OPTIMIZING DATA PROCESSING IN IDENTIFICATION FRIEND OR FOE SYSTEMS

Ganna E. Zavolodko

Department of Information Systems, National Technical University, Kharkiv Polytechnic Institute, 2 Kyrpychova Str., 61002, Kharkiv, Ukraine

Ivan I. Obod

Department of Microprocessor Technologies and Systems, Kharkiv National University of Radio Electronics, Kharkiv, Ukraine

Iryna V. Svyd

Department of Microprocessor Technologies and Systems, Kharkiv National University of Radio Electronics, Kharkiv, Ukraine

ABSTRACT. *This paper proposes, in accordance with the Neyman−Pearson criterion, an optimal framework of data processing in airborne object detection by identification friend or foe (IFF) systems with due regard to the current IFF system design as a single-channel fault-tolerant queuing system, which dictates multichannel reception of request signals and imposes limitations on aircraft transponder availability factor. We consider two signal-processing models with two alternative implementations in each one: (1) cross-channel merging of previous channel decisions on tracking either request signals or their impulse components and (2) either preliminary or subsequent inter-period processing of response signals. Data processing is optimized for both temporal and spatial request signal parameters, the aircraft transponder availability factor also being considered. The preliminary inter-channel merging of request/response signal-pulse component detection results proves to be preferable to the current algorithm of subsequent merging request/response signal detection results as this procedure improves the quality of signal detection and reduces the dependence of detection probability on the aircraft transponder availability factor.*

KEY WORDS: *Identification Friend or Foe, air traffic control, airborne object, aircraft transponder, data processing, request signal, response signal, signal detection optimization, airborne object detection optimization, Neyman-Pearson criterion, aircraft transponder availability.*

G. Zovolodko, I. Obod and I. Svyd. "Optimizing Data Processing in Identification Friend or Foe Systems", *Telecommunications and Radio Engineering*, vol. 81, no. 5, pp. 1-14, 2022. doi: 10.1615/TelecomRadEng.2022037852.

www.doi.org/10.1615/TelecomRadEng.2022037852

REFERENCE

1. Coleman, H. and Wright, B., A Compact Flush-Mounting Antenna with Direction Finding and Steerable Cardioid Pattern Capability, IEEE Trans. Antennas Propag., vol. 32, no. 4, pp. 412-414, 1984. DOI: 10.1109/tap.1984.1143319.
2. Du, X., Liao, K., and Shen, X., Secondary Radar Signal Processing Based on Deep Residual Separable Neural Network, in 2020 IEEE Int. Conf. on Power, Intelligent Computing and Systems (ICPICS), pp. 12-16, 2020.
3. Duan, V., Cheng, Y., Shen, B., He, K., and Bai, G., LFM Interference Cancellation Algorithm Based on MDPT-WC for Mark XIIA Mode 5, in 2020 IEEE 20th Intl. Conf. on Communication Technology (ICCT), pp. 246-252, 2020.
4. El-Badawy, E.A., EL-Masry, W.A., Mokhtar, M.A., and Hafez, S.A., A Secured Chaos Encrypted Mode-S Aircraft Identification Friend or Foe (IFF) System, in 4th Intl. Conf. on Signal Processing and Communication Systems, 2010.
5. Federal Aviation Administration, DOT, Automatic Dependent Surveillance-Broadcast (ADS-B) Out Performance Requirements to Support Air Traffic Control (ATC) Service; Technical Amendment. Final rule; technical amendment, Federal Aviation Administration, Renton, WA, 2015.
6. Han, C., Sun, J., Liu, Y., and Zhao, Z., Identification Friend or Foe (IFF) of Aircraft Target Based on TS-ANFIS, in 33rd Chinese Control and Decision Conf. (CCDC), pp. 3847-3852, 2021.
7. Jarama, A.J., Lopez-Araquistain, J., Miguel, G.D., and Besada, J.A., Complete Systematic Error Model of SSR for Sensor Registration in ATC Surveillance Networks, Sensors, vol. 17, no. 10, p. 2171, 2017.
8. Jiang, Y., Yang, Z., Bo, C., and Zhang, D., Continuous IFF Response Signal Recognition Technology Based on Capsule Network, in Artificial Intelligence for Communications and Networks, AICON 2021. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, X. Wang, K.K. Wong, S. Chen, and M. Liu, Eds., Cham, Switzerland: Springer, 2021.
9. John-Baptiste, P., Brandewie, A., Vinci, J., Bell, K., Johnson, T. J., Neese, F.C., and Rangaswamy, M., Multi-Task Tracking and Classification with an Adaptive Radar, IETRadar, Sonar Navigation, vol. 16, no. 11, 2021. DOI: 10.1049/rsn2.12213.
10. Kim, E. and Sivits, K., Blended Secondary Surveillance Radar Solutions to Improve Air Traffic Surveillance, Aerosp. Sci. Technol., vol. 45, pp. 203-208, 2015.
11. Kolosowski, W., Sedek, E., Borejko, M., and Jeziorski, A., Monopulse IFF Antennas, in MIKON 2008 - 17th Intl. Conf. on Microwaves, Radar and Wireless Communications, Wroclaw, Poland, pp. 1-4, 2008.
12. Leonardi, M. and Di Fausto, D., Secondary Surveillance Radar Transponders classification by RF Fingerprinting, in 2018 19th Intl. Radar Symp. (IRS), 2018.
13. Obod, I., Svyd, I., Maltsev, O., and Bakumenko, B. Comparative Analysis of Noise Immunity Systems Identification Friend or Foe, in 2020 IEEE 40th Intl. Conf. on Electronics and Nanotechnology (EL-NANO), Kyiv, Ukraine, pp. 751-756, 2020.
14. Obod, I., Svyd, I., Maltsev, O., Zavolodko, G., Pavlova, D., and Maistrenko G., Fusion the Coordinate Data of Airborne Objects in the Networks of Surveillance Radar Observation Systems, in Data-Centric Business and Applications, Lecture Notes on Data Engineering and Communications Technologies, T. Radivilova, D. Ageyev, and N. Kryvinska, Eds., Cham, Switzerland: Springer, pp. 731-746, 2021.
15. Otsuyama, T., Honda, J., Naganawa, J., and Miyazaki, H., Analysis of Signal Environment on 1030/1090MHz Aeronautical Surveillance Systems, in 2018 IEEE Intl. Symp. on Electromagnetic Compatibility and 2018 IEEE Asia-Pacific Symp. on Electromagnetic Compatibility (EMC/APEMC), Singapore, p. 71, 2018.
16. Pollack, J. and Ranganathan, P., Aviation Navigation Systems Security: ADS-B, GPS, IFF, Intl. Conf. on Security & Management, SAM'18, Las Vegas, NV, pp. 129-135, 2018.
17. Poornima, P., Reddy, B.R., and Murthy, B.A., Design and Simulation of Two-Chain Monopulse Receiver for IFF Radar Application, in 2018 3rd IEEE Intl. Conf. on Recent Trends in

Electronics, Information & Communication Technology (RTEICT), Bangalore, India, pp. 1114-1118, 2018.

18. Sharifi-Tehrani, O., Sadeghi, A., and Razavi, S.M.J., Design and Simulation of IFF/ATC Antenna for Unmanned Aerial Vehicle, Majlesi J. Mechatron. Systems, vol. 6, no. 1, 2017.

19. Solonskaya, S. and Zhyrnov, V., Semantic Technology in a Survey Radar at Aircrafts Detection and Recognition, Radiotekhnika, vol. 1, no. 196, pp. 32-37, 2019. DOI: 10.30837/rt.2019.1.196.03.

20. STANAG 4193 Document, Technical Characteristics of IFF Mk X and Mk XII Interrogators and Transponders (Part V) - Technical Description of the MkXII System, NATO Standard, 2016.

21. Stevens, B.L., Lewis, F.L., and Johnson, E.N., Aircraft Control and Simulation: Dynamics, Controls Design, and Autonomous Systems, John Wiley & Sons, 2015.

22. Strelnytskyi, O., Svyd, I., Obod, I., Maltsev, O., Voloshchuk, O., and Zavolodko, G., Assessment Reliability of Data in the Identification Friend or Foe Systems, in 2019 IEEE 39th Intl. Conf. on Electronics and Nanotechnology (ELNANO), Kyiv, Ukraine, pp. 728-731, 2019.

23. Strohmeier, M., Large-Scale Analysis of Aircraft Transponder Data, IEEE Aerosp. Electron. Syst. Mag., vol. 32, no. 1, pp. 42-44, 2017. DOI: 10.1109/MAES.2017.160149.

24. Svyd, I., Maltsev, O., Obod, I., and Zavolodko, G., Fusion Method of Primary Surveillance Radar Data and IFF Systems Data, in 2020 IEEE 11th Intl. Conf. on Dependable Systems, Services and Technologies (DESSERT), Kyiv, Ukraine, pp. 336-340, 2020.

25. Svyd, I., Obod, I., and Maltsev, O., Interference Immunity Assessment Identification Friend or Foe Systems, in Data-Centric Business and Applications, Lecture Notes on Data Engineering and Communications Technologies, D. Ageyev, T. Radivilova, and N. Kryvinska, Eds., Cham, Switzerland: Springer, 2021.

26. Svyd, I., Obod, I., Maltsev, O., Shtykh, I., and Zavolodko, G., Model and Method for Detecting RSs in Identification Friend or Foe Systems, in 2019 IEEE 15th Intl. Conf. on the Experience of Designing and Application of CAD Systems (CADSM), Polyana, Ukraine, pp. 1-4, 2019a.

27. Svyd, I., Obod, I., Maltsev, O., Shtykh, I., Maistrenko, G., and Zavolodko, G., Comparative Quality Analysis of the Air Objects Detection by the Secondary Surveillance Radar, in 2019 IEEE 39th Intl. Conf. on Electronics and Nanotechnology (ELNANO), Kyiv, Ukraine, pp. 724-727, 2019b.

28. Svyd, I., Obod, I., Maltsev, O., Strelnytskyi, O., Zubkov, O., and Zavolodko, G., Method of Increasing the Identification Friend or Foe Systems Information Security, in 2019 3rd Intl. Conf. on Advanced Information and Communications Technologies (AICT), Lviv, Ukraine, pp. 434-438, 2019c.

29. Svyd, I., Obod, I., Maltsev, O., Tkachova, T., and Zavolodko, G., Improving Noise Immunity in Identification Friend or Foe Systems, in 2019 IEEE 2nd Ukraine Conf. on Electrical and Computer Engineering (UKRCON), Lviv, Ukraine, pp. 73-77, 2019d.

30. Uzan, S.T. and Colak, S.A., IFF System Simulator Design Based on DSP, in 2016 24th Signal Processing and Communication Application Conf., SIU 2016 - Proc., pp. 1-4, 2016.

31. Yang, C., Wang, Y., and Yi, W., Network Architecture Optimization for Area Surveillance in Multistatic Radar Systems, 2020 IEEE Radar Conf., 2020.

32. Zhyrnov, V. and Solonskaya, S., Semantic Analysis of Fluctuations of a Radar Pack for Identification ofAir Objects, Radiotekhnika, no. 203, pp. 197-203, 2020. DOI: 10.30837/rt.2020.4.203.22.

33. Zhyrnov, V., Solonskaya, S., and Zarytskyi, V., Method for Dealing with Non-Stationary Natural and Simulating Interference in Intellectual Surveillance Radars, Radiotekhnika, no. 206, pp. 115-121, 2021. DOI: 10.30837/rt.2021.3.206.10.