Chapter 28

Speckle Noise Filtering Using Back-Propagation Multi-Layer Perceptron Network in Synthetic Aperture Radar Image

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ABSTRACT

Synthetic Aperture Radar (SAR) are imaging Radar, it uses electromagnetic radiation to illuminate the scanned surface and produce high resolution images in all-weather condition, day and night. Interference of signals causes noise and degrades the quality of the image, it causes serious difficulty in analyzing the images. Speckle is multiplicative noise that inherently exist in SAR images. Artificial Neural Network (ANN) have the capability of learning and is gaining popularity in SAR image processing. Multi-Layer Perceptron (MLP) is a feed forward artificial neural network model that consists of an input layer, several hidden layers, and an output layer. We have simulated MLP with two hidden layer in Matlab. Speckle noises were added to the target SAR image and applied MLP for speckle noise reduction. It is found that speckle noise in SAR images can be reduced by using MLP. We have considered Log-sigmoid, Tan-Sigmoid and Linear Transfer Function for the hidden layers. The MLP network are trained using Gradient descent with momentum back propagation, Resilient back propagation and Levenberg-Marquardt back propagation and comparatively evaluated the performance.

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1. INTRODUCTION

Radar system was developed during World War II to track aircrafts and ships. Radar system measures distance to the target by precisely calculating the time delay between sent and received signal. Doppler shifts were used to measure target speed. In 1951, Carl Wiley from Goodyear Aerospace found that radar can be used to create images from target and earth surface. In 1970s applications of Remote Sensing was open for civilian use (Chan and Koo, 2008). It drew the attention of researchers and application grew rapidly.

SAR produces high resolution two dimensional images of mapped areas (Tomiyasu, 1978). It is mounted on moving platform such as aircraft or spacecraft. A SAR works by illuminating the scanned surface with a beam of coherent electromagnetic radiation in a side-looking direction, the returned echo form the illuminated are collected by SAR receiver and processed to reconstruct the image of the surface. SAR geometry is shown in Figure 1(Dastgir, 2007). The SAR platform flies along the azimuth direction at constant velocity. It is not feasible for a spacecraft to carry a very large antenna, which is required for producing high resolution image of the earth surface. SAR uses the forward motion of platform to synthesize a very large antenna. Range is the direction perpendicular to flight path of the aircraft. By measuring the time difference between the transmitted pulse and received echo, the range of the reflecting object can be determined.

Range resolution is the ability to separate two object points in the range direction. Mathematically Range resolution(***R***) can be defined as:

$$R = \frac{ct}{2} \tag{1}$$

where ***t*** is the pulse width and ***c*** is the speed of light. From the equation shown above it can be observed that smaller value of ***t*** will give high (finer) resolution. However decreasing the value of ***t*** will also reduce Signal to Noise Ratio (SNR). To solve this problem SAR uses pulse compression techniques. In this technique long-duration Linear Frequency Modulated (LFM) pulse are transmitted, it allows the pulse energy to be transmitted with a lower peak power. The LFM pulse when filtered with a matched filter produces a narrow pulse in which all the pulse energy is collected to the peak value. Thus, when a matched filter is applied to the received echo signal, it is same as transmitting narrow pulse.

Azimuth is the direction parallel to the flight path of the aircraft. To obtain high azimuth resolution, a large antenna is needed to focus the transmitted and received echo into a sharp pencil like beam. The sharpness of the beam defines the Azimuth resolution (***A***).

$$A = \frac{R\lambda}{L} \tag{2}$$

where ***R*** is slant range, λ is the wave length of the transmitted signal and ***L*** is the length of the antenna.

SAR has different mode of operations based on their application. Following are the modes of operation:

- **Stripmap SAR:** In this mode, the antenna points to a fixed direction. The beam sweeps along the surface with a constant rate and a contiguous image is formed.

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