A Novel Super Resolution Algorithm for Weather Radar Echo Based on Sparse Representation

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Extreme weather events often result in serious economic loss. The key to disaster prevention and mitigation is to provide early warning and timely forecasting of extreme weather. The new generation of Doppler weather radar system plays an important role in the monitoring and forecasting of severe convective weather process. The volume scan time for CINRAD-SA radar in VCP 21 mode is 6 minutes, and the reflectivity distance resolution is 1km. Small-scale severe convective weather systems have short generation and extinction periods and rapid changes. For example, most tornadoes last only a few minutes. Small-scale weather systems range from tens of meters to 2 kilometers. Therefore, the small-scale weather system in radar echoes is only represented as having several valid data in the distance direction due to radar resolution limitations. Besides, factors such as blurring, deformation, and shifting generated by the receiver make it difficult to observe the detailed internal structure of the echoes. Enhancing the resolution of weather radar echo data helps to observe and track the occurrence and development of severe convective weather processes, obtain refined information about the internal structure of atmospheric motion and meteorological targets, and provide stronger support for extreme weather forecasts and warnings.

In order to solve this problem, some radar echo super-resolution reconstruction algorithms have been proposed, but the algorithm may result in an excessively smooth edge and detail in a local region. To reconstruct radar echo with better edges and finer details, a novel Nonlocal Self-Similarity Sparse Representation (NSSR) model is proposed. The NSSR model is based on the sparse representation of weather radar echoes to better reconstruct the echo edge and detail information. The sparseness of low-resolution should be as close as possible to the sparseness of high-resolution radar echo in order to ideally reconstruct high-resolution radar echo. the sparse coding noise was adapted to describe the difference between the sparse code of low-resolution radar echo and the sparse code of high-resolution radar echo. Although the high-resolution radar echo cannot be directly obtained, sparse code of high-resolution can be estimated by using the spatial redundancy in the observed low-resolution radar echo. A set of sub-dictionaries can be learned by training from observed low-resolution radar echo, and the set of sub-dictionaries are adaptively used to code the radar echo patch that needs to code. We exploit the radar echo nonlocal self-similarity to recover more realistic details based on NSSR model. Experiment results demonstrate that the proposed NSSR outperforms current general-purpose radar echo super-resolution approaches on both visual effects and objective radar echo quality.

Keywords: Super resolution, Sparse Representation, Weather radar