Numerical Investigations on Sea States Estimation Based on the Convolution Neural Networks Deep Learning Technique

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ABSTRACT
Maritime X-band radar has become a very popular tool in ocean waves remote sensing. Conventional approach is difficult to extract high-precision wave parameters. In this paper, a method for ocean wave remote sensing by using Convolution Neural Networks (CNN) is proposed. The CNN models are employed to retrieve ocean wave parameters from simulation radar images. Validations are carried out on the basis of the simulated wave radar data. The results of different CNN models are also compared. Numerical results suggest that considerable accuracy is obtained in predicting the wave parameters. The present work provides another feasible way for accurate waves remote sensing.

KEY WORDS: Ocean waves remote sensing; Radar images; Deep learning; CNN.

INTRODUCTION
Ocean wave is the main environmental factor that leads to the loads and motion responses of ships and ocean structures. Therefore, as the key factor affecting the safety and efficiency of ocean operation, ocean wave is an indispensable object in research. Traditional method to obtain wave parameters is to use buoys, sea current meters, maritime survey ships and other detection equipment. These traditional measurement tools can accurately reflect the time-varying characteristics of wave parameters at observation points. However, the detection area only covers local detection points, and can’t fully reflect the situation of the sea area to be measured. Moreover, due to the limitations of meteorology and sea conditions, real-time continuous data can’t be obtained. With the progress of aerospace technology and the development of marine remote sensing technology, airborne and spaceborne synthetic aperture radar (SAR) has been able to monitor large areas of the sea in real time. However, satellite remote sensing has a low temporal resolution due to limited sampling frequency. And due to the restriction of bad weather, aerial remote sensing can’t obtain the observation data under extreme weather conditions. Shore based HF surface wave radar has a large blind area in the nearshore area, so it can’t meet the needs of all aspects at the same time.

The emergence of X-band maritime radar makes up for the shortcomings of the above methods. It can achieve all-weather real-time monitoring and high spatial and temporal resolution. X-band maritime radar is an active microwave imaging radar equipment. It can generate the sea clutter image characterizing scattering intensity by transmitting electromagnetic wave to the sea surface and receiving its backscattered echo signal. And then the relevant retrieval algorithm can be used to obtain the parameters such as the significant wave height and characteristic period of the sea wave. Wright (1965) is a pioneer in the use of X-band radar to observe waves. He interpreted the direction and wavelength of sea waves directly from X-band radar images. Ziemer and Rosenthal (1983) applied two-dimensional Fourier transform to radar image to obtain wavenumber energy spectrum, and used the wavenumber spectrum to estimate wave parameters, opening the door to obtain wave parameters from radar images by wave spectral analysis method. Young (1985) applied the three-dimensional Fourier method to radar image sequence, and this theory has been an important theoretical basis in the field. Thereafter, Senet (2001), Gangeskar (2002) and some other researchers proposed some improvements to the retrieval algorithm to improve the accuracy. With the development of retrieval algorithms, commercial applications of X-band radar-based wave observation system have been developed. The WaMoS II (Wave Monitoring System II) in Germany and the WAVEX (Marine Radar Wave Extractor) in Norway are the most representative. In summary, up to now, the main idea of obtaining wave parameters from X-band radar images is using Fourier transform to obtain the radar image spectrum, and then using the spectral analysis to estimate the relevant parameters of the wave. It is a method that based on physical equations, which is based on the assumption that the flow field in the sea area is uniform field and satisfies the linear wave theory. So, there exist severe challenges for improving accuracy based on this method.

Since 2006, with the rise of big data and the improvement of computer performance, Deep Learning technology has made breakthroughs.