Application of AR model for radar recognition of meteorological objects

V. Bezruk, E.Belov, O.Voitovych, K.Netrebenko, V.Tikhonov, G.Rudnev, G.Khlopov, S.Khomenko

Abstract-**The algorithm and measuring radar for recognition of meteorological objects are described.**

Keywords - **meteorological objects, spectrum-correlation processing, autoregressive model.**

I. INTRODUCTION

One of the sources of hazards phenomena are cumulus clouds, which can be detected by radar and recognition of the type of such clouds is quite actual problem. Therefore the algorithm of recognition of cumulus clouds on the base of autoregressive (AR) model [1], the peculiarities of the radar and results of experimental study are described in this paper.

II. PROBLEM STATEMENT

Let's assume, that M stochastic signals are used for recognition $X^i(t),\ i=\overline{1,M}$, that defined on finite interval $(0,T)$ by set of equidistant samples $X_l, l=\overline{1,L}$. The signals distinguish by its unknown correlation functions and the classified sampling is given $\{X^i_{lr}, l=\overline{1,L};\ r=\overline{1,n_i};\ i=\overline{1,M}\}$.

The linear AR model of Gaussian signal is used in form of recurrence relation [5]

$$X^i_j = \sum_{l=1}^{p} \phi^i_l X^i_{j-l} + \sigma^i_a a_j,\ \ j=\overline{1,L}, \tag{1}$$

where ϕ^i_l – coefficients of AR model, a_j –stochastic values with null average and unit dispersion, p - order of the model, $(\sigma^i_a)^2$ – dispersion of the prediction error. To find parameters of the model the Yule-Woker equation is solved and the simple decision rule was obtained by neglecting the end effects [1]

$$k_k(\mathbf{x}) - k_i(\mathbf{x}) + \ln\frac{(2\pi\sigma_i)^{p_i-L}}{(2\pi\sigma_k)^{p_k-L}} \ge \ln\frac{P_k}{P_i}, k=\overline{1,M}\ ,\ k\ne i. \tag{2}$$

where

$$k_k(\mathbf{x}) = \frac{1}{2\sigma_k^2}\sum_{l=p+1}^{L}\left[x_l - \mu_k - \sum_{j=1}^{p_k} a^k_j (x_{l-j} - \mu_k)\right]^2. \tag{3}$$

III. MEASURING RADAR FOR EXPERIMENTAL STUDY

The radar used was developed on the base of meteorological incoherent pulse radar MRL-1 [2], which includes – fig. antenna control unit (ACU), TV-viewer (TVV), calibration unit (CU), interface unit (IU) and PC for the radar control and signal processing. The radar permits to scan sector within 0°÷80° during 150 s with scan losses 10%.

IV. RESULTS OF EXPERIMENTAL STUDY

For study three types of objects were chosen: Altocumulus opacus clouds, Cumulonimbus clouds and reflections from "clear air" formed by Bragg scattering.

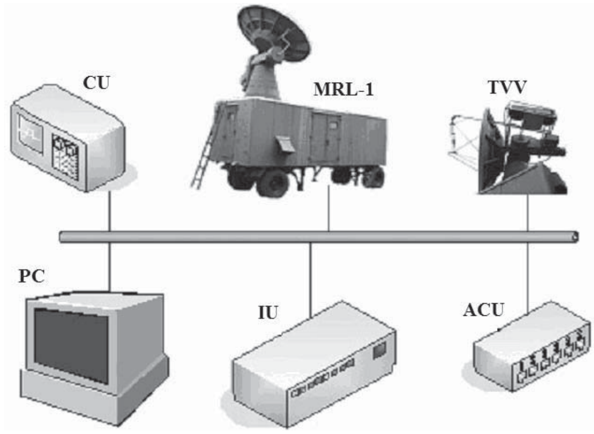

Fig. Block diagram of the measuring radar

As a result the dependence of likelihood right recognition P_c from the order of AR model p is shown in the table.

Table. Likelihood of right recognition

Order	Altocumulus opacus clouds	Cumulonimbus clouds	"Clear air"
2	0,96	0,79	0,42
4	0,97	0,8	0,44
8	1	0,81	0,44
16	1	0,86	0,56
32	0,99	0,86	0,6
64	0,96	0,84	0,6

As it can be seen the likelihood of the recognition is quite high even for not great order of the AR model that confirm the efficiency of the model used for clouds, but it is not suitable for the reflection from "clear air".

V. CONCLUSIONS

1. The algorithm of meteorological object recognition is proposed on the base of AR-model.
2. The experimental testing confirm the efficiency of the algorithm suggested for cumulus clouds.

REFERENCES

1. Bezruk V.M., Tikhonov V.A., Tikhonov D.V. Recognition of stochastic signals on the base of parameters of their autoregressive model // ASU i pribory automatiki. 2001. - Vol.114. - P.28-32.
2. Belov E.N., Voitovych O.A., Makulina T.A., Rudnev G.A., Khlopov G.I., Khomenko S.I. Hadware-Software complex for study of radar backscattering from meteorological constitutions// Radiophizika I Elektronika. -2009. -Vol 14, №1. - P.67-63.