A technique for automatic concealment of confidential targets in high spatial resolution imagery

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ABSTRACT:

With the commercial availability of very high resolution satellite imagery, the concealment of national confidential targets such as military facilities became one of the most bothering task to the image distributors. This task has been carried out by handwork masking of the target objects. Therefore, the quality of the concealment was fully depends on the ability and skill of a worker. In this study, a spectral clustering based technique for the seamless concealment of confidential targets in high resolution imagery was developed. The applicability test shows that the proposed technique can be used as a practical procedure for those who need to hide some information in image before public distribution

KEY WORDS: Concealment; Confidential Target; Masking

1. INTRODUCTION

The accessibility of the commercial very high resolution satellite imagery increases the amount of information on land cover at local to national scales(Aplin et al. 1999, Thomas et al. 2003). However, it also reveals very detail information on national confidential objects such as military bases or facilities to the hostile. In Korea, when analogue air photo was used to produce topographic map, confidential target areas were cut out from the film before the distribution of the air photo to the private sector. Even though now very high performance digital image processing S/W systems are used for the masking process of the confidential targets, it is still done by handwork of skillful expertise and regarded as a labour intensive, time consuming procedure to the image distributors. Recently, many techniques have been developed for the extraction of spatial information from the very high resolution image using segmentation (Tilton 1998, Hofmann. 2001, Cufi et al. 2002) and object based classification(Shaban and Dikshit 2001, Wang et al. 2004). However, there was no research on the technique for the concealment of spatial objects in image. It seemed that a process for the masking of target objects has not been treated as something to be technically addressed because it is not a process for extracting information from image data, but a kind of process to hide or degrade the information in image data. However, for the organizations which have the mission to receive, process, and distribute the image data not only to the national intelligence agencies but to the private sector, hiding the national confidential facilities in an image has been one of the most bothering task which needs skillful labour, time and expenses. In this study, an automatic method is proposed to conceal the confidential targets in very high resolution imagery seamlessly using spectral clustering and neighborhood relationship analysis.

2. CONCEALMENT ALGORITHM

Figure 1 shows the conventional handwork masking procedure for the concealment of confidential targets in high resolution imagery. Even though the quality of the concealment effect is usually very high because this manipulation is carried out by skillful expertise, it is a labour intensive and also time consuming process. Moreover, because it is a kind of artificial manipulation rather than a logical image processing, it does not provide repeatability at all. In this study, we tried to implement this handwork process as a logical image processing procedure which provides not only repeatability but also seamless concealment performance. In order to automate the concealment process, it is required to extract the targets to conceal and also the source pixels to replace target pixels by a logical algorithm. The first step of the algorithm is to classify the pixels in a given area into clusters which has homogeneous spectral characteristics. (b) of Figure 2 shows an example of classified result. In order to automate the clustering process, we modified K-Means clustering algorithm. In modified K-Means algorithm, input parameters such as maximum radius of a cluster, minimum distance between clusters are not required because when a pixel is given, the pixel is classified into the closest cluster. The only needed parameter for the modified K-Means clustering algorithm is the number of maximum clusters. In this technique, we do not classify whole image but a very small area of an image where the targets to be concealed are located. Therefore, it is expected that there are only limited number of land cover types. In this study, the maximum number of clusters was set to 5. The second step is to extract the targets from the clustered result. The condition for the pixels to be extracted as target pixels is that they should be isolated from the boundary of the given area. Even in the case some isolated pixels are not actually the targets to be concealed, it does not degrade the concealment effect at all. Before the isolated pixels are extracted from the classified result, a 3×3 majority filter was applied in order to produce more simplified spatial land cover distribution. The black pixels in (c) of the Figure 2 are the extracted target pixels. The third step is to find out the source pixels to replace the extracted target pixels. In order to conceal the targets more seamlessly, the target pixels should not be distinct from the neighbouring pixels. Therefore, the neighbouring pixels are the best candidate to replace the target

pixels. However if we fill the target pixels using only the neighbouring pixels, the texture of the target objects will be very homogenous due to the limited number of source pixels and seamless concealment can not be expected. Therefore, in this study, a cluster which has the largest number of neighbouring pixels to the targets is extracted first, and then the whole pixels of the cluster are used to replace the target pixels. When the total number of the source pixels is less then the number of the target pixels to be replaced, the source pixels are used repeatedly. The grey pixels in (d) of Figure 2 represent the extracted source cluster and the pixels of this cluster will be used to replace the target pixels.

Finally, to enhance the concealment effect, a 3 × 3 average smoothing filter is applied only to the replaced target pixels. An example of replaced result is shown in (e) of Figure 2 and the smoothing filter applied final result is shown in (f) of Figure 2.

3. EXPERIMENTS AND DISCUSSION

The proposed algorithm was implemented as an executable software using C++. A user needs to provide only the coordinate information of a rectangular area where the confidential targets to be concealed are located. Figure 3 shows various examples of the applicability test results. The concealment effect in (p) of Figure 3 is not satisfactory because the number of source pixels shown as grey colored pixels in (o) of Figure 3 was much less than that of target pixels shown as black colored pixels in (o) of Figure 3. Because this technique finds the source pixels only from the inside of the rectangular area given by a user, the area need to be selected large enough to secure enough number of the source pixels. While because we limited the maximum number of clusters as 5, too large area which can have more than 5 types of land cover might produce unexpected results. Therefore, it is recommended to select the size of rectangular target area about 3 times larger than the size of the targets to be concealed.

4. CONCLUSIONS

In this study, an algorithm for the automatic concealment of confidential targets in high resolution imagery was proposed. Even though there was practical need for this kind of technique, it seemed that a process for masking of targets has not been treated as something to be technically addressed. The proposed algorithm was implemented as an executable software and applied to various kinds of targets in high resolution image. The applicability test result shows that this technique can be used as a practical solution to the image distributors who need to conceal some spatial information in an image before public distribution. More robust and fully automatic clustering algorithm which does not require the maximum number of clusters as an input parameter is expected to enhance the performance of this concealment technique.

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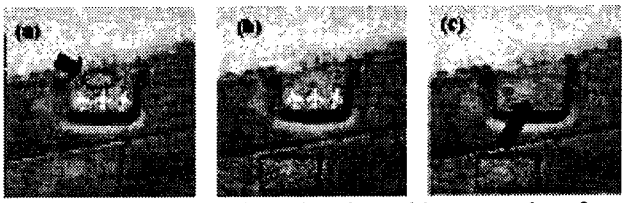

Figure 1. Conventional handwork masking procedure for concealment of the confidential targets in image. (a) visually analyze the spectral characteristics of the pixels in target's neighbour. (b) select area which has similar spectral characteristics to the target's neighbour and also has enough size to cover the targets. (c) copy the selected area and paste it over the targets.

Figure 2. Proposed automatic concealment algorithm. (a) Input image. Suppose that the airplanes are the targets to be concealed for intelligence security. (b) Unsupervised classification was applied. (c) Black pixels are the extracted targets. (d) Grey pixels are the extracted source pixels to replace the target pixels. (e) Target pixels are replaced with source pixels. (f) Smoothing filter was applied (to the replaced pixels only).

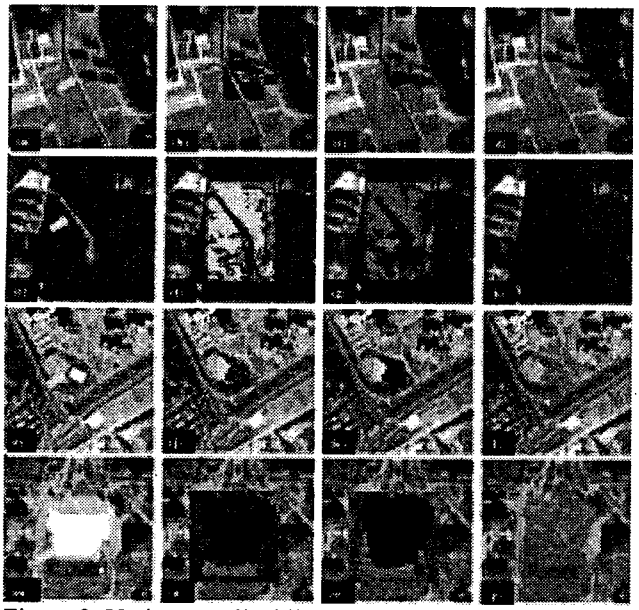

Figure 3. Various applicability test results.
(a)~(d) Applied result for concealment of a building and shadow. (e)~(f) Applied result for concealment of the road in the forested area. (i)~(p) Applied result for concealment of a ground facility.