ISSN 0735-2727, Radioelectronics and Communications Systems, 2019, Vol. 62, No. 7, pp. 342–355. © Allerton Press, Inc., 2019.
Russian Text © The Author(s), 2019, published in Izvestiya Vysshikh Uchebnykh Zavedenii, Radioelektronika, 2019, Vol. 62, No. 7, pp. 413–426.

Adaptive Algorithm of Maneuvering Target Tracking in Complex Jamming Situation for Multifunctional Radar with Phased Antenna Array

T. V. Baringolts[1*], D. V. Domin[1], S. Ya. Zhuk[2], and V. V. Tsisarzh[1]**

[1]*Kvant Radar Systems Scientific Research Institute, Kyiv, Ukraine*
[2]*National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine*
**e-mail: kvant-rs@ln.ua*
***ORCID: 0000-0002-0046-8450, e-mail: s.zhuk@kpi.ua*

Received July 2, 2018
Revised June 27, 2019
Accepted June 27, 2019

Abstract—Adaptive multimodel algorithms based on the target movement model in the form of discrete stochastic dynamic system with random structure are adequate to the problem of target tracking based on data of the multifunctional radar station (MFRS) with phased antenna array (PAA) under conditions of complex dynamically varying signal and jamming situation. This study presents an optimal and quasioptimal algorithms of adaptive estimation of movement parameters of maneuvering targets in the Cartesian coordinate system for MFRS with PAA based on the mathematical tools of mixed Markov processes in discrete time. They describe the evolution of joint a posteriori probability density of the vector of target movement parameters and switching variable determining the mode of its movement, while the filters implementing them are referred to the class of devices with feedbacks between channels. The identification of blips in the tracking strobe is performed in the spherical coordinate system by selecting the blip, which is the closest to the strobe center. The efficiency analysis of the developed tracking algorithm is performed by using the test paths of two targets with different intensities of the maneuver and parameters of tracking modes. The accuracy characteristics of adaptive filter and indicators of the tracking efficiency at different false alarm probabilities have been determined.

DOI: 10.3103/S0735272719070021

INTRODUCTION

Modern multifunctional radar stations (MFRS) are forced to operate in complex dynamically varying signal and jamming situation stipulated by the presence of a large number of different targets of various kinds that differ in their speed, height, and maneuvering characteristics and also by the presence of interferences of natural and artificial origin [1–3].

The following possibilities are available in solving functional problems in MFRS with two-dimensional phased antenna array (PAA) [4, 5]:

– infinitely fast control by the beam of antenna array pattern in space during the search and tracking of targets;

– control of radiation energy in the fixed direction, where the beam of antenna directivity diagram is located.

Such possibilities of MFRS with PAA make it possible to simultaneously carry out several tasks:

– space surveillance;

– starting of paths of detected targets;

– path tracking.

Owing to the specified properties, the effective solution of the above tasks in complex operating conditions is ensured at the expense of operation in the mode of time and energy division between the main functional tasks: search, lock-on, and tracking of targets. Practical implementation of the principle of time and energy division is performed by using the methods of adaptive dynamic control by the space scanning program [6, 7].

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ADDITIONAL INFORMATION

The initial version of this paper in Russian is published in the journal "Izvestiya Vysshikh Uchebnykh Zavedenii. Radioelektronika," ISSN 2307-6011 (Online), ISSN 0021-3470 (Print) on the link http://radio.kpi.ua/article/view/S0021347019070021 with DOI: 10.20535/S0021347019070021.

REFERENCES

1. V. S. Verba, *Air Radar Surveillance and Guidance Complexes. The State of Art and Development Trends* [in Russian] (Radiotekhnika, Moscow, 2008).
2. V. I. Gouz, V. P. Lipatov, T. V. Baringolts, S. S. Bilokoz, E. V. Smertenko, L. B. Subbotina, V. V. Torhonskyy, "Design concepts of complex information processing systems with data from many different-type sources located at one or several mobile platforms," *Radioelectron. Commun. Syst.* **55**, No. 1, 1 (2012). DOI: 10.3103/S0735272712010013.
3. M. Balinin, A. Dalandin, "State of the art and development prospects of ground distant early warning radars," *Zarubezhnoye Voyennoye Obozreniye*, No. 1, 69 (2016).
4. V. I. Gouz, A. V. Butyrin, V. P. Lipatov, T. V. Baringolts, "Adaptive control of distribution of the energy and time resource of radar systems with phased antenna array," *Radioelectron. Commun. Syst.* **50**, No. 2, 55 (2007). DOI: 10.3103/S073527270702001X.
5. M. Schikorr, U. Fuchs, M. Bockmair, "Radar resource management study for multifunction phased array radar," *Proc. of 2016 European Radar Conf.*, EuRAD, 5-7 Oct. 2016, London, UK (IEEE, 2016), pp. 213-216. URI: https://ieeexplore.ieee.org/document/7811685.
6. H.-W. Zhang, J.-W. Xie, W.-L. Lu, C. Sheng, B.-F. Zong, "A scheduling method based on a hybrid genetic particle swarm algorithm for multifunction phased array radar," *Frontiers Inf. Technol. Electronic Engineering* **18**, No. 11, 1806 (2017). DOI: 10.1631/fitee.1601358.

7. M. S. Alahmadi, G. E. Smith, C. J. Baker, "A recursive approach for adaptive parameters selection in a multifunction radar," *Proc. of 2016 IEEE Radar Conf.*, RadarConf, 2-6 May 2016, Philadelphia, USA (IEEE, 2016). DOI: 10.1109/radar.2016.7485148.
8. O. L. Smirnov, O. N. Stavitskiy, A. A. Nakonechnyi, "Adaptive control of tracking mode parameters of a multi-function radar," *Science and Technologies of Air Forces of Armed Forces of Ukraine*, No. 1, 71 (2017). DOI: 10.30748/nitps.2017.26.15.
9. A. A. Konovalov, *Essentials of Trajectory Processing of Radar Information*, Part 2 [in Russian] (LETI, St. Petersburg, 2014).
10. X. Rong Li, V. P. Jilkov, "Survey of maneuvering target tracking. Part V. Multiple-model methods," *IEEE Trans. Aerospace Electron. Syst.* **41**, No. 4, 1255 (2005). DOI: 10.1109/TAES.2005.1561886.
11. D. K. Barton, *Radar System Analysis and Modelling* (Artech House, Inc., Norwood, MA, 2005).
12. V. I. Gouz, A. V. Butyrin, T. V. Baringolts, L. B. Subbotina, "Peculiarities of airway processing when tracking air targets observed at small elevation over underlying surface," *Radioelectron. Commun. Syst.* **50**, No. 1, 9 (2007). DOI: 10.3103/S0735272707010025.
13. Y. Bar-Shalom, Xiao-Rong Li, *Estimation and Tracking: Principles*, *Techniques*, *and Software* (YBS Pub., 1998).
14. S. Blackman, R. Popoli, *Design and Analysis of Modern Tracking Systems* (Artech House, Boston, 1999).
15. S. Ya. Zhuk, "Joint filtering of mixed Markov processes in discrete time," *Radioelectron. Commun. Syst.* **31**, No. 1, 29 (1988). URI: http://radioelektronika.org/article/view/S073527271988010066.
16. S. Z. Kuz'min, *Digital Radiolocation. Introduction to the Theory* [in Russian] (KViTs, Kyiv, 2000).
17. A. Farina, F. A. Studer, *Radar Data Processing*. Vol. I: *Introduction and Tracking* (Wiley, 1985).
18. H. You, X. Jianjuan, G. Xin, *Radar Data Processing with Applications* (John Wiley & Sons Singapore Pte. Ltd., 2016). DOI: 10.1002/9781118956878.
19. V. I. Merkulov, V. S. Verba, A. R. Il'chuk, A. P. Kirsanov, *Automatic Target Tracking in Radars of Integrated Air Complexes. Multitarget Tracking*, Part 3 [in Russian] (Radiotekhnika, Moscow, 2018).
20. S. Ya. Zhuk, I. O. Tovkach, Yu. Yu. Reutska, "Adaptive filtration of radio source movement parameters based on sensor network TDOA measurements in presence of anomalous measurements," *Radioelectron. Commun. Syst.* **62**, No. 2, 61 (2019). DOI: 10.3103/S073527271902002X.