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Datasheet for the decision of 2 August 2018

Case Number: T 2420/12 - 3.4.01

Application Number: 08150604.0

Publication Number: 2068269

IPC: G06K9/00, G06K9/32, G06T7/20, B60W30/08, G08G1/16, G05D1/02

Language of the proceedings: EN

Title of invention:
Collision warning system

Applicant:
Mobileye Vision Technologies Ltd.

Headword:
Collision warning / MOBILEYE

Relevant legal provisions:
EPC Art. 56

Keyword:
Inventive step - (no) - reasonable expectation of success (yes)

Decisions cited:
T 0439/92, T 0478/91, T 0110/92, T 1435/10

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Case Number: T 2420/12 - 3.4.01

D E C I S I O N
of Technical Board of Appeal 3.4.01
of 2 August 2018

Appellant: (Applicant)
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Decision under appeal:
Decision of the Examining Division of the European Patent Office posted on 11 July 2012 refusing European patent application No. 08150604.0 pursuant to Article 97(2) EPC.

Composition of the Board:

Chairman P. Scriven
Members: F. Neumann
R. Winkelhofer

Summary of Facts and Submissions

I. The appeal is directed against the decision of the Examining Division to refuse European patent application 08 150 604.0.

II. The application was refused because the subject-matter of claim 1 on file at that time was, inter alia, not new.

III. At oral proceedings before the Board, the Appellant formulated as its sole final request, that the decision under appeal be set aside and that a patent be granted on the basis of the second auxiliary request filed during the oral proceedings before the Board.

IV. The following documents were referred to during the appeal proceedings:

D3: WO-A-01/39018;
D11: Stein G. P. et al.; "Vision-based ACC with a Single Camera: Bounds on Range and Range Rate Accuracy"; IEEE Intelligent Vehicles Symposium (IV2003); June 2003; Columbus OH.

V. Claim 1 reads as follows:

"A method of determining a time to collision (TTC) of a following vehicle (22) with a lead vehicle (21), the method comprising the steps of:
acquiring with a collision warning/avoidance system (CWAS), which images the environment in front of the following vehicle, a plurality of images (70) of the lead vehicle (21) at known time intervals Δt between the times *t* at which the images (70) are acquired, the

plurality of images including a first image acquired at a first time tl and a second image acquired at a second time t2;
determining a relative scale S(t) wherein S(t) = w(t2)/ w(tl), w(tl) represents a dimension of a feature of the lead vehicle in the first image, and w(t2) represents the same dimension of the same feature of the lead vehicle in the second image;
on the basis of the relative scale S(t), determining a time $T_V(t)$, wherein $T_V(t)$ equals

$$\frac{\Delta t}{S(t)-1};$$

and characterised by
determining the time to collision (TTC) based on a rate of change of time $T_V(t)$ over times t, wherein the time to collision (TTC) equals

$$\frac{T_v(t)}{C(t)}(1-\sqrt{1-2C(t)})$$

where $C(t) = T_V'(t) + 1$ and $T_V'(t)$ is the rate of change of time $T_V(t)$ over times t;[sic]"

VI. The arguments of the Appellant, insofar as they are pertinent, are set out below in the reasons for the decision.

Reasons for the Decision

1. The Appellant's earlier application, document D3, discloses a method for determining the time to contact (TTC), also referred to as "time to collision", of a vehicle with an obstacle. As the present application acknowledges, the method of D3 is based on the assumption of constant relative velocity between the vehicle and the obstacle. Since this assumption is not always valid, the present application extends the teaching of D3 to provide a method of determining TTC taking any relative acceleration between the vehicle and the obstacle into account.

2. D3 is based on a system using a monocular imaging device which provides estimates of range using the laws of perspective. The range estimates, derived purely from the dimensions of the obstacle in the image, are used to estimate the time to contact (which is denoted $T_V(t)$ in the present application). In D3, a feature of the image is tracked to determine, at time t, the ratio (the "relative scale $S(t)$") between a dimension of a feature of the obstacle in first and second images. The TTC is determined on the basis of this relative scale measurement $S(t)$ and the time period ΔT between the two images, without needing any information as to the actual distance between the vehicle and the obstacle. Specifically, the time to contact $T_V(t)$ is calculated using the equation $T_V(t) = \Delta T / (S(t) - 1)$. Thus, in order to calculate TTC, only dimensional information from the images and the time period ΔT are needed. All method steps of the preamble of claim 1 are known from D3.

3. The method of claim 1 of the present application is distinguished from the method of D3 in that the TTC (which is denoted $T_a(t)$ when using the method of the present application) is determined based on the rate of change ($T_v'(t)$) of $T_v(t)$, where $T_a(t)$ equals

$$\frac{T_v(t)}{C(t)}(1-\sqrt{1-2C(t)})$$

and $C(t) = T_v'(t) + 1$. $T_a(t)$ is the TTC estimated using the present invention. $T_v(t)$ is the estimate from D3.

4. The technical effect of this distinguishing feature is that a more accurate, image-based TTC, which takes relative acceleration between the vehicle and the obstacle into account, may be calculated.

5. Starting from D3, the objective technical problem may therefore be seen as how to modify the method of D3 so as to calculate an image-based TTC taking the relative acceleration between the vehicle and the obstacle into account.

6. It is acknowledged in D3 that the equation used to determine TTC is based on the assumption of constant relative velocity between the vehicle and the obstacle (see D3, equation (13) and the explanatory text thereto). Thus it is immediately apparent from D3 that if the relative velocity were to change, then the TTC calculation of D3 would be incorrect.

It is therefore evident that a problem associated with the method used in D3 is the fact that relative acceleration between the vehicle and the obstacle is ignored.

7. In order to take relative acceleration into account, the skilled person would turn to well-known equations of motion to establish the effect that acceleration has on range $Z(t)$ and velocity $V(t)$. Equation (6) of the present application expresses the distance to a collision $Z(t+T_a(t))$ in terms of the instantaneous separation of the vehicles at time t and the change in distance between the vehicles due to a constant relative acceleration:

$$Z\big(t+T_a(t)\big) = Z(t) + V(t)T_a(t) + \frac{a(t)T_a^2(t)}{2}.$$

This equation is, in fact, recited in D11 (see equation 18) which was introduced by the Appellant to illustrate the background to the invention. No inventive step would be involved in formulating or adopting equation (6). Using the quadratic formula to solve equation (6) for $T_a(t)$ results in equation (7)

$$T_a(t) = \frac{-V(t) + \sqrt{V^2(t) - 2Z(t)a(t)}}{a(t)}.$$

Again, no inventive step would be involved in performing this algebraic operation.

8. Starting from D3, any further development will normally have to remain within its framework (see e.g. T 439/92, *Trennwand/ALTURA*). The aim of D3 is to determine TTC based solely on dimensional information of features in the images and the time interval between the images. Using D3 as a starting point, this means that the skilled person, seeking to take acceleration into account, would try to do so using only image-based data.

9. In doing so, the skilled person would at least attempt to re-formulate equation (7) of the application in terms of the relative scale and time interval measurements made using the image-based method of D3. In particular, the velocity $V(t)$ and the acceleration $a(t)$ in equation (7) would have to be determined using just the data which is derivable from D3.

As shown in equation (5) of the present application, the instantaneous TTC in D3 may be expressed as

$T_V(t) = -Z(t) / V(t)$ and
$T_V(t) = \Delta t / (S(t) - 1)$

where $Z(t)$ is the distance to the object at time t, $V(t)$ is the relative velocity at time t and $S(t)$ is the relative scale between two images separated by a time interval Δt. The first of these equations is common general knowledge. The second equation is known from D3 (see equation 16).

The skilled person would realise that the rate of change of time to contact will reflect the rate of change of distance to contact and that the velocity may therefore be determined by taking the time derivative of $T_V(t)$. Equation (8) of the application states that

$$T'_v(t) = \frac{a(t)Z(t)}{V^2(t)} - 1$$

and provides an expression for the time derivative of $T_V(t)$ which can be obtained by straightforward algebra from the definition of $T_V(t)$ appearing in equation (5) of the application. Substituting the expression for $T_V'(t)$ from equation (8) into the expression for $T_a(t)$

in equation (7) would lead, after more straightforward manipulation, to equation (11):

$$T_a(t) = \frac{T_v(t)}{C(t)}(1 - \sqrt{1 - 2C(t)}) \cdot$$

The algebraic manipulation involved in the derivation of equation (11) is routine work for the skilled person. The skilled person would therefore arrive at the subject-matter of claim 1 in an obvious manner.

10. The Appellant presented a number of arguments as set out below. However, none of these arguments concerns the fundamental question of whether it would have been obvious to the skilled person to modify the method of D3 by determining the TTC based on the rate of change of time $T_v(t)$. Since the arguments only concern issues which are extraneous to this fundamental question, they all fail.

11. The Appellant argued that the claimed invention involved more than just algebra and that extensive testing was required to ensure the accuracy of the TTC calculations. In fact, a test methodology and apparatus had to be developed such that field tests could be performed. Specifically, in order to test the accuracy of warnings at TTC values below 3 seconds, a new test rig had to be designed and built. With the old test rig, an actual collision could not be simulated without destroying the test vehicle. Evasive action had to be taken at about 3 seconds before impact to avoid collision. Thus, with the old test rig, it was not clear how well the TTC calculation fitted with reality below about 3 seconds. Until an improved test equipment had been constructed, the claimed relative acceleration model showed no signs of success. On the contrary, the

calculations incorporating relative acceleration were no better than the results achieved with the method of D3. Thus, the skilled person would not even have investigated whether any improvement in accuracy could be achieved at TTC values less than 3 seconds. It was only after introduction of a newly designed test rig that testing could be performed down to *TTC=0* (i.e. a simulated actual collision) and it could be demonstrated that the use of the time derivative of $T_V(t)$ was in fact an improvement over the prior art. As could be seen from Fig. 7 of the priority document, these tests showed a very close fit to the actual TTC at times below 2 seconds. It took over a year of research to reduce the false positive and false negative collision warnings to an acceptable level. Without the new test rig, it would have been impossible to predict whether the use of $T_V'(t)$ would actually achieve an improvement over D3.

12. The testing method and equipment are not part of the claimed invention. Thus, whilst it is appreciated that significant investment went into testing whether equation (11) actually delivered reliable results, this factor cannot be taken into consideration when assessing the inventive step of the claimed subject-matter. As shown above, the modification of D3 is based, firstly, on the obvious desire to take acceleration into account and, secondly, on straightforward algebra which results in an expression for TTC incorporating *Tv'(t)* as claimed. Testing to see whether or not the envisaged modification would be an improvement over the prior art and would be worth pursuing further only becomes necessary once the invention has been conceived. It is the conception of the idea to use *Tv'(t)* in the TTC computation that has to be assessed for inventive step. The development of

good test equipment to prove the accuracy of the conceived idea does not influence the question of whether that idea itself was obvious or not.

13. Coupled to this argument, the Appellant indicated that using the old test rig, the computed values of $T_V(t)$ were clearly very noisy and therefore unreliable. The skilled person would therefore not consider using the $T_V(t)$ results of D3 in any alternative method for determining TTC. In particular, taking a derivative of these noisy results would lead to even more noise. At the priority date, the skilled person would have believed that relative acceleration could not be derived sufficiently accurately from images to be able to provide a reliable collision warning. In fact, the Appellant's own attempts to extend and improve the TTC calculation of D3 to take the acceleration into account by using the derivative of scale dS/dt had not been promising. It could be seen from D11 that equation (6) of the present application had been previously discussed in relation to the effect of relative acceleration on the range and velocity calculations, but the authors of D11 did not seek to include relative acceleration in the calculation of time to contact. The Appellant pointed out that equation (7) of the present application contained a single fraction with the acceleration as the denominator. The skilled person would reasonably assume that the relative acceleration, with its significant error, would have far too great an influence over the calculation of TTC and would undermine the calculation to such an extent that the skilled person would not consider that the pursuit of any option involving equation (7) would be worthwhile. Nevertheless, the Appellant persevered in spite of this assumption and developed a calculation incorporating the time derivative of $T_V(t)$. The design and

construction of a new test rig enabled the Appellant to assess the accuracy of the computed results at times closer to contact (i.e. at times less than three seconds) and to establish that the new calculation was actually an improvement over the prior art calculation.

14. The assumption that the calculation of TTC using equation (7) would be compromised by the errors involved in the image-based determination of acceleration cannot be seen to be a technical prejudice in the sense used in the case law. No evidence has been supplied to suggest that this assumption reflects an opinion or preconceived idea widely or universally held by experts in the field (see Case Law of the Boards of Appeal of the European Patent Office, 8th edition, I.D. 10.2). In this regard, the fact that the invention involved ignoring or questioning this assumption cannot be used to support an inventive step.

15. Any estimation of TTC which does not take account of the relative acceleration between the vehicle and the obstacle will be incorrect. The skilled person would expect that including acceleration in the calculation would inevitably lead to an improved accuracy. This expectation of success is the driving force which motivates the skilled person to look more closely at equation (7) to try to find a form which could be used with just the image-based data of D3. Based on the routine algebraic manipulation outlined above, it would be obvious to the skilled person at least to attempt to use $T_V'(t)$ to obtain an improved calculation of TTC.

Having decided to work within the constraints of the single camera system of D3, the skilled person is faced with a trade off: any noise involved in the determination of acceleration from image-based data will have to be accepted if a single-camera system is to be used. Knowing that the acceleration must be somehow incorporated into the calculation to improve its accuracy, the skilled person would have to experiment to see how the use of image-based acceleration in equation (7) would affect the accuracy of the TTC calculation. In this respect, the skilled person would be in a "try and see" situation in which he or she would at least attempt to use image-based data to derive the acceleration and to thereby maintain the advantages of the single-camera system of D3 (see T 1435/10).

16. The Appellant further argued that the tracking error depended on the image size of the object being tracked. Since there was no good model for the tracking error, it was not possible to predict success ahead of experimentation. In other words, an accurate theoretical simulation could not be run since the errors involved in the tracking method could not be specified. Without the ability to test down to moments before the collision (i.e. down to TTC < 2 seconds), it was not clear that the claimed method would provide improved results.

17. Again, this argument cannot be followed since the question of whether or not a theoretical simulation could predict success does not play a role in the assessment of inventive step.

18. The Appellant further argued that there would need to be a convincing demonstration that the TTC calculation could be improved by the incorporation of relative acceleration before the skilled person would consider modifying document D3 in such a way.

19. It is indeed evident that a modified TTC calculation will only be implemented in collision warning systems once it has been convincingly demonstrated that the results are reliably improved. However, this argument concerns the implementation of the claimed invention and is not helpful for considering whether the invention itself involves an inventive step.

20. A further argument submitted by the Appellant concerned the commercial success of the invention. It was submitted that the technology discussed in the present application has been instrumental in developing the first commercial camera-based collision warning system. Sales of the product have increased dramatically since its introduction.

21. Commercial success alone is not indicative of inventive step. The commercial success must derive from the technical features of the invention and not from other influences such as advertising and marketing (see, e.g., T 478/91 *Poulie à gorges*, and T 110/92). In the present case, it is not clear whether the commercial success of the product should be attributed to the claimed method of determining the TTC or whether other aspects of the product or the marketing thereof may have contributed to the increasing sales. Even if the success of the camera-based collision warning system were derived from the technical features of the claimed method, the technical examination of the claimed subject-matter leads to the result that claim 1 lacks an inventive step.

22. As a result, the subject-matter of claim 1 cannot be considered as comprising an inventive step (Art. 56 EPC).

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

M.H.A. Patin P. Scriven

Decision electronically authenticated