航空学报
ACTA AERONAUTICA ET ASTRONAUTICA SINICA
ISSN 1000-6893
CN 11-1929/V

航空学报 » 2013, Vol. 34 » Issue (4) :846-854 DOI: 10.7527/S1000-6893.2013.0145

基于周期FRFT的多分量LFMCW雷达信号分离

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Periodic FRFT-based Multi-component LFMCW Radar Signal Separating

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摘要

多分量线性调频连续波(LFMCW)信号的截获和特征提取是雷达情报侦察的难点,为了实现对多分量LFMCW信号的快速检测和有效分离,提出了一种基于周期分数阶Fourier变换(PFRFT)的多分量LFMCW雷达信号分离新方法。首先介绍了PFRFT,分析了PFRFT和FRFT之间的关系,讨论了LFMCW信号的PFRFT特征。然后给出了一种离散PFRFT的计算方法,结合周期分数阶Fourier域(PFRFD)的窄带滤波和CLEAN算法实现了多分量LFMCW信号的分离。仿真结果表明:①PFRFT的计算效率较周期Wigner-Hough变换(PWHT)具有明显优势;②LFMCW信号分量在特定PFRFD中具有能量峰值,分离后能较好保留时频特征;③当两个LFMCW信号分量的功率相差较大时,适合在PFRFD分离,反之适合在时域分离;④当信噪比(SNR)为0 dB时,两个具有相同功率的LFMCW信号分量分离后,与初始信号分量的相关系数都达到了0.9以上。

关键词： 分数阶Fourier变换 线性调频连续波 检测 信号分离 特征提取

Abstract:

The interception and feature extraction of multi-component linear frequency modulation continuous waveform (LFMCW) signals is difficult to perform for a radar intelligence reconnaissance system. In order to fast detect and efficiently separate multi-component LFMCW radar signals, a novel method is presented. First, with the introduction of periodic fractional Fourier transform (PFRFT), the relationship between PFRFT and FRFT is analyzed, and the PFRFT of a LFMCW signal is discussed. Then, a numerical computation method of discrete PFRFT is given, and the separation of the multi-component LFMCW signals is realized by narrowband filtering on the periodic fractional Fourier domain (PFRFD) with CLEAN. Finally, simulation results show several conclusions: (a) the computation efficiency of PFRFT outperforms periodic Wigner-Hough transform (PWHT); (b) the LFMCW signal component has energy peak on a certain PFRFD and preserves its time-frequency characteristic after separating; (c) when the powers of two LFMCW signals are widely different, it is efficient to separate on the PFRFD, otherwise separation on the time domain is better; (d) when the two LFMCW signal components have similar powers and the signal noise ratio (SNR) is 0 dB, the correlation coefficients between the separated and original LFMCW signal components are both greater than 0.9.

Keywords: fractional Fourier transform linear frequency modulation continuous waveform detection signal separating feature extraction

Received 2012-05-17;

Fund:

国家自然科学基金(60902054);中国博士后科学基金(20090460114,201003758)

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引用本文:

黄宇, 刘锋, 王泽众, 向崇文, 邓兵. 基于周期FRFT的多分量LFMCW雷达信号分离[J]. 航空学报, 2013, 34(4): 846-854.DOI: 10.7527/S1000-6893.2013.0145

HUANG Yu, LIU Feng, WANG Zezhong, XIANG Chongwen, DENG Bing. Periodic FRFT-based Multi-component LFMCW Radar Signal Separating[J]. Acta Aeronautica et Astronautica Sinica, 2013, 34(4): 846-854.DOI: 10.7527/S1000-6893.2013.0145