
A STUDY ON THE DIGITAL IMAGE ENHANCEMENT OF LOW RESOLUTION SENSOR

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ABSTRACT

Resently, the field of digital photogrammetry is developing wonderfully according to the increase of computer capacity, the development of image matching algorithm, & the reduction of price to be able to extract image with near real-time in digital format. In spite of much development, the application field of digital photogrammetry is often restricted by the resolution of image. So, the resolution of image has important meaning in digital photogrammetry. To use the expensive equipment may acquire better image, but this is a burden economically. Therefore, in this study, this researcher tries to obtain the image that the resolution was improved by acquiring the image with digital camera of which the price is cheap and enhancing the image through computer algorithm. As the result of study, to use the area-based matching technique to be based on least square method could improve the resolution of image greatly. So, it is expected that the digital photogrammetry to be competitive in price economically will be possible from now on.

1. Introduction

As the handling speed of computer became fast and the capacity increased and the price of equipment to be able to extract image with near real time from digital format was reduced, the field of photogrammetry achieved the development to be worthy of close attention. Besides, the development speed of digital photogrammetry is being accelerated all the more with the development of algorithm of image matching such as area matching or feature based matching etc. But, in spite of much development, the greatest restriction in the application of digital photogrammetry is the resolution of digital image to be used. As for the method to constitute hardware with CCD sensor of big capacity that the number of pixel increased or the method to acquire high resolution image by deciding the quantity of sub-pixel beforehand by moving sensor, price is expensive. So, we are being restricted economically much in utilizing this widely. The aim of digital photogrammetry for acquiring the exact positional coordinate about object is not different from former analytical photogrammetry. In analytical photogrammetry, digital camera, workstation, or PC are being utilized in digital photogrammetry instead of film, camera, and stereo plotter. As for former analytical photogrammetry, high-degree skill is required in almost all the courses. But, the techniques of digital photogrammetry have the merit to be able to reduce the dependence degree about worker. The merit in digital photogrammetry is to be able to extract the grey value of pixel which is based on the number of row and column with near real time by computer algorithm. So, the automatization of measurement came to be possible. However, we may not exclude the role of worker completely.

The development of digital image technique and digital photogrammetry is being used for wide fields such as industry, archaeology, architecture, universe, medicine, renewal of GIS data, manufacture of aerial map, close range photogrammetry(CRP) and legal base data etc. usefully. Applications in industry field are diverse with the measurement of turbine wing of Robson(1996), the observation of feature of train surface of Kochi(1996), and the measurement of aftershock equipment by the physical model of Petran(1996) etc. As for the application in medicine field, not only CCD camera but also X-ray and even other medical image sensor are used as image. Gabel(1996) measured the change of soft tissue after plastic operation, and Hoflinger(1996) used photogrammetry for the position determination during or after the period of orthodontics etc. Mitchell and Oh etc. executed the precision measurement of small object by the digital photogrammetry of microscope. And, recently, Fryer and McIntosh presented the image enhancement technique about static object.

The goal of this study is to calculate high resolution image that there is the competitive power of price from the image that resolution is low through deciding the shift and rotation of pixel by acquiring image with digital camera that price is cheap and matching digital image with the technique of area matching to be based on least square method.

2. DIGITAL PHOTOGRAMMETRY

Image sensor like CCD is what used semiconductor technique. Then, this technique developed fast and brought the increase of storage capacity of computer. CCD sensor is the equipment to store the ray of light incident by changing it into electron. Then, sensor is being divided into various small scraps to be pixel. If the grey value of each pixel is stored, it changes into analog sign by using the system of signal recorded simultaneously with recording instrument. Analog sign is what collected the grey value about each pixel discontinuously, and grey value indicates the quantity of ray of light incident to come into sensor from given position.

Analog video camera digitalizes the analog signal to be generated from camera externally by frame grabber. As for digital still camera, as signal is digitalized immediately and digital image is stored inside camera, handling course is internal. As for digital still camera that resolution is low, price is cheap. But, as for the sensor of high resolution which developed recently, price is expensive.

Digital image systems are very diverse from the basic system of digital still camera linked to the computer for individual to more complex image platform. The price of digital video camera is falling, but it is being restricted much yet because of the storage capacity of system of image acquisition. Photogrammetry scholars are grafting their digital photogrammetry system to map manufacture or industry field fast. There is already the example which applied GPS in aerial photogrammetry or ground photogrammetry, and some people used the wireless technique for transmitting image from digital camera to host computer, and they chose target selectively in industry field by utilizing fast multiplexing.

Software brought very effective result in handling digital image data. In case of image matching, algorithm of software is very important element. As matching algorithm may create digital terrain model automatically, it is used for digital photogrammetry. Image matching is used for finding the position of fiducial mark automatically in inner orientation and eliminating parallax in relative orientation. There are 2 kinds of methods in image matching. That is, there are feature based matching and area based matching. Feature based matching is for discovering the striking feature in image and describing these features in mathematical item and for deciding whether same element that image was matched is described with 2 kinds. Area based matching is to find the most consistent point between the window to correspond in matched image. This method is to decide the shift and rotation between 2 images. Then, it is more exact than feature based matching. So, it is more suitable for digital photogrammetry. One method of area based matching is to solve the variable to be included in matching course with least square method. Least square method based matching is the method to form observed equation by using the grey value of standard area and search area of the image to try to match and to use the condition to minimize the difference of grey value of 2 images. In the algorithm of basic least square method, matching area and search area should be standardized, so that they may have same average and variance before each repetition, and repetitive calculation should be made until the size may be ignored. As for the least square method based image matching, it has the merit to be exact in comparison with other method and to be able to evaluate the accuracy of time differential directly, as it decides the point to correspond to the level of sub-pixel. But, it has the demerit that much time is required for calculation and that the initial position of search area for matching should be forecast with the range within 2 pixels exactly.

Digital photogrammetry may be applied effectively, but it is often restricted by the resolution of image. So, the relation between expense and resolution is very important function in digital photogrammetry. As for high resolution sensor, it may be used commercially, but price is expensive, and carrying is inconvenient. So, it cannot help being

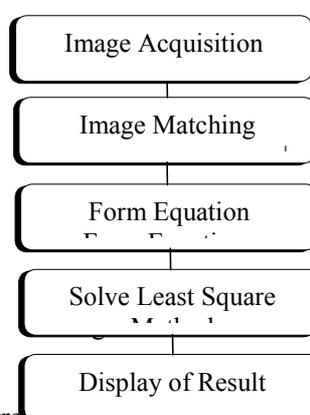
restricted for the application. Besides, as for the image that resolution is low, price is cheap relatively in comparison with the image the resolution is high, but the demand accuracy becomes issue. Thus, it will be very desirable to be able to acquire the image of high resolution with cheap price.

3. ENHANCEMENT THE RESOLUTION OF DIGITAL IMAGE

Method for enhancing the resolution of image may be classified into the method to use hardware and the method to use software. There are various kinds in the methods to enhance the resolution of digital image which uses hardware. Then, they are based on the exact movement of CCD equipment to be at the level of sub-pixel. About the method for enhancing resolution, Lenz(1993) mentioned micro-scanning and discussed macro-scanning, and it is being included to mosaic digital image by making big digital image to have the resolution to be same as original image. These methods may be combined and used in ProgRes 3000 camera at the same time. Wiman acquired the image of air photo to the unit of sub-pixel by using scanner and insisted that the grey value of pixel could be decided by using Pseudo-inverse method that the system of equation was decided less in high resolution image but that study is more necessary. Method by hardware is the method which is expensive or which fails to draw a conclusion. More objective solution is that the equipment to obtain image should be independent ideally.

Jenson announced the non-linear interpolation to enhance the resolution of digital still image by deciding the boundary within the level of sub-pixel of image. Then, this method was used more in comparison with other enhancement method. Long, Hardin and Whiting announced the method for creating the radar image that the resolution of the surface of the ground was enhanced by using spaceborne scatterometry. Though enhanced data are different from the general image to be used in digital photogrammetry, only the method is receiving recognition about value. In measuring antenna at mutually different time, least square solution is used on the basis of the technique of image reconstruction which utilizes spatial overlap, and the limitation of final resolution is decided by the measurement collate of overlap and noise level. Long insisted that noise is increased at result image, if resolution increases.

This algorithm is the method to produce the image that resolution was improved by enhancing image through the technique of image matching out of least square matching methods about multiple digital image that resolution is low.



That is, it is the method to extract new grey value by deciding the shift and rotation among raw images with least square matching method and by obtaining the solution of observation equation formed through making the grey value and enhancement ratio of each image of variables. Enhancement ratio is derived in accordance with sampling theory of Nyquist frequency, and it may not be more than 2.0. So, the range is from 1.1 to 1.9. In this case, enhancement ratio is the rate versus the number of pixel of high resolution image to be output. We may formulate observation equation by using grey value, enhancement rate and offset from raw image and may obtain the grey value that resolution was improved from this equation.

4. ACQUISITION AND HANDLING OF DIGITAL IMAGE

As for Kodak DC210 Plus Zoom Camera in Fig. 2 which was used for the acquisition of raw image in this

experiment, it has the image resolution of 1152×864 pixel in case of high resolution, and it has the image resolution of 640×480 pixel in case of standard resolution. Image acquired by photography is stored in camera itself or PCMCIA card in the form of FLASHPIX or JPEG. Image acquired like this gets to use PHOTO EASY SOFTWARE for the downloading to computer. Then, the form conversion of file which is based on the simple handling and use goal of image is possible, and it is being devised, so that the user may use the image that he(or she) demands by choosing it through displaying all the acquired images. Especially, this system enables users to acquire image simply by including the functions such as capture mode to be able to photograph and delete and correct exposure, review mode for displaying photographed image, preference mode for correcting all sorts of setting of camera, and connect mode for transmitting photographed image to computer etc.

For the acquisition of enhanced image, we should be able to decide the exact shift and rotation of multiple images. In this technique, this researcher used least square matching technique for the decision of shift among images. Least square matching technique may produce more exact matching result in the image to have the change of diverse grey values as the technique to match on the basis of grey value. Therefore, in this study, this researcher chose the object of Fig. 3 which can include the information of diverse grey values.

Image was acquired from the photography distance of 0.6m, and this researcher acquired 4 images about the object in Fig. 3 by moving camera below 1 pixel in real scale.



Fig. 2. Kodak DC210 Plus Zoom Camera

In this study, this researcher set camera with standard resolution(640×480 pixel) and executed the downloading of image directly by using PHOTO EASY SOFTWARE, so that we may examine the image that image is improved by enhancement technique more clearly. And, this researcher used image format after converting it into BMP form so as to apply to enhancement technique more effectively. Images acquired like this require considerable time in the solution of observation equation and get to need big storage space. So, after choosing only interest domain out of whole images, this researcher applied it to enhancement technique. In this case, after limiting the size of sampling image to 80×40 pixel, this researcher acquired 4 image from raw image.



Fig. 3. Object

Applying acquired sample images to the technique of image enhancement gets to be able to acquire the image that resolution was improved. For the application to enhancement technique, we should decide the input image number and enhancement ratio which are initial variables and the level of noise. Input image is being composed, so that 3 images or more may be set. But, this researcher limited to 4 images in consideration of the handling time of data and the number of information of input grey value. Enhancement ratio is the core element to decide the resolution of enhancement image as what indicates the increase rate of pixel of raw image and result image which is based on enhancement algorithm.

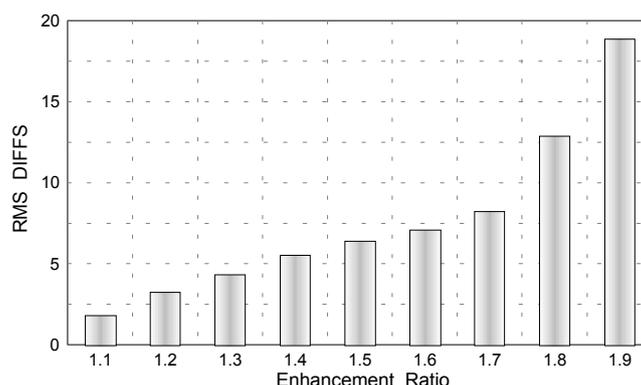


Fig. 4. Enhancement Ratio

Fig.4 is the result of data handling for deciding the optimal enhancement ratio. We may see that the error of grey value between raw image and enhancement image is increasing gradually. This is caused by the fact that the noise to be generated in the course of enhancement is generated in proportion to the increase of enhancement ratio. In case that enhancement ratio is low as 1.1 or 1.2, noise is small, but we may not feel that result image is enhanced. And, in case that enhancement ratio is 1.8 or 1.9, we may see that result image was enhanced, but noise appears largely. So, it is considered that optimal enhancement ratio is 1.5 or so. And, this experiment is only for the improvement of resolution which is based on enhancement technique. So, this researcher didn't apply the element of noise.

Fig.5 is what indicated the sampling image acquired by passing through above course. And, Fig.6 is what indicated the result image in case of enhancing raw image with 1.5 of enhancement ratio. This researcher could obtain the result image of 120×60 pixel by enhancing the raw image of 80×40 pixel with 1.5 enhancement ratio. In case that enhancement is 1.5, 2 pixels at raw image is enhanced to 3 pixels at result image in 1 dimension linear, and 4 pixels at raw image is enhanced to 9 pixels at result image in 2 dimension area. After all, as the number of pixels per unit area increases with 2 times or more, raw image felt roughly was enhanced as more fine image. So, we may see that resolution was improved.

Fig. 5. Sampling Image

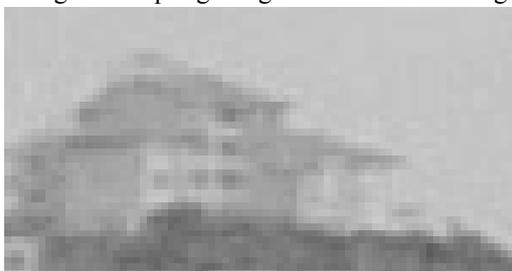


Fig. 6. Result Image



Therefore, as this researcher could improve the resolution of image by mathematical algorithm without depending on expensive equipment, the image interpretation of high accuracy which is based on a little more economical method came to be possible. In addition, the application range is very wide with the reproduction of old photo, the security of legal base data for criminal investigation, and the record, conversation, restoration and management etc.

of cultural properties and painting etc.

Thus, in case of using this digital solution, not only the digital photogrammetry that there is the competitive power of price is possible but also the application in all sorts of industry fields is expected by enhancing image with the expense which is very cheap than the method by hardware.

5. CONCLUSION

This researcher could acquire 4 images that resolution is low by using digital photogrammetry that price is cheap and obtain the following conclusion by matching through least square method. As for the enhancement ratio of image, resolution is low at result image in case of 1.1~1.2, and noise increases at result image in case of 1.8~1.9. So, it is considered that optimal enhancement ratio is 1.5~1.6. The technique of area matching through least square method could improve the resolution of image greatly by enhancing raw image that resolution is low, and that the resolution of multiple image is enhanced to about 2 times will contribute toward the improvement of accuracy of digital photogrammetry greatly. In addition, it is expected that improving the resolution of image with software solution will enable more economical digital photogrammetry by digital camera or video camcorder that price is cheap.

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