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(54) **Driver's arousal level estimating apparatus for vehicle and method of estimating arousal level**

Appareil d'estimation de l'état d'éveil du conducteur pour un véhicule et méthode d'estimation de l'état d'éveil

Vorrichtung zum Abschätzen des Wachzustandes des Fahrers von Kraftfahrzeugen und Verfahren zum Abschätzen des Wachzustandes

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- **PATENT ABSTRACTS OF JAPAN** vol. 017, no. 368 (M-1443), 12 July 1993 (1993-07-12) & JP 05 058192 A (TOYOTA MOTOR CORP), 9 March 1993 (1993-03-09)
- **PATENT ABSTRACTS OF JAPAN** vol. 2000, no. 10, 17 November 2000 (2000-11-17) & JP 2000 185575 A (FUJI HEAVY IND LTD), 4 July 2000 (2000-07-04)

EP 1 209 019 B9

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Description

[0001] The present invention relates to an apparatus and method of estimating an arousal level of a vehicle driver by particularly monitoring lateral displacements of a vehicle.

[0002] A technology for preventing car accidents caused by the decline of driver's arousal level is one of most important developmental subjects of today from the view point of vehicle safety. In recent years, studies for detecting drowsiness or arousal level of vehicle drivers, developments of techniques for warning them against falling into drowsy state are vigorously undertaken. When driver's arousal level descends, especially when a vehicle travels at high speeds, serious accidents may happen. Even if he or she does not fall into such drowsy state, drowsiness induces him or her to an absent-minded state which hinders a quick action for averting accidents, this also leading to accidents.

[0003] JP-A-5-58192 discloses a technique in which so-called "dozing at the wheel" is detected based on low frequency components in displacement quantity of a vehicle. In this disclosure, displacement quantities such as steering angle, lateral displacement of a vehicle and the like are monitored consecutively and low frequency components in frequency spectrum of the displacement quantity are extracted. On the other hand, low frequency components in frequency spectrum of displacement quantity at normal operations are memorized as sample data beforehand. Then, the low frequency components after a specified time elapses from the start of the vehicle are compared with those sample data. If a difference between the low frequency components and the sample data exceeds a predetermined value, it is judged that the driver dozes at the wheel.

[0004] However, the sample data which are used for the judgment reference are ones collected under a certain traveling condition (weather, road surface conditions, time, degree of traffic jams, vehicle speed and others). If the traveling condition changes, the judgment whether or not the driver is in a dozing state is accompanied by errors. That is, this background art has a problem that, when the traveling condition changes largely, it is difficult to obtain a correct judgment as to whether or not the driver is in a dozing state.

[0005] The applicant of the present invention has already proposed a method of estimating arousal level to solve such a problem in JP-A-2000-185575 which defines the preamble of claims 1 and 8. According to the technique disclosed in this publication, quantities of displacement in a widthwise direction of the vehicle are detected consecutively and respective frequency component powers are obtained by applying frequency conversion to these quantities of displacement. Next, the frequency domain is divided into a low frequency domain and a high frequency domain and an integration A1 of the frequency components powers in the low frequency domain and an integration A2 of the frequency

components powers in the high frequency domain are obtained respectively. Then, evaluation values are calculated using these integrations A1, A2 and an arousal level of a vehicle driver is judged based on the evaluation values.

[0006] It is an object of the present invention to provide an arousal level estimating apparatus capable of making an accurate judgment of driver's arousal level as well as a corresponding method.

[0007] The object is achieved by an arousal level estimating apparatus according to claim 1 and a method according to claim 8.

Fig. 1 is a block diagram showing an arousal level estimating apparatus according to the present invention;

Fig. 2 is a flowchart of a routine for calculating evaluation values;

Fig. 3 is a diagram showing time versus change of lateral displacement;

Fig. 4 is a graph showing respective powers of frequency components;

Fig. 5 is an explanatory view showing calculations of evaluation values;

Fig. 6 is a flowchart of a routine for judging warning; and

Fig. 7 is a diagram showing actual measuring results in traveling on a highway.

[0008] Referring now to Fig. 1, reference numeral 1 denotes a lateral displacement detecting section for detecting a displacement in a widthwise direction of the vehicle (hereinafter referred to as lateral displacement). For the purpose of the lateral displacement detecting section 1, for example, a stereoscopic camera using CCD and the like or a monocular camera can be used. An image information processing section 2 serves as processing images acquired by the lateral displacement detecting section 1 and obtaining quantities of displacement of the vehicle. For example, left and right lane markers of roads are imaged by a CCD camera and image data of one frame are stored in a memory of the image information processing section 2. Then, the left and right lane markers are recognized respectively by utilizing image recognition technique. That is, an area corresponding to the left and right lane markers is identified from the image data of one frame using known methods of recognition like a template method or stereomatching method. The position of the own vehicle within the left and right lane markers can be calculated from the lateral distance from a center of the vehicle to a center of the left and right lane markers.

[0009] Besides the CCD camera, lateral displacement can be detected also by a vehicle-road communication system using magnetic nails buried in roads, a GPS navigation system combined with vehicle speeds and the like (regarding a technique of warning using a navigation system, see Japanese Patent Application

Laid-open No. Toku-Kai-Hei 9-99756). Also, lateral displacement can be estimated by steering angles and the lateral displacement detecting section 1 can be replaced with a steering angle sensor. Furthermore, lateral displacement may be estimated by detecting yaw rate or lateral acceleration. Fluctuations or displacement quantities in the lateral direction of the vehicle are measured with resolution of 1.0 millimeter at a time interval of 0.1 seconds. Displacement related data is stored in a shift register of a FFT signal processing section 3 for obtaining frequency components power. A group of displacement data calculated in time series and accumulated for a specified time are stored. These data are updated successively by newly calculated data.

[0010] The FFT signal processing section 3, an evaluation value calculating section 4 and a judging section 5 are constituted by CPU, RAM, ROM and input and output circuits respectively and act as functional units in the computer. These functional units 3 to 5 are realized when respective components of the computer operate on each other under the control of an application program for executing a routine which will be described hereinafter. In the ROM, programs, a lower limit value PLOW, a table for establishing a step value α , warning judging values D1, D2 and the like are stored.

[0011] Fig. 2 is a flowchart of a routine for calculating evaluation values. This routine is executed repeatedly at a specified time interval. At a step 1, the displacement data acquired for the past X seconds and stored in the shift register of the FFT signal processing section 3 are read out every Y seconds (for example, 90 seconds). The sampling time X should be established at a rather long time (for example 50 to 80 seconds) in order to make an accurate estimation of arousal level.

[0012] At a step 2, the FFT signal processing section 3 applies a frequency conversion to the displacement quantity using a fast Fourier transformation (FFT) and the like and calculates respective frequency components power (amplitude) $P[i]$ in a frequency spectrum. In case of this embodiment, 16 frequency components powers $P[1]$ to $P[16]$ are calculated at an interval of 0.02 [Hz] in a frequency domain of 0.03 to 0.3[Hz]. The reason why the frequency domain below 0.03Hz is not taken into consideration is that powers of that domain tend to increase when the vehicle travels on a curved road and the frequency domain has no direct relationship with driver's arousal level. Further, the reason why the frequency domain above 0.3Hz is not taken into consideration is that since normally powers are negligibly small at that frequency domain, the amount of calculation of evaluation value H can be reduced.

[0013] The relationship between displacement quantity and frequency component power will be described. Fig. 3 shows graphs of the relationship between the change of lateral displacement quantity and elapsed time from the start of a vehicle. These graphs show the result of measurement when the vehicle travels on a relatively less crowded highway under a relatively monot-

onous traveling condition. The graph "After 10 minutes" shows a state immediately after the vehicle enters into the traffic stream and the displacement quantity is still small. When 20 minutes elapses, a driver gets accustomed to the traveling condition and becomes relaxed. As a result, compared with the graph "After 10 minutes", low frequency components increases and high frequency components decreases. Further, when 50 minutes elapses, the driver is bored and becomes slightly dozy. As a result, occasionally, a large displacement tends to generate. Compared with the graph "After 20 minutes", there is an outstanding tendency that the displacement quantity of low frequency components increases.

[0014] Fig. 4 is a graph showing a relationship between a frequency component i and a power $P[i]$ at the frequency component i , when the displacement quantity for each elapsed time of Fig. 3 is subjected to frequency conversion and a graph expressing discrete respective frequency component powers $P[i]$ as broken line. In this graph, a dotted line shows frequency component powers $P[i]$ when 10 minutes elapse after the start of the vehicle, a broken line shows frequency component powers $P[i]$ when 20 minutes elapse after the start of the vehicle, and a solid line shows frequency powers $P[i]$ when 50 minute elapse after the start of the vehicle. The graph indicates that frequency component powers $P[i]$ of the low frequency domain have a tendency to increase as traveling time is elongated.

[0015] At a step 3, respective frequency component powers $P[i]$ ($i=1$ to 16) in a frequency domain of 0.03 to 0.3[Hz] are subjected to a leveling process according to the following formula to obtain leveled frequency component powers $P'[i]$.

[Formula 1]

$$P'[i] = P[i] \cdot f^n$$

where exponent n : 2.0 to 3.0; f = frequency.

[0016] Assuming that the fluctuation of the vehicle within a lane is one of various fluctuations existing in the natural world, the amplitude of the fluctuation is $1/f$ and the power of the fluctuation is $1/f^2$. Accordingly, the exponent n of the formula 1 is theoretically 2. However, according to experiments, it has been found that $n = 2.5$ is most preferable. The reason why $n = 2.5$ is considered to be ascribed to vehicle, and human factors, the effect of roads or the like. Nevertheless, it is possible to judge an arousal level using an arbitrary exponent n ranging from 2.0 to 3.0. This embodiment adopts 2.5 for exponent n .

[0017] Fig. 5 shows a relationship between frequency components i and leveled frequency component powers $P'[i]$. An overall feature can be visually recognized from a distribution of the leveled frequency component powers $P'[i]$. The frequency component X power after 50 minutes indicates that a power $P'[4]$ at 0.09Hz and a

power P'[5] at 0.11Hz of a low frequency domain abruptly increase in vicinity of a fluctuation frequency f1 (= 0.1Hz). When driver's arousal level is at a low level, there is a tendency that with respect to lateral displacement of the vehicle the powers near the fluctuation frequency f1 increase. In other words, when an arousal level is low, there is a feature that only powers in a low frequency domain including the fluctuation frequency f1 increases and powers except that domain are low. In view of these tendencies, driver's arousal level can be judged by comparing a peak of powers near the fluctuation frequency f1 with powers at frequency domains other than the fluctuation frequency f1.

[0018] The fluctuation frequency f1 is defined as a frequency which increases when driver's arousal level is low (including a dozing condition). Generally, in case of passenger cars, the fluctuation frequency tends to appear at a frequency domain around 0.08 to 0.12 Hz. In actual cases, since the fluctuation frequency is affected by a response lag of vehicle behavior accompanied by steering operations, vehicle characteristics, vehicle speeds and the like, appropriate values are established for each model through experiments or simulations. In this embodiment, the fluctuation frequency f1 is established to 0.1Hz.

[0019] At a step 4, the evaluation value calculating section 4 obtains a grand total of respective frequency component powers P'[1] to P'[16] and calculates an average value P'_{ave}. According to the embodiment, in order to correctly reflect driver's arousal level on an evaluation value H which will be described hereinafter, a maximum power being excluded from the frequency component powers P'[1] to P'[16], the average value P'_{ave} is calculated from the rest of frequency component powers P'[1] to P'[16]. The reason why thus filtering is performed is that the effect of increasing power of the fluctuation frequency f1 and the effect of disturbances are deleted.

[0020] At a step 5, the evaluation value calculating section 4 judges whether or not the average value P'_{ave} is smaller than a lower limit value PLOW (for example 100) established beforehand. In case where the average value P'_{ave} is smaller than the lower limit value PLOW, the arousal condition of the driver is judged to be stable and the lower limit value PLOW is set to the average value P'_{ave} (step 6). This is for preventing the evaluation value H from growing unreasonably large when the evaluation value H is calculated at a step 10. On the other hand, in case where the average value P'_{ave} is larger than the lower limit value PLOW, the program skips to a step 7.

[0021] At the step 7, the evaluation value calculating section 4 makes a comparison of sizes between frequency component powers P'[4] and P'[5] in a specified frequency domain (0.09 to 0.11Hz). That frequency domain includes a fluctuation frequency f1 (0.01Hz). Then, a larger one is set as a fluctuation frequency power P'_{slp}. That is, in case where the power P'[5] at 0.11Hz is larger

than the power P'[4] at 0.09Hz, the power P'[5] is set to the fluctuation frequency power P'_{slp} (step 8). On the other hand, in case where the power P'[5] at 0.11Hz is smaller than the power P'[4] at 0.09Hz, the power P'[4] is set to the fluctuation frequency power P'_{slp} (step 9).

[0022] At a step 10, the evaluation value calculating section 4 calculates an evaluation value H according to the following formula:

[Formula 2]

$$H = P'_{slp} / P'_{ave} \times 100$$

This evaluation value is considered to be a momentary arousal level not including a time factor and is calculated as a ratio of the maximum power P'_{slp} at the frequency domain 0.09 to 0.11Hz to the average value P'_{ave} of respective frequency component powers P'[i]. After the evaluation value H is calculated at the step 10, the program leaves the routine. As shown in Fig. 5, when 10 minutes elapse, since the power P'_{slp} (P'[4] or P'[5]) is small; the evaluation value H is also small. On the other hand, when 50 minutes elapse, a driver's arousal level goes down. As a result, the power P'_{slp} increases and the evaluation value H becomes large. Thus, it is understood that the evaluation value H has a strong correlation with the driver's arousal level.

[0023] Fig. 6 is a flowchart of a routine for judging warnings. This routine is repeatedly executed at a specified interval. First, at a step 21, the judging section 5 establishes constants $\alpha 1$ to $\alpha 8$, 0 as step values according to the following table based on an evaluation value H calculated in the evaluation value calculating routine. These constants are for varying a value of an arousal level counter D and have a nonlinear relationship like $|\alpha 1| > |\alpha 2| > |\alpha 3| > |\alpha 4| > |\alpha 5|, |\alpha 6| < |\alpha 7| < |\alpha 8|$.

(Establishment of step values)

[0024]

Evaluation value	Step value
> 1000	+ $\alpha 1$
> 900	+ $\alpha 2$
> 800	+ $\alpha 3$
> 500	+ $\alpha 4$
> 400	+ $\alpha 5$
> 300	± 0
> 200	- $\alpha 6$
> 100	- $\alpha 7$
> 0	- $\alpha 8$

[0025] Next, at a step 22, the judging section 5 updates the value of the arousal level counter D by adding or subtracting a step value a to or from the present value

of the arousal level counter D. Then, at a step 23, it is judged whether or not the updated value of the arousal level counter D is larger than a first judging value D1 (1st warning judgment). If the updated value of the arousal level counter D is smaller than the first judging value D1, it is judged that the driver is in an arousal state and the program leaves the routine. On the other hand, if the updated value of the arousal level counter D is larger than the first judging value D1, the program goes to a step 24.

[0026] At the step 24, it is judged whether or not the value of the arousal level counter D is larger than a second judging value D2 (2nd warning judgment). If the value of the arousal level counter D is smaller than the second judging value D2, the program goes to a step 25 where, in order to warn fluctuations of the vehicle, it is instructed to the warning section 6 that a first warning should be issued and leaves the routine. On the other hand, if the value of the arousal level counter D is larger than the second judging value D2, the program goes to a step 26, where in order to warn the driver in a dozing state, it is instructed to the warning section 6 that a second warning should be issued and leaves the routine.

[0027] The warning section 6 executes miscellaneous warning processes to urge the driver to wake up responding to the instruction from the judging section 5. There is a variety of warning processes. One example is to sound an alarm. In case where it is judged that the arousal level descends, an reference inter-vehicle distance may be established to a rather long value. The warning section 6 may sound a lane running-off alarm in a rather early timing or sound a dozing alarm directly. Further, when the arousal level descends, the warning section 6 may instruct to display "Car fluctuates" on a dashboard of the vehicle.

[0028] Fig. 7 is a graph showing an actual measurement result when a vehicle travels at high speeds. In which, a lower diagram indicates a characteristic of lateral displacement of a vehicle, upper one indicates a characteristic of evaluation values H and a middle one indicates a characteristic of the arousal level counter D, respectively. According to this measurement result, when around 1400 seconds elapse from the start of the vehicle, peaks characteristic of lateral displacement appear successively and the fluctuation frequency f1 (= 0.1Hz) is found. As a result, the evaluation value H increases and the value of the arousal level counter D is incremented. When this increment occurs successively, an alarm is raised to the driver at an appropriate timing. According to the characteristic of lateral displacement of Fig. 7, the peaks appear before 1400 seconds. However, according to the embodiment, unless such peaks appear successively (unless the arousal level counter D is successively incremented), the warning section 6 does not raise a warning.

[0029] Thus, according to the embodiment, the driver's arousal level is judged by comparing the peaks of powers around the fluctuation frequency f1 with the powers

of other frequency domains. Therefore, the driver's arousal level can be judged only on the basis of the present and previous data. As a result, the arousal level can be properly judged even if the traveling condition changes.

[0030] In calculating the evaluation value H, with respect to the average value P'_{ave} of the frequency powers $P'[i]$, since the lower limit value is established in order to prevent the denominator of the formula 2 from becoming excessively small, the arousal level can be estimated accurately without having adverse effects of small disturbances when the vehicle travels at high speeds and driving patterns inherent to individual drivers.

[0031] Further, in this embodiment, when peaks of powers in the frequency domain including the fluctuation frequency f1 stand out against powers of other frequency domains, the lowered arousal level is detected. This method provides an advantage of preventing erroneous judgments of the arousal level even when lateral displacement quantity is small, or even when the vehicle has a light side wind or even when a large vehicle passes by.

[0032] Further, according to a prior art, a final arousal level is calculated from a time average of sporadic arousal levels and the judgment of warning is made by comparing this final arousal level with a threshold value. However, this method according to the prior art has a problem that the warning is accompanied by time lag. On the other hand, according to the method of the present invention, in case where an evaluation value H corresponding to sporadic arousal levels is large (particularly in case where the arousal level is substantially low), the step value α of the arousal level counter D is established to a large value. Accordingly, the warning can be issued without time lag.

[0033] While the present invention has been disclosed in terms of the preferred embodiment in order to facilitate better understanding of the invention, it should be appreciated that the invention can be embodied in various ways without departing from the principle of the invention. Therefore, the invention should be understood to include all possible embodiments which can be embodied without departing from the principle of the invention set out in the appended claims.

Claims

1. An arousal level estimating apparatus for estimating an arousal level of a driver of a vehicle comprising:

a power calculating means (3) for calculating a frequency component power by applying a frequency conversion method to a lateral displacement quantity detected successively
a first value calculating means (3) for calculating a first value; a second value calculating

- means (3) for calculating a second value;
 an evaluation value calculating means (4) for
 calculating an evaluation value (H) from a ratio
 of said first value and said second value; and
 a judging means (5) for judging a driver's arousal
 level based on said evaluation value **character-**
ised in that said first value calculating
 means (3) calculates said first value based on
 a sum of said frequency component powers
 calculated by said power calculating means (3),
 and said second value calculating means (3)
 calculates a maximum value of frequency compo-
 nent powers in a specified frequency domain
 including a fluctuation frequency (f_1) which in-
 creases when a driver's arousal level is low, as
 said second value.
2. The apparatus according to claim 1, wherein
 said evaluation value calculating means (4)
 further levels said frequency component powers.
3. The apparatus according to claim 2, wherein
 said evaluation value calculating means (4)
 calculates said leveled frequency component pow-
 ers by multiplying said frequency component pow-
 ers by a frequency raised to a power.
4. The apparatus according to claim 3, wherein
 said exponent n is a value not more than 3
 and not less than 2.
5. The apparatus according to claim 1, 2, 3 or 4,
 wherein
 said first value is obtained based on said fre-
 quency component powers excluding a maximum
 one from said respective frequency component
 powers calculated by said power calculating means
 (3).
6. The apparatus according to claim 1, 2, 3, 4 or 5,
 wherein
 said evaluation value calculating means (4)
 calculates said evaluation value (H) in time se-
 quence and said judging means (5) increases or de-
 creases a counter value according to said evalua-
 tion value (H) and when said counter value reaches
 a judging value, judges that a warning should be
 raised to a driver of said vehicle.
7. The apparatus according to claim 6, wherein
 said judging means (5) changes said counter
 value according to said evaluation value (H).
8. An arousal level estimating method, comprising the
 steps of:
 calculating a frequency component power by
 applying a frequency conversion method to a
 lateral displacement quantity detected succes-
 sively;
 calculating a first value; s
 calculating a second value;
 calculating an evaluation value (H) from a ratio
 of said first value and said second value; and
 judging a driver's arousal level based on said
 evaluation value, **characterized in that** said
 first value is calculated based on a sum of said
 calculated frequency component powers and
 said second value is a maximum value of fre-
 quency component powers in a specified fre-
 quency domain including a fluctuation frequen-
 cy (f_1) which increases when a drier's arousal
 level is low.
9. The method according to claim 8, wherein
 Said step of calculating said first value is ob-
 taining said first value based on said frequency
 component powers excluding a maximum one from
 said respective frequency component powers cal-
 culated by said step of calculating said frequency
 component power.
10. The method according to claim 8 or 9, wherein
 said step of calculating said evaluation value
 (H) is calculating said evaluation value (H) in time
 sequence and said step of judging is increasing or
 decreasing a counter value according to said eval-
 uation value (H) and when said counter value
 reaches a judging value, is judging that a warning
 should be raised to a driver of said vehicle.

35 Patentansprüche

1. Wachzustands-Abschätzvorrichtung zum Abschät-
 zen eines Wachzustands eines Fahrers eines Fahr-
 zeugs mit:

einer Leistungsberechnungseinrichtung (3)
 zum Berechnen einer Frequenzanteilsleistung
 durch Anwenden eines Frequenzumwand-
 lungsverfahrens auf eine fortlaufend detektier-
 te Querabweichungsgröße;
 einer ersten Wertberechnungseinrichtung (3)
 zum Berechnen eines ersten Werts;
 einer zweiten Wertberechnungseinrichtung (3)
 zum Berechnen eines zweiten Werts;
 einer Evaluationswert-Berechnungseinrich-
 tung (4) zum Berechnen eines Evaluations-
 werts (H) anhand eines Verhältnisses des er-
 sten Werts und des zweiten Werts; und
 einer Beurteilungseinrichtung (5) zum Beurtei-
 len des Wachzustands eines Fahrers auf der
 Grundlage des Evaluationswerts,

dadurch gekennzeichnet, daß die erste Wertbe-

- rechnungseinrichtung (3) den ersten Wert auf der Grundlage einer Summe der Frequenzanteilsleistungen berechnet, die durch die Leistungsberechnungseinrichtung (3) berechnet werden, und die zweite Wertberechnungseinrichtung (3) einen Maximalwert von Frequenzanteilsleistungen in einem festgelegten Frequenzbereich, der eine Schwankungsfrequenz (f_1) aufweist, die zunimmt, wenn der Wachzustand eines Fahrers gering ist, als zweiten Wert berechnet. 5
2. Vorrichtung nach Anspruch 1, wobei die Evaluationswert-Berechnungseinrichtung (4) ferner die Frequenzanteilsleistungen nivelliert. 10
3. Vorrichtung nach Anspruch 2, wobei die Evaluationswert-Berechnungseinrichtung (4) die nivellierten Frequenzanteilsleistungen durch Multiplizieren der Frequenzanteilsleistungen mit einer mit n potenzierten Frequenz berechnet. 20
4. Vorrichtung nach Anspruch 3, wobei der Exponent n einen Wert von höchstens 3 und mindestens 2 hat. 25
5. Vorrichtung nach Anspruch 1, 2, 3 oder 4, wobei der erste Wert auf der Grundlage der Frequenzanteilsleistungen mit Ausnahme einer maximalen aus den jeweiligen Frequenzanteilsleistungen erhalten wird, die durch die Leistungsberechnungseinrichtung (3) berechnet werden. 30
6. Vorrichtung nach Anspruch 1, 2, 3, 4 oder 5, wobei die Evaluationswert-Berechnungseinrichtung (4) den Evaluationswert (H) in zeitlicher Folge berechnet und die Beurteilungseinrichtung (5) einen Zählerwert entsprechend dem Evaluationswert (H) erhöht oder verringert und dann, wenn der Zählerwert einen Beurteilungswert erreicht, bestimmt, daß eine Warnung für einen Fahrer des Fahrzeugs ausgegeben werden sollte. 40
7. Vorrichtung nach Anspruch 6, wobei die Beurteilungseinrichtung (5) den Zählerwert entsprechend dem Evaluationswert (H) ändert. 45
8. Verfahren zum Abschätzen des Wachzustands mit den folgenden Schritten:
- Berechnen einer Frequenzanteilsleistung durch Anwenden eines Frequenzumwandlungsverfahrens auf eine fortlaufend detektierte Querabweichungsgröße; 50
 - Berechnen eines ersten Werts;
 - Berechnen eines zweiten Werts; 55
 - Berechnen eines Evaluationswerts (H) anhand eines Verhältnisses des ersten Werts und des zweiten Werts; und
- Beurteilen des Wachzustands eines Fahrers auf der Grundlage des Evaluationswerts,
- dadurch gekennzeichnet, daß** der erste Wert auf der Grundlage einer Summe der berechneten Frequenzanteilsleistungen berechnet wird und der zweite Wert ein Maximalwert von Frequenzanteilsleistungen in einem festgelegten Frequenzbereich ist, der eine Schwankungsfrequenz (f_1) aufweist, die zunimmt, wenn der Wachzustand eines Fahrers gering ist.
9. Verfahren nach Anspruch 8, wobei der Schritt des Berechnens des ersten Werts das Erhalten des ersten Werts auf der Grundlage der Frequenzanteilsleistungen mit Ausnahme einer maximalen aus den jeweiligen Frequenzanteilsleistungen aufweist, die durch den Schritt des Berechnens der Frequenzanteilsleistung berechnet werden.
10. Verfahren nach Anspruch 8 oder 9, wobei der Schritt des Berechnens des Evaluationswerts (H) das Berechnen des Evaluationswerts (H) in zeitlicher Folge aufweist und der Schritt des Beurteilens das Erhöhen oder Verringern eines Zählerwerts entsprechend dem Evaluationswert (H) und dann, wenn der Zählerwert einen Beurteilungswert erreicht, das Beurteilen aufweist, daß eine Warnung für einen Fahrer des Fahrzeugs ausgegeben werden sollte.

Revendications

1. Dispositif d'estimation de niveau d'éveil destiné à estimer le niveau d'éveil du conducteur d'un véhicule comprenant :

un moyen de calcul de puissance (3) destiné à calculer une puissance de composante de fréquence en appliquant une méthode de conversion de fréquence à une quantité de déplacement latéral détectée tour à tour ;
 un premier moyen de calcul (3) de valeur destiné à calculer une première valeur ;
 un second moyen de calcul (3) de valeur destiné à calculer une seconde valeur ;
 un moyen de calcul de valeur d'évaluation (4) destiné à calculer une valeur d'évaluation (H) d'après un rapport de ladite première valeur et de ladite seconde valeur ; et
 un moyen d'estimation (5) destiné à estimer le niveau d'éveil du conducteur sur la base de ladite valeur d'évaluation, **caractérisé en ce que** ledit premier moyen de calcul (3) de valeur calcule ladite première valeur sur la base d'une somme desdites puissances de composantes

- de fréquences calculées par ledit moyen de calcul (3) de puissance, et ledit second moyen de calcul (3) de valeur calcule une valeur maximum de puissances de composantes de fréquences dans une plage de fréquences spécifiée comprenant une fréquence de fluctuation (f_1) qui augmente lorsque le niveau d'éveil d'un conducteur est faible, en tant que dite seconde valeur.
- 5
2. Dispositif selon la revendication 1, dans lequel ledit moyen de calcul de valeur d'évaluation (4) uniformise en outre lesdites puissances de composantes de fréquences.
- 10
3. Dispositif selon la revendication 2, dans lequel ledit moyen de calcul de valeur d'évaluation (4) calcule lesdites puissances de composantes de fréquences uniformisées en multipliant lesdites puissances de composantes de fréquences par une fréquence élevée à la puissance n.
- 15
4. Dispositif selon la revendication 3, dans lequel ledit exposant n est une valeur qui n'est pas supérieure à 3 et qui n'est pas inférieure à 2.
- 20
5. Dispositif selon la revendication 1, 2, 3 ou 4, dans lequel ladite première valeur est obtenue sur la base desdites puissances de composantes de fréquences en excluant une puissance maximum parmi lesdites puissances de composantes de fréquences respectives calculées par ledit moyen de calcul (3) de puissance.
- 25
6. Dispositif selon la revendication 1, 2, 3, 4 ou 5 dans lequel ledit moyen de calcul de valeur d'évaluation (4) calcule ladite valeur d'évaluation (H) selon une séquence dans le temps et ledit moyen d'évaluation (5) augmente ou diminue une valeur de compteur en fonction de ladite valeur d'évaluation (H) et, lorsque ladite valeur de compteur atteint une valeur d'estimation, estime qu'un avertissement devrait être émis vers le conducteur dudit véhicule.
- 30
- 35
- 40
- 45
7. Dispositif selon la revendication 6, dans lequel ledit moyen d'estimation (5) modifie ladite valeur de compteur en fonction de ladite valeur d'évaluation (H).
- 50
8. Procédé d'estimation du niveau d'éveil comprenant les étapes consistant à :
- calculer une puissance de composante de fréquence en appliquant une méthode de conversion de fréquence à une quantité de déplacement latéral détectée tour à tour ;
- 55
- calculer une première valeur ;
calculer une seconde valeur ;
calculer une valeur d'évaluation (H) d'après un rapport de ladite première valeur et ladite seconde valeur, et
estimer le niveau d'éveil du conducteur sur la base de ladite valeur d'évaluation, **caractérisé en ce que** ladite première valeur est calculée sur la base d'une somme desdites puissances de composantes de fréquences calculées, et **en ce que** ladite seconde valeur est une valeur maximum de puissances de composantes de fréquences dans une plage de fréquences spécifiée comprenant une fréquence de fluctuation (f_1) qui augmente lorsque le niveau d'éveil du conducteur est faible.
9. Procédé selon la revendication 8, dans lequel ladite étape de calcul de ladite première valeur consiste à obtenir ladite première valeur sur la base desdites puissances de composantes de fréquences en excluant une puissance maximum desdites puissances de composantes de fréquences respectives calculées par ladite étape de calcul desdites puissances de composantes de fréquences.
10. Procédé selon la revendication 8 ou 9, dans lequel ladite étape de calcul de ladite valeur d'évaluation (H) consiste à calculer ladite valeur d'évaluation (H) selon une séquence dans le temps, et ladite étape d'évaluation consiste à augmenter ou diminuer une valeur de compteur en fonction de ladite valeur d'évaluation (H) et, lorsque ladite valeur de compteur atteint une valeur d'estimation, consiste à estimer qu'un avertissement devrait être émis vers le conducteur dudit véhicule.

FIG.1

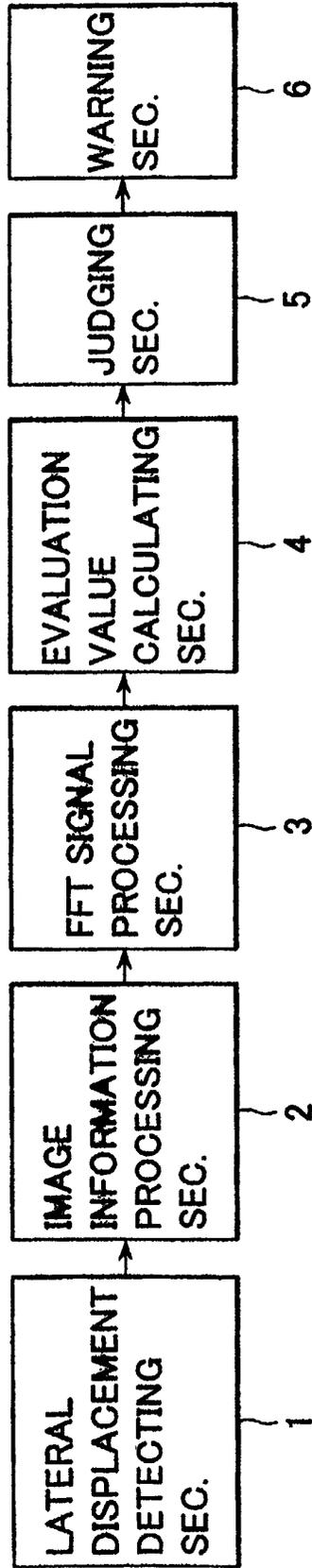


FIG.2

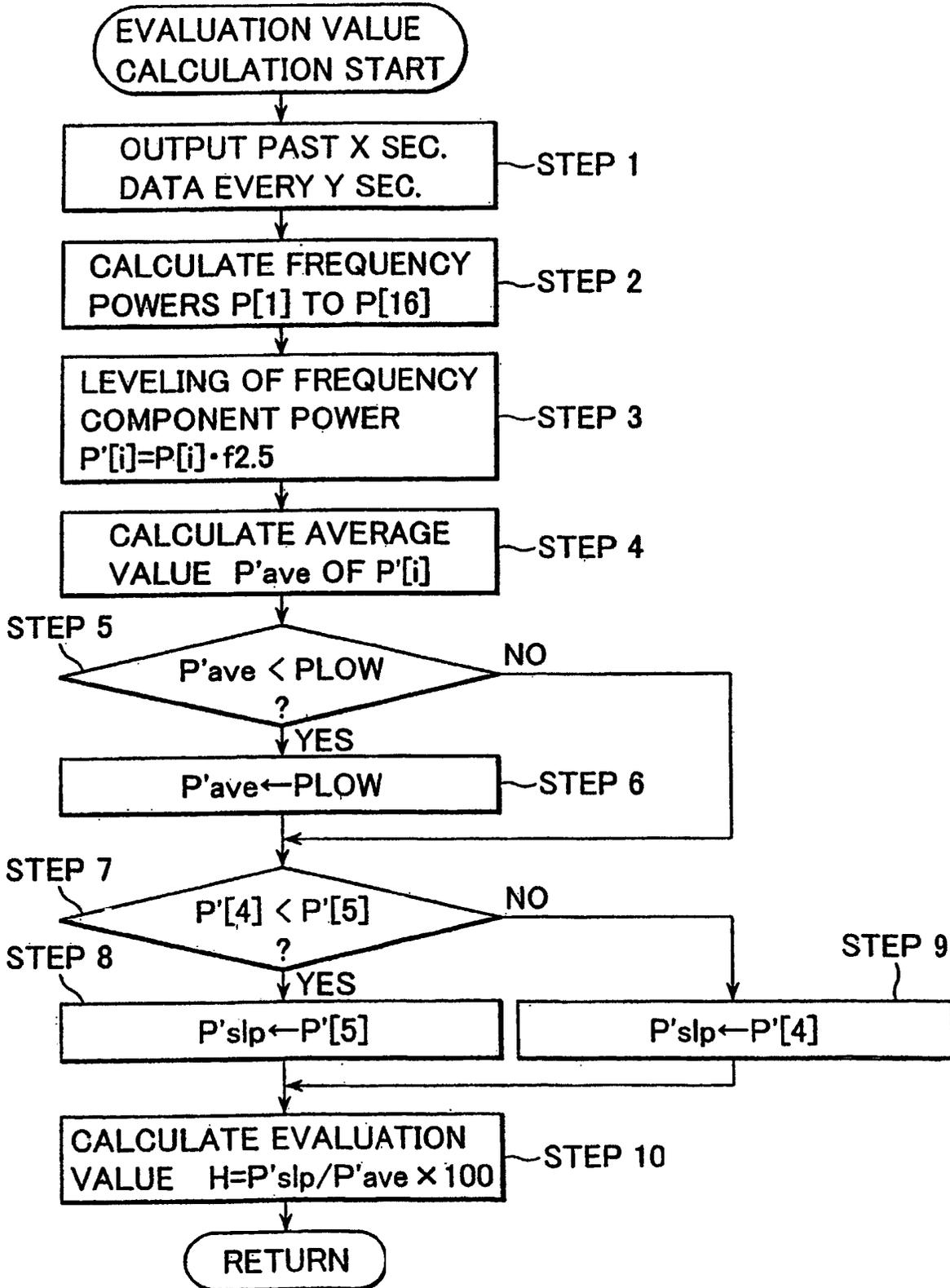


FIG.3

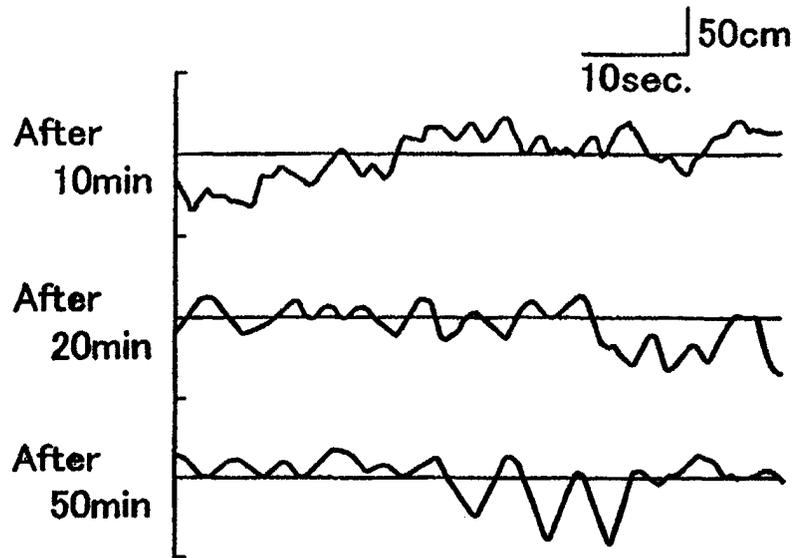


FIG.4

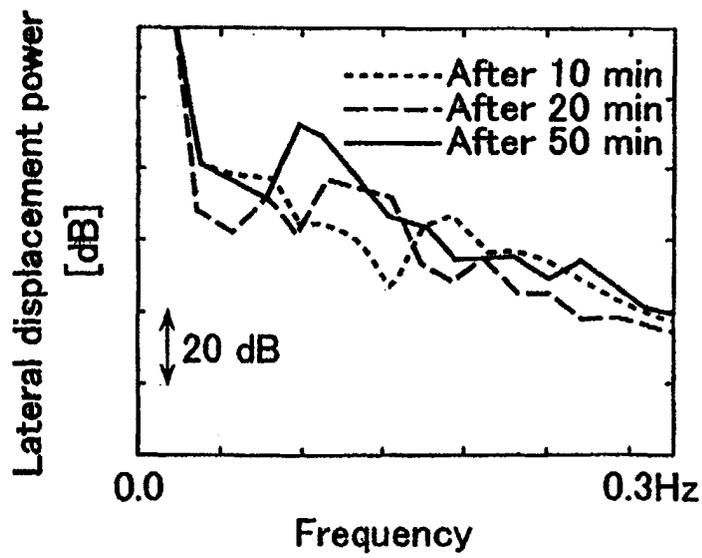


FIG.5

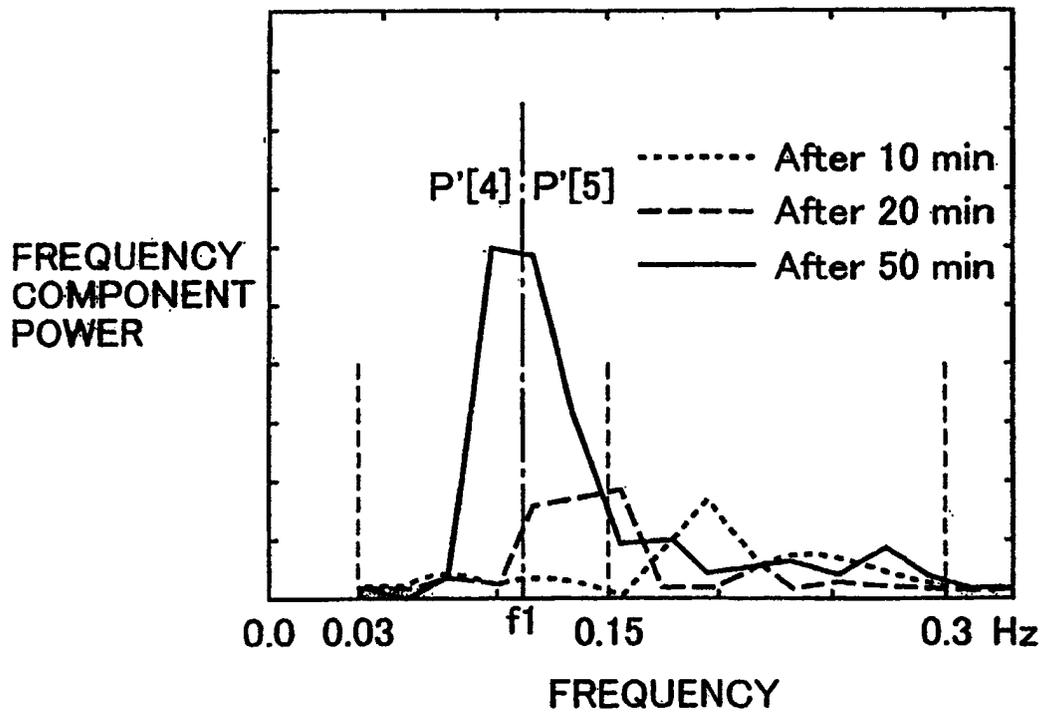


FIG.6

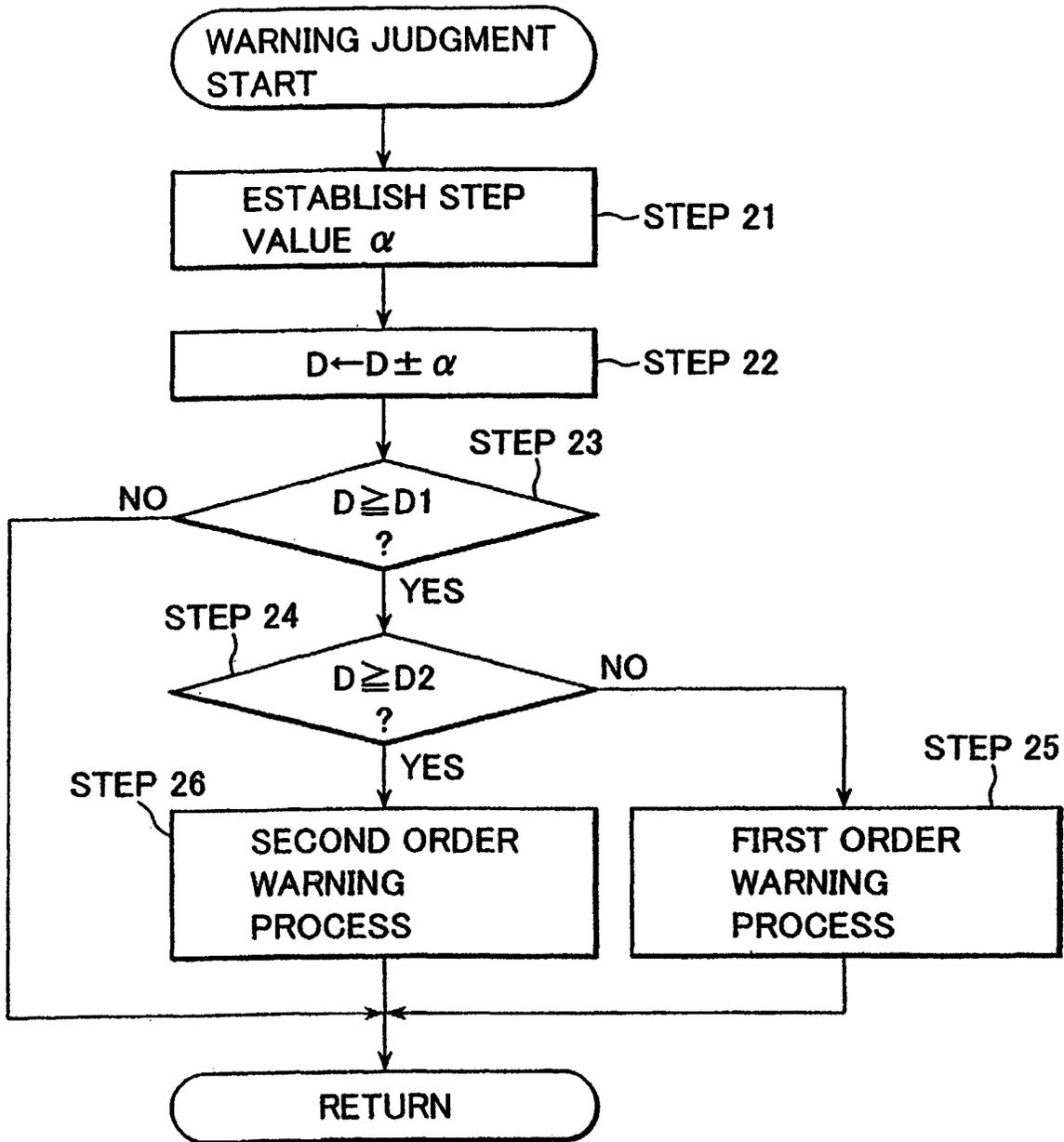


FIG.7

