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(54) Title of the Invention: **Method for environment recognition and driving assistance system**
Abstract Title: **Method for discriminating between pulse echo signals and noise or interference in a driving assistance system**

(57) A method for environment recognition using at least one distance sensor that is capable of emitting a pulse 38, 38.1 with a defined transmission spectrum and receiving at least one signal in a measurement cycle ΔT; the received signal is classified as an echo signal 40 or rejected as noise or interference 41 based on whether the received signal amplitude and phase lie within a plausible range. An interference signal may be detected as originating from an external source and its distance calculated and provided to a driving assistance system. The pulse transmitter is preferably ultrasonic but may be electromagnetic (radar, lidar or infra-red), and at least one parameter of the transmission spectrum may be varied in reaction to an interference signal. The method described may be carried out by a computer program or a driver assistance system in a vehicle.

Fig. 2

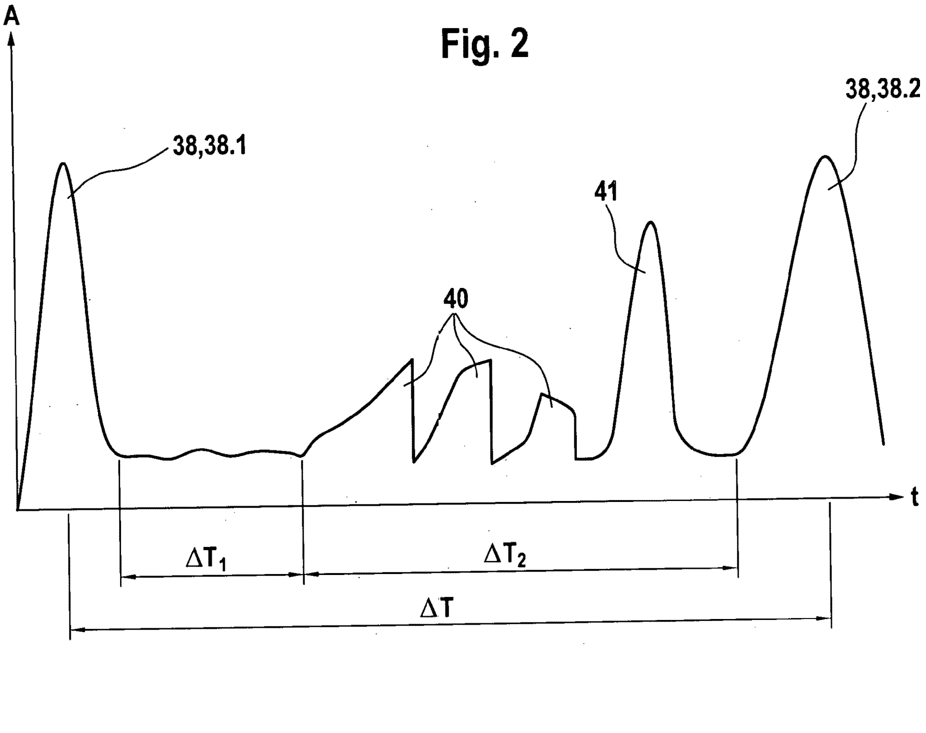

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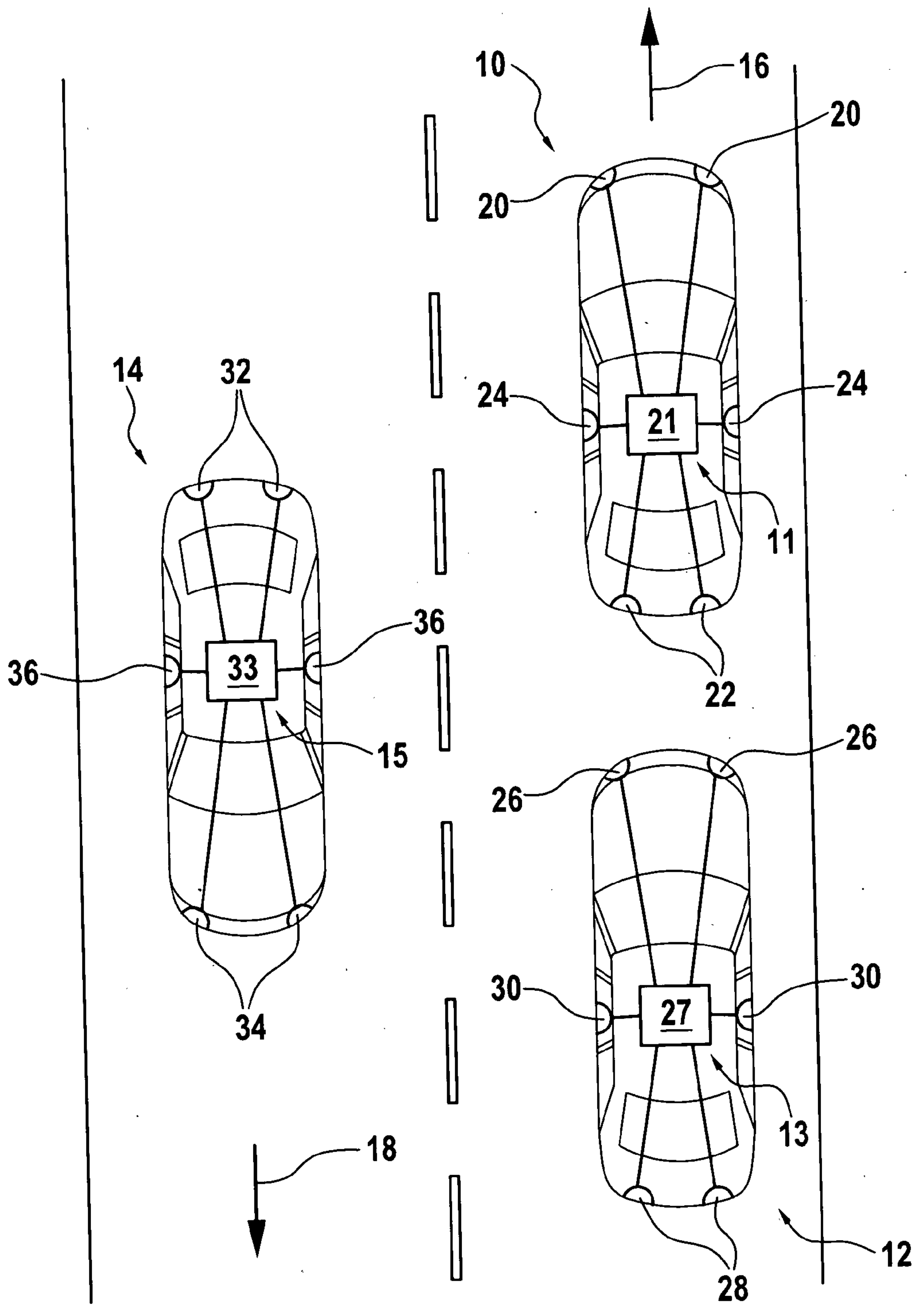
Fig. 1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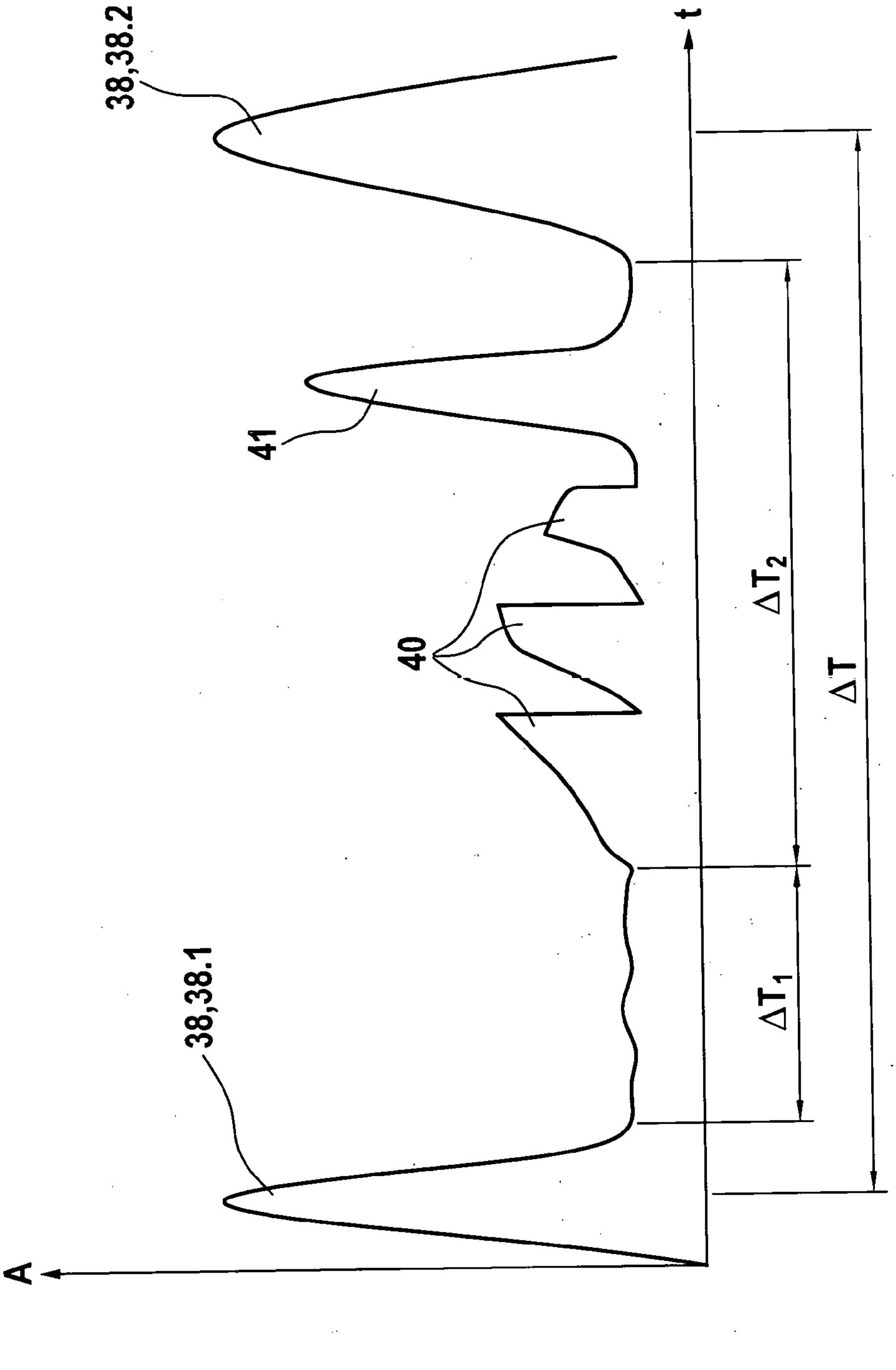


Fig. 2

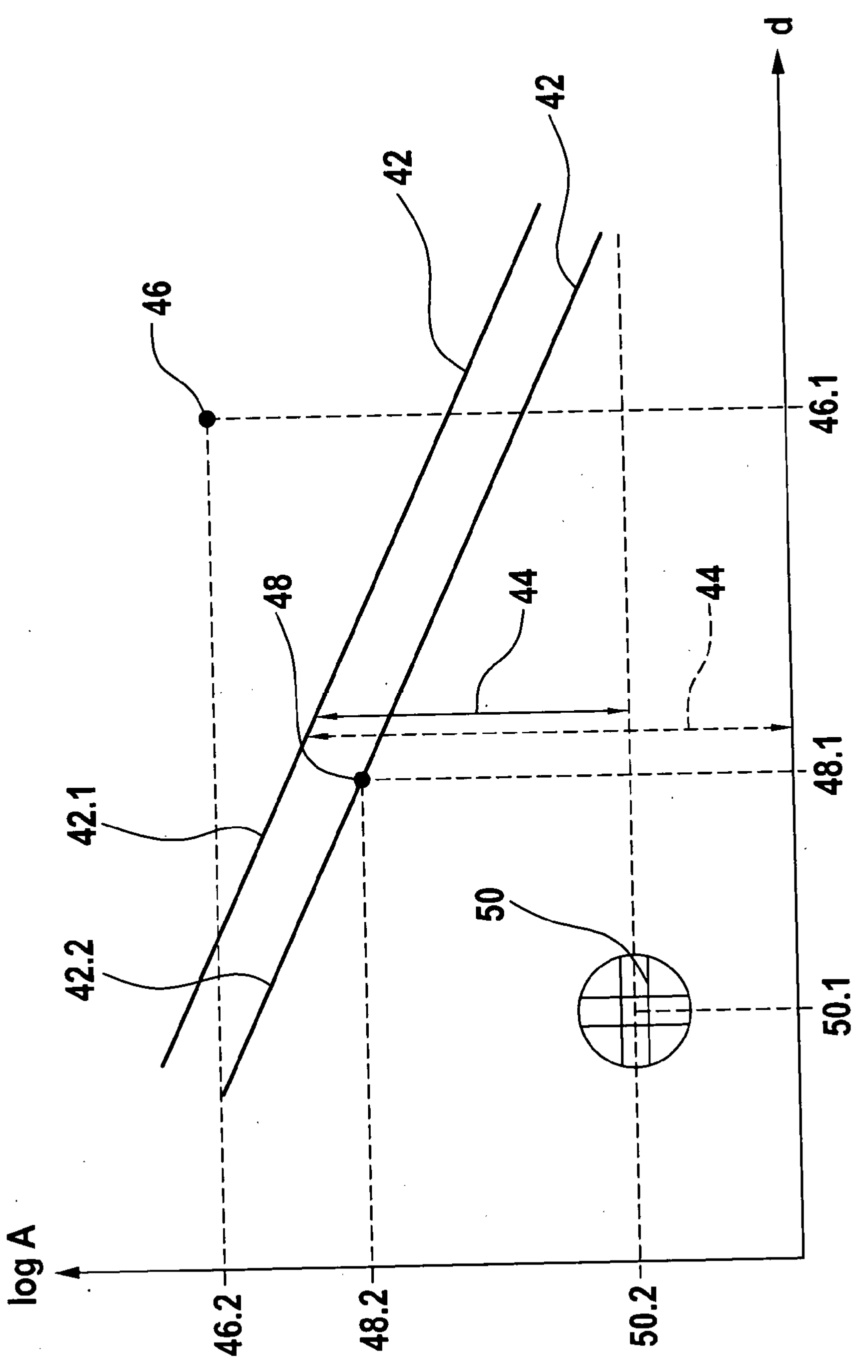


Fig. 3

Fig. 4

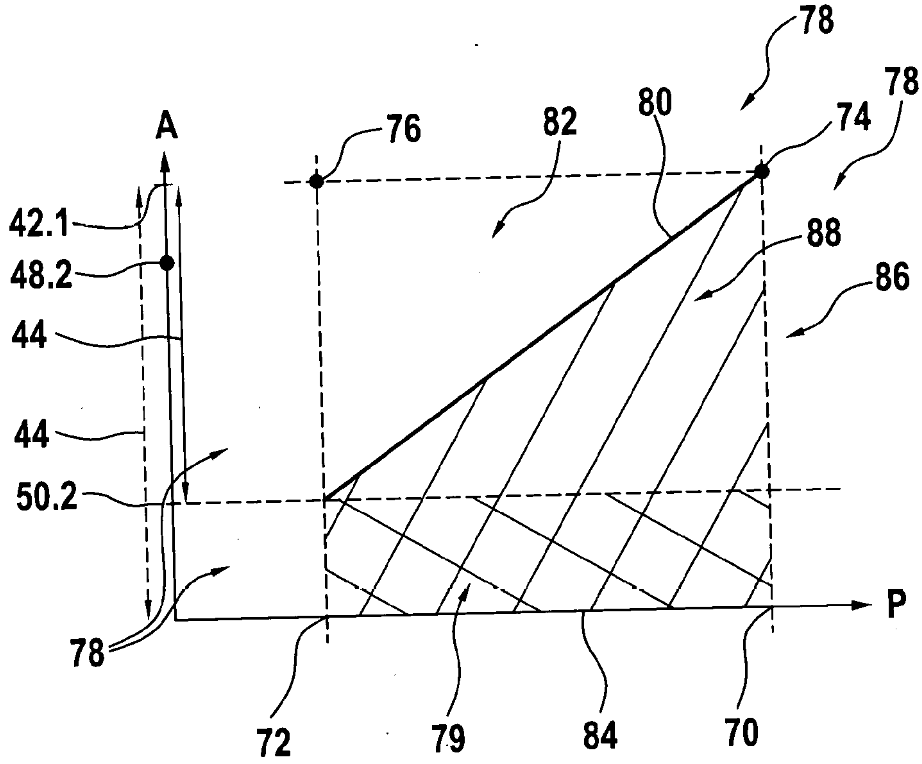
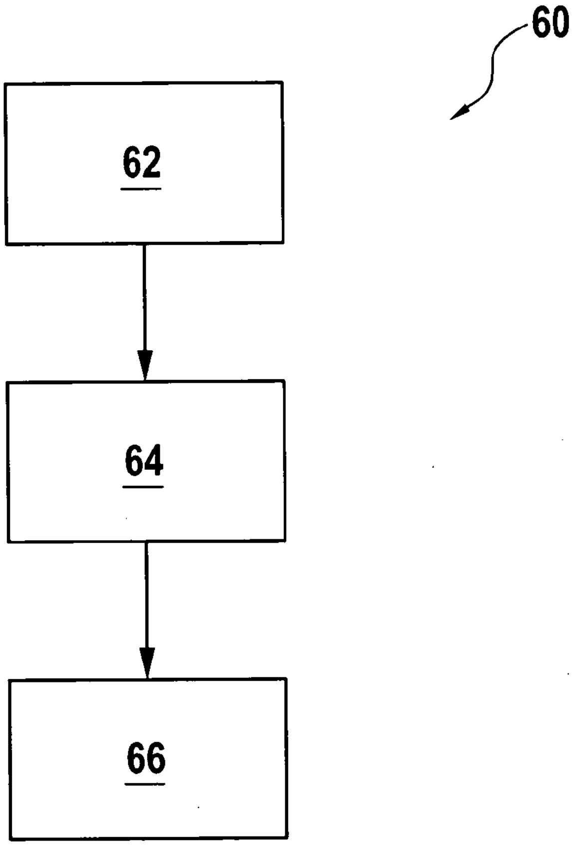


Fig. 5



Description

Title

Method for environment recognition and driving assistance system

Prior art

The invention relates to a method for environment recognition using a distance sensor of a driving assistance system. The invention further relates to a driving assistance system for carrying out the method.

Driving assistance systems are additional devices in a vehicle which assist the driver with the driving of the vehicle. Such driving assistance systems typically comprise different subsystems, such as driver information systems or predictive safety systems. For various of these subsystems, environment sensor systems are required which monitor the environment of the vehicle in order, for example, to detect objects which may constitute potential obstacles on the roadway. Typically, for environment recognition, distance sensors are used in a vehicle which, based on a pulse echo method, measure the distance from objects in the environment of the vehicle and the measured data of which serve as a basis for subsystems, such as the parking assistance, the blind spot monitoring or the lane monitoring.

In the pulse echo method, the propagation delay between transmitted pulse and received echo is measured. In order to be able to derive an unambiguous distance from the propagation delay, distance sensors work in an unambiguous range. This means that the length of the measuring cycles is determined by the maximum propagation delay of the transmit pulse to be expected. For example, in order to achieve a measuring distance of 5 m, at a speed of sound of 343 m/s a measuring cycle of about 30 ms has to be observed. From KR 10 2001 0105677 A it is known to assign a detection time to an ultrasonic sensor. In the case of a signal which is detected after the detection time has elapsed, this is assumed to be interference. For verification, a signal is transmitted by a second sensor.

During the distance measurement, noise is additionally superimposed on the measured data and reduces the measuring accuracy. In order to take account of only the measured values which lie above the noise level to be expected, threshold value characteristics are typically preset. DE 10 2004 006 015 A1 describes such a method, in which the detection threshold is varied as a function of external conditions of the system.

Besides the noise level, environmental influences may also interfere with the measurement. For example, air flows when driving comparatively quickly may constitute interference sources. Ultrasonic sensors of other vehicles which themselves emit ultrasonic signals may also cause interference. In order to mask out this kind of interference, the received echo signals are typically filtered before they become the basis of the distance calculation. From DE 10 2009 002 870 A1 there is known a method for recognising external interferers, in which ultrasonic pulses are emitted by a plurality of transmitters simultaneously, in order to verify echoes of the first ultrasonic pulse.

Present-day driving assistance systems have high requirements in terms of the stability and the reliability of the sensor systems used and the environment data obtained therefrom, since a driving assistance system can recognise situations and react accordingly, only on the basis of the environment data. There is therefore a continuous interest in masking out interference as reliably as possible, in order to be able to utilise the provided environment data optimally for the assisted driving.

Disclosure of the invention

According to the invention, a method for environment recognition using at least one distance sensor is proposed, which comprises the following steps:

(a) emitting at least one pulse with a defined transmission spectrum;

(b) receiving at least one signal in a measuring cycle;

(c) classifying the received signal as an echo signal or as an interference signal, with a plausibility check being performed based on an amplitude and phase information of the received signal.

According to the invention, a driving assistance system for carrying out the above-described method is furthermore proposed, which comprises the following components:

(i) at least one distance sensor for emitting at least one pulse with a defined transmission spectrum and/or for receiving at least one signal in a measuring cycle;

(ii) a component for classifying the received signal as an echo signal or as an interference signal by performing a plausibility check based on an amplitude and phase information of the received signal.

In the context of the invention, the distance sensor may be part of the environment sensor system of a driving assistance system with different subsystems, for example a parking assistant, a blind spot monitoring or an adaptive cruise control (ACC) system. In this regard, the environment sensor system of the driving assistance system serves for monitoring the vehicle environment, for which ultrasonic sensors, radar sensors, infrared sensors, LIDAR sensors or optical sensors may be used. In particular, sensors which determine the distance from objects in the environment of the vehicle according to the principle of a pulse echo method are employed for the distance measurement. Preferably, ultrasonic sensors are suitable as distance sensors.

In general, the transmission spectrum of the distance sensor is determined by parameters, such as frequency, amplitude and phase. Thus, the transmission spectrum may comprise a signal with defined frequency, amplitude and signal shape, for example a square-wave pulse. Furthermore, the transmission spectrum may be modulated in one parameter, for instance the frequency. In particular, a transmission spectrum whose frequency varies over time (chirps) is suitable for distance sensors. A further possibility is constituted by the superimposition of different signals with, for example, different frequencies or amplitudes in a transmission spectrum.

A measuring cycle in the context of the invention refers to a sequence of transmission and receiving intervals. In particular in the case of distance sensors which determine the distance according to the principle of a pulse echo method, a measuring cycle comprises at least one transmission interval, in which a transmit pulse with a transmission spectrum is emitted, and at least one receiving interval, in which echoes of the transmit pulse can be received. In this regard, the length of a measuring cycle is typically determined by the maximum time to be expected between emitting the pulse and receiving the associated echo.

In the context of the invention, the distance sensor can both emit a pulse and receive an echo. Although this design is advantageous, it is in no way compulsory. Equally, constructionally separate transmitters and receivers are also possible. In the case of constructionally separate units, at least two distance sensors are used to carry out the method according to the invention, one distance sensors acting as "transmitter" when it emits a pulse, and one distance sensor acting as "receiver" when it receives a signal.

The method according to the invention can be carried out in the context of a propagation delay measurement, the propagation delay measurement being performed with the aid of the distance sensor. In this regard, the distance sensor is firstly activated to emit pulses with a defined transmission spectrum. The activation of the distance sensor can be effected in a driving assistance system, for example centrally, from a control device of the driving assistance system or from an electronic device assigned to the sensor, the transmission parameters, for instance the frequency, the amplitude, the transmission duration or the modulation of a pulse or successive pulses, being variable and being adaptable to the particular situation, for example to the speed of the vehicle or to the driving manoeuvre to be performed. Subsequently, the emitted pulses are detected, on reflection on objects, as echoes by the distance sensor. From the propagation delay of a pulse, i.e. the time between transmitting the pulse and receiving the echo, there then results the distance between the object and the distance sensor, while taking account of the speed of the signal and optionally the vehicle speed.

Signals received by the distance sensor are typically supplied to an electronic unit, such as the control device of a driving assistance system or an electronic device assigned to the sensor, and are further processed there, in order to extract information, such as the propagation delay of the transmit pulse, from the received signal. Besides the propagation delay and the distance determination resulting therefrom, it is also possible to analyse received signals with regard to the amplitude and the phase information. The phase information is given here by the phase correlation between the received signal and the transmit pulse. With the aid of the amplitude and the phase information, the received signal is classified in the context of a plausibility check as an echo signal or as an interference signal.

In one implementation of the method according to the invention, both for the amplitude and for the phase information of the received signal, a plausibility range is set. The plausibility range here is dependent, similar to the length of a measuring cycle, on the values to be expected for the amplitude and for the phase information of an echo signal. This is determined in particular by the parameters of the transmitted pulse. Thus, for example, for a given amplitude and frequency modulation of the transmit pulse, a characteristic is calculated which correlates the amplitude of an echo signal to be expected with the distance or with the propagation delay. From this there results, for each measured propagation delay or the distance resulting therefrom and for each measured amplitude of the received signal, a physically plausible range which takes account of the measuring inaccuracies. Here, the amplitude of the received signal is dependent on the reflectivity of the reflecting objects and because of this may vary greatly.

The plausibility range for the amplitude therefore preferably comprises a threshold value as upper limit. In particular, the plausibility range for the amplitude comprises amplitudes which lie below a threshold value of 5 to 10% above the valve to be expected for the amplitude at a given distance. Interference signals with amplitudes which lie below this threshold value are classified by performing a plausibility check with the phase information. In addition to the threshold value, it is possible to consider as lower limit a minimum value for the amplitude which depends on the determinability of the phase information. This value is determined by the error in determining the phase information, which increases for decreasing amplitudes. The phase information thus becomes less accurate and can no longer be readily utilised, for instance by means of additional filters, for performing a plausibility check.

Similarly, a physically plausible range can be set for the phase information. Thus, for each measured propagation delay or the distance resulting therefrom, there results a phase correlation to be expected of an echo signal with respect to the transmit pulse. For each measured phase correlation of the received signal with respect to the transmit pulse, a physically plausible range can be set which takes account of measuring inaccuracies with respect to the value to be expected. In this regard, phase information of 1 corresponds to a received signal having a maximum correlation with the transmitted signal. For example, the plausibility range for the phase information may lie between plausibility coefficients of 0.2 and 1, with a lower limit lying at 0.2 to 0.4 and an upper limit lying at 0.9 to 1 of the value to be expected for the phase information at a given propagation delay. The plausibility range for the phase information may lie, for example, between a phase correlation coefficient of 0.4 to 1.

In one implementation of the method according to the invention, in the context of the plausibility check it is determined whether the amplitude and the phase information of the received signal lie within or outside the respective plausibility range. Furthermore, the plausibility check with regard to the phase information can be performed under the condition that the amplitude of the signal exceeds a minimum value. Additionally or alternatively, received signals with amplitudes lying below the minimum value can be filtered by, for example, identifying them by means of a matched filter and optionally suppressing them.

In a further implementation of the method according to the invention, the plausibility range for the phase information can vary as a function of the amplitude, where, for example, a linear relationship between the plausibility range for the phase information and the amplitude can be assumed. If the phase information, for example, lies in the lower range of the associated plausibility range and the amplitude lies in the upper range of the associated plausibility range, it can be inferred from this that an interference signal is present. This is because the greater the amplitude is, the more accurate the phase information and thus the correlation between received and transmitted signal can be determined. The error in determining the phase information for large amplitudes close to the threshold value thus allows a smaller plausibility range in the phase information. Conversely, the determination of the phase information is less accurate, the smaller the amplitude, i.e. the closer the amplitude lies to the minimum value for the amplitude, and the phase information is thus plausible over a larger range.

If the distance sensor receives signals, the amplitude and phase information of which lies within the respective plausibility range, the received signal constitutes an echo of the transmit pulse. The result of this is that the received signal can be identified as an echo signal and thus as object detection.

Conversely, the distance sensor can also receive signals, the amplitude and phase information of which do not lie in the respective plausibility range, and are identified as interference. Such signals can come, for example, from an external interferer, such as another distance sensor, compressed-air guns, background noises, such as key rattling, or electromagnetic interferers, such as induction loops, and there is no correlation between the transmit pulse and the received signal. Consequently, classifying such signals as echo signals would result in an incorrect distance measurement.

In a further implementation of the method according to the invention, interference signals in particular for the distance determination are rejected. Alternatively, the amplitude and/or the phase information of the received interference signal can be further processed. Thus, for example, from the amplitude and/or the phase information of the received interference signal, an external interferer can be recognised and a distance of the distance sensor from the external interferer, in particular an ultrasonic sensor of another vehicle, can be estimated. From the distance of the external interferer, it is also possible to extract further information, comprising, for example, the movement, the speed, the acceleration and information regarding the position of an external interferer. Additionally or alternatively, at least one parameter of the transmission spectrum, for instance the frequency or its modulation, can be varied in reaction to an interference signal which can be assigned, for example, to an external interferer, in order to reduce the influence of the external interferer on the distance sensor.

The information that an external interferer has been detected and/or its distance can be furthermore provided to a higher-order system, in particular a driving assistance system. Thus, this information can be utilised for further subsystems, in particular those based on tracking algorithms, for instance the parking assistance, the blind spot monitoring or the lane monitoring.

The driving assistance system according to the invention is preferably designed for carrying out the method described above. In this regard, the individual components constitute functional components or routines which are, for example, executed in the context of a computer program on an electronic unit, such as programmable computer device. The computer device may, for example, be a control device (ECU) for implementing a driving assistance system or a subsystem thereof in a vehicle.

The distance sensor of the driving assistance system may, for example, be configured as an ultrasonic sensor, radar sensor, infrared sensor, LIDAR sensor or optical sensor, which can act a receiver and/or transmitter. Preferably, the distance sensor is an ultrasonic sensor.

The ECU can communicate with the distance sensor via control signals. Thus, control signals can be generated which trigger the distance sensor to emit pulses with a defined transmission spectrum. Conversely, the distance sensor can also pass on received signals to the ECU for signal processing. Thus, in the context of the signal processing in the ECU, the classification of the received signal as an echo signal or as an interference signal can be carried out. For this purpose, a plausibility check is performed which is based on an amplitude and phase information of the received signal. Alternatively, the signal processing, in particular the generation of a control signal and the plausibility check, can be carried out in an electronic device assigned to the sensor, the results of which can be optionally communicated to the ECU.

According to the invention, a computer program for carrying out a method described herein when the computer program is executed on a programmable computer device is furthermore proposed. The computer program can be stored on a machine-readable storage medium, for instance on a permanent or rewritable storage medium or in assignment to a computer device, or on a removable CD-Rom, DVD or a USB stick. Additionally or alternatively, the computer program can be provided on a computer device such as a server for downloading, for example via a data network, such as the Internet or a communications connection, such as for instance a telephone line or a wireless connection.

Advantages of the invention

The invention enables a more reliable environment recognition using a distance sensor, and in particular through the simultaneous inclusion of the amplitude and the phase information of the received signal in a plausibility check, interference signals can be reliably distinguished from echo signals. As a result, high-quality data are available, allowing a reliable object recognition and distance measurement. Thus, the measured data of the distance sensor can be utilised to provide the maximum information content to subsequent systems. In particular, the plausibility check makes it possible to distinguish external interferers, such as distance sensors of other vehicles, from actual obstacles.

On detection of an external interferer, the measured values can be utilised to determine further information. Thus, external interferers can be detected even before entering the detection range of the distance sensor and taken into account early by the driving assistance system. Furthermore, interference by the external interferers in one's own system can be minimised by changing the frequencies in the transmission spectrum of the distance sensor. The invention thus assists not only one's own driving assistance system but also external systems and can contribute to a general improvement of the environment detection.

Driving assistance systems frequently utilise distance sensors for environment recognition. With the improved processing of the measured data, the environment recognition of the driving assistance system is thus also improved. This is reflected immediately in the responsiveness and the reliability of the driving assistance system. In particular, the information that there is an external interferer with an estimated distance can be utilised to adapt the reaction of the driving assistance system accordingly. For example, interventions of the driving assistance system in active system components of the vehicle, such as the brake system or the drive system, which interventions are to be performed owing to incorrect distance values, can be prevented.

Situations in which the environment sensor system of the driving assistance system provides the relevant data for assisting the driver occur frequently and a driving assistance system designed according to the invention can thus contribute to improved assistance. The increased system availability additionally increases the utility value and the acceptance of corresponding driving assistance systems. Moreover, the proposed method for environment detection can be implemented, without additional hardware components, by a software update, thus enabling cost-effective and simple realisation.

Brief description of the drawings

Further aspects and advantages of the invention will now be described with reference to the appended drawings, in which:

Figure 1 shows a vehicle equipped with a driving assistance system according to the invention, in an exemplary driving situation,

Figure 2 schematically shows a signal profile for a complete measuring cycle for distance measurement,

Figure 3 shows characteristic curves with exemplary measuring points for discrimination between actual objects and interference signals,

Figure 4 shows an exemplary representation of the plausibility ranges for the amplitude and the phase information at a given distance,

Figure 5 shows a working method of the driving assistance system from Figure 1, in the form of a flow diagram.

Embodiments of the invention

In Figure 1 there is schematically indicated a driving situation with several vehicles 10, 12, 14 situated in the immediate vicinity of one another. In this case, the vehicles 10, 12 are moving directly behind one another in a first direction 16. A further vehicle 14 is travelling on the opposite lane, in a direction 18 opposite the first direction 16, past the vehicles 10, 12. Furthermore, the vehicles 10, 12, 14 are each equipped with a driving assistance system 11, 13, 15. The driving assistance system 11, 13, 15 comprises an ultrasound-based system for monitoring the environment having several ultrasonic sensors 20, 22, 24, 26, 28, 30, 32, 34, 36 (abbreviated 20...36), which are installed at the front, at the rear and at the sides on the vehicles 10, 12, 14. Each ultrasound-based system is controlled by a central ECU 37, 38, 39 which communicates with the ultrasonic sensors 20...36. Besides the ultrasound-based system for monitoring the environment, the driving assistance system 11, 13, 15 may comprise further environment sensor systems, not shown in Figure 1.

As vehicles 10, 12, 14 are travelling past or in situations with a high traffic volume, for example in a traffic jam or at a red light, the vehicles 10, 12, 14 may be situated in the immediate vicinity of one another, at least for a short time. The respective driving assistance systems 11, 13, 15 can therefore detect further vehicles 10, 12, 14, situated in front of, behind or beside them, as objects using the ultrasonic sensors 20...36 installed on the vehicle.

Furthermore, the ultrasonic sensors 20...36 of the vehicles 10, 12, 14 may interfere with one another. Thus, for example in the situation shown in Figure 1, the ultrasonic sensors 26 fitted at the rear on the vehicle 12 may interfere with the ultrasonic sensors 22 fitted at the front on the vehicle 10. Such interference comprises, for example, the reception of incorrect ultrasonic signals by an ultrasonic sensor, for example 22, which have been emitted by another ultrasonic sensor, for example 26, and have no connection with the emitted pulse of the ultrasonic sensor 22. These interference signals result in the detection of "ghost objects" and may cause incorrect behaviour of the driving assistance system 11.

In order to avoid such situations, the driving assistance system 11, 13, 15 according to the invention performs a plausibility check, by means of which actual echoes 40 can be distinguished from interference signals 41. The amplitude 46.2, 48.2, 50.2 and the phase information of the received signals 40, 41 are utilised for this, an actual echo signal 40 being assumed when the amplitude 46 and phase information lie in a predetermined plausibility range 44. Otherwise, an interference signal 41 is inferred, which is rejected or further processed in the ECU 21, 27, 33.

The phase information in this case describes the phase matching which determines how well the receive signal matches the transmit signal if the two were graphically laid on top of one another. Mathematically, this is described by the correlation function of transmit and receive signal. For example: if a signal were transmitted at 50 kHz and the receive signal had 60 kHz, then there would be a poor correlation and a correlation coefficient less than 1, because the wave crests and troughs diverge. If the receive signal likewise had 50 kHz and the wave crests and troughs coincided, this corresponds to a high correlation between the signals and the correlation coefficient would be 1. The phase information therefore typically corresponds to the correlation coefficient between the transmit and receive signal.

In Figure 2 there is plotted a signal profile of the oscillation amplitude, A, against time, t, for a complete measuring cycle ΔT, which amplitude is measured by an ultrasonic sensor 20...36. The measuring cycle ΔT begins with a transmit pulse 38.1 and lasts until a further transmit pulse 38.2. Firstly, the ultrasonic sensor 20...36 receives a digital transmit pulse or a transmit command from the ECU 21, 27, 33 of the driving assistance system 11, 13, 15. As a result, the ultrasonic sensor 20...36 is excited to oscillate with, for example, square-wave pulses. The ultrasonic sensor 20...36 emits an ultrasonic pulse for a certain time, with no reception being possible during the decay time ΔT_1. After the time interval ΔT_1, the ultrasonic sensor is ready to receive for the time interval ΔT_2. The sound reflected by objects, for example another vehicle 10, 12, 14, causes the membrane, which has settled again, of the ultrasonic sensor 20...36 to oscillate again, resulting in the echo signals 40.

The oscillations are converted by the ultrasonic sensor 20...36 into an electrical signal and further processed by the sensor electronics. The acquired environment data are finally provided to the ECU 21, 27, 33 and utilised for controlling further components of the driving assistance system 11, 13, 15, for example for issuing warnings to the driver. Furthermore, from the instants at which the echo signals 40 were detected and the initially emitted pulse 38, there results the propagation delay or, taking account of the speed of sound, the distance between the ultrasonic sensor 20...36 and the detected object.

Besides the echo signals 40, however, signals 41 may also occur during a measuring cycle ΔT. Over the course of the measuring cycle ΔT, the signal 41 has a higher amplitude than the echo signals 40, despite the distance damping of the echo amplitude which is to be expected. Such signals 41 may come, in particular, from active external interferers, such as ultrasonic sensors 20...36 of other vehicles 10, 12, 14. Recognition and suppression of such signals can be carried out firstly on the basis of the amplitude values 46.2, 48.2, 50.2. A more reliable way, however, consists in taking account also of the phase information of the received signal 40, 41 in the plausibility check, since the phase information of the received signal 40, 41 can provide further information about its origin. In this case, advantageously the effects are combined, so that the amplitude 46.2, 48.2, 50.2 of the signal 40, 41 decreases with the distance, and for signals 40, 41 with large amplitudes 46.2, 48.2, 50.2 the phase information can be determined more accurately.

With the aid of the plausibility check, it is thus possible to distinguish between echo signals 40 and interference signals 41. Figure 3 shows, by way of example, characteristics 42 of an ultrasonic sensor 20...36 with measuring points 46.2, 48.2, 50.2, with the aid of which the plausibility check according to the invention is described in more detail.

Figure 3 shows characteristics 42 which link the amplitude 46.2, 48.2, 50.2 of received signals 40, 41 with the propagation delay or equivalently the distance d of a detected object. In this case, a maximum amplitude 48.2 to be expected results from the distance damping of the amplitude 46.2, 48.2, 50.2 for each measured propagation delay between transmitted pulse 30 and received pulse 40. These values correspond to the characteristic 42.2. Owing to measuring inaccuracies and deviations from the assumed model for the distance damping, furthermore a plausibility range 44 is set which takes account of deviations from the values 42.1 to be expected. This plausibility range 44 is given by the threshold values of the characteristics 42.1 and lies, for example, between ± 5 to 10% of the amplitude to be expected.

During the operation of the ultrasonic sensor 20...36, different signals 40, 41 are received and firstly evaluated with the aid of the characteristics 42, as shown in Figure 3. If a signal having a distance 48.1 and an amplitude 48.2 is received, this point 48 lies within the plausibility range 44 for the amplitude and indicates an echo signal 41. Received signals 40, 41 having an amplitude below the threshold value, and thus below the characteristic 42.1, may be plausible owing to the reflectivity of objects and the atmospheric damping due to the absorption in air, and therefore likewise lie in the plausibility range 44.

Received signals 40, 41, having for example a distance 46.1 and an amplitude 46.2, lie with the point 46 outside the plausibility range 44 and are unphysical. Such signals are therefore implausible and can be identified as interference signals without checking the phase information. The plausibility check with regard to the phase information is thus performed when the amplitude of the received signal 40, 41 at a given distance is below a threshold value 42.1. Additionally, the phase information can be determined only inaccurately for smaller amplitudes 50.2. Therefore, it is furthermore conceivable to perform the plausibility check with regard to the phase information when the amplitude of the received signal 40, 41 exceeds a minimum value 50.2.

If the amplitude of the received signal 40, 41 lies in the plausibility range 44 and if additionally the phase correlation extracted from the received signal 40, 41 with respect to the transmitted pulse 38 is inconsistent with the phase correlation to be expected, then, for example, the signal corresponding to point 48 is classified as an interference signal 41 from an external interferer, for instance an ultrasonic sensor 20...36 of another vehicle 10, 12, 14. The information that an ultrasonic sensor 20...36 of another vehicle has been detected as an external interferer and optionally its distance can furthermore be provided to the higher-order driving assistance system 11, 13, 15.

Figure 4 shows the plausibility check with regard to the amplitude 48.2, 50.2 and the phase information of the received signal 40, 41 with the aid of an exemplary representation of the plausibility ranges 44, 84 for the amplitude and the phase information at a given distance. Thus, the plausibility range 86 is firstly set by the respective plausibility ranges of the amplitude 44 and the phase information 84. For the amplitude, this results from the maximum physically possible threshold value 42.1 and optionally from the minimum value 50.2 starting from which a checking of the phase information is useful. The plausibility range 84 for the phase information likewise results from the physically possible limits 72, 70 between which the phase information can lie. A typical range 84 for the phase information lies, for example, between 0.4 and 1.

From the respective plausibility ranges 44, 84 for the amplitude and the phase information, there results a two-dimensional range 86 comprising plausible values. In order to refine the plausibility check further, a further discrimination is performed in the range 86, the plausibility range 84 for the phase information being matched to the respective amplitude, since at amplitudes below the minimum amplitude value 50.2, the phase information can only be determined inaccurately. Therefore, in the range 79 a greater plausibility range 84 is assumed and optionally further filters are used to discriminate signals from noise. Towards greater amplitude values, the determination of the phase information becomes more accurate and the plausibility range 84 can be continuously reduced with increasing amplitudes.

From this there results the division, shown by way of example in Figure 4, of the range 86 into an implausible range 82 and a plausible range 88. Finally, the plausibility check in the context of the method according to the invention can be refined to such an extent that only values which fall within the range 88 at a given distance are identified as echo signals, and signals which lie outside this range 86 are identified as interference signals. Thus, high-quality data are provided, which allow reliable object recognition and distance measurement.

Additionally, the data of detected external interferers are utilised to determine further information. For instance, external interferers can be detected even before entering the detection range of the distance sensor and be taken into account early by the driving assistance system. Furthermore, interference by the external interferer in one's own system can be minimised by changing the frequencies in the transmission spectrum of the distance sensor.

In Figure 5 there is illustrated a flow diagram 60 which explains the interplay between the components of the driving assistance system 11, 13, 15 according to the invention. In a step 62, pulses are emitted by the distance sensor with a defined transmission spectrum, for instance a frequency-modulated transmission spectrum. With this, the measuring cycle ΔT begins. In step 64, the distance sensor is ready to receive and receives signals until the end of the measuring cycle ΔT.

In step 66, the received signals 40, 41 are analysed and classified as an echo signal 40 or as an interference signal 41. In doing so, based on the amplitude 46.2, 48.2, 50.2 and the phase information of the received signals 40, 41, a plausibility check is performed and it is checked whether the amplitude 46.2, 48.2, 50.2 and the phase information of the lie within the respective plausibility range 44. Thus, in a particularly advantageous manner, use is made of the fact that the amplitude 46.2, 48.2, 50.2 of the signal 40, 41 decreases with the distance, and for signals 40, 41 with large amplitudes the phase information can be determined relatively accurately. The check with regard to amplitude 46.2, 48.2, 50.2 and phase information thus constitutes a reliable way of recognising and suppressing external interferers in the receiving spectrum of an ultrasonic sensor 20...36.

The invention is not limited to the exemplary embodiments described here and the aspects highlighted therein. Rather, a multiplicity of modifications lying within the scope of practice of a person skilled in the art are possible within the scope specified by the appended claims.

Claims

1. Method for environment recognition (60) using at least one distance sensor (20...36) comprising the following steps:

(a) emitting (62) at least one pulse (38, 38.2, 38.1) with a defined transmission spectrum;

(b) receiving (64) at least one signal (40, 41) in a measuring cycle (ΔT);

(c) classifying (66) the received signal (40, 41) as an echo signal (40) or as an interference signal (41), with a plausibility check being performed based on an amplitude (46.2, 48.2, 50.2) and phase information of the received signal (40, 41).

2. Method according to Claim 1, characterised in that a propagation delay measurement is performed with the aid of the distance sensor (20...36).

3. Method according to one of Claims 1 and 2, characterised in that, for the amplitude (46.2, 48.2, 50.2) and the phase information of the received signal (40, 41), in each case a plausibility range (44, 84) is set, and in the plausibility check it is determined whether the amplitude (46.2, 48.2, 50.2) and the phase information of the received signal (40, 41) lie within or outside the respective plausibility range (44, 84).

4. Method according to Claim 3, characterised in that the plausibility range for the amplitude comprises amplitudes

which lie below a threshold value of 5 to 10% above the value to be expected for the amplitude at a given distance.

5. Method according to one of Claims 3 and 4, characterised in that the plausibility range for the phase information lies between phase correlation coefficients of 0.2 and 1.

6. Method according to one of Claims 3 to 5, characterised in that the plausibility range for the phase information varies as a function of the amplitude.

7. Method according to one of Claims 3 to 6, characterised in that a received signal (40, 41), the amplitude (46.2, 48.2, 50.2) and phase information of which lie within the respective plausibility range (44), is classified as an echo signal (40), and a received signal (40, 41), the amplitude (46.2, 48.2, 50.2) or phase information of which lie outside the respective plausibility range (44), is identified as an interference signal (41).

8. Method according to one of Claims 1 to 7, characterised in that the received interference signal (41) is rejected.

9. Method according to one of Claims 1 to 8, characterised in that at least one parameter of the transmission spectrum is varied in reaction to an interference signal (41).

10. Method according to one of Claims 1 to 9, characterised in that the amplitude (46.2, 48.2, 50.2)

and/or the phase information of the received interference signal (41) are further processed.

11. Method according to Claim 10, characterised in that, from the amplitude (46.2, 48.2, 50.2) and/or the phase information of the received interference signal (41), an external interferer is recognised and a distance of the distance sensor (20...36) from the external interferer is estimated.

12. Method according to Claim 11, characterised in that the information that an external interferer has been detected and/or its distance are provided to a higher-order system (11, 13, 15).

13. Computer program for carrying out the method according to one of Claims 1 to 12 when the computer program is executed on a programmable computer device.

14. Driving assistance system (11, 13, 15) for carrying out the method according to one of Claims 1 to 12 having the following components:

(i) at least one distance sensor (20...36) for emitting at least one pulse (38, 38.2, 38.1) with a defined transmission spectrum and/or for receiving at least one signal (40, 41) in a measuring cycle (ΔT);

(ii) a component (21, 27, 33) for classifying the received signal (40, 41) as an echo signal (40) or as an interference signal (41), with a plausibility check being performed based on an amplitude (46.2, 48.2, 50.2) and phase information of the received signal (40, 41).

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Claims searched: 1-14 **Date of search:** 5 July 2013

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X,Y	1-3, 7-9, 13, 14; 11-12	US6356510 B1 (WAGSTAFF) See abstract, column 1, lines 5-9, 53-67, column 2, lines 1-10, column 3, lines 54-59.
X,Y	1-3, 7-9, 13, 14; 11-12	US6418083 B1 (WAGSTAFF) See abstract, column 1, lines 5-9, column 3, lines 10-24, column 5, lines 38-45, column 6, lines 38-67, column 7, lines 1-14.
X,Y	1-3, 7-9, 13, 14; 11-12	WO2013/051944 A1 (VALAND) See abstract, figure 1, page 2, lines 23-31, page 3, lines 20-28.
X,Y	1-3, 7, 8, 13, 14; 11-12	US2004/0051639 A1 (BALDWIN) See paragraphs [0012], [0013], [0014], [0062], [0064].
X,Y	1-3, 7-9, 13, 14; 11-12	GB2487649 A (SYMES) See paragraphs [0005], [0043], [0052], [0053].
Y	11-12	JP2007155551 A (KOIKE) See EPODOC/WPI abstract.
Y	11-12	EP2322952 A2 (HALLEK) See EPODOC/WPI abstract, figure 3.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^X :

Worldwide search of patent documents classified in the following areas of the IPC

G01S

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC

International Classification:

Subclass	Subgroup	Valid From
G01S	0007/527	01/01/2006