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(54) **PROCEDE DE DETERMINATION DE LA POSITION D'UNE  
CIBLE DE RADAR**

(54) **PROCESS FOR DETERMINING THE POSITION OF A RADAR  
TARGET**

(57) Un procédé sert à déterminer la position et/ou le déplacement dans le temps (trace) d'une surface cible (de radar) au moyen d'une installation radar. On détermine d'abord pour la surface cible un nombre prédéterminable M des plus grandes amplitudes d'écho ainsi que les cellules de résolution correspondantes (coordonnées de distance et d'azimut). En calculant ensuite la moyenne des coordonnées de distance et d'azimut des cellules de résolution sélectionnées, on détermine les coordonnées d'un point de référence stable dans l'espace par rapport à la surface cible. Ce point de référence est utilisé pour déterminer la position et/ou pour suivre la trace d'objets, notamment de navires.

(57) A process is disclosed for determining the position and/or the displacement in time (trace) of a (radar) target surface by means of a radar installation. A predeterminable number M of the largest echo amplitudes is first determined for the target surface, as well as the corresponding resolution cells (distance and azimuth co-ordinates). By averaging the distance and azimuth co-ordinates of the selected resolution cells, co-ordinates are determined for a reference point that is stable in space in relation to the target surface. This reference point is used for locating and/or tracing objects, in particular ships.



A process is disclosed for determining the position and/or the displacement in time (trace) of a (radar) target surface by means of a radar installation. A predeterminable number  $M$  of the largest echo amplitudes is first determined for the target surface, as well as the corresponding resolution cells (distance and azimuth co-ordinates). By averaging the distance and azimuth co-ordinates of the selected resolution cells, co-ordinates are determined for a reference point that is stable in space in relation to the target surface. This reference point is used for locating and/or tracing objects, in particular ships.

Description

Process for Determining the Position of a Radar Target

The invention relates to a process for determining the position of a radar target according to the preamble of patent claim 1.

The term "resolution cell" used in the present patent application is intended to cover the terms "radar resolution cell" as well as "area resolution cell". A radar resolution cell identifies the spatial resolution of a radar installation. A radar resolution cell is a design-dependent constant of the radar installation. In an area resolution cell, several radar resolution cells are combined as needed. Therefore, an area resolution cell is considerably larger in its spatial extension than a radar resolution cell.

The invention relates in particular to the determination of the position of a large-surface radar target such as, for example, an oceangoing freight ship or passenger ship. Such radar targets comprise several resolution cells, for example, a few hundred, when such a radar target moves past a radar set at a relatively small distance and/or when the radar set

has a high spatial resolution. This condition exists, for example, in the (radar) monitoring of harbor access routes and/or shipping routes. There, it is necessary, for example, to determine and to track the position of one or several  
5 ships as accurately as possible with a stationary radar set, which ships generally have little maneuverability because of their size, so that, for example, compliance with a predetermined route can be checked and/or advance warning of a possible collision can be given.

10 Such target surfaces, for example, a ship having a length of approximately 200 m, due to their design, e. g., the superstructures and/or the freight, may have a plurality of radar reflectors. A moving ship also generates bow waves as well as stern waves (stern sea) which also reflect radar  
15 waves and thus change the extension of the actual radar target, the ship. A particularly disturbing effect on the determination of the target position results from reflections which are generated on the ship itself and which melt into the useful echoes. Furthermore, a radar installation may  
20 also create apparent radar targets, for example, due to the so-called minor lobes of the radar antenna, which apparent

radar targets can also move along with the actual radar target, the ship.

If, for such a (radar) situation, the position of a (radar) target surface, for example, the ship, is now  
5 intended to be determined accurately solely on the basis of the radar information, for example, by way of the spatial resolution capacity possible per se of the radar installation of, for example, one tenth of the length of the ship, it is first necessary to find a characteristic (radar) reference  
10 point for the desired radar target, the ship, and to then track the position of the reference point continuously in time.

In this context, it is obvious to select for this (radar) reference point the reflector with the largest  
15 (radar) echo amplitude. But this method fails in a disadvantageous manner if several equivalent reflectors and/or apparent reflectors are arranged so as to be closely adjacent to one another.

For a large-surface radar target, which is comprised of  
20 several actual and/or apparent individual targets, it is furthermore obvious to determine and track a surface center point or surface center of gravity of the radar target as

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characteristic reference point by way of averaging and/or integration method. A reference point determined in this manner can also greatly change its position in a disadvantageous manner and thus stimulate a change of position of the actual target, for example, of the ship. Such a case arises, for example, when the stern sea of a ship changes considerably, e.g., as a result of a speed change of the ship. In such a case, there is a great change of the radar reflection to be associated with the stern sea, which radar reflection changes the (radar) position of the (radar) surface target in a disturbing manner because of the above-mentioned averaging and/or integral formation. Similar problems arise as a result of aspect-dependent reflections on the ship itself.

It is the object of the invention to propose a process of the generic type by means of which a reliable determination of a reference point to be associated with the radar target becomes possible for a large-surface radar target.

This object is accomplished by the characteristics listed in the characterizing part of patent claim 1.

According to the present invention there is provided a process for determining the position of a radar target extending over several resolution cells, wherein echo signals reflected from resolution cells are mixed into the baseband so that an amplitude-modulated signal of the radar target is generated, in the baseband, at least for all resolution cells to be associated with a radar target the amplitude values are determined, and the position of the radar target is determined from the size of the amplitude values and/or their distribution in the area defined by the resolution cell, characterized in that in a predeterminable region of each associated resolution cell from which at least one echo signal is received an

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amplitude value is determined which corresponds to the echo signal, from the amplitude values of a resolution cell a maximum amplitude value is determined which is associated with the resolution cell, from the maximum amplitude values of all  
5 resolution cells the M largest amplitude values are selected, with M being predeterminable, integer, positive number, the coordinates (E, AZ) of the associated resolution cells are determined for the M largest amplitude values, the associated mean values (E(F), AZ(F)) are formed from the coordinates (E,  
10 AZ), and the mean values (E/(F), AZ(F)) form the coordinates of a reference point which determines the position of the radar target.

Advantageous features and/or modifications can be taken from the further claims.

A first advantage of the invention is that the determined (radar) reference point is stable relative to the (radar) shape of the (radar) target surface. The latter can therefore move without any disturbing jumps of the reference point, i. e., simulating fast apparent spatial changes. Thus, it is assured that a reliable trace tracking (tracking)<sup>1</sup> of a target becomes possible.

A second advantage is that, for the above-mentioned larger ships, the reference point essentially corresponds to the actual center of the ship so that the determination of the position by way of the reference point corresponds in a reliable manner to the actual position which is always indicated for the center of the ship.

Further advantages result from the description which follows.

In the following, the invention is described in greater detail by way of embodiments.

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<sup>1</sup> Translator's note: The English word "tracking" appears in parenthesis in the original German text.

The invention is based on the evaluation of demodulated radar echo signals in the baseband, e. g., the video band. There, the echo signals associated with a radar target as well as with a resolution cell are represented as amplitude-  
5 modulated signals, i. e., a large amplitude value is allocated to a good (radar) reflector. It is advisable to select the size of the resolution cells to be considerably smaller, e. g., ten times smaller, than the size of the radar target to be expected, e. g. of a ship. This accomplishes a  
10 good (radar) representation of the radar target.

If a predeterminable area, which is composed of a plurality of resolution cells, includes a large-surface radar target, e. g., a ship, a reference point defining the large-surface radar target is advantageously determined by means of  
15 the SGS method (center of gravity method with the assistance of an ordered statistics)<sup>2</sup> described below. For a ship, this reference point advantageously corresponds to the center of the ship. In the SGS method, those resolution cells having the M largest amplitudes are first selected from the

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20 <sup>2</sup> Translator's note: "SGS" is the German acronym for "Schwerpunkt-Verfahren mit Hilfe einer Geordneten Statistik" [center of gravity method with the assistance of an ordered statistics] appearing in parenthesis in the German text.

area, with M being a predeterminable, integer, positive  
number. This selection of the M largest amplitudes is  
possible in different ways. For example, the amplitudes can  
be selected from the entire area or only from a spatially  
5 limited partial area which, for example, has a strip-shaped  
form. The latter may comprise, for example, the radar  
representation of a ship including all reflections as well as  
the associated bow waves and stern waves. In the selection  
of these M largest amplitudes, the allocation to the  
10 respective resolution cell is maintained in each case.

The determination of the largest amplitudes preferably  
takes place in that the distance range and the azimuth range  
of the radar monitoring area are quantized for digital data  
processing. Each echo is completely characterized by  
15 amplitude, distance and azimuth. In each distance quantum,  
there exists a moving window detector for the target  
recognition criterion and a maximum window arranged  
azimuthally for determining the amplitude maximum in this  
distance quantum. If several amplitudes in a distance  
20 quantum are at the same level, a definite maximum amplitude  
does not exist. Then, the mean position of all identical  
amplitudes is relevant. The maximum amplitude is allocated

to this mean position. For all maximum amplitudes determined in this manner, the mean positions are formed and from these an amplitude ranking, which is stored in a list, is formed by means of the ordered statistics. Subsequently, the largest  
5 amplitude appearing in the list is selected.

On the basis of this (in absolute terms) largest amplitude value, the next-smaller maximum amplitudes are selected, namely  $M - 1$  piece. These were also determined by way of the ordered statistics method.

10 This determination of the  $M$  largest amplitudes as well as of the associated resolution cells of a target surface is carried out with each rotation of the radar antenna or a comparable pivot process of the antenna lobe.

15 If the antenna lobe leaves the target surface  $F$  during the pivot process, a reference point having the distance coordinate  $E(F)$  as well as the azimuth coordinate  $AZ(F)$  is formed for the target surface according to the formulas

$$E(F) = S(E)/M \text{ and } AZ(F) = S(AZ)/M.$$

Here,

20  $S(E)$  = is the sum of all distances, measured from the radar antenna, of the resolution cells which are associated with the  $M$  selected amplitudes;

S(AZ) = is the sum of all azimuth values which are associated with the M selected resolution cells;

M = is the number of the resolution cells = number of the selected amplitude values.

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A reference point determined in this manner is stable in an advantageous manner, i. e., is associated with the (radar) shape (shape of a target surface on a radar screen) of a target surface and thus largely independent of the time (number of pivot processes of the antenna lobe). Such a reference point can therefore be used reliably for determining the position as well as for the tracking of a target surface. It is particularly advantageous that, for a larger ship, a reference point which was determined in this manner corresponds to the center of the ship. Therewith reliable tracking becomes possible.

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The process described is not limited to the application of monitoring ship traffic but can be applied in many different ways to further (radar) targets. For example, the size of a resolution cell can be selected according to the size of the target surface and/or the accuracy of the location of the reference point to be determined. It is

advisable, for example, to select the number M as a variable that can be set which is determined empirically. In high-resolution radar installations, M is selected to be larger than in low-resolution radar installations. Furthermore, M is a function of the absolute level of the amplitude (values) of the echo signals. For example, for a target surface to which small amplitudes are allocated, the number M should be smaller than for a target surface of identical size which, however, generates larger echo amplitudes, i. e., represents a better radar reflector.

The invention is therefore not limited to the examples described but it can be applied analogously to all (radar) target surfaces wherein a reference point is necessary for determining the position and/or the movement (trace).

Patent Claims

1. A process for determining the position of a radar target extending over several resolution cells, wherein
- echo signals reflected from resolution cells are mixed into the baseband so that an amplitude-modulated signal of the radar target is generated,
  - in the baseband, at least for all resolution cells to be associated with a radar target the amplitude values are determined, and
  - the position of the radar target is determined from the size of the amplitude values and/or their distribution in the area defined by the resolution cell,

characterized in that

- in a predeterminable region of each associated resolution cell from which at least one echo signal is received an amplitude value is determined which corresponds to the echo signal,
- from the amplitude values of a resolution cell a maximum amplitude value is determined which is associated with the resolution cell,

- from the maximum amplitude values of all resolution cells the M largest amplitude values are selected, with M being a predeterminable, integer, positive number,
- the coordinates (E, AZ) of the associated resolution cells are determined for the M largest amplitude values,
- the associated mean values (E(F), AZ(F)) are formed from the coordinates (E, AZ), and
- the mean values (E/(F), AZ(F)) form the coordinates of a reference point which determines the position of the radar target.

2. A method according to claim 1, characterized in that at least the M largest amplitude values are determined by an ordered statistics method.

3. A method according to claim 1 or claim 2, characterized in that the maximum amplitude value of a resolution cell is determined by an integration method wherein all amplitudes associated with the resolution cell are added.

4. A method according to one of the preceding claims, characterized in that the number M is selected as a function of the size of a resolution cell and/or the size of the maximum amplitude values.

5. A method according to one of the preceding claims, characterized in that the size (surface, volume) of a resolution cell is selected as a function of the size of the radar target such that the size of the resolution cell is considerably smaller than that of the radar target.

6. A method according to one of the preceding claims, characterized in that a ship is selected as radar target and that the reference point is set to be the center of the ship.