DESIGNING AN ILLEGAL MINING DETECTION SYSTEM BASED ON DINSAR

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1. INTRODUCTION

Satellite Differential Radar Interferometry (DInSAR) has demonstrated its ability for monitoring mine-induced ground subsidence [1][2]. However, it is still a challenging task to routinely identify all mining activities from the large-scale coverage interferogram, especially the illegal mines. In response to this challenge an underground mining detection system based on DInSAR is described. The system is tested over a dense mining area in Asia. With such a system it is hoped that the detection efficiency of illegal underground mining using DInSAR can be improved.

2. SYSTEM DESIGN AND METHODOLOGY

The detailed processing flow of the Illegal Underground Mining Detection System (IUMDS) is shown in Figure 1, which is composed of six modules: *Mask Generation*, *Phase Unwrapping*, *Gradient Calculation*, *Contours Generation and Selection*, *Shape and Gradient Correlation*, and *Mining Plan Comparing*.

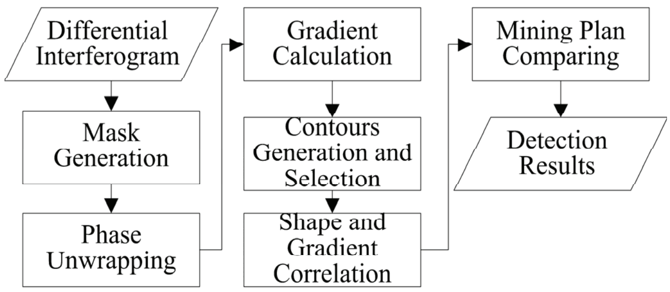

Figure 1. Processing Flow of IMDS

The most important module of IUMDS's initial steps is *Phase Unwrapping*, which is used to obtain the absolute deformation values from Differential Interferogram [3]. In order to obtain a high quality unwrapped result, a mask is necessary [5]. It is used to block out the areas that may bring in errors or impact the result's quality negatively.

As illustrated in Figure 1, the *Mask Generation* module is therefore the first to be implemented, right before the *Phase Unwrapping* one.

After obtaining the absolute phase values of differential interferogram through *Phase Unwrapping*, the gradient of deformation will be computed by the *Gradient Calculation* module. Since magnitude values of gradient on the edge of deformation area are the same and larger than none-deformation region, contours are then generated by the *Contours Generation* module based on this principle. As a result, mining candidates are selected. The gradient values on the contours can be obtained from deformation modes for specific mining areas.

In the following step, correlation operations are implemented between mining candidates enclosed by selective contours and two references. The first one is a shape reference represented as an oval, whose size and curvature are determined by the target candidate to be applied correlation on. Another one is referred as gradient reference which is produced based on the selective contour. The gradient magnitudes are determined by the gradient of the contour. Also, directions of all the gradients are perpendicular to the contour, pointing outside. After calculating the correlation coefficients for each mining candidates, the ones with high correlation values are then selected, confirming as mining locations. Finally, all of these detected mines are then compared with the mining plan to identify illegal mines.

3. RESULTS DEMONSTRATION

To demonstrate the performance of IMDS, a case study is presented here. The selected location is a site in Asia, where some underground coral mines are in exploitation and a few of them are illegal.

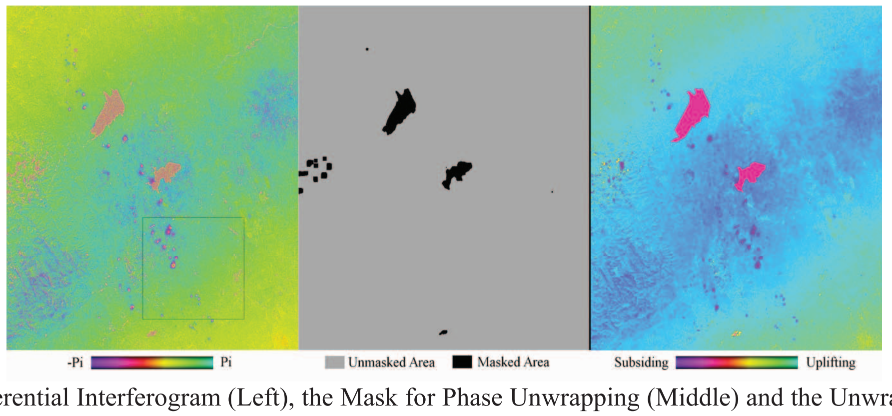

Figure 2. The Differential Interferogram (Left), the Mask for Phase Unwrapping (Middle) and the Unwrapped Result (Right) of Selected Site

The DInSAR interferogram for region is shown in Figure 2, whose coverage is around 70×70 km2. The interferogram is generated by using two-pass DInSAR method [6] with two ALOS (Advanced Land Observing Satellite) PALSAR (Phased Array type L-band SAR) images. The master image was taken on 15 December 2007 and the slave one was acquired on 30 January 2008. Their Track and Frame of the images are 453 and 72 respectively. As can be seen from Figure 2 (left), there are several areas with noise fringes, so a mask is generated based on the density of residual points to ensure the high quality of unwrapped result. The mask and unwrapped interferogram is also illustrated in Figure 2 (middle and right respectively). In order to represent all the following processes more clearly, results are zoomed to the area indicated by the rectangle in Figure 2.

After obtaining the unwrapped result that indicates the absolute deformation values, gradients are computed based on it. Sequentially, contours can be obtained for selecting mining candidates. The magnitude , phase and calculated contours are given in Figure 3. The correlations are then computed on the gradient of unwrapped result, and values that are larger than presetting threshold are recognized as underground mining. For the zoomed area, 17 out of 28 of the mining candidates have been identified as mining sites and illustrated in Figure 4. After that, it will be compared with the exploitation plan, finally find out the possible illegal mines that are outside the region of planning longwalls.

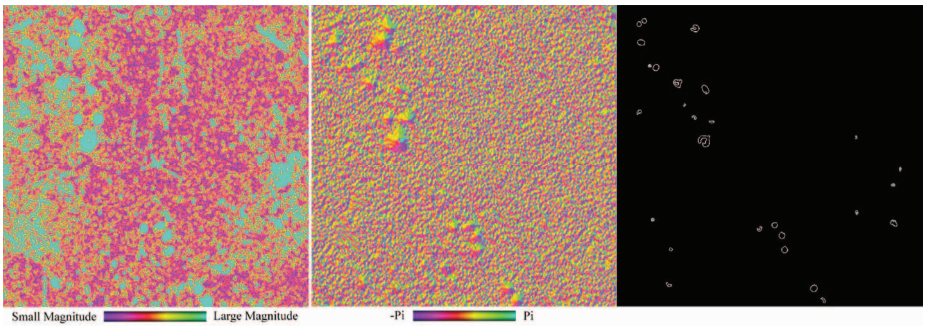

Figure 3. Magnitude (Left) and Phase (Middle) of Unwrapped Result, and Generated Contours (Right) in Zoomed Area

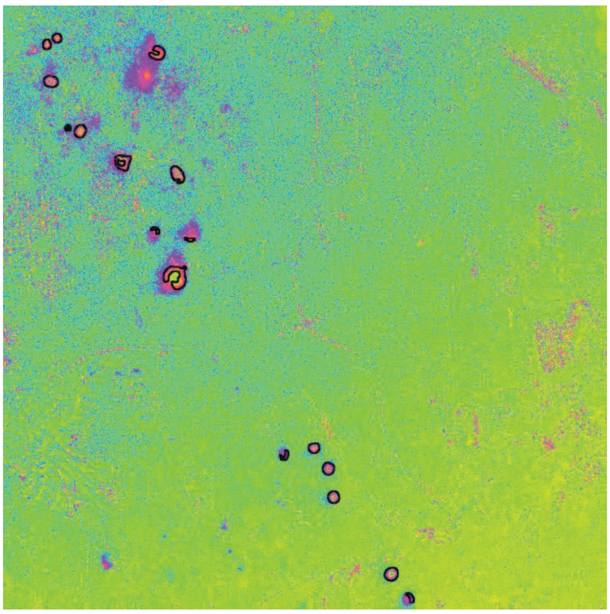
Figure 4. Detecting Result of Underground Mining

4. CONCLUSION\

In this paper, DInSAR remote sensing technique has been used to detect the mining subsidence in a large-scale area. Based on the obtained differential interferogram, an IUMDS system has been proposed to increase the detection efficiency of underground mining. From demonstration of its application on the site in Asia, it can be seen that most mines have been identified from the initial interferogram, and then the results are used to detect the illegal mines in the region.

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11. REFERENCES

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