are looking for more
10 secure ways to identify users who log on to public or private networks, or who carry out financial transactions over the Internet. For these purposes biometric measures can be employed.

Biometric identification and authentication is a relatively new field of science, dealing with the determination or verification of individual identity of subjects,
15 e.g. humans, using their physiological characteristics. Biometric authentication characteristics, unlike identification codes or passwords, cannot be lost, forgotten or transferred and are always in possession of the individual.

The classic biometric measures were rather simple to acquire from a person, like body height or colour of the eyes. In the second half of the nineteenth
20 century fingerprints were introduced for the purpose of identifying people, which is still today certainly the most important biometric measure used. Modern fingerprint sensors and eye scanners are offered by several manufacturers. In principle an optical detector is used in these devices, capturing the fine pattern of the ridges in the skin surface or of the iris.

25 More recent developments concentrate on the investigation of electrophysiological signals of a person, like the electrocardiogram (ECG). The ECG is widely investigated as a biometric signal for the purpose of identifying a person. Research shows that feature extraction and template matching, together with a decision-based neural network, can provide a highly reliable identification of individuals in
30 groups.

All the techniques mentioned above suffer from one or more disadvantages, e.g. they require (skin) contact to the subject under examination, they are expensive, they are not very accurate, or they are easy to deceive.

It is therefore an object of the present invention to provide a biometric
5 identification technology, which is highly accurate, non-invasive, simple to implement, and resistant to spoofing.

This object is achieved according to the invention by a method of identifying a subject, the method comprising the steps of carrying out a Doppler radar measurement to obtain a Doppler radar signal representing information on the
10 mechanical activity of an inner part of the subject's body; determining the characteristics of said mechanical activity from said Doppler radar signal; and identifying the subject using said characteristics.

The object of the present invention is also achieved by a system for identifying a subject, the system comprising a Doppler radar measurement unit adapted
15 for obtaining a Doppler radar signal representing information on the mechanical activity of an inner part of the subject's body; a signal processing and analyzing unit adapted for determining the characteristics of said mechanical activity from said Doppler radar signal; and an identifying unit adapted for identifying the subject using said characteristics.

20 The object of the present invention is also achieved by a computer program for such a system, the computer program comprising computer instructions to determine the characteristics of said mechanical activity from said Doppler radar signal, and computer instructions to identify the subject using said characteristics, when the computer program is executed in a computer.

25 It has been found that in very much the same way that the ECG is unique to a person, the movement of the heart is also unique to a person. Therefore, a core idea of the invention is not to use an electrophysiological measurement (like ECG), but to observe the mechanical motion of an inner part of the subject, in particular the mechanical motion of an inner organ, in particular the heart, or other parts of a subject's
30 body for unambiguously identifying that subject.

A core idea of the invention is therefore to obtain information on the

mechanical motion of an inner part of the subject (e.g. the subject's heart) with the help of a Doppler radar measurement. An electromagnetic radar wave is sent into the body where it is reflected at boundary layers that separate areas with different electrical conductivities inside the subject's body. The frequency of the reflected signal is shifted
5 with respect to the frequency of the incoming signal if the boundary layer moves (Doppler shift). The most distinctive changes in electrical conductivity occur at the inner organs like the heart, because the organs contain significant amounts of blood that is rather conductive, compared to the surrounding area. So the Doppler radar signal reflected at the inner organs represents direct information on the mechanical activity of
10 these organs.

The present invention provides unprecedented biometric information on the mechanical activity of inner organs, in particular the heart, in order to uniquely identify a person. No skin contact is required, in contrast to an ECG measurement. Thus, another core idea of the invention is to use the characteristic features of the mechanical
15 activity of the inner parts of the subject, obtained by means of Doppler radar measurement, for identification purposes, i.e. to identify subjects.

The present invention can preferably be applied in biometric identification systems and for authorization purposes for humans, e.g. in access control points, in airports, railway stations, bus terminals, etc. Furthermore the invention can be used to
20 identify animals, like dogs, racehorses, etc. This identification technique is not only highly accurate and non-invasive, but also simple to implement. Furthermore the technique is resistant to spoofing.

These and other aspects of the invention will be further elaborated on the basis of the following embodiments which are defined in the dependent claims.

25 In order to enhance the reliability of identification it is proposed, according to preferred embodiments of the invention, to exploit the fact that certain organs like the heart perform a periodic motion, and to investigate the characteristics of that motion. It is therefore part of this invention to apply a signal processing technique that allows e.g. for identifying the characteristic points in time when the organ under
30 investigation (e.g. the heart) is shortly at rest during its periodic motion. Other features, which can preferably be determined in order to identify the subject, are the morphologic

features of the Doppler radar signal, the heart phase pattern (or the phase pattern of any other inner organ performing a periodic movement), the heart resting points (or the resting point of any other inner organ performing a periodic movement), and the position of the heart within the subject's body (or the position of any other inner organ).

5 These and other aspects of the invention will be described in detail hereinafter, by way of example, with reference to the following embodiments and the accompanying drawings; in which:

Fig.1 shows a schematic illustration of a subject and a system according to the invention,

10 Fig. 2 shows two charts illustrating a Doppler radar signal and a corresponding ECG signal,

Fig. 3 shows a schematic block diagram of a system according to the invention,

15 Fig. 4 shows a chart illustrating the phasing of output signals in case of a target moving away from the RF transceiver module,

Fig. 5 shows a chart illustrating a the phasing of output signals in case of a target approaching the RF transceiver module,

Fig. 6 shows a chart illustrating output signals for different target distances,

20 Fig. 7 shows a chart illustrating resulting Lissajous figures for different target distances,

Fig. 8 shows a schematic block diagram of the analysing unit according to the invention.

First, a general setup and method according to the invention will be
25 described with respect to Figs. 1 and 2. In a first embodiment of the invention a Doppler radar measurement unit 1 is used. The Doppler radar measurement unit 1 comprises a radio frequency (RF) transceiver module 2, which operates at radio frequencies as high as 2,45 GHz, which has been identified as a very useful frequency for the purpose of the present invention. The main lobe of the electromagnetic waves emitted by a transmitter 3
30 of the RF transceiver module 2 is directed towards the object under examination, e.g. the heart 4 of a person 5. For this purpose the RF transmitter 3 is positioned near the object

under examination, e.g. a person's heart 4. The frequency of the electromagnetic waves reflected by the object (e.g. the heart 4) is shifted with respect to the frequency f_0 of the emitted waves. The frequency shift f_{Doppler} is related to the velocity v of the object:

$$f_{\text{Doppler}} = \pm f_0 \cdot \frac{2 \cdot v}{c}$$

5 with f_0 being the frequency of the electromagnetic wave emitted by the RF transmitter 3, and v being the velocity of the object approaching the RF transmitter 3 or departing from it, resulting in a positive or negative frequency shift, respectively. A RF receiver 6 located close to the RF transmitter 3 receives the electromagnetic waves reflected by the object.

10 The Doppler radar measurement unit 1 further comprises a mixer 7 and a lowpass filter 8. Mixing emitted and received frequencies by means of the mixer 7 and further use of the lowpass filter 7 yields an output signal exhibiting the Doppler frequency f_{Doppler} , thereby providing information on how fast the object, e.g. the person's heart 4, moves with respect to the RF transceiver module 2. Uniform movements result
15 in a single-frequency sine wave output; complex movements result in a wide spectrum of output frequencies. In the following this output signal is also called Doppler radar signal 9. Subsequently, the results of such measurements are investigated. For this purpose the Doppler radar signal is transferred from the Doppler radar measurement unit 1 to a signal processing and analyzing unit 10 (not shown in Fig. 1).

20 Fig. 2 shows the Doppler radar signal 9 together with an ECG signal 11 of the same person 5, which has been recorded simultaneously. The correlation between the two signals 9, 11 is obvious. The dashed vertical lines 12 in Fig. 2 mark the different phases of the heart cycle. The duration of these phases give a characteristic pattern. As explained in more detail below, this pattern, combined with morphologic features
25 extracted from the Doppler radar signal 9, is used according to the invention for the unique identification of the person 5.

In the following a more detailed explanation of the system and method according to the present invention is given. In order to enhance the reliability of the method movement information is extracted from the received Doppler radar signal 9.
30 Such movement information is very characteristic of inner organs (lungs, heart, etc.), undergoing a periodic movement inside the subject's body. By way of example, system

and method of the present invention will be described with respect to a person's heart 4. In practice the RF transceiver module 2 of the Doppler radar measurement unit 1 will be placed on the person's chest. The RF transceiver module 2 is preferably placed on the chest in a way that there is no relative movement between the chest and the RF

5 transceiver module 2. For the purpose of the invention a skin contact is not required, i.e. the RF transceiver module 2 can be placed on clothing.

In the present invention a signal processing technique is provided by the signal processing and analyzing unit 10, which allows to identify the moments in time when the heart 4 is shortly at rest during the cardiac cycle. Those moments cannot be

10 seen in any electrophysiological measurement, which renders this signal processing technique extremely valuable.

In order to identify those moments in time when there is no motion of the periodically moving heart 4 under investigation, a special radar setup is chosen. Fig. 3 shows a schematic block diagram of the required Doppler radar measurement unit 1,

15 which, according to a preferred embodiment of the invention, is used in order to derive information on the mechanical activity of the heart 4.

A characteristic feature of the Doppler radar measurement unit 1 is the use of two mixer units M_1 , M_2 . The mixer units M_1 , M_2 are driven by the same oscillator OS, but with a defined phase difference. This makes it possible to recognize the direction

20 of movement, i.e. if the target is receding or approaching the RF transceiver module 2. Such a Doppler radar module is for example the KMY24 type module by Micro Systems Engineering GmbH (Germany), which is commercially available.

The following elements are shown in Fig. 3: OS is an oscillator operating at the frequency $\omega_0 = 2\pi f_0$; M_1 and M_2 are two mixers, each with two inputs and one

25 output; A_S and A_R are the sending antenna and the receiving antenna, respectively; v is the velocity of the target (i.e. the velocity of the heart 4). The four blocks named PS are phase shifters, and Φ_1 and Φ_2 are the phase shifts introduced by these phase shifters PS, wherein Φ_1 is a fixed phase shift of 90° , and Φ_2 is a variable phase shift, that is because Φ_2 does not only contain a fixed part, but also contains information about the distance

30 between the antennas A_S , A_R and the heart 4, which is variable. From the two mixer units M_1 , M_2 a signal $s_1(t)$ and a signal $s_2(t)$ derive, having the same frequency f_{Doppler} , but

different phasing, as explained in more detail below. Subsequent to the mixer units M_1 , M_2 the signals $s_1(t)$ and $s_2(t)$ pass a lowpass filter (not shown), in which the resulting sum frequencies are blocked. Only the difference frequencies pass, resulting to output signals $s_{1LP}(t)$ and $s_{2LP}(t)$. These output signals $s_{1LP}(t)$ and $s_{2LP}(t)$ are fed into the signal
 5 processing and analyzing unit 10 (not shown in Fig. 3).

The signal processing technique of the present invention requires the calculation of the time derivatives of the two output signals $s_{1LP}(t)$ and $s_{2LP}(t)$ delivered by the setup illustrated in Fig. 3. The criterion found for the identification of those moments in time, when the heart rests shortly during a periodic motion, says that both
 10 time derivatives must then be zero. The signal theory behind the system and method according to the present invention is described in detail below.

The oscillator OS produces a sine wave signal that can be described with the following equation:

$$s(t) = \sin(\omega_0 \cdot t)$$

15 The signal $s_1(t)$ is the result of a multiplication (M_1). The oscillator signal $s(t)$, shifted by Φ_1 , is the first input to this multiplication. This first input signal is shifted by Φ_2 , reflected at the target and Doppler shifted in frequency. Travelling back gives another shift by Φ_2 , and the result is fed to the mixer M_1 as the second input. The mixer's output signal can therefore be described with the following equation:

20

$$s_1(t) = A_1 \cdot \sin(\omega_0 \cdot t + \Phi_1) \cdot \sin(\omega_0 \cdot t \pm \frac{2v}{c} \cdot \omega_0 \cdot t + \Phi_1 + 2 \cdot \Phi_2)$$

The first term in parentheses corresponds to the oscillator signal shifted by Φ_1 , which is the first input to M_1 . The second term in parentheses corresponds to the oscillator signal shifted by Φ_1 , travelling to the target and back ($+2\Phi_2$) and Doppler
 25 shifted in frequency. A_1 represents the attenuation of the signal amplitude. In a similar manner, the output of mixer M_2 can be derived. The first input to M_2 is the oscillator signal $s(t)$. The second input to M_2 is the oscillator signal shifted two times by Φ_1 and two times by Φ_2 , and being Doppler shifted in frequency. A_2 is the attenuation factor for the signal $s_2(t)$:

30

$$s_2(t) = A_2 \cdot \sin(\omega_0 \cdot t) \cdot \sin(\omega_0 \cdot t \pm \frac{2v}{c} \cdot \omega_0 \cdot t + 2 \cdot \Phi_1 + 2 \cdot \Phi_2)$$

The expressions for $s_1(t)$ and $s_2(t)$ can be further simplified with the help of the following equation:

$$\sin(x) \cdot \sin(y) = \frac{1}{2} \cdot (\cos(x - y) - \cos(x + y))$$

After low-pass filtering, this results in the following equations for the
5 output signals and phase shift:

$$s_{1LP}(t) = \frac{A_1}{2} \cdot \cos\left(\mp \frac{2v}{c} \cdot \omega_0 \cdot t - 2 \cdot \Phi_2\right)$$

$$s_{2LP}(t) = \frac{A_2}{2} \cdot \cos\left(\mp \frac{2v}{c} \cdot \omega_0 \cdot t - 2 \cdot \Phi_2 - 2 \cdot \Phi_1\right)$$

$$\Phi_1 = n \cdot \frac{\pi}{4} \Rightarrow 2 \cdot \Phi_1 = n \cdot \frac{\pi}{2}$$

The phase shift Φ_1 is internal to the Doppler radar measurement unit 1
10 and fixed by design; it is a multiple of $\pi/4$. In the following, two cases are investigated. In the first case the target moves away from the RF transceiver module 2:

$$s_{1LP}(t) = \frac{A_1}{2} \cdot \cos\left(\frac{2v}{c} \cdot \omega_0 \cdot t - 2 \cdot \Phi_2\right) := A \cdot \cos(t')$$

$$s_{2LP}(t) = \frac{A_2}{2} \cdot \cos\left(\frac{2v}{c} \cdot \omega_0 \cdot t - 2 \cdot \Phi_2 - 2 \cdot \Phi_1\right) := A \cdot \cos(t' - n \cdot \frac{\pi}{2})$$

15 Fig. 4 illustrates the phasing of the output signals $s_{1LP}(t)$ and $s_{2LP}(t)$ in this case.

In the second case, which is illustrated in Fig. 5, the target approaches the RF transceiver module 2. The attenuation is in both cases modelled to be exponential with the distance:

20
$$s_{1LP}(t) = \frac{A_1}{2} \cdot \cos\left(-\frac{2v}{c} \cdot \omega_0 \cdot t - 2 \cdot \Phi_2\right) := A \cdot \cos(-t')$$

$$s_{2LP}(t) = \frac{A_2}{2} \cdot \cos\left(-\frac{2v}{c} \cdot \omega_0 \cdot t - 2 \cdot \Phi_2 - 2 \cdot \Phi_1\right) := A \cdot \cos(-t' - n \cdot \frac{\pi}{2})$$

As can be seen, the direction of motion can be determined by observing which of the two signals is leading (in the first case, the dotted line signal is leading; in
25 the second case the solid line signal is leading).

In a test setup using the Doppler radar measurement unit 1 as described above, a phantom target has been periodically moved back and forth along a defined path, driven by a motor. Results of the measurements delivered by a KMY24 module are illustrated in Fig. 6, which shows plots of $ds_{1LP}(t)/dt$ over t and of $ds_{2LP}(t)/dt$ over t .

In particular, the two output signals $s_{1LP}(t)$ and $s_{2LP}(t)$ are shown in the time domain for three different distances d between the RF transceiver module 2 and the phantom target. The graphs G_1 and G_2 illustrate a first measurement using a first target distance d_0 . The graphs G_3 and G_4 illustrate a second measurement using a second target distance $d_{0,04}$. Compared to the first target distance d_0 the second target distance $d_{0,04}$ has been reduced by $\delta d/\lambda$. In case of a working frequency of 2,45 GHz, the wavelength λ is about 12 cm in air, resulting in a δd value of about $0,04 \cdot 12 \text{ cm} = 0,48 \text{ cm}$. The graphs G_5 and G_6 illustrate a third measurement using a third target distance $d_{0,08}$. Compared to the first target distance d_0 the third target distance has been further reduced, wherein a $\delta d/\lambda$ of 0,08 corresponds to a displacement of about 0,96 cm.

In practice, the distance d corresponds to the “heart distance” between the RF transceiver module 2 and e.g. the moving wall of the subject’s heart.

The time derivatives of the output signals can be displayed in a Lissajous figure. In Fig. 7 a plot of ds_{2LP}/dt over ds_{1LP}/dt for different distances d is shown. In particular Fig. 7 illustrates Lissajous figures resulting from three Doppler radar measurements of a periodically moving target. Each of the three measurements has been carried out using a different target distance d . Each measurement leads to a closed Lissajous figure. However, the orientation angle compared to the coordinate system changes with the target distance d , as the arrow Z in clockwise direction illustrates, starting from a first measurement (graph G_0) with $\delta d/\lambda = 0$, to the second measurement (graph $G_{0,04}$) with $\delta d/\lambda = 0,04$, and to the third measurement (graph $G_{0,08}$) with $\delta d/\lambda = 0,08$. The graphs G_0 , $G_{0,04}$, and $G_{0,08}$ indicate measurements with different distances d between the RF transceiver module 2 and the phantom target. As it can be seen from Fig. 7, the target distance d , i.e. the distance between the RF transceiver module 2 and the reflecting wall of the target, can be obtained from the orientation angle of the Lissajous figure.

All signals exhibit a clear zero-crossing X and a separation between the two regions of forward and backward movement.

Moments in time when the target stopped at the ends of the path and returned in the other direction are clearly visible in the centre of the figure, when both time derivatives are zero (zero-crossing, i.e. $v_{\text{target}} = 0$). In Figs. 6 and 7 simple periodic

movements have been shown for illustrating purposes. However, real heart movements would lead to other more complex Lissajous figures. In those Lissajous figures the zero-crossings X correspond to moments in time, where no heart movement is detected, i.e. where the heart is shortly at rest. Different heart phases can now be differentiated from the sequence of the zero-crossings X in such Lissajous figures.

With the help of the signal processing technique described above and executed by the signal processing and analyzing unit 10, it is possible to enrich the information extracted from the reflected radar signal as shown in Fig. 2 (upper chart). According to preferred embodiments of the invention, the following four characteristics are proposed to be used for the unique identification of the subject under examination:

- (a) heart phase pattern, i.e. pattern of the durations of the different heart phases,
- (b) morphologic features, i.e. morphologic features extracted from the reflected radar signal, i.e. the Doppler radar signal,
- (c) resting points, i.e. information on the moments in time when the heart is shortly at rest during its periodic motion, and
- (d) heart distance, i.e. information on the distance between the heart 4 and the RF transceiver module 2.

In other words, the decision whether there is a match of the current Doppler radar signal 9 with a Doppler radar signal recorded in the past is based on one or more of these four attributes (features). For this purpose the currently determined information is compared by means of an identifying unit to known data, which has been acquired in the past. Preferably the identifying unit is realized as part of the signal processing and analyzing unit 10. Past data are stored in a database 13, see Fig. 8. The database 13 is either part of the signal processing and analyzing unit 10 or is realized externally in a way that it can be used by the signal processing and analyzing unit 10, e.g. by means of a communication technique (network access or the like).

The structure of the identification algorithm, which is based on the signals obtained from the radar reflection at the heart wall, and which is executed in the signal processing and analyzing unit 10, is explained in the following with respect to Fig. 8.

Heart phase pattern (HPP): The heart cycle consists of a number of

different heart phases. These phases (atrial contraction, isovolumetric contraction, rapid ejection, reduced ejection, isovolumetric relaxation, rapid filling, reduced filling) exhibit different lengths, such that their sequence can be expressed as a series of numbers representing the durations of the different heart phases. Based on the radar signal that is reflected at the moving heart wall, which represents direct information about the heart's mechanical activity, it is possible to differentiate between different heart phases which means, that the duration of these phases can be determined, see Fig. 2. According to the invention the current heart phase duration pattern is compared to what was recorded and stored in a database in the past. The match between current and former pattern is expressed with the help of the confidence measure CHPP. It is to be understood that the term "length" can be interpreted both as absolute duration as well as relative duration with respect to the total duration of the heart cycle.

Morphologic features (MF): The radar signal is characterized by morphologic details that originate in the way how the heart wall moves. As much as the heart wall motion is individual to every subject, the morphologic differences between Doppler radar signals obtained from different subjects are individual, too. It is tested whether the currently observed radar signal or sections of it can be fitted to one from the database. Preferably this is done by means of scaling the amplitude and shifting the signal sections in the time domain (cross-correlation). If this is possible, a high measure of confidence CMF results.

The morphologic features are basically contained in the Lissajous method described above. Therefore it is also part of this invention to use the Lissajous figure itself as a comprehensive pattern template for the comparison of signal features while trying to identify a specific signal in a set of known signals.

Resting points (RP): The resting points are the points in time when the heart is mostly or totally at rest during the heart cycle. The resting points can be extracted from the radar signal with the help of an algorithm taking into account the calculation of time derivatives (Lissajous plot). Depending on the subject's anatomy, the resting points may be more or less pronounced, which is characteristic for that person. The resulting confidence measure CRP expresses, how well the resting points found in the current signal match the ones in a signal recalled from the database. This also

includes testing whether certain resting points are visible at all, which is not the case for all test persons.

Heart distance (HD): In the Lissajous plot, the cyclic heart motion results in a closed curve. The orientation of that curve with respect to the coordinate axes (see Fig. 7) depends on the distance (heart distance) between the RF transceiver module 2 and the heart wall. In general words, the position of the heart within the subject's body is determined. Measured on a rather skinny person, the curve will be less tilted (corresponding to a smaller heart distance) than a curve measured on a full figured person (corresponding to a larger heart distance). The tilt angle is thus characteristic for the person's anatomy. The degree of matching between the tilt angles in the currently measured signal and in the signal from the database is expressed with the help of the confidence measure CHD.

In order to obtain reliable identification results, it has to be assured, that the position of the RF transceiver module 2 with respect to the subject's body is the same or approximately the same during the measurement of the reference Doppler radar signals stored in the database on the one hand and during the "field measurement" of the Doppler radar signals for identification purposes on the other hand. This is in particular important for the heart distance.

According to the invention at least one of the confidence measures described above, but preferably all four confidence measures, are taken into account in order to calculate (e.g. in percent) the degree of matching between the Doppler radar signal 9 currently measured on a subject, and a signal taken from the database 13. This degree of matching is used as an identifier itself, or can be combined with other biometric modalities in order to improve the overall reliability.

In another embodiment of the invention the database may not comprise full Doppler radar signals 9, but only the characteristic features (heart phase pattern, morphologic features, resting points, and/or heart distance) extracted from previously measured signals.

Details on the signal matching procedure, the use of confidence measures and other measures regarding the identification process itself are known from the prior art and will therefore not be discussed in detail.

The above described signal processing and analysing steps are carried out by means of the signal processing and analyzing unit 10, which preferably also includes the identifying unit. The signal processing and analyzing unit 10 comprises at least a data processing means 14, e.g. a microprocessor. Furthermore the signal processing and
5 analyzing unit 10 comprises a data storage means, e.g. a database 13, in which previous results (data) are stored, and from which they are retrieved, or the signal processing and analyzing unit 10 is connectable to such a data storage means. Additionally the data storage means is adapted to receive and to store new data resulting from current measurement for future match assessment.

10 The signal processing and analyzing unit 10 including the identifying unit is adapted for performing all tasks of calculating and computing the measured data as well as determining and assessing results. This is achieved according to the invention by means of a computer software comprising computer instructions adapted for carrying out the steps of the inventive method, when the software is executed in the data
15 processing means 14 of the signal processing and analyzing unit 10. The data processing means 14 itself may comprise functional modules or units 15, which are implemented in form of hardware, software or in form of a combination of both.

The technical effects necessary according to the invention can thus be realized on the basis of the instructions of a computer program in accordance with the
20 invention. Such a computer program can be stored on a carrier such as a CD-ROM or DVD-ROM or it can be available over the internet or another computer network. Prior to executing the computer program is loaded into the computer by reading the computer program from the carrier, for example by means of a CD-ROM or DVD-ROM player, or from the internet, and storing it in the memory of the computer. The computer includes
25 inter alia a central processor unit (CPU), a bus system, memory means, e.g. RAM or ROM etc., storage means, e.g. floppy disk or hard disk units etc. and input/output units. Alternatively, the inventive method could be implemented in hardware, e. g. using one or more integrated circuits.

All appliances are adapted to carry out the method according to the
30 present invention. All devices, e. g. the Doppler radar measurement unit 1 as well as the signal processing and analyzing unit 10 including the identifying unit, are constructed

and programmed in a way that the procedures for obtaining data and for data processing run in accordance with the method of the invention.

It will be evident to those skilled in the art that the invention is not limited to the details of the foregoing illustrative embodiments, and that the present invention
5 may be embodied in other specific forms without departing from the spirit or essential attributes thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be
10 embraced therein. It will furthermore be evident that the word “comprising” does not exclude other elements or steps, that the words “a” or “an” do not exclude a plurality, and that a single element, such as a computer system or another unit may fulfil the functions of several means recited in the claims. Any reference signs in the claims shall not be construed as limiting the claim concerned.

REFERENCE NUMERALS

	1	Doppler radar measurement unit
	2	RF transceiver module
5	3	RF transmitter
	4	heart
	5	person
	6	RF receiver
	7	mixer
10	8	low pass filter
	9	Doppler radar signal
	10	signal processing and analyzing unit
	11	ECG signal
	12	pattern lines
15	13	database
	14	processor
	15	processor units
	OS	oscillator
	M	mixer
20	A	antenna
	PS	phase shifter
	Φ	phase shift
	$s_{1LP}(t)$	first output signal
	$s_{2LP}(t)$	second output signal
25	G	graph
	X	zero crossing
	Z	arrow

CLAIMS:

5

1. A method of identifying a subject (5), the method comprising the steps of
- carrying out a Doppler radar measurement to obtain a Doppler radar
signal (9) representing information on the mechanical activity of an inner part (4) of the
subject's body,

10 - determining the characteristics of said mechanical activity from said
Doppler radar signal (9), and
- identifying the subject (5) using said characteristics.

2. The method as claimed in claim 1, wherein the Doppler radar
15 measurement is carried out to obtain a Doppler radar signal (9) representing information
on the mechanical activity of an inner organ (4) of the subject (5).

3. The method as claimed in claim 2, wherein the Doppler radar
measurement is carried out to obtain a Doppler radar signal (9) representing information
20 on the mechanical activity of the subject's heart (5) .

4. The method as claimed in claim 3, wherein the determining step
comprises the determining of heart phase pattern (HPP).

25 5. The method as claimed in claim 3, wherein the determining step
comprises the determining of morphologic features (MF) of the Doppler radar signal (9).

6. The method as claimed in claim 3, wherein the determining step
comprises the determining of heart resting points (RP).

30

7. The method as claimed in claim 3, wherein the determining step comprises the determining of the position (HD) of the heart (4) within the subject's body.

5 8. The method as claimed in claim 1, wherein the identifying step comprises the comparing of previously measured characteristics with one or more of the characteristics of the mechanical activity of the current subject (5).

9. A system for identifying a subject (5), the system comprising
10 - a Doppler radar measurement unit (1) adapted for obtaining a Doppler radar signal (9) representing information on the mechanical activity of an inner part (4) of the subject's body,
- a signal processing and analyzing unit (10) adapted for determining the characteristics of said mechanical activity from said Doppler radar signal (9), and
15 - an identifying unit (10) adapted for identifying the subject (5) using said characteristics.

10. A computer program for a system for identifying a subject (5), the system comprising a Doppler radar measurement unit (1) adapted for obtaining a Doppler radar
20 signal (9) representing information on the mechanical activity of an inner part (4) of the subject's body, the computer program comprising
- computer instructions to determine the characteristics of said mechanical activity from said Doppler radar signal (9), and
- computer instructions to identify the subject (5) using said characteristics,
25 when the computer program is executed in a computer (14).

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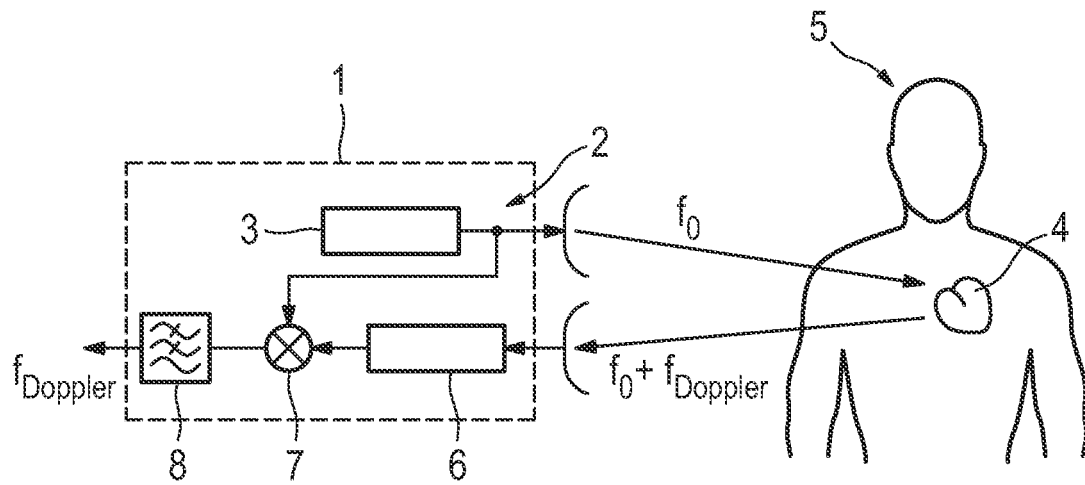


FIG. 1

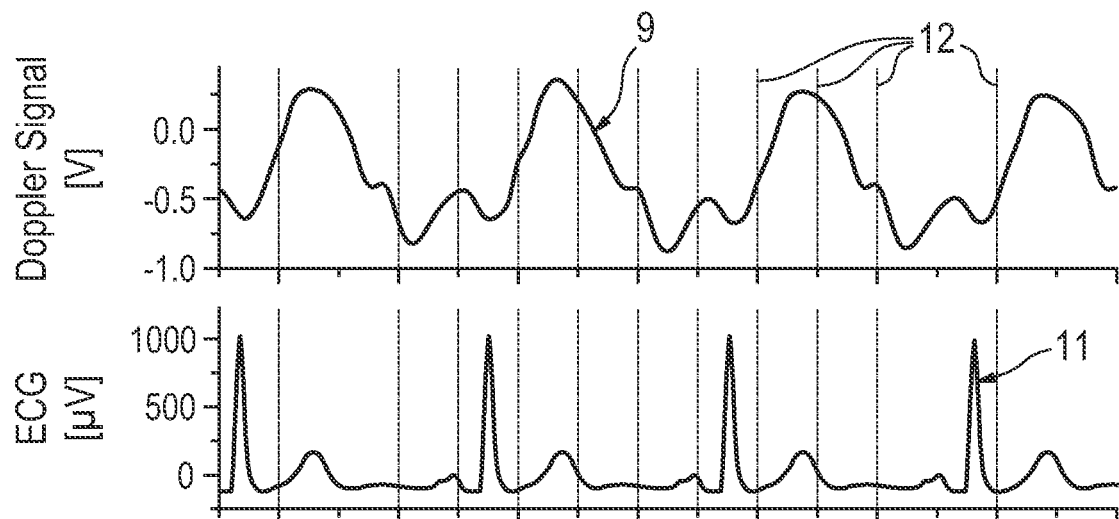


FIG. 2

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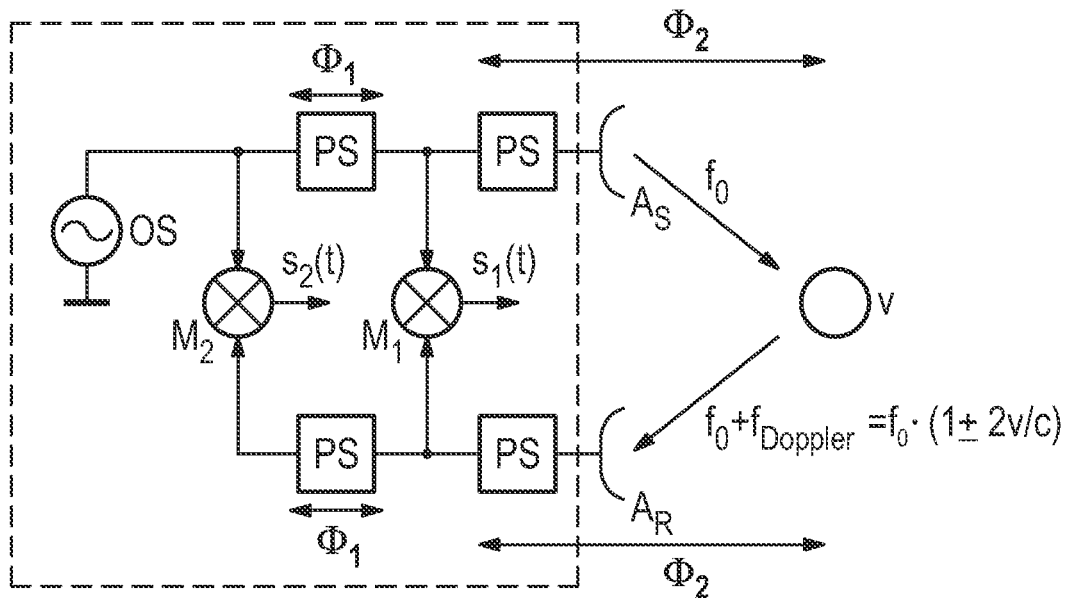


FIG. 3

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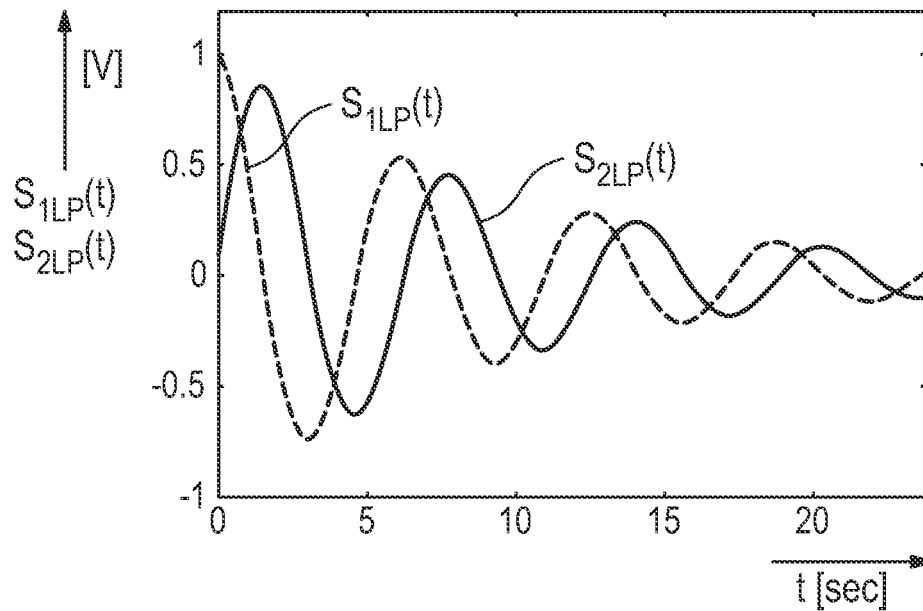


FIG. 4

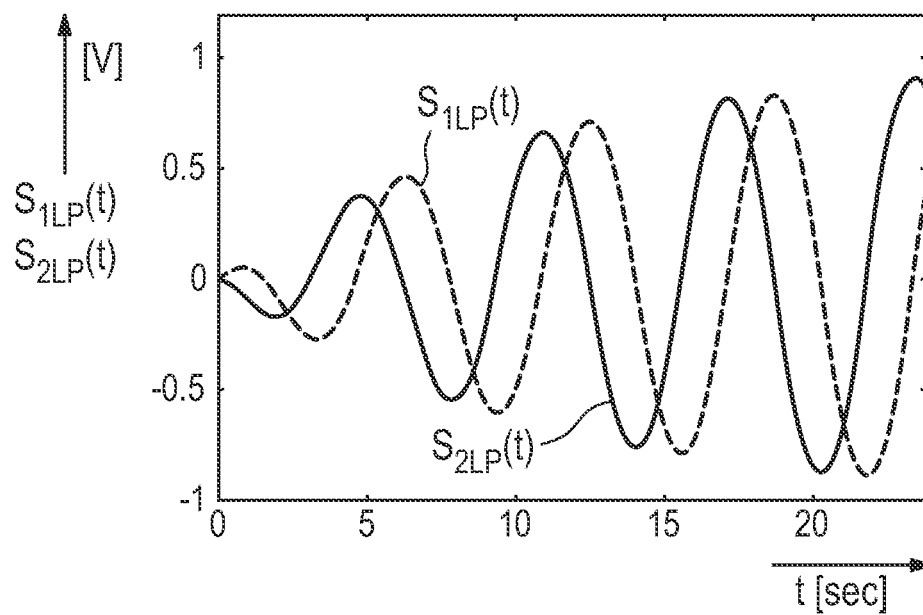


FIG. 5

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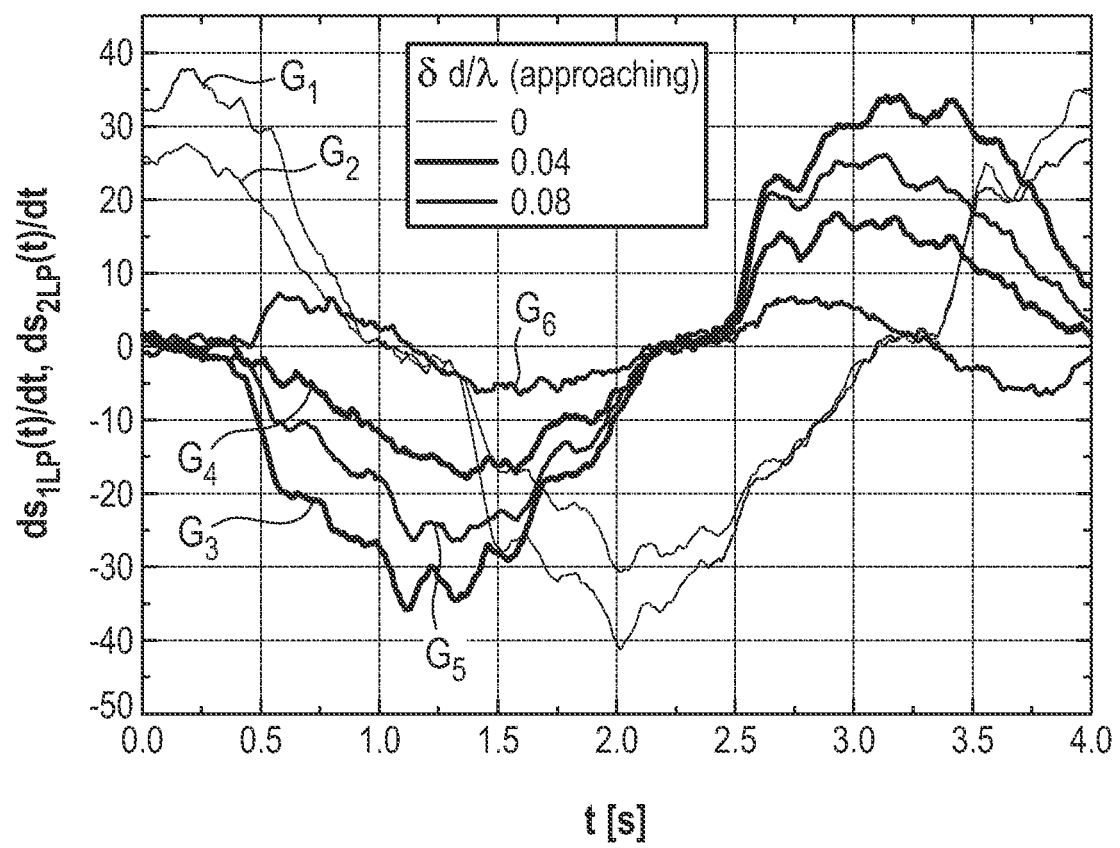


FIG. 6

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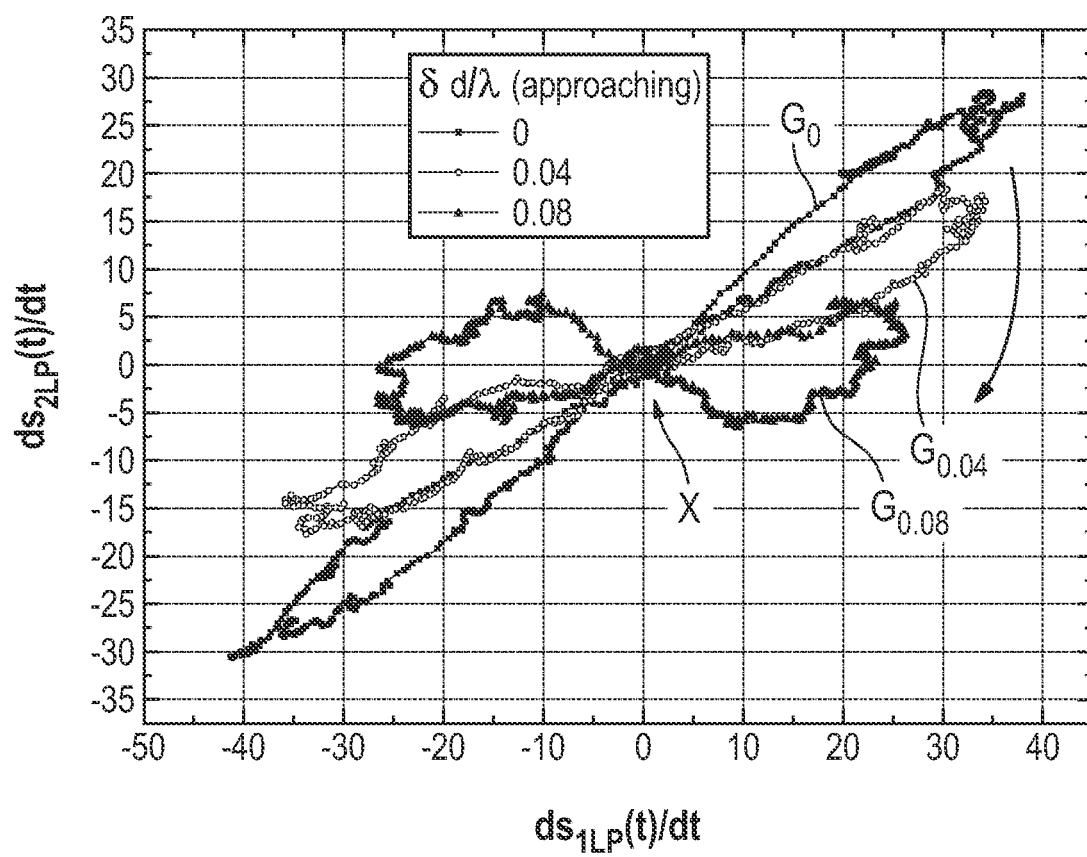


FIG. 7

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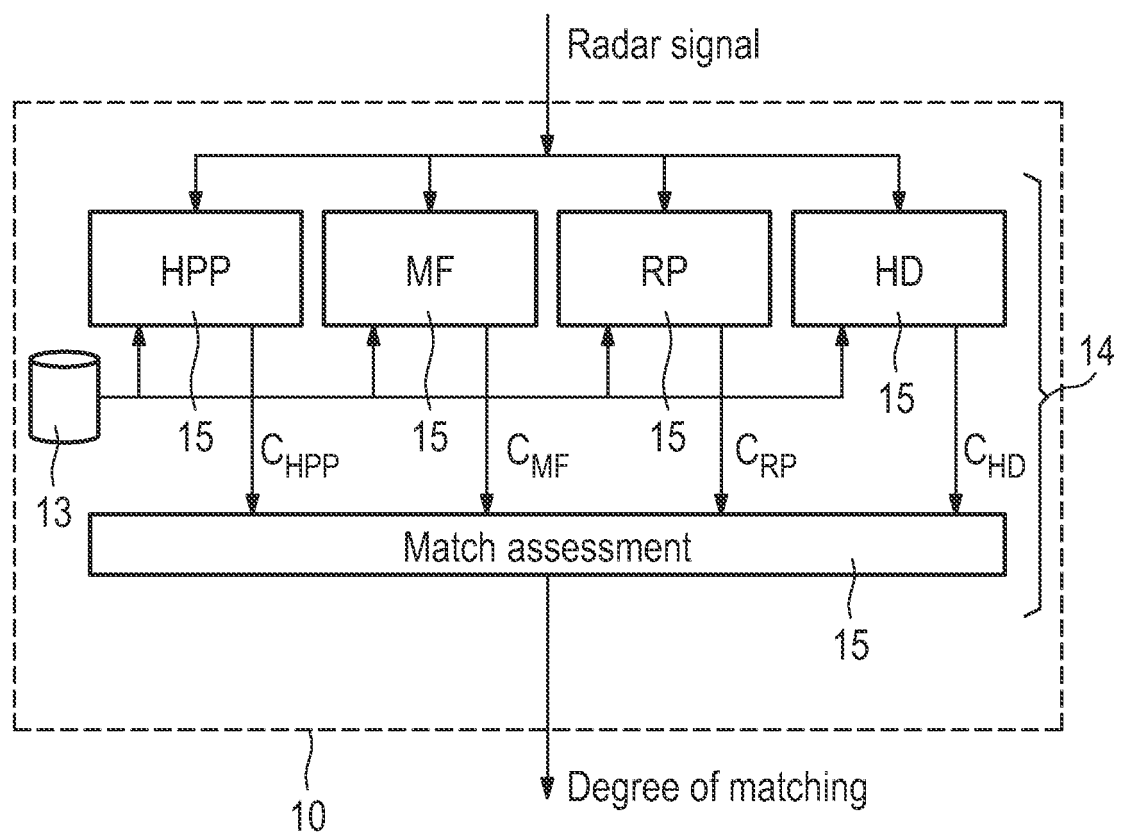


FIG. 8