

Use of Hazard Function for Signal Detection on Ionograms

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Abstract

© 2004-2012 IEEE. This letter considers a new method for sample detection of ionospheric propagation modes at the receiver output of a chirp ionosonde. The method is based on the use of the hazard function. Within the framework of the two-component mixture model, it is shown that the hazard function can be used to detect samples of the second component in the mixture when the corresponding fraction of samples in the total number is small. The implementation of the method is carried out using training sets. An average normalized hazard function is constructed for the training set not containing the signal. Normalization is carried out in such a way that the hazard function can be considered as a probability density function of a certain random variable. We used Pearson's statistic to test the agreement between the average normalized hazard function of samples that do not contain the signal and an arbitrary normalized hazard function. The critical value of the statistic was determined using the Neyman-Pearson criterion. The effectiveness of the proposed method has been tested for the determination of the lowest and maximum observed frequencies of radio paths from oblique ionospheric sounding ionograms obtained in the Russian network of circumpolar radio paths. The method suggested in this letter can be used not only when processing ionograms but also for the detection of samples of signals of arbitrary nature against a background noise, provided that statistical signal-to-noise ratios are similar to those considered here.

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Keywords

Geophysical signal processing, hazard function, image processing, ionosphere, signal detection

References

- [1] B. W. Reinisch et al., "New Digisonde for research and monitoring applications, " *Radio Sci.*, vol. 44, no. 1, pp. 1-15, 2009.
- [2] G. G. Vertogradov, V. P. Uryadov, E. G. Vertogradova, V. G. Vertogradov, and S. V. Kubatko, "Chirp ionosonde-radiodirection finder as a new tool for studying the ionosphere and radio-wave propagation, " *Radiophys. Quantum Electron.*, vol. 56, no. 5, pp. 259-275, 2013.
- [3] F. Su, Z. Zhao, S. Li, M. Yao, G. Chen, and Y. Zhou, "Signal identification and trace extraction for the vertical ionogram, " *IEEE Geosci. Remote Sens. Lett.*, vol. 9, no. 6, pp. 1031-1035, Nov. 2012.
- [4] C. Jiang, G. Yang, Z. Zhao, Y. Zhang, P. Zhu, and H. Sun, "An automatic scaling technique for obtaining F2 parameters and F1 critical frequency from vertical incidence ionograms, " *Radio Sci.*, vol. 48, no. 6, pp. 739-751, 2013.

- [5] A. Ippolito, C. Scotto, D. Sabbagh, V. Sgrigna, and P. Maher, "A procedure for the reliability improvement of the oblique ionograms automatic scaling algorithm, " *Radio Sci.*, vol. 51, no. 5, pp. 454-460, 2016.
- [6] A. Nina, S. Simic, V. A. Sreckovic, and L. C. Popovic, "Detection of short-term response of the low ionosphere on gamma ray bursts, " *Geophys. Res. Lett.*, vol. 42, no. 19, pp. 8250-8261, 2015.
- [7] E.-V. Pikoulis and E. Z. Psarakis, "Automatic seismic signal detection via record segmentation, " *IEEE Trans. Geosci. Remote Sens.*, vol. 53, no. 7, pp. 3870-3884, Jul. 2015.
- [8] Z. Wang, T. Hegazy, Z. Long, and G. AlRegib, "Noise-robust detection and tracking of salt domes in postmigrated volumes using texture, tensors, and subspace learning, " *Geophysics*, vol. 80, no. 6, pp. WD101-WD116, 2015.
- [9] A. A. Kolchev and A. O. Shchyry, "Estimation of parameters of interference concentrated in spectrum at the output of LFM iono-probe receiver, " *Radioelectron. Commun. Syst.*, vol. 50, no. 5, pp. 269-274, May 2007.
- [10] V. A. Ivanov, V. I. Kurkin, V. E. Nosov, V. P. Uryadov, and V. V. Shumaev, "Chirp ionosonde and its application in the ionospheric research, " *Radiophys. Quantum Electron.*, vol. 46, no. 11, pp. 821-851, 2003.
- [11] A. A. Kolchev, A. E. Nedopekin, and D. V. Khober, "Application of techniques for separating anomalous samples during the processing of SW LFM Signal, " *Radioelectron. Commun. Syst.*, vol. 55, no. 9, pp. 418-425, 2012.
- [12] C. Forbes, M. Evans, N. Hastings, and B. Peacock, *Statistical Distributions*, 4th ed. New York, NY, USA: Wiley, 2011, p. 230.
- [13] H. V. Poor, *An Introduction to Signal Detection and Estimation*, 2nd ed. New York, NY, USA: Springer-Verlag, 1994, p. 398