

UNDERWATER ACOUSTIC SIGNAL SIMULATION OF SONAR SYSTEMS WITH A FAN-SHAPED RECEIVING ANTENNAS

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The paper considers math models and algorithms for modeling the propagation of an acoustic signal for a wide class of sonar systems with fan-shaped transceiver antennas (side and sector scan sonars, multibeam echo sounders). A mathematical model is presented for seabed generating in order to simulate the antennas signals and underwater acoustic echograms. Mathematical models for calculating receiving antenna signals are described. The advantages of the approach include the relatively low computational complexity of applied algorithms (in comparison with the solution of the wave equation with boundary conditions), as well as the possibility of parallelizing computational processes on several threads and computers. A series of numerical experiments was carried out to simulate acoustic echograms and signals from two receiving antennas of an interferometric side-scan sonar. The presented results are applicable for sonar signal algorithms debugging, object detection methods developing and other tasks related to underwater acoustic images simulation.

Keywords: acoustic signal simulation, sonar systems, acoustic echograms, image modeling, side-scan sonar, bathymetry, sector-scan sonar, multibeam echosounder.

References

1. Khmel'nov A.E., Zolotarev V.V. Simulation of sonar images by using the graphics accelerators. *Underwater investigations and robotics*. 2011. No. 1(11). P. 41–48.
2. Bagnitskiy A.V., Inzartsev A.V., Pavin A.M., Melman S.V., Morozov M.A. A model solution of an automatic underwater pipelines inspection problem using side scan sonar. *Underwater investigations and robotics*. 2011. No. 1(11). P. 17–23.
3. Kostousov A.V., Kostousov V.B. Simulation of synthetic aperture side-scan sonar device. *Underwater investigations and robotics*. 2008. No. 2(6). P. 16–29.
4. Ageev A.L., Igumnov G.A., Kostousov V.B., Agaphonov I.B., Zolotarev V.V., Madison E.A. Aperture synthesising for multichannel side-scan sonar with compensation of trajectory instability. *Underwater investigations and robotics*. 2012. No. 2(14). P. 13–27.
5. Gorm Wendelboe, Finn Jacobsen, Judith M. Bell. An equivalent roughness model for seabed backscattering at very high frequencies using a band-matrix approach // *The Journal of the Acoustical Society of America*. 2007. Vol. 121, No. 4. P. 814–823.
6. Darrel R. Jackson, Michael D. Richardson. *High-Frequency Seafloor Acoustics* New York: Springer Science+Business Media, 2007.
7. Ol'shevskij V.V. *Statisticheskie metody v gidrolokacii*. Leningrad: Sudostroenie, 1983.
8. Francois R.E., Garrison G.R. Sound absorption based on ocean measurements. Part II: Boric acid contribution and equation for total absorption. *The Journal of the Acoustical Society of America*. 1982. Vol. 72, No. 6. P. 1879–1890.
9. Zhitkovskij Ju.Ju. Obratnoe rasseyanie zvuka dnom okeana. *Akusticheskij zhurnal*. Vol. 41, No. 5. P. 779–783.
10. Judith M. Bell. *A Model for the Simulation of Sidescan Sonar*. Edinburgh: Heriot-Watt University, 1995.
11. P. Blondel *The Handbook of Sidescan Sonar*. Chichester: Praxis Publishing, 2009. P. 313.
12. Melman S.V., Bobkov V.A., Inzartsev A.V., Pavin A.M., Cherkashin A.S. *Software Simulation Framework on the Base of Multiprocessing Architecture for Autonomous Underwater Vehicles*. *Underwater investigations and robotics*. 2015. No. 1(19). P. 23–32.

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