A Multi-view Sonar Image Fusion Method Based on the Morphological Wavelet and Directional Filters

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Aim

In underwater tasks of object detection and identification, high-frequency forward-looking sonar is an effective device to measure accurate information, including sequence images of continuous changes in scene views. A single image usually describes partial structures or local regions of the large object surface. To improve the capability of object detection, we use image fusion method to obtain the advantage or complementary information among redundant images.

In our work, we present a sonar image fusion method based on the directional filters and morphological wavelet, which combine features of multi-resolution wavelet analysis and nonlinear filters. Applying this method to multi-view sonar images, the results indicate that the fusion image can effectively describe the advantage details of source images in multi-resolution and directions, and the method maintains a good ability to suppress noise.

Methods

1. Morphological wavelet transform (MWT)

\[
x'(2m,2n) = x(2m,2n+1)
\]

![Fig. 1. Decomposition of 2-D morphological wavelet transforms.](image)

In morphological minimum wavelet transform of two dimensions (MWTMin), \(D\) is the calculation of minimum operation, and \(D'\) is the maximum. If we replace both \(D\) and \(D'\) by median operation, we can get the improved morphological median wavelet transform (MWTMed) which has combined the nonlinear sorting process with linear operation.

2. Directional filter bank (DFB)

The directional filter bank from contourlet transform is fully reconstructed. The reconstruction principle is:

\[
x_{\omega} \approx x_{\omega}, \quad x_{\omega} \approx x_{\omega}, \quad x_{\omega} \approx x_{\omega}, \quad x_{\omega} \approx x_{\omega}
\]

![Fig. 2. The structure of a fan filter.](image)

In the result images from MWTMed and MWTMin, the target area has good regional coherence and gray scale was enriched. The outline in the upper part and the lost detail in the lower part were enhanced and the noise was reduced. IE of contourlet, MWTMed and MWTMin were still similar to each other, however, MI and Q of MWTMed and MWTMin were bigger significantly than contourlet and MWTMin was the best. This shows that in the sonar image with high level noise, the directional morphological wavelet fusion has obvious advantages.

Discussion and Conclusions

- The effect of noise on the multiscale transform is reduced by nonlinear morphological filter. By using the downsampling directional filter, the directional analysis ability of the high frequency part is enhanced.
- For real sonar image fusion with high level noise, the proposed method maintains a good robustness of noise and a preserving ability of contour and edge when compared to the contourlet transform.
- Morphological operations used in the morphological wavelet transform are more suitable for hardware implementation, which promises a better development prospect in practical application.