Extraction and Recognition of Bridges over Water in High Resolution SAR Image

XiongMei Zhang, JianShe Song, ZhaoXiang Yi, and JunHui Xu
Xi'an Research Institute of High Tech
Xi'an 710025, China
zxw.ok@163.com

Abstract. Based on the characteristics of bridges over water in high resolution SAR image, a novel method for bridge extraction and recognition by combining the multi-scale decomposition and region analysis is proposed. Firstly, the non-subsampled pyramid (NSP) transform is employed to denoise the SAR image. And then, by using the information provided by the multi-scale subbands and analyzing the region characteristics in the segmentation results, the contour of water region is extracted. Finally, the bridge is detected and recognized according to the knowledge of bridges over water. Experimental results obtained on real SAR images confirm the effectiveness of the proposed method.

Keywords: SAR image, bridge, multi-scale decomposition, nonsubsampled pyramid (NSP), image segmentation.

1 Introduction

With the development of Synthetic Aperture Radar (SAR) technique, the acquisition of high quality and high spatial resolution SAR images becomes available. Accordingly, the recognition of bridges over water in high resolution SAR images has received an increasing amount of attention from the image processing community and many methods have been proposed over the last few years [1-3]. However, due to the complex nature of SAR image as well as the complicated terrain appearances, the above methods may fail in many cases.

As an important component of nonsubsampled contour transform (NSCT) [4], the nonsubsampled pyramid (NSP) transform is a fully shift-invariant and multi-scale expansion. When used to image, it can filter the noises as well as the high frequency information to obtain low-pass subbands of the same size to the original one. All the above characteristics enable it to deal efficiently with images having smooth contours, thereby providing robust performance when used in image processing. In this paper, based on the aforementioned NSP and the region analysis, a novel method for extraction and recognition of bridges over water is proposed (see Fig.1). The ideal is to automatically obtain the number of bridges in the coarse subbands of NSP which is fed back to the procedure of the fine subbands to extract the bridges. Experiments carried out on real SAR images show that the new method is able to extract bridges precisely and effectively.
2 Image Denoise Based on NSP

As a foundational component of NSCT, NSP provides multi-scale decomposition and can be iterated repeatedly on the low-pass subband output of previous stage. The building block of NSP is a two-channel nonsubsampled filter bank (NSFB). Since NSFB has no downsampling or upsampling, it is shift-invariant. The perfect reconstruction condition is given as

$$H_0(z)G_0(z)+H_1(z)G_1(z)=1$$  \hspace{1cm} (1)

Particularly, the $G_0(z)$ and $G_1(z)$ are low-pass and high-pass. Thus, they can filter certain parts of the noise spectrum in the processed pyramid coefficients. The filters for subsequent stages are obtained by upsampling the filters of the first stage.

The NSP is shift-invariant such that each pixel of the transform subbands corresponds to that of the original image in the same location. Therefore, we employ the NSP to denoise the original SAR images. A SAR image including bridges over water as well as its 3-stage decomposition of NSP are shown in Fig.2. It can be observed that with the increase of stage, though more noises are removed, the contour and edge are blurred, which is unfavorable in bridges extraction. An effective solution is to obtain the overall information in coarse stages and detailed information such as edges and parameters in fine stages.