Journal of Electrical Engineering & Electronic Technology

perspective A SCITECHNOL JOURNAL

Moving Targets Tracking Using Radar Based on Compressed Sensing

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Received date: 16 May, 2022, Manuscript No. JEEET-22-54779;

Editor assigned date: 18 May, 2022; PreQC No. JEEET-22-54779(PQ);

Reviewed date: 27 May, 2022, QC No. JEEET-22-54779;

Revised date: 13 June, 2022, Manuscript No. JEEET-22-54779(R);

Published date: 23 June, 2022, DOI: 10.4172/jeeet.1000914.

Description

A Compressed Sensing (CS) based method under the unknown sparse degree to track ground moving targets using Pulse-Doppler (PD) radar. We use the sparsity of delay-Doppler plane in the process of disposing PD radar echo to set up a sparse signal model in each pulse interval. At the state prediction stage, we can get the predicted values of target states by dynamic equations, with which we can build a delay-Doppler grid that is used to form orthogonal dictionary. At the state update stage, we can get the target state estimation through reconstruction algorithm, so as to realize precise tracking of targets.

The problem of target tracking by PD radar will be transformed into the reconstruction of the sparse signal, which is accomplished by getting the location of targets in the grid, as a result of achieving ground target tracking based on Orthogonal Matching Pursuit. Then, aiming at the sparsity problem in the method of target tracking based on Orthogonal Matching Pursuit, we propose a new target tracking method based on Sparsity Adaptive Matching Pursuit (SAMP) algorithm. Numerical simulations show that our tracking method can not only provide the equivalent computational time but also get better tracking performance than the KF-based tracking.

Target tracking by radar is the process that people use all kinds of observation and computing methods to realize the procedure of target states modeling and tracking using radar. This technology is widely used in the military and civil fields, such as airborne early warning, multi-target attack, ballistic missile defense, marine monitoring, battlefield surveillance in military field and traffic control system, intelligent traffic control system in civil field.

In target tracking of radar, the environment generally includes air targets, ground targets and sea targets. Among them, the air and sea targets are relatively easy to track due to the little effect of environment and their research is also gradually mature from the perspective of international literature. However, the ground target tracking has some certain practical difficulties, such as the limitations of terrain shade, minimum detectable rate, the seriousness of ground clutter, the restriction of road network, the density and flexible of targets. CS is provided to the limitations of ballistic missile defence and marine monitoring of system alleviate the pressure of huge amount of information demand caused by the signal sampling, transmission and storage.

Radar Signal Processing

Compared with the traditional Nyquist sampling theorem, the difference of CS is that we can use an observation matrix reversing the basic shift matrix to make the transformation of high-dimensional signals cast onto a low-dimensional space and reconstruct the original signal with a high probability by solving a nonlinear problem. AS the CS theory can reduce the cost of sampling and computing, it has important influences and practical significance on many disciplines and fields. In recent years, some experts and scholars applied the CS theory to the radar signal processing and obtained many important achievements. In this system, we prove that the targets are sparse in delay-Doppler plane through the establishment of delay-Doppler grid and achieve accurate reconstruction of signals after realizing the sparse representation of echo signal by setting up orthogonal dictionary. In addition, we use the particularity of the grid to search for location of the grid corresponding to the largest coefficient while rebuild signals. Finally, we get the accurate approximation of target measurements. We mainly discuss the ground target tracking method based on CS using PD radar, analyze the features of receiving echo and apply the CS theory to the tracking procedure which can reduce the computational time and improve the tracking accuracy. Therefore, the research of this dissertation has very vital significance sparse signal must remain the geometric properties under the influence of observation matrix, so if we want to get a perfect reconstruction.

We must make sure that the observation matrix won't let the two different k-sparse signal maps into the same sample collection and this requests the matrix consisted of column vectors from observation matrix is singular. Some relevant scholars proved that the observation of signals won't destroy the geometry nature of signals when the observation matrix and sparse matrix are irrelevant we can get the target's estimation state at the kth pulse interval using new measurement values to modify the predicted state. And the OMP algorithm can be used to reconstruct the signal in the update stage so that we can get the best sparse approximation of objective measurement values. Initialize the allowance as original echo signal and compute the correlation coefficient of allowance and sparse dictionary, which is to make inner-products of allowance and each column in sparse dictionary. Save the column corresponding to the largest absolute value to the index set and put this column in a support set Use the least square method to make sparse approximation of signal Update the allowance. Continue the iteration until the allowance is less than a certain minimum value. The column serial number in index set corresponding to the location of grid is the target's location.

Orthogonal Matching Pursuit

The sparse degree of signal is usually unknown, for that the number of target in delay-Doppler plane is unknown before the sparsity estimation. Aiming at this problem, we put forward a method of SAMP-based target tracking using PD radar that can tracking target in the condition of unknown sparsity. The tracking procedure is as follows. Calculate the target's prediction state in the kth pulse interval by the target dynamic equation and set up the delay-Doppler grids by the target's prediction state; Build the sparse dictionary according to the grid values and make sparse decomposition of original echo signal, the sparsity of signal is unknown; Initialize the allowance as original echo signal and compute the correlation coefficient of allowance and sparse dictionary, which is to make inner-products of allowance and each column in sparse dictionary save the columns corresponding to the first L absolute values to the candidate set and use the least square method to make original sparse approximation of signal. Save the columns of candidate corresponding to the first absolute values to support set and use the least square method to make final sparse approximation of signal. Update the allowance, if it's bigger than original value, then change to the next stage and increase L. Otherwise, continue the iteration until the allowance is less than a certain minimum value.

The column serial number in index set corresponding to the location of grid is the target's location. Compressed Sensing (CS), Pulse-Doppler (PD) Radar, Target Tracking, Orthogonal Matching Pursuit (OMP), Sparsity Adaptive Matching Pursuit (SAMP) Algorithm. Feature extraction has been widely used in complex data analysis in biomedical field. Such as feature extraction applied in mass spectrometry data analysis. Artificial neural network is deemed to important intelligent algorithm in pattern recognition. It has been widely used in a variety of biomedical respects. For example, used in magnetic resonance spectroscopy in hepatocellular carcinoma based on neural network. We find out that the outer margin of RT, TNM of tumor stage and the DNA levels are the risk factors reactivation by feature extraction method of logistic regression analysis in this article. The feature extraction method reduced the dimension and improved the classification accuracy.