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Multi person micro Doppler spectrum extraction based on Kmeans clustering

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Abstract

A multi person micro Doppler spectrum extraction method based on Kmeans clustering is proposed to address the problem of spectrum aliasing caused by the simultaneous movement of multiple targets in millimeter wave radar. Firstly, FFT transform is applied to the raw radar data in the distance dimension to obtain the distance map. Then, FFT is applied in the velocity dimension to obtain the distance Doppler map. The CFAR detection algorithm is used to detect the approximate information of the two targets. Then, Kmeans clustering is used to obtain two separate targets, Extracting the position information of two targets separately and applying short-time Fourier transform to the radar data of the range spectrum can obtain the micro Doppler spectra of each target.

Keywords

Millimeter wave radar, multiple target detection, Kmeans clustering.

1. Introduction

As a non-contact detection device, radar does not require people to adapt to its existence. The privacy exposure of cameras and the protection of privacy information by radar have been widely recognized. Due to its high stability, radar can still provide reliable target distance, angle, and Doppler information in rainy, foggy and other weather conditions, or even when the ambient light suddenly changes or even becomes completely dim. By extracting information from millimeter wave radar, target information can be effectively interpreted and applied.

H. Zhao studied gesture separation networks, which separate dual target gestures into two single target gestures. Then, convolutional neural networks and long short-term memory (CNN+LSTM) models are applied to classification recognition. The CNN+LSTM model was validated using a test set, and the results showed that the maximum accuracy at different positions reached 99%. In addition, the average accuracy of separating the two staggered targets in different environments is 93% [1].

Z. Gu proposed a solution based on single input multiple output front-end and blind motion separation algorithm. With the assistance of additional receiving channels, the algorithm originally developed for separating human voices can be extended to separate Doppler signals from different types of motion. The effectiveness of this method was verified through experiments on the separation of gestures and interfering actions. The proposed solution can be applied to new applications such as human gait and gesture recognition [2].

G. W. Fang proposed a new method for simultaneously monitoring multi-target vital signs under resolution constraints. By using advanced signal processing such as adaptive boundaries, even if the distance difference between two targets is less than the distance resolution of FMCW radar, multi-target vital signs can be detected. The integrated empirical mode decomposition (EEMD) algorithm was used to extract the intrinsic mode functions of respiratory rate RR and heart rate HR. The average vital sign errors for two targets located 70 cm and 50 cm apart were 2.35% and 4.44%, respectively [3].

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G. Wang proposed a hybrid radar system that combines linear frequency modulated continuous wave (FMCW) mode and interferometric measurement mode for indoor human body positioning and life activity monitoring applications. The FMCW mode is responsible for distance detection, while the interferometric measurement mode is responsible for monitoring vital activities (breathing, heartbeat, body movements, and gestures). Beam scanning is used to determine azimuth information, enabling the system to draw a 360 ° two-dimensional map where room layout and object positions can be clearly identified, distinguishing humans from nearby stationary clutter [4].

However, most studies have not effectively extracted information on the simultaneous movement of multiple targets. This article mainly studies how to extract the position information of a single target in the range Doppler spectrum, in order to obtain the micro Doppler spectrum of a single target.

2. Multi person micro Doppler spectrum extraction based on Kmeans clustering

After reading the raw ADC data, N chirps are first extracted in chronological order as data for each frame. Then, the fast time dimension (distance dimension) is FFT processed to generate a distance spectrum, see Fig. 1. Then, the slow time dimension (velocity dimension) is FFT transformed to generate a distance Doppler spectrum, see Fig. 2.

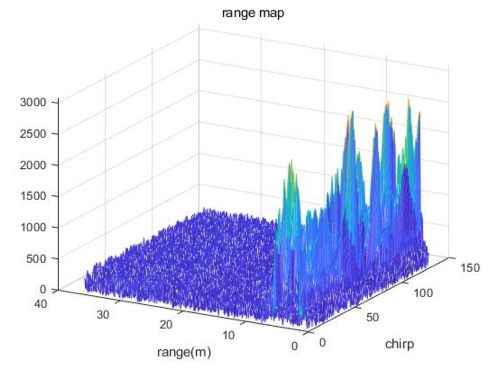


Fig. 1 Range map

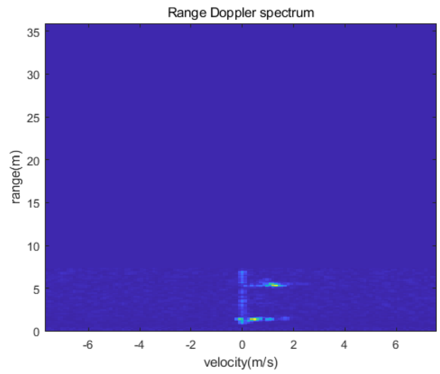


Fig. 2 Range doppler spectrum

However, in actual radar detection equipment, there are residual components of noise and clutter at the input of the detector, and the internal noise and clutter undergo slow and time-varying changes due to the influence of the simulator device in the receiver. When using a fixed threshold for detection, the selection of the threshold has a significant impact on the accuracy of object detection. If the threshold is selected too high, it will cause a low false alarm rate and a high probability of missed detection of the target; If the threshold is selected too low, an increase in the number of detected targets may lead to a large number of false alarms. To avoid this problem, the CFAR algorithm is introduced to ensure that the target detection has a constant false alarm probability. The principle of the CFAR algorithm is to use an adaptive detection threshold instead of the original fixed threshold value to achieve a constant false alarm probability. The adaptive threshold will change adaptively with the size of the noise and clutter signal near the detected unit. When the detected background noise and clutter components are large, raise the adaptive threshold; When the background noise and clutter components are small, lower the adaptive threshold to ensure a constant false alarm probability. The results of CFAR, see Fig. 3.

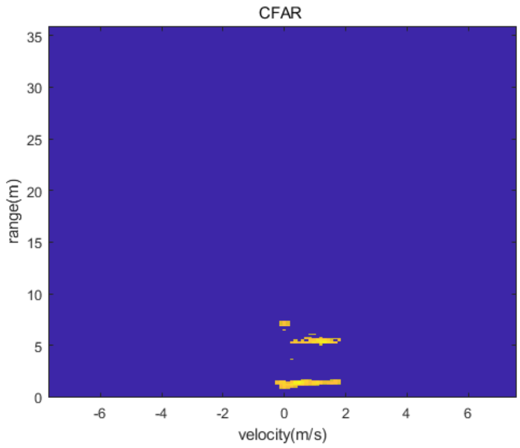


Fig. 3 CFAR result

However, the results of CFAR detection cannot separate the two targets, so this article uses the K-means clustering algorithm to solve this problem. The K-means algorithm is a distance based clustering algorithm that has the characteristics of simple algorithm idea, fast convergence speed, high processing efficiency for large-scale datasets, and good clustering effect for convex or spherical distribution datasets. The clustering results, see Fig. 4.

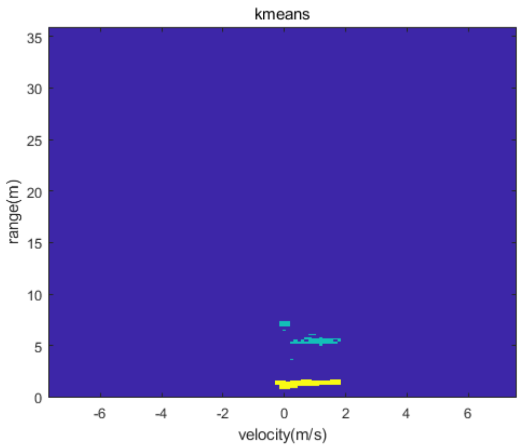
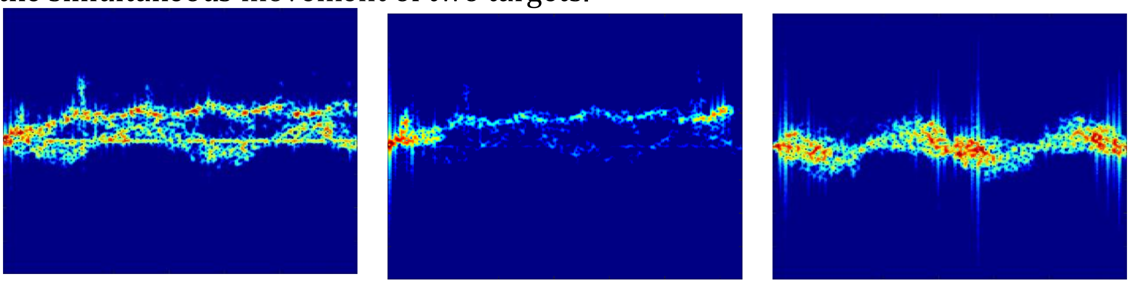


Fig. 4 Kmeans result

The different colors of the clustering results represent each target, and at this point, the position information of each target can be easily obtained. The position information can be mapped to the original data, and then the short-time Fourier transform can be performed to obtain the micro Doppler spectrum of each target. Fig. 5 (a) shows the micro Doppler spectra of two individuals moving simultaneously, Fig. 5 (b) shows the micro Doppler spectra of the first individual moving alone, and Fig. 5 (c) shows the micro Doppler spectra of the second individual moving alone. This completes the extraction of the micro Doppler spectra of a single individual from the simultaneous movement of two targets.



(a) (b) (c)

Fig. 5 experimental result

3. Conclusion

In order to solve the problem of spectrum aliasing caused by the simultaneous movement of multiple targets, this paper uses the KMEANS clustering algorithm to obtain the distance information of a single target, and then processes the radar data to obtain the micro Doppler spectrum of a single target among multiple targets. The effectiveness of the method has been demonstrated through experiments.

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