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COMPRESSION OF RADIO INFORMATION FROM AN ON-BOARD RADIO LOCATION STATION

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Abstract

A significant problem in the automatic primary processing of radar information is its real-time execution, with the simultaneous coordination of the time for formation of radio location information with the speed of the input channel of the computer system. In this regard, in the present scientific paper, the large information redundancy of radio location information is being proved. Based on this, a method for its compression is proposed. Through this method, the volume of radar information entered into the computer system for processing can be reduced while preserving its accuracy characteristics.

Introduction

Radar location stations (radar stations) are an essential and indivisible element of the composition of modern aviation and space on-board radio technical complexes. The importance of solving tasks requires their continuous development and improvement with a view to expanding their functional capabilities. This requires solving a wide range of tasks with a theoretical and applied nature [3]. A significant part of these tasks refers to the real-time processing of radio location information in a complex radar environment and in conditions of significant and different physical disturbances. [1 - 3, 8, 9].

The radar information is a set of obtained data using radio location means and contains information about the coordinates of the location objects (called further as targets), their kind, and movement parameters. The specifics of aviation and space systems and complexes require the real-time processing of radar information in conditions of significant limitations of available time resources to be carried out. This largely refers to the primary processing of the radar information, which must periodically be carried out for a time that does not exceed the time for scanning the space of a location by the antenna radar system. Simultaneously, it is necessary to cohere the high speed of formation of radar information with the speed characteristics of the channel for entering the information into a computer system. These problems, with the help of compression methods, are solved [1].

Compression of radar information by applying adequate methods for coding, selecting, and rejecting available information redundancy. In this presentation, a method for compressing radar information from a pulsed radar is proposed can be made.

In this scientific work, a method for compressing radar information from a pulsed radio location station is proposed.

As a result of binary discretization of the radar location signals from a pulse radar location station, which arrive at the output of the radar receiver for one scanning period of its antenna, its survey area (location space) conditionally as a set of elementary sections (cells) can be represented (illustrated in Fig. 1).

If $D_{\max}$ is the maximum target detection range of a given radar location station, and its resolving power with respect to distance is ΔD and along azimuth $\Delta\beta$ then each of the cells will have dimensions $\Delta D \Delta\beta$. Their common number N_0 will be determined as:

$$N_0 = \frac{D_{\max} T_a}{\Delta D T_c},$$

where, T_a is the period of scanning the space location by the antenna of a given radar location station, and T_c represents a period of following her probing impulses. To a given cell will be assigned a content equal to logical one if at its corresponding location space, a target is available and otherwise will be logical zero (illustrated in Fig. 1).

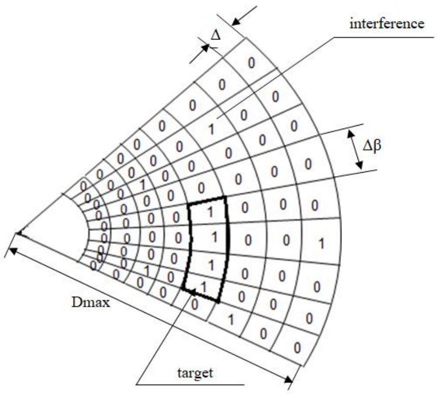

Fig. 1.

a sign of a message of the first kind

a sign of a message of the second kind

message of first kind	0
message of second kind	1
message of second kind	1
………………………………………..	
message of second kind	1

Fig. 2

For the purposes of the exposition, the following concepts will be introduced:

Definition 1: A probe will be called any n-digit binary number, $n = \frac{D_{\max}}{\Delta D}$, which is a result of the binary discretization of the radio location signals from the output of the radar receiver, obtained from one probing pulse.

Definition 2: It will be called this probe informational, for which it is fair:

$$V_{i=1}^{n} \xi_i = 1; \; i = 1 \ldots n,$$

where ξ_i is the value of $i-$order.

In this sense, the information probe is a probe in which at least one of its digits is equal to a logical one. This logical one can be generated by either a signal reflected from a target or an interference received by the radar.

The ability to compress the radar information presented through the digital quantized signals is based on the following three statements:

Statement 1: If an information probe contains orders equal to logical zero, then the same are not recorded in the operational memory of the computer system for processing of radar information and are not analyzed by it.

Statement 2: Non informational probes are not entered into the computer's memory and are not analyzed by it.

Statement 3: The processing of radio location information, which in the form of compressed binary sampled signals is represented, is possible if the radio location information (radar information) is represented and entered into the computer system in the form of a coded sequence that defines the information probes and the location of the information probes relative to the main reporting direction, for example, the line the geographical north, the direction of the aircraft, and etc.

In accordance with the above statements, the procedure of compression of radar information contains the following stages: analysis of the received probes for the presence of orders in them equal to logical ones; selection of information probes and rejection of non-informational probes; selecting digital quantized signals that have a value equal to logical one; rejecting those digital quantized signals that have a value equal to logical zero; forming a coded sequence containing the selected radar information and entering the same into the computer system for further processing.

Each coded sequence contains information obtained from one probing pulse of radio location station and has the following structure (illustrated in Fig. 2): a message of the first kind, which contains the number of the probe pulse, relative to the beginning of the reporting, as a result of which an information probe is received; messages of the second kind, each of which contains the number of the corresponding order of the information probe, equal to a logical one. The number of messages of the second kind in one coded sequence is equal to the number of logical ones in the corresponding information probe.

The last order of each message of the two specified kinds contains a message sign, for example, logical zero for messages of the first kind and logical one for messages of the second kind. In the processing computer of radio location information, the information sequence after its formation is entered.

The primary processing of radar information, i.e., the detection of the presence of targets and the determination of their coordinates for each period of scanning the space of a location by the antenna system of the radio location station, is carried out. The time τ_0 for processing of each coded sequence is equal to or less than the scanning period of the antenna, i.e. $\tau_0 \le T_a$.

The bit rate of the message of the first kind is defined as:

$$n_1 = \log_2\left(\frac{T_a}{T_c}\right) + 1.$$

The messages of the second kind are with the following bit rate

$$n_2 = \log_2\left(\frac{D_{\max}}{\Delta D}\right) + 1.$$

The radar information presented in this way allows the presence of targets in the space of a location to be determined, and also their coordinates. The distance to the target is calculated using the following formula:

$$D = n_c \Delta D,$$

where the value n_c of the information field in the corresponding word of the first kind in the analyzed code sequence obtained as a result of the analysis of the particular information probe.

If there are no additional errors in the process of time and binary discretization of the received radar signals, then the determination error of the distance to the target does not exceed the resolving capability of the radiolocation station in terms of distance.

The angular coordinates of the target relative to the center of the packet of binary discretized signals received from it as a result of the location in space are determined:

$$\beta = \frac{\beta_n - \beta_k}{2},$$

where the angular coordinates $\beta_n = N_{k1} \Delta\beta$ corresponding to the beginning of the binary sampled signal packet from the relevant location target; the angular coordinates $\beta_k = N_{k2} \Delta\beta$ corresponding to the end of the binary sampled signals packet from the location target; N_{k1} and N_{k2} are values of the information fields of the messages of the first kind, corresponding to the beginning and the end of the packet of binary discretized signals, referring to the target whose coordinates are an object of determination.

The presented above is valid for an ideal case, when for the time of space scanning, there are no logical ones after binary sampling of radar information from the output of the radio location station, generated by different types of interference. In reality, things take a slightly different shape. We will dwell on this in more detail. This will be considered in more detail.

Let N_1 denote the number of logical ones formed for one period of space location. Then the degree K of information redundancy can be represented as:

$$K = \frac{N_0 - N_1}{N_1}.$$

or:

$$K = \frac{N_0}{N_1} - 1.$$

as $N_0 \rangle\rangle N_1$, then

(1) $$K \approx \frac{N_0}{N_1}.$$

In fact, the number of logical ones N_1 formed for one period of space location represents the sum of the logical ones N_s generated as a result of reflected signals and logical ones, in quantity N_n, that by the impact of interferences are formed:

(2) $$N_1 = N_s + N_n$$

Let it be assumed that in the location space enter targets, the amount of which for the scan time of the antenna of the radio location station is a random value with a Poisson distribution law with parameter λ_s, and their being there is a random value with an exponential distribution law with a parameter μ_s. Then, for T_a the scan period of the antenna of the radio location station, targets will enter the location space, as the number N_l of which will be

$$N_l = \lambda_s T_a .$$

The average amount N_c of targets that appear in the location space for the time T_a of the radar antenna scan will be

$$N_s = \frac{\lambda_s}{\mu_s} T_a .$$

The amount of logical ones in the packet of binary sampled signals reflected from a real target depends on the sizes of the target, its effective reflecting surface, the distance to the target, its spatial location, and the characteristics of the radio location station [4, 5, 6, 7].

By mathematically estimating m of the number of logical ones formed as a result of the location of a single target, the common amount of binary sampled signals that have a value of a logical one for one scanning period of the radar antenna will be:

$$N_s = m \frac{\lambda_s}{\mu_s} T_a$$

The amount N_n logical ones generated from interferences for the conditions of a bell-shaped filter with amplitude frequency characteristics of the type represented by the expression

$$K(if) = K_0 \exp\left[-\pi\left(\frac{f - f_0}{\Delta f}\right)\right]\exp[-i(f - f_0)t_0],$$

where f_o is an average frequency in the frequency band Δf, according to the following formula, will be determined [2]:

(3) $$N_n = \frac{0{,}8\pi\,\Delta f U_d}{\sqrt{2\pi}\sigma_n} e^{-\frac{U_d^2}{2\sigma_n^2}}.$$

where U_d is an amplitude sampling level and σ_n is a noise spectral density.

It will be put (3) into (1), and for the degree of information redundancy, it will be obtained:

(4) $$K = \frac{N_0}{N_s + \frac{0{,}8\pi\Delta f U_\partial}{\sqrt{2\pi}\sigma_n} e^{-\frac{U_\partial^2}{2\sigma_n^2}}}.$$

It will be represented (3) by the normalized threshold $x_o = \frac{U_d}{\sigma_n}$ of amplitude discretization:

(5) $$N_n \approx \sqrt{\pi}\,\Delta f\, x_o\, e^{-\frac{x_o^2}{2}}.$$

Then (4) in the following form will be written:

(6) $$K = \frac{N_0}{N_s + \sqrt{\pi}\Delta f x_0 e^{-\frac{x_0^2}{2}}}$$

After appropriate transformations, the following final expression for the compression ratio of the radio location information (radar information) will be obtained:

(7) $$K = \frac{D_{\max} T_a}{\Delta D T_c (N_s + \sqrt{\pi}\Delta f x_0 e^{-\frac{x_0^2}{2}})}$$

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КОМПРЕСИРАНЕ НА РАДИОИНФОРМАЦИЯ ОТ БОРДОВА РАДИОЛОКАЦИОННА СТАНЦИЯ

А. Начев

Резюме

Съществен проблем при автоматичната първична обработка на радиолокационната информация (РЛИ) е изпълнение й в реално време, при едновременно съгласуване на времето за формиране на РЛИ със скоростта на входния канал на компютърната система. В тази връзка в настоящата научна статия се доказва големият информационен излишък на информацията, получавана от импулсна РЛС. Въз основа на това се предлага метод за нейното компресиране. Методът позволява на няколко порядъка да се съкрати обемът на РЛИ при запазване на точностите й характеристики.