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Automatic Change Detection of Buildings from Aerial Images

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Abstract—**Recently, the research that extracts the feature from aerial images is very active. In the efficient analysis of the city space, the information gathering technology that uses the aerial images is being established. Especially, the application that investigates the building in the large area is expected. In this paper the algorithm that automatically extracts the building change to the large area is proposed by comparing aerial images of the same place taken a picture at different time. To acquire the building change in the automatic operation, the tone is corrected between images and the building is extracted by using the shape feature in the building.**

Keywords—Aerial images, change extraction, building, feature, Building change extraction

I. INTRODUCTION

Recently, the attempt to make city space information a data base, and to use has extended. The city always changes with the time passage. The change in the cityscape occurs chiefly because of factors of building, extension and rebuilding, and dismantlement. In Japan in 2009, one million buildings that hit 2% of a total building have been changed. There is a necessity for surveying the change part in high speed, minuteness, and the large area. In the research of the past when the building change was extracted, the research that acquired three dimension data of geographical features and extracted the building change by analyzing this existed. However, it costs a huge calculation cost to three dimension of geographical features re-composition. It is easy for the change extraction technique before to have received the season, the date, and the influence of strength of sunlight. We should reduce the influence so that these may lower the detection accuracy.

In Previous studies, change detection of buildings method uses comparison of histograms. The difference of the histogram of two images is calculated, and the presence of the change is provided. However, it is not comparable accurately because there is a change by external causes other than the building change in former image.

Then in this paper the building change part is specified by the image processing by using the aerial images of the same place taken a picture at different time. Especially, we propose the method of doing the change extraction by using the feature of the building considering the shadow of the building in the aerial images. We break down the problem that the accuracy of the building change has decreased by the shadow by using this algorithm. And we propose the technique for extracting the building change by correcting the tone of two images automatically compared, and using the shape of the building. The proposal technique is done to some aerial images and accuracy is verified, and evaluated.

II. AERIAL IMAGES

The aerial images used for the analysis are pictures of the general residential quarter. The natural terrain exists it is having of the building the part that has been very overcrowded. As for these aerial images,shooting location and shooting date and time are different. Therefore, the position is corrected like Fig 1 between aerial images. The resolution of the aerial images is 25 centimeter/pixel.

III. PROPOSED ALGORITHM

The method of extracting the building change that uses the aerial images is shown in Fig1. As for two input images, the position of each pixel is accurate each other. The input image should use the one taken a picture of in daytime.

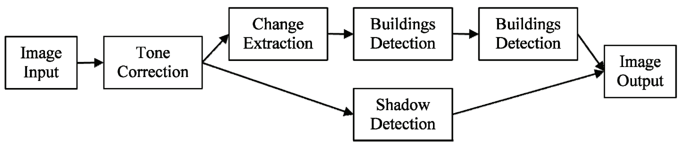


Fig1.Our Proposed Method.

The change part is shown in the output image. As a result, we understand the position of the change part in the image. As a result, we understand the position of the change part in the image.

A. *Automatic Tone Correction*

It was impossible to take a picture of the same image to the Aerial images when the taking a picture time was different or the camera was different even if taking a picture in the same place. Moreover, the high degree in the sun changes depending on time to take a picture of the aerial images. In the grasp of geographical features, and the investigation of changing of the building, It is preferable to compare the same tone images. So the tone is corrected before and after taking a picture automatically, and then images are compared.

We propose the tone correction method. In two images, a tone correction is done by the automatic operation. The other image is matched to the tone of the other image. For this, we use the straight line type tone curve (1).

$$
\begin{aligned}
Y_R &= a_R X_R + b_R \\
Y_G &= a_G X_G + b_G \\
Y_B &= a_B X_B + b_B
\end{aligned}
\tag{1}
$$

Input pixel value is X and output pixel value are Y. We use three channels information on RGB. The parameter used for this function is decided automatically. In the proper method, it is used that two compared images take a picture of the same place from the same position. Moreover, there are not too a lot of change parts between compared images assumption. Then a is a contrast coefficient, and b is a coefficient in which brightness is uniformly changed into all pixels. If two variables of *a* and *b* are provided, the tone of the image can be corrected.

A1 Contrast

The contrast shows the range of pixel highest value and pixel lowest value in image. The contrast in the image depends on the standard deviation of pixel value of the image inside. We assume the evaluation function by using the difference of the standard deviation of two compared images.

Using function (1), a is changed within the range of 0 to 3, and the standard deviation value of image X and image Y is obtained. We provide it is the best *a* to which the difference of the standard deviation value of input image *X* and output image *Y* is minimized.

A2 Brightness

b coefficient is a variable that shows uniform addition in all pixels of the object of comparison image and the image for processing.

$$
F(b) = \begin{cases} 1 & | \quad X - Y + b| \\ 0 & otherwise \end{cases} \tag{2}
$$

$$
\sum^{Puxels} F(b) = number \tag{3}
$$

The value of b is changed between from 0 to 255, and the function of (2) is applied. Afterwards, we count *number*. In the function of (3), when number becomes the maximum, b is assumed to be variable b of the tone curve. This approach, by adding a pixel value is that the most similar images retrieved. Assumption is to take a picture of the same part.

We show the corrected image by the proper move method.

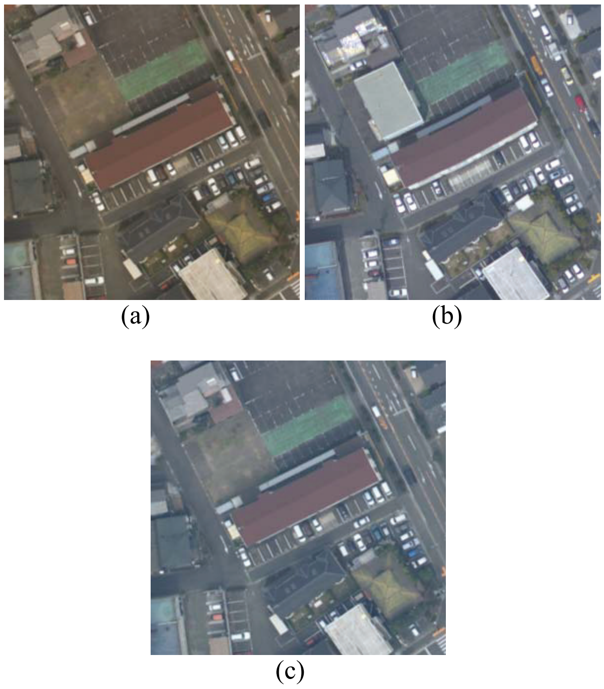


Fig2. (a) Aerial image taken in 2007, (b) Aerial image taken in 2009, (c) Corrected the tone image (a) to (b).

The image of (a) and (b) is the input images, and (c) is the output images. The taking a picture time of the image of (a) and (b) is different for two years. Therefore, the building appears newly in the central left. Therefore, the building appears newly in the central left. Features can be compared by the correction more accurately.

B. Extraction Of Color Change Part

The value recorded in the pixel of the aerial image is a surface color seen from the sky. In the aerial image, as for the building, the rooftop color is recorded. There was a change in the building and geographical features that pixel value had changed greatly by two compared images. Because an automatic tone is corrected, the change of pixel value of the place in which the building is not changed is few. Then, the part where the color of the ground level changes is decided by installing the threshold in the amount of the change of pixel value. The method of providing for the threshold of the amount of pixel value change is set from the histogram of the difference image. The difference image is an absolute value difference image as for pixel value of two compared images. In the difference picture, the occurrence rate of pixel value is normal distribution. The probability density function of normal distribution is (4).

$$
f(x) = \frac{1}{\sqrt{2\pi\sigma}} \exp(-\frac{(x-\ \ )^2}{2\sigma^2}) \tag{4}
$$

Where *f(x)* is probability of occurrence, x is pixel value, σ is variance. The probability of occurrence of pixel value changes depending on the σ value.

C. Buildings Detection

The next step detects the part from the change part to the building. As for an artificial building, the shape is simpler than the natural product, and the linearity is higher. Then, a natural product and an artificial building are separated, and detected by using the shape feature. There are a lot of quadrangles of the building. Because we make securing residence space the maximum, and building strength strong. So the rooftop shape in the building becomes a rectangle, too.

Moreover, the rooftop material of the building is constant in the building. The color of the rooftop becomes the same when the material is the same, and it takes a picture from the sky. The parameter function *(R)* is made by using the surroundings length *(L)* and the area of the building *(S)*.

$$R = \frac{16 \times S}{L^2} \qquad (5)$$

When it becomes a square, this parameter becomes 1. When the object is a circle, R reaches maximum value 1.27. The threshold is installed in R, and the building and the natural product are separated.

Very small areas are not a building. They are the cars and natural small products and so on. Then, too small areas are assumed that they are a noise and removed.

D. Shadow Detection

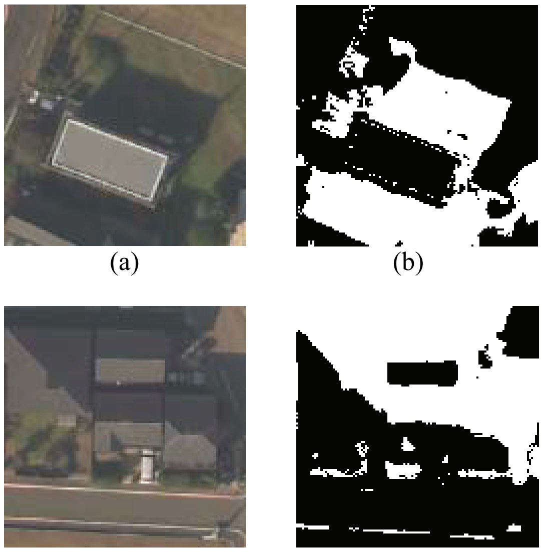
The aerial images contain a lot of shadow areas. In this section, we propose a method of finding shade. This method converts RGB input images to HSV color model. In the HSI color model, H and V mean the hue-equivalent and light-value components. The range of H and V, scaled from 0 to 1. we can obtain the light value-equivalent image and hue-equivalent image. From this, H and V can make a ratio image. The ratio map $r(x,y)$ is defined by

$$r(x,y) = round\left(\frac{H_e(x,y)}{I_e(x,y)+1}\right) \qquad (6)$$

(x, y) is the position of pixel. $H_e(x, y)$, and $I_e(x, y)$ are hue-equivalent image and light value-equivalent image. The value of $r(x, y)$ is scaled to the range [0, 255]. Then, we make ratio map R. The map is defined by

$$R(x,y) = \begin{cases} e^{-\frac{(r(x,y)-T_S)^2}{4\sigma^2}} \times 255 & if \quad r(x,y) < T_S \\ 255, & otherwise \end{cases} \qquad (7)$$

The value of T_S is Threshold. Ts is determined when the condition $\sum_{i=0}^{Ts} P(i) = Ps$ is held, where $P(i)$ denotes the probability of the ratio value i in $\{r(x, y)\}$; σ is calculated by $\sqrt{\sum_{i=0}^{Ts} P(i)(i-Ts)^2}$ and Ps is set to 0.95.



(a) (b) (c) (d)

Fig3 (a) Aerial image taken in 2009, (b) Shadow image detected from the image (a), (c) Aerial image taken in 2009, (d) Shadow image detected from the image (c),

In image (b) and (d), white pixels show the area of the shadow and black pixels show non-shadow area. The shadow with the natural product and the shadow with the artificial material can be acquired accurately. As for these, it is required that the shadow is included in the image, and the shadow be a little area. As a result, the Shadow Image to which the area of the shadow and non-shadow separates can be obtained.

E. Experiments

We performed this technique on aerial photographs. We obtained two shadow images and one change image from two compared images. The change part image is multiplied to two shadow images, and the result is shown below.

We compare the image Fig3 (a) and the picture was taken four months later. The processing result is Table 1. Target area size is 2.0km × 1.5km. A lot of residential quarters, rivers, railways, the stations, parks, and the natural terrains are included in the area. There was a change in 28 places in four months.

We were able to extract the change in 26 places. The Failure Change Part actually means the feature was not a building though was able to detect the change part. The features were the fields, the green houses, and blue tarps, etc. Moreover, there is actually a part that is not the change either. Extraction Failed Correct Answer Part is a part that was not able to be detected by our technique though it is a part with the change.

(a)

Fig4 (a) Aerial image of target area.

Table 1: Detection Results By Our Method				
	Changes Found	Correct Answer Change Part	Failure Change Part	Extraction Failed Correct Answer Part
Number Of Objects	26	19	7	2

Some causes of the false detection exist. One of the causes is artificial features other than the building. Because the blue tarp and the green house are the same types as a square division, it had been recognized the building. Moreover, the building where the color of the rooftop changes greatly by the reflection of light has been detected.

There were two parts that were not able to be detected though it was a change part. These were not able to be extracted because the rooftop color in the building had looked like the color of the soil very much.

We were able to extract the building change part from the aerial image of the large area.

IV. CONCLUSIONS & FUTURE WORKS

Extracted by comparing the color change in the building, found that the negative effects of shadow. In this method, by performing more accurate searches of the shadow region has fewer false positives. Therefore, compared with conventional methods, we propose a method for extracting building a better change.

However, to detect the objects under the shadow feature is still difficult. We need to consider methods less susceptible to shadow object extraction. Technologies to establish a method to extract individual buildings, it is necessary. Then, we are developing a better building extraction technique from the image.

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