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(בעברית) (Hebrew) שיטה ומתקן לזיהוי שינויי מסלול ו/או שינויי מהירות ליעד

(באנגלית) (English) METHOD AND APPRATUS FOR IDENTIFYING CHANGES OF COURSE AND/OR CHANGES OF SPPED FOR A DESTINATION

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METHOD AND APPRATUS FOR IDENTIFYING CHANGES OF COURSE AND/OR CHANGES OF SPPED FOR A DESTINATION

2197ATL-IL

METHOD AND APPARATUS FOR IDENTIFYING CHANGES OF COURSE AND/OR CHANGES OF SPEED FOR A DESTINATION

FIELD OF THE INVENTION

The invention relates to a method and an apparatus for identification of course changes and/or velocity changes of a target according to the precharacterizing clause of Claims 1 and 9, respectively.

In sonar technology, various types of sensors for directionally selective reception of sound waves are normally used for passive determination of target data by a carrier vehicle, for example a surface vessel or a submarine. In this case, a sensor means a hydroacoustic receiving antenna, also an underwater antenna, such as a cylinder base, a flank antenna or a towed antenna.

In order to determine the position, velocity and course of a target, for example of a surface vessel, of a submarine or of a moving underwater body as so-called target data from the carrier vehicle without giving itself away, sound which is transmitted or radiated by the target, that is to say sound that is produced or reflected unavoidably by the target (for example by the vessel engine or pumps, etc.), is received by a method known as the TMA method (Target Motion Analysis method) for the passive determination of target data by means of a sonar receiving installation, and a bearing angle to the target is measured. The target data of the target is estimated from successive measured bearing angles, and own positions of the carrier vehicle associated with these bearing angles. By way of example, this is done using a method which iteratively determines a target track for which the sum of weighted square errors between the measured bearing angles and estimated bearing angles associated with this target track is a minimum. A method of this type is described e.g. in DE 34 46 658 C2 or in INCEL ET AL.: "An evolutionary computing approach for the target motion analysis (TMA) problem for underwater tracks", EXPERT SYSTEMS WITH APPLICATIONS, OXFORD, GB LNKD- DOI: 10.1016/J.ESWA.2008.02.046, vol. 36, No. 2, 1 March 2009, pages 3866-3879.

DE 103 52 738 A1 discloses a method for shortening the iteration time. Limit values for the range and/or the course and/or the velocity of the target are preset for this purpose. Even coarse presets shorten the computation time and make it possible to exclude estimates of target positions which cannot possibly be detected by the sonar receiving installation.

In the known methods for determination of target data, bearing angles from a previous predetermined time period are in each case used for a current target data estimate. This means that the profile of the target bearing is considered over a long predefined time period, and this profile is used for the current target data estimate. The measured bearing angles from the previous time period are therefore used, and are subjected to filtering, in order to determine a new set of target data. The target data estimate is therefore quite inert and, after a target manoeuvre, that is to say after a course and/or velocity change, in some circumstances does not produce good results again until after a time which corresponds to the filter length. The target manoeuvre must therefore have occurred sufficiently far in advance that it is no longer in the time period considered by the filter length.

The target data estimate produces reliably good target data when the target is moving uniformly relative to the carrier vehicle. However, as soon as the target changes its course and/or its velocity, the estimated target data deteriorates significantly and does not converge again until the target has continued to move without acceleration for a relatively long time on a constant course.

Conventionally, a target manoeuvre is identified by a good target data estimate, which is already converging, in a TMA method becoming poorer again. However, this is possible only if a convergent TMA solution already exists. If, for example, a target manoeuvre takes place shortly after the start of a track, the TMA will not yet have calculated a convergent solution, and the target manoeuvre therefore cannot be detected.

DE 10 2007 019 445 A1 discloses e.g. a method for generating target-marking bearing tracks for a plurality of sound-emitting targets, the bearing of which is taken in a sea area. For the case where continuous reception of the sonar receiving installation is not available, WO 99/17134 discloses a method for linking a bearing track defined after a pause with a group of bearing tracks defined before the pause, wherein the first bearing track is compared with each bearing track from the group and calculations relating to the movement between two positions are performed with respect to each comparison.

Considered over a time period, the target bearing angles measured by means of the sonar receiving installation represent a bearing profile of this identified target. If the bearing profile is displayed in the form of a graph, for example, on a waterfall plot, by plotting the measured bearing angle on a first axis and the time on a second axis, a target manoeuvre produces a differently pronounced kink in the bearing profile. For someone observing the waterfall model, in particular an operator, it is possible to visually identify a target manoeuvre and to define an associated time of the target manoeuvre. However, this is dependent on there being a considerably pronounced kink in the bearing profile. The disadvantage of visual identification of a target manoeuvre by the operator is that a less considerably pronounced kink in the bearing profile may not be identified.

The invention is therefore based on the object of identifying target manoeuvres, that is to say a course change and/or a velocity change of a target, automatically at any time, and of defining a time associated with this target manoeuvre.

The invention solves the problem by a method having the features of Claim 1 and by an apparatus having the features of Claim 9.

Bearing angles to a target are measured by means of an arrangement of water sound sensors, such as electroacoustic or optoacoustic transducers in a sonar receiving installation, on the basis of which bearing angles two bearing profiles are determined. The bearing angles to the target are recorded over time for this purpose.

According to the invention, a processing time period is defined which consists of at least the sum of a number i and of a number k of most recently determined bearing angles. It is possible to include a further predefined number h of determined bearing angles between the number i and the number k which, however, are not included in the calculation of the bearing profiles.

First of all, two bearing profiles are determined from the most recently determined i+k bearing angles, with the first bearing profile being calculated from the k most recent bearing angles and the second bearing profile being calculated from the i older bearing angles which were determined before the k bearing angles.

An expected bearing angle of the two bearing profiles can in each case be calculated at a current time on the basis of these two bearing profiles. The invention has identified that the expected bearing angles of the two bearing profiles differ from one another when a target manoeuvre takes place, that is to say a course change and/or a velocity change of the target.

A bearing angle difference at the current time is then calculated from the expected bearing angle of the first bearing profile and the expected bearing angle of the second bearing profile. If the target is moving uniformly, the two calculated bearing profiles are close to one another. This means that the bearing angle difference between the two expected bearing angles at the current time is small.

However, as soon as the target changes its course and/or its velocity, that is to say carries out a manoeuvre, the two bearing profiles deviate from one another. This results in a significant bearing angle difference at the current time.

In a next step of the method according to the invention, the bearing angle difference is compared with at least one threshold value. The threshold values are either already predefined or are defined during the course of the method. When the bearing angle difference reaches and/or exceeds one of the threshold values, an intersection point of the two bearing profiles is determined. The time associated with this intersection point is identified as the target manoeuvre time. Furthermore, an information signal relating to the identification of the target manoeuvre is produced, and is provided, together with the target manoeuvre time.

The method according to the invention has the advantage that a target manoeuvre can be identified automatically at any time, and the target manoeuvre time can be made available to any subsequent TMA processing, as a result of which this can start in real time with the calculation of a new target leg. In this case, a "target leg" refers to a path along which the target is moving with a constant course and constant velocity.

In one preferred embodiment of the invention, the bearing angles measured by a sensor over a predetermined time period are subjected to prefiltering in order to smooth the bearing profile. This time period preferably corresponds to the duration of one pass through the TMA method. The measured bearing angles obtained in this time period are averaged, ignoring any spurious bearings identified. This advantageously results in prefiltered, smoothed bearing angles being available for further processing, rather than noisy, individual bearing angles. A further advantage of this prefiltering is the capability to estimate bearing noise and to determine a bearing migration rate for each prefiltered bearing angle. In this case, the bearing noise indicates the fluctuation in the bearing angles about their mean value, and the bearing migration rate represents the bearing dynamics.

In a further embodiment of the invention, the bearing noise is used for determination of the processing time period. The processing time period extends over the prefiltered bearing angles used to identify a target manoeuvre. This means that the number k of prefiltered bearing angles and the number i of prefiltered bearing angles, as well as any number h of prefiltered bearing angles which may be present, are defined as a function of the estimated bearing noise. This has the advantage that the length of the bearing profiles to be calculated can be optimally matched to the quality of the measured values, in order to keep the computation complexity low.

In a further embodiment of the invention, a first and a second threshold value are defined taking account of the bearing migration rate, in order to indicate a reliability of the identified course change and/or velocity change of the target. A first threshold value, determined as a function of the bearing migration rate, indicates, for example, the identification of a reliable target manoeuvre and a possible further threshold value, which is lower than the first threshold value, indicates, for example, the identification of a possible target manoeuvre. This makes it possible to indicate how reliable the identification of the target manoeuvre is.

In a further embodiment of the invention, the bearing profiles determined for the use of the method are linearly approximated over the processing time period. This means that a linear approximation is carried out, preferably by means of the least squares method, for the first bearing profile and the second bearing profile in each case. This advantageously simplifies the determination of the expected bearing angles and the associated bearing angle difference at the current time, as well as the determination of the associated intersection point of the two bearing profiles.

In a further embodiment of the invention, the information signal relating to the identification of the course change and/or velocity change of the target is indicated visually and/or audibly to an operator, and/or is made available as a data signal for further processing, in particular for a TMA method. This has the advantage that, when a possible target manoeuvre is identified with a low reliability, the presence of a possible target manoeuvre is indicated to the operator, in which case, however, the decision about the further action is left to the operator himself. In the case of a false alarm, that is to say when no target manoeuvre has occurred, the operator is given the option to restart the process. In the case of a correctly identified target manoeuvre, the operator is given the option of validating the identified target manoeuvre or of himself entering a target manoeuvre time in order, for example, that the TMA method can start with the calculation of a new target leg.

In a further embodiment of the invention, a value which is associated with the bearing angle difference is output, wherein this value represents a measure of a probability of a possible course change and/or velocity change. The value of the bearing angle difference indicates how far the bearing angle difference is below a threshold value to be compared with. If an operator knows the threshold values with which the bearing angle difference is compared then, in addition to the information relating to a possible target manoeuvre, the operator is advantageously also provided with a measure of the probability of a target manoeuvre. This advantageously assists the operator in making a manual choice.

In a further embodiment of the invention, the identification of a target manoeuvre, and the associated information signal, are suppressed for the duration of an own manoeuvre and for a predetermined time period after the identification of a target manoeuvre.

Such kinks which can be identified in the bearing profile of a target are produced both by an own manoeuvre and by a target manoeuvre. Since it is not possible to tell whether a kink which has been identified in the bearing profile results from the own manoeuvre being carried out or from a target manoeuvre, the identification of a target manoeuvre, and the associated information signal, is suppressed. The method according to the invention is preferably used again only after the own manoeuvre and after at least one time period which corresponds to the processing time period.

When a target manoeuvre has been identified, further identification of a target manoeuvre is likewise suppressed for a predetermined time period. In this case, the duration of the time period is preferably dependent on the threshold value which was used for identification of the target manoeuvre. The identification of a target manoeuvre and the associated information signal is, for example, suppressed until the current bearing angle difference has become significantly less than the threshold value. This has the advantage that a target manoeuvre is not identified repeatedly in successive runs through the process.

The apparatus for carrying out the method according to the invention includes a deactivation unit for suppression of the output. This is used to suppress an output unit for the duration of an own manoeuvre and/or for a predetermined processing time period after the identification of a target manoeuvre.

In a further embodiment of the invention, the threshold values are defined based on the method in DE 103 52 738 A1, taking account of predetermined limits, the so-called constraints. For example, if changes are considered in the profile of marine vessel routes, then a target manoeuvre within the marine vessel route is very probable.

In a further embodiment of the invention, each sensor in the carrier vehicle is in each case followed by an apparatus according to the invention such as this. When a plurality of sensors detect the bearing to a target, a target manoeuvre is assumed as soon as at least one of these apparatuses which follow the sensors has identified a target manoeuvre.

Further advantageous embodiments result from the dependent claims and from the exemplary embodiments explained in more detail with reference to the attached drawing, in which:

Figure 1 shows a waterfall plot for a plurality of bearing profiles,

Figure 2 shows a schematic illustration in order to explain prefiltering of measured bearing angles,

Figure 3 shows a flowchart in order to illustrate the method according to one exemplary embodiment,

Figure 4 shows an illustration in the form of a graph of two bearing profiles over a processing time period and

Figure 5 shows a block diagram in order to describe the apparatus according to the invention on the basis of one exemplary embodiment.

In the exemplary embodiment of the invention described in the following text, a time associated with a course change or a velocity change is determined, and is made available to a subsequent TMA method. The TMA method, in which kinematic data such as range, course, velocity of the target are estimated as target data from passively determined bearings, is therefore able to start to calculate a new target leg in real time.

Figure 1 shows an instantaneous record of a waterfall plot of three bearing profiles 10, which can be associated with three different targets. In this case the bearing angle is plotted in degrees on the horizontal axis 12, and the time which has passed is plotted in minutes on the vertical axis 14. In places, the illustrated bearing profiles 10 have a profile in the form of an arctangent. However, these can be approximated by linear sections.

Furthermore, Figure 1 shows an own course 16 of a carrier vehicle, in particular of a submarine. While the carrier vehicle is moving on its own course 16, sound is continuously received on a directionally selective basis for each identified target by means of at least one sensor, and a bearing angle to the target is measured. This is sound produced by the target itself, in particular by propulsion motors or other noise sources and/or sound transmitted directly by the target.

Both own manoeuvres and target manoeuvres produce a differently pronounced kink 18, 20 in the bearing profile 10 of a target. The measured bearing angles are subjected to prefiltering in order automatically to identify such kinks 20, which are produced by a target manoeuvre, according to one exemplary embodiment of the method according to the invention.

Figure 2 shows a schematic explanation of this prefiltering. The figure shows a multiplicity of measured bearing angles 22 which are averaged over a predetermined time period 24 for smoothing. This time period 24 preferably corresponds to the duration of one TMA run. A prefiltered bearing 26 which corresponds to the mean value is therefore available for each TMA run. Furthermore, a bearing noise σ is estimated, and a bearing migration rate BP is determined for each predetermined time period 24 with so-called spurious bearings being ignored in the averaging process. The results of the prefiltering, for example, the prefiltered bearing 26, the bearing noise σ and the bearing migration rate BP, are made available to the method according to the invention in order to identify a target manoeuvre.

Figure 3 shows a flowchart in order to illustrate the method according to the invention, on the basis of one exemplary embodiment.

First of all, bearing angles to a target are measured 30 by means of a sensor in a sonar receiving installation. As explained in more detail with reference to Figure 2, the measured bearing angles 22 are prefiltered 32 for smoothing. A prefiltered bearing 26, bearing noise σ and a bearing migration rate BP are therefore available for the further processing in the method.

A processing time period is then defined 34, which comprises the prefiltered bearing angles 26 required for identification of a target manoeuvre. Taking account of the bearing noise σ, a number k of most recently prefiltered bearing angles 26 is defined, as well as a number i of early bearing angles 26 which were prefiltered before the k bearing angles and which in total form the processing time period, over which the bearing profiles associated with the prefiltered bearing angles 26 are calculated 36.

Figure 4 shows an illustration in the form of a graph of a first bearing profile 40 and a second bearing profile 42 over a processing time period 44. The time is plotted in seconds on the horizontal axis 46, and the prefiltered bearing angles 26 are plotted in degrees on the vertical axis 48. The two bearing profiles 40, 42 are each linearly approximated, preferably by means of the least-squares method.

The processing time period 44 illustrated in Figure 4 extends over the k most recent bearing angles which are presented in the form of a circle, and i bearing angles, which are presented in the form of a star, before the last k bearing angles. This exemplary embodiment in this case relates to i+k successive bearing angles. However, other combinations of numbers of bearing angles to be used are also feasible. For example, it is possible to introduce a further predefined number h of bearing angles into the processing time period 44 between the i bearing angles and the k bearing angles. For example, if the target has already been classified by other methods, then statements can be made about the possible duration of a manoeuvre. If the target manoeuvre is predicted to extend over a plurality of prefiltered bearing angles, in particular over the number h, then these are ignored in the calculation of the two bearing profiles 40, 42.

In the following text, a first expected bearing angle 56 of the first bearing profile 40 and a second expected bearing angle 58 of the second bearing profile 42 are calculated for a current time 54. These bearing angles, which are shown as triangles in Figure 4, can be determined directly from the respective approximation straight lines 40, 42 which represent the bearing profile, for the current time 54.

In a corresponding manner to the method shown in Figure 3, following the calculation 62 of the expected bearing angles 56, 58, a difference between these two expected bearing angles 56, 58 is calculated 64, specifically the bearing angle difference $|d|$.

In a next step of the method, the bearing angle difference $|d|$ is compared with one or more threshold values. In this case, the threshold values may be predefined or else may be determined 70 as a function of the bearing migration rate BP during the course of the method.

If the bearing angle difference $|d|$ in a comparison 68 with a first threshold value C1, which for example indicates a reliable target manoeuvre, reaches this threshold value C1 or the bearing angle difference $|d|$ exceeds this threshold value C1, then an intersection point 72 (see Figure 4) of the two bearing profiles 40, 42 is determined 73 after branching via Y. A target manoeuvre time 74 associated with the intersection point 72 can be stated for this intersection point 72.

Furthermore, an information signal 75 is produced 73, which in this case includes the signalling of a reliable target manoeuvre. The information signal 75 is output 76 together with the target manoeuvre time 74. In the case of a reliable target manoeuvre, the information signal 75 is transferred with the target manoeuvre time 74 to a subsequent TMA method, as a result of which this can immediately start to calculate a new target leg. After a target manoeuvre, the target data estimate is therefore automatically updated, and matched to the manoeuvre.

However, if the bearing angle difference $|d|$ does not 68 reach the first threshold value C1, a comparison of the bearing angle difference $|d|$ with a threshold value C2, which is lower than C1, is carried out 78 after branching via N. In this case, the threshold value C2 can likewise be predefined or else can be determined 70 during the course of the method. By way of example, this threshold value C2 indicates a possible target manoeuvre.

If the bearing angle difference $|d|$ in the comparison 78 with this threshold value C2 reaches this threshold value C2 or the bearing angle difference $|d|$ exceeds this threshold value C2, then an intersection point 72 (see Figure 4) with the two bearing profiles 40, 42 and an associated target manoeuvre time 74 are indicated 73 after branching via Y.

An information signal 75 associated with the threshold value C2 is produced, in this case indicating a possible target manoeuvre. In the case of a possible target manoeuvre, the information signal 75 is indicated 80 visually and/or audibly to an operator together with the associated target manoeuvre time 74. The operator has the option of restarting the method for identification of a target manoeuvre in the event of a false alarm, that is to say if no target manoeuvre has taken place. In this case, detection of a new target manoeuvre is possible immediately without having to wait for a lead-in time in the method.

Furthermore, the operator has the option of confirming a possible target manoeuvre, in order to transfer the target manoeuvre time 74 to any subsequent TMA method.

However, if the bearing angle difference $|d|$ also does not reach the threshold value C2 during a comparison 78, then the method is started again, after branching via N. The process moves to the start of the method via a branch 81 in the flowchart in Figure 3.

When a reliable target manoeuvre or a possible target manoeuvre is identified, the output 76, 80 of the information signal 75 for the following method runs must be suppressed 82, since, otherwise, the process would react repeatedly to one and the same target manoeuvre in successive method runs. According to this exemplary embodiment, the duration of the suppression 82 has a predetermined time value or lasts until the bearing angle difference $|d|$ has once again become significantly less than the threshold value C1.

If the carrier vehicle carries out a manoeuvre, the output 76, 80 of the information signal 75 is likewise suppressed. This is because it is not possible to tell whether a detected kink in the bearing profile can be associated with the own manoeuvre being carried out, or with a target manoeuvre. The method according to the invention requires a predetermined lead-in time before the information signal 75 can be output again, after an own manoeuvre and after a track start, that is to say the detection of a new target. All the prefiltered bearing angles 26 which are required for identification of a target manoeuvre must be present. The predetermined lead-in time therefore comprises at least the duration of the processing time period 44.

The method starts again after the suppression 82 of the output 76, 80 of the information signal 75 over the required time period. This is indicated by a feedback branch 84 in the flowchart shown in Figure 3.

Figure 5 shows a block diagram in order to describe an apparatus for carrying out the method as described above, according to one exemplary embodiment. The apparatus is used to identify course changes and/or velocity changes, that is to say target manoeuvres of a target.

First of all a sensor 86 detects bearing angles 22 to an identified target at different times. These bearing angles 22 are transferred to a prefilter unit 88 for smoothing. The prefilter unit 88 determines a bearing noise σ, a bearing migration rate BP and a prefiltered bearing angle 26 for each predetermined time period 24. The value of the bearing noise σ is transferred together with the prefiltered bearing angle 26 to an approximation module 90 which calculates a first bearing profile 40 and a second bearing profile 42. A calculation unit 92 in each case calculates an expected bearing angle 56, 58 of the two bearing profiles 40, 42 at a current time 54. These expected bearing angles 56, 58 are transferred to a difference module 94, which uses them to determine a bearing angle difference $|d|$. The bearing angle difference $|d|$ is compared with one or more threshold values in a threshold value detection module 96. In this case, the threshold values may be predefined or may be redefined for each method run by means of a threshold determination unit 97 in the threshold value detection module 96 as a function of the bearing migration rate BP determined in the prefilter unit 88.

If the bearing angle difference $|d|$ reaches and/or exceeds one or more of the threshold values, the maximum threshold value C reached is transferred, together with the bearing angle difference $|d|$, to a further calculation unit 98 in order to determine an intersection point 72 of the two bearing profiles 40, 42 and a time associated with this intersection point 72, specifically the target manoeuvre time 74.

A signal unit 100 produces an information signal 75 which is associated with the maximum threshold value C and which indicates a reliable or possible target manoeuvre. A subsequent output unit 102 presents the information signal 75 and the associated target manoeuvre time 74. The presentation is provided visually and/or audibly, or the information signal 75 and the target manoeuvre time 74 are made available as a data signal for further processing.

The output unit 102 is preceded by a deactivation unit 104. This is used to suppress the output unit 102 for the duration of an own manoeuvre and/or after the identification of a target manoeuvre.

All of the features mentioned in the above description and in the claims can be used according to the invention both individually and in any desired combination. The invention is therefore not restricted to the described and claimed feature combinations. In fact, all combinations of individual features should be regarded as having been disclosed.

Claims

1. Method for identification of course changes and/or velocity changes of a target by means of a multiplicity of bearing angles (22) which are measured at different times and are determined by directionally selective reception of sound waves, radiated or emitted by the target, by means of an arrangement of water sound sensors (86) in a sonar receiving installation,
characterized in that
the method has the following steps:
   a) calculation of a first bearing profile (40) from a predetermined number k of most recently determined bearing angles,
   b) calculation of a second bearing profile (42) from a predetermined number i of earlier bearing angles determined before the k bearing angles,
   c) calculation of in each case one expected bearing angle (56, 58) from the two bearing profiles (40, 42) at a current time (54),
   d) calculation of a bearing angle difference ($|d|$) between the two expected bearing angles (56, 58) at the current time (54),
   e) comparison of the bearing angle difference ($|d|$) with one or more threshold values (C1, C2),
   f) determination of an intersection point (72) of the two bearing profiles (40, 42) and of a time (74) associated with this intersection point (72), on reaching and/or exceeding the bearing angle difference ($|d|$) of the threshold value or values (C1, C2),
   g) production of an information signal (75) relating to the identification of the course change and/or velocity change of the target and provision of the determined time (74) of the course change and/or velocity change.

2. Method according to Claim 1,
characterized in that
the bearing angles (22) measured over a predetermined time period (24) are subjected to prefiltering (32) for smoothing, wherein a bearing noise (σ) and a bearing migration rate (BP) are determined for this time period (24).

3. Method according to Claim 2,
characterized in that
the number k of prefiltered bearing angles (26) in the first bearing profile (40) and the number i of prefiltered bearing angles (26) in the second bearing profile (42) are defined as a function of the bearing noise (σ).

4. Method according to Claim 2 or 3,
characterized in that
a first and a second threshold value (C1, C2) are defined taking account of the bearing migration rate (BP), in order to indicate a reliability of the identified course change and/or velocity change of the target.

5. Method according to one of the preceding claims,
characterized in that
the first bearing profile (40) and the second bearing profile (42) are each linearly approximated.

6. Method according to one of the preceding claims,
characterized in that
the information signal (75) relating to the identification of the course change and/or velocity change of the target is indicated visually and/or audibly to an operator, and/or is made available as a data signal for further processing, in particular for a TMA method.

7. Method according to one of the preceding claims,
characterized in that
a value which is associated with the bearing angle difference ($|d|$) is output, wherein this value represents a measure of a probability of a possible course change and/or velocity change.

8. Method according to one of the preceding claims,
characterized in that

the information signal (75) is suppressed for the duration of an own manoeuvre and/or for a predetermined time period after the identification of a course change and/or a velocity change of the target.

9. Apparatus for identification of course changes and/or velocity changes of a target by means of a multiplicity of bearing angles (22) which can be measured at different times and are determined by directionally selective reception of sound waves, radiated or emitted by the target, by means of an arrangement of water sound sensors (86) in a sonar receiving installation, in particular for carrying out a method according to one of Claims 1 to 8,
characterized by
an approximation module (90) for calculation of a first bearing profile (40) from a predetermined number k of most recently determined bearing angles, and of a second bearing profile (42) of a predetermined number i of earlier bearing angles determined before the k bearing angles,
a calculation unit (92) for the calculation of in each case one expected bearing angle (56, 58) from the two bearing profiles (40, 42) at a current time (54),
a difference module (94) for determination of a bearing angle difference ($|d|$)at the current time (54),
a threshold value detection module (96) for carrying out a comparison of the bearing angle difference ($|d|$) with one or more threshold values (C1, C2),
a further calculation unit (98) for determination of a time (74) associated with the intersection point (72) of the two bearing profiles (40, 42) on reaching and/or exceeding the bearing angle difference ($|d|$) of the threshold values (C1, C2),
a signal unit (100) for production of an information signal (75) relating to the identification of the course change and/or velocity change of the target,
an output unit (102) for provision of the determined time (74) of the course change and/or velocity change and of the associated information signal (75).

10. Apparatus according to Claim 9,
characterized by

a prefiltering unit (88) for smoothing the bearing angles (22) measured over a predetermined time period (24), wherein a bearing noise (σ) and a bearing migration rate (BP) can be determined for this time period (24).

11. Apparatus according to one of Claims 9 or 10,
characterized by
a deactivation unit (104) for suppression of the output unit (102) for the duration of an own manoeuvre and/or for a predetermined time period after the identification of a course change and/or a velocity change of the target.

12. Apparatus according to one of Claims 9 to 11,
characterized by
a threshold determination unit (97) for definition of one or more threshold values (C1, C2), wherein the threshold values (C1, C2) can be determined as a function of predetermined limits.

For the Applicant,

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