RESOLUTION ENHANCEMENT OF SAR IMAGE USING A MULTIFRAME SUPER RESOLUTION TECHNIQUE

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1. INTRODUCTION

As observations by SAR are generally less susceptible than other remotely sensed data to weather conditions and observation timing, SAR images obtained by observing the same area multiple times can be combined to obtain higher resolutions. The resolution of SAR images in the azimuth direction in case of the strip mode SAR observation is approximately half of the antenna length in the azimuth direction. The resolution in the range direction is inversely proportional to the bandwidth of chirp modulation [1]. There is a strong demand for observing the ground surface more precisely and this demand has been met primarily through improving the resolution by expanding the bandwidth. Alternatively, a super resolution technique using multiple observation images of similar resolutions has been proposed as a means of improving resolution. This technique has been proven to be effective when applied to images taken by digital camera [2]. This paper proposes a method of enhancing image resolution by applying the high precision co-registration method used in the interferometric SAR to the super resolution process of multiple SAR images obtained by observing the same area. An experimental results are shown using multiple real SAR images.

2. RESOLUTION ENHANCEMENT METHOD TO MULTIPLE SAR IMAGES

Since the geometric relations among individual SAR images considered here are dependent on the orbit deviations of the satellite, the intervals and directions of interpolations cannot be expected to be uniform over the entire image. Moreover, it is necessary to keep in mind that SAR images observed at different times include areas that vary temporally. Therefore, we adopted a super resolution technique with high robustness by means of highly repetitious local arithmetic operations proposed by Irani, et al. [3]. Fig. 1 shows the super resolution process of producing a single high resolution image $f(x,y)$ from n-frames of low resolution images $\{g_k(u,v)\}, k=1,\cdots,n$, where g_k corresponds to SAR_k, the k-th SAR image. Firstly, the scaling constant, α, which is to be used for obtaining the updating value described later, is determined. The area correlation method is applied to the master image SAR_1 and other SAR images using a method similar to that used in co-registration process of the interferometric SAR. The coefficients $\Delta u_k, \Delta v_k$ of the offset function are estimated using the least squares method with a resolution of 1/32 of a pixel (Step 1, Fig. 1). Next, SAR_1 is simply enlarged to generate an initial high-resolution image $f^{(0)}$ (Step 2, Fig. 1). Low resolution SAR images

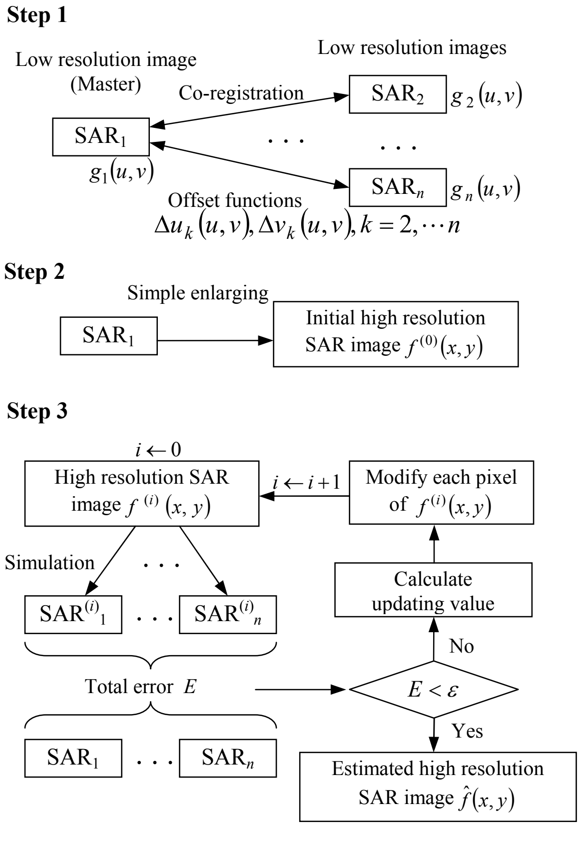


Figure. 1 Flow of the super resolution process for multiple SAR images.

are then simulated from $f^{(i)}$ using the offset function to produce $SAR^{(i)}_k$. $SAR^{(i)}_k$ is compared with SAR_k , $k = 1,\cdots,n$, to obtain the total error E. If E is larger than the tolerance ε , the updating value is calculated based on the method given in expression (4) of the reference document [3] to obtain $f^{(i+1)}$ by modifying each pixel value of $f^{(i)}$ (Step 3, Fig. 1). The process is terminated when $E < \varepsilon$, and it is concluded that $f^{(i)}$ is the estimated high resolution image.

3. EXPERIMENTAL RESULTS

The Advanced Land Observing Satellite (ALOS) launched by Japan in January 2006 is operating smoothly. ALOS is equipped with a high performance SAR named Phased Array L-band SAR (PALSAR). The target area where the super resolution process is applied to SAR images is the eastern region of Tokushima prefecture, indicated by observation path No.67 and central frame No.2930. PALSAR observations over this area using the fine beam, HH polarization, descending orbit, and off-nadir angle of 34.3 degree have occurred eleven times so far. Of these observations, nine scenes (n=9) were selected for the experiment, eliminating those with excessive positional errors. Firstly, Single Look Complex (SLC) images are generated using the SAR processor based on the range-Doppler method [1]. Then, the offset functions are obtained using the SAR_k converted from SLC into amplitude images. As a result, the residual errors in the azimuth and range directions were on average -0.10 lines and -0.08 pixels, respectively, providing sufficient accuracy. Fig. 2 shows the convergence of the total error E when the super resolution process is applied using four values of α . It can be seen that the convergence occurs after about ten repetitions. Fig. 3(a) shows the initial high resolution image $f^{(0)}$ enlarged two times in both the azimuth and range directions using the master image, SAR_1. Fig. 3(b) shows an estimated high resolution image. Although it provides a higher resolution as desired, it is developing a fringe pattern in the range direction.

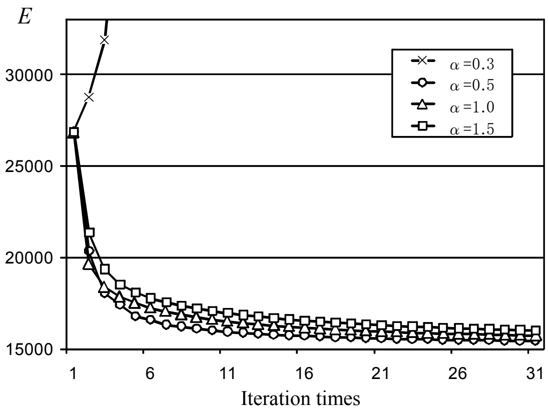
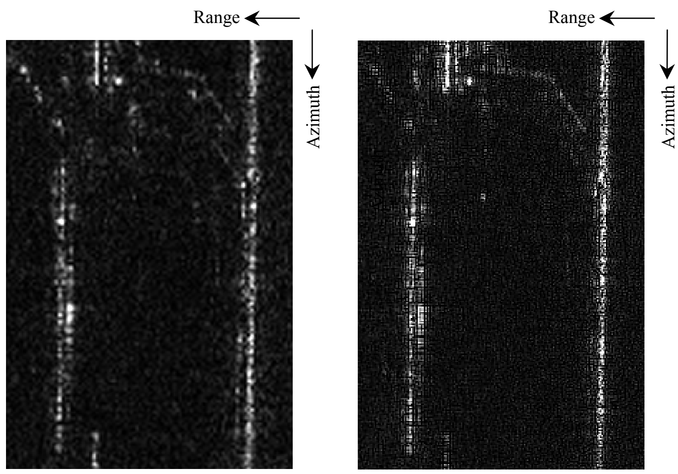


Figure. 2 Convergence state in super resolution process

4. CONCLUSIONS

This paper shows that resolution enhancement is possible by applying the super resolution technique to multiple SAR images taken from the same area, exemplified in the results of processing PALSAR images. It is necessary to ascertain the cause of fringe pattern development in the range direction and also to develop a quantitative evaluation method for the super resolution process.



(a) Initial high resolution SAR image $f^{(0)}$.

(b) Estimated high resolution SAR image $f^{(31)}$ ($\alpha = 1.0$).

Figure. 3 Results of the super resolution process using PALSAR images (In the vicinity of Tokushima airport terminal building). The coordinate of both images is slant-range.

5. REFERENCES

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