Prediction the Direction of Storm Based on the Sub Pixel Registration

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Abstract— In the field of natural disaster management, storm detection, forecasting the weather condition and change detection are occupied as essential role. The storm direction detection is provided to manage and to prevent the possible attacked region of the land. The storm regions are extracted by the feature extraction method based on Morphological processing and the color segmentation approach based on the intensity transformation and color spaces. The movement of the interested cloud region are estimated by the modified sub pixel registration approach. The direction of the storm can be tracked from these computations. Especially, the attacked region of Myanmar Land is forecasted from multi-date satellite images. The digital image correlation method is developed based on the sub-pixel accuracy method. According to the experiment and its result, the proposed method work effectively.

Index Terms—Connected neighborhood, digital image correlation, sub-pixel registration algorithm.

1. INTRODUCTION

Weather conditions are mostly related to agriculture and people's lives. The weather prediction is very important for human daily life to prevent and reduce the attack of natural disaster. The storm direction detecting system is developed based on the sub-pixel accuracy method. The pixel correlation among the images is computed accurately by the Digital Image Correlation (DIC) for motion detection. The various applications had been reported for two-dimensional measurement of displacement and strain field using the method of DIC.

Tsang-Long Pao[1] proposed the estimation of the Typhoon locating and reconstruction of the typhooe shape from the infrared satellite cloud image. In their approach, the satellite cloud image is divided into slices for extracting the typhoon features. They used morphology operations and statistical image classification methods to locate the center and the contour of the typhoon. Using the collected satellite cloud images, they perform the recognize, locate and reconstruct typhoon images. C. Thinzar[2] present the detecting of the correlated region by sub-pixel registration approach of Newton Raphson Method. The integer pixel registration algorithm is applied in their correlation computation. B, Pan et al. [3], investigated the problem of subset size selection in the DIC technique based on the Sum of Squared Differences (SSD) correlation criterion. They assumed that the gray intensity gradients of image noise are much lower than that of speckle image. A theoretical model of the displacement measurement accuracy of DIC is derived for choosing an optimal subset size for speckle patterns.

The most applications of two-dimensional DIC are found in determining the displacement and strain calculation problem and strain deformation [4-7]. B. Pan et al. [6] describes the performance of three different types of sub-pixel displacement registration algorithms in terms of the registration accuracy and the computational efficiency. Goh Kok Yong [7] studied the deformation in shear region of glued laminated timber beam by applying the digital image correlation.

This paper is presented the development and the limited experimental verification of sub-pixel registration algorithm for storm prediction from the multi-dates satellite images. The overview of the proposed system is described in Section2. Cloud region segmentation and extraction are performed by morphological processing approaches and the color segmentation approach based on the intensity transformation and color spaces. The modified morphological relation is presented in Section 3. For predicting the storm direction, the motion detection algorithm is developed based on the sub-pixel registration approach. Section 4 describes about the sub-pixel registration algorithm.

The proposed approach is not required the predefined matched feature point pairs of base and input image as like the existing sub pixel registration correlation approach. This algorithm not only measures the displacements but also predict the nearest attack region of Myanmar Land such as Rakhing State, Delta and Taninthari State, etc. The experiments and results are described in Section 5 and conclude about the proposed method in Section 6, respectively.

2. OVERVIEW OF THE SYSTEM

The overview of the proposed system is shown in Figure 1. The multi-date satellite images are obtained from KALPANA SATELLITE. Noise filtering, skewing, grayscale and binary converting process are performed as image enhancing. The cloud region is detected by the combination of color intensity and morphological process. The template matching method is applied for determining the detected cloud region with storm database. The possible storm region in next image is detected by the morphological processing. These detected regions are used as the initial control points for correlation computation.

Then the displacement and correlated region of the storm are computed among the multi-date satellite images.

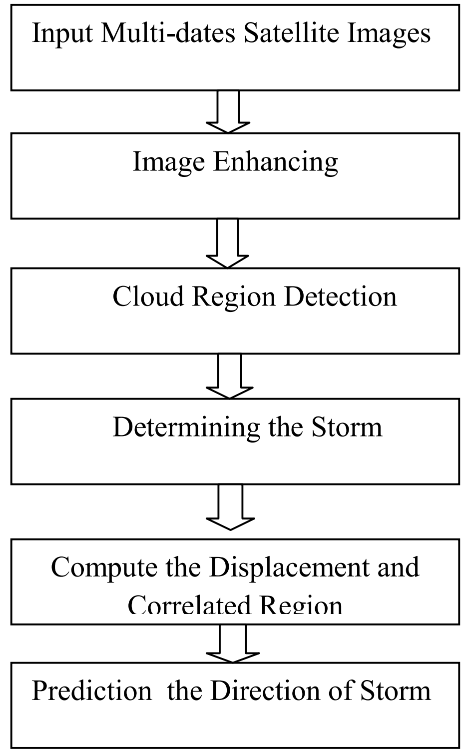


Figure 1. Overview of the Storm Direction Prediction

The direction of storm will predict according to the storm movement in multi-dates satellite images. Now the next section will present the sub-pixel registration algorithm for Digital Image Correlation.

3. MORPHOLOGICAL OPERATORS

The dilation, erosion, opening and closing operation are the most basic morphological operations. Morphological operators are applied to an image with a set of a known shape, called a structural element (SE).

The number of pixels added or removed from the objects in an image depends on the size and shape of the *structuring element* used to process the image. The cloud region extraction is performed by the modified morphological method. The opening and closing of set A by structuring element B, can be defined as

$$A \circ B = (A \ominus B) \oplus B = \cup\{(B)z \mid (B)z \subseteq A\} \quad ..(1)$$

$$A \bullet B = (A \oplus B) \ominus B = \{z \mid (B)z \cap A \neq \varphi\}. \quad ...(2)$$

where $A \oplus B = \{z|(\hat{B})_z \cap A \neq \varphi\}$ is dilation and the $A \Theta B = \{z \mid (B)_z \subseteq A\}$ is the erosion of A by B, respectively. The hit-or miss transformed of A by $B = (B_1, B_2)$ is defined as

$$A \otimes B = (A\Theta B_1) \cap (A^c \Theta B_2) \qquad \ldots(3)$$

If A contains the multiple disjoint sets, the small window W which is enclosed by one of the disjoint set X and background can be eliminated by using the following relation

$$A \otimes B = (A\Theta B_1) \cap (A^c \Theta [W - X]) \qquad ..(4)$$

The above relation (5) can be modified by considering the region filling process as following

$$A \otimes B = (A\Theta B_1) \cap (A^c \Theta [W - (X \oplus B) \cap A^c]).(5)$$

The segmentation of the cloud region and extraction the position of possible storm can be performed by the modified equation (4).

4. SUB-PIXEL REGISTRATION IN DIC

The operation of Digital Image Correlation is required the images of a moving or deforming subject. The numerous sub-images are divided from each image. The center of each sub-image is on the correlation control point from which the sub-pixel displacement will be calculated. The basic principle of DIC is to match two speckle patterns before and after deformation. Typically, a subset of $(2M+1) \times (2M+1)$ pixels from the un-deformed image is chosen to find its location in the deformed image. Figure 2 illustrated the sub-pixel displacement in before and after deformation. The displacements of the subset centre can be determined once the location of the subset in the deformed image is found.

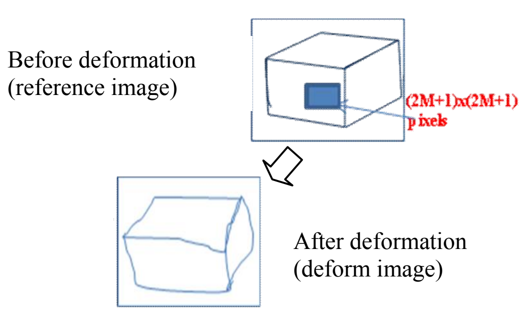


Figure 2. Illustration of the Sub-pixel Displacement

The following cross-correlation coefficient is most commonly used for the best estimation of the displacements.

$$C(u,v) = \sum_{x=-M}^{M} \sum_{y=-M}^{M} [f(x,y) - f_m][g(x+u, y+v) - g_m] \times \left(\sum_{x=-M}^{M} \sum_{y=-M}^{M} [f(x,y) - f_m]^2 \right)^{1/2} \times \left(\sum_{x=-M}^{M} \sum_{y=-M}^{M} [g(x+u, y+v) - g_m]^2 \right)^{-1/2} \qquad ....(5)$$

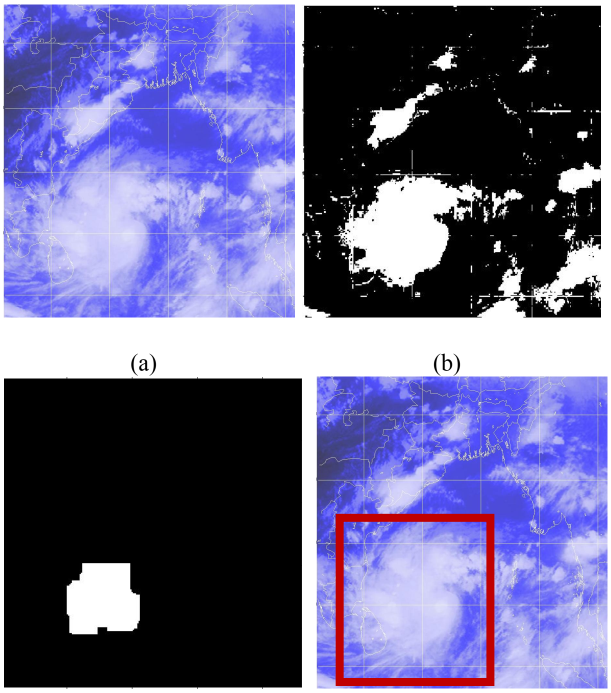
Where $f(x,y)$ and $g(x+u, y+v)$ are the grey values of the subset centered at the source and target point located in the reference and deformed images respectively; u and v are the displacements between two subsets; and gm and fm are the ensemble averages. Because the minimal unit in digital image is one pixel, the displacement calculated from (5) an integer multiple of one pixel.

Moreover sub-pixel registration can be used in a variety of application areas because it provides a way to accurately measure displacements of individual points of a plane, without any contact and disturbance. The correlation coefficient curve fitting method, gradient based method and bi-cubic are well known sub-pixel registration methods for the sub-pixel accuracy. For achieving sub-pixel accuracy, interpolation schemes are used to reconstruct a continuous gray value distribution in the deformed images. The higher order interpolation would provide more accurate results, but with the limitation of requiring more computation time.

5. EXPERIMENTS AND RESULTS

This section describes the experiments and results. The several experiments have been done to evaluate the proposed method. The cloud region from image is extracted after scaling, skewing and noise filtering stages. Figure 3 (a) shows the input color image and Figure 3(b) shows the converted binary image, respectively. The biggest cloud region is detected by the morphological processing.

Figure 3(c) described the location of the big cloud region and Figure 3(d) is the detected cloud region.



(a) (b)

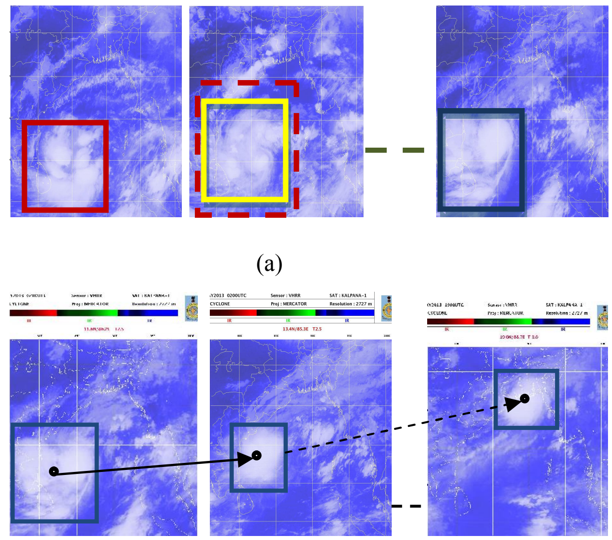
(c) (d)

Figure 3. Detection the Big Cloud Region

Using the storm database, the cropped region is classified the storm or not storm. The multi-dates satellite images and detected storm regions are shown in Fig. 4(a). The exact correlated region determined by the sub-pixel registration approach. Then the center or eye of the position of storm are computed for each extracted storm region and its result is shown in Fig. 4(b). By connecting the eyes of the storms in successive image, the trajectory of the storm movement can be obtained. The direction of storm can be computed from the two correlated eyes.

For example: The two eyes position $E_1(x_1, y_1)$ and E_2 (x_2, y_2), the slope of the direction can be express as;

$$slope\ angle(\theta) = \tan^{-1}\left(\frac{y_2 - y_1}{x_2 - x_1}\right) \quad (6)$$



(a)

(b)

Figure4. Prediction the Direction of the Storm Movement

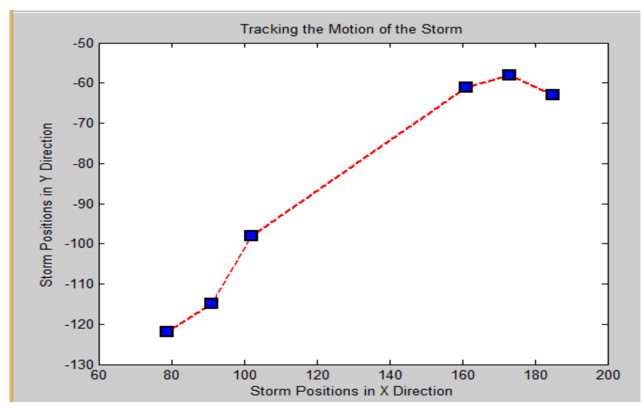


Figure5. Tracking the Storm Motion

Finally, the proposed system can produce the direction of the storm direction by using the successive multi dates satellite images. The tracking results of the storm movement is shown in figure 5.

The comparison result of the tracking errors between the correlation method and proposed methods is shown in figure 6.

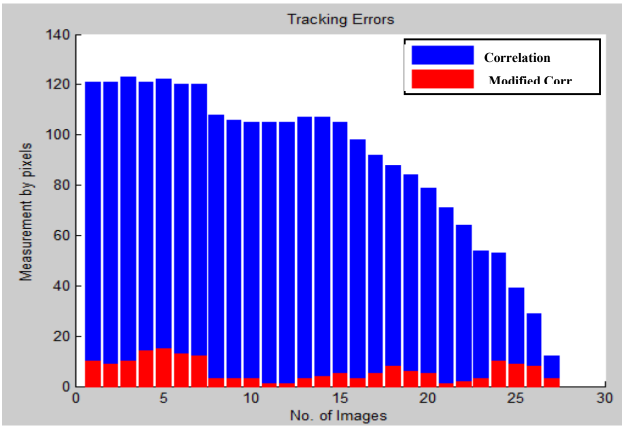


Figure6. Comparison Result

6. CONCLUSIONS

The sub-pixel registration algorithm based on the correlation coefficient method is developed for detecting the correlated region among the images. The modified morphological operation will provid for extracting the storm region and computing the pre-defined control points for sub-pixel registration process. This approach can not only detect the storm motion but also the object deformation. The direction of storm movement can be predicted through the successive estimated direction of the storm. The comparison results show the more accurate for the proposed approach and it is recommended for measuring the storm movement. The prediction of the nearest attack region of Myanmar Land is ongoing research work. The comparison of proposed approach with other Gaussian correlation approach will consider as a future work.

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