

# Panoramic Images Mapping Tools Integrated Within the ESRI ArcGIS Software

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**Abstract.** There is a general study on panoramic images which are presented along with appearance of the Google street map. Despite 360 degree viewing of street, we can realize more applications over panoramic images. This paper developed a toolkits plugged in ArcGIS, which can view panoramic photographs at street level directly from ArcMap and measure and capture all visible elements as frontages, trees and bridges. We use a series of panoramic images adjoined with absolute coordinate through GPS and IMU. There are two methods in this paper to measure object from these panoramic images: one is to intersect object position through a stereogram; the other one is multichip matching involved more than three images which all cover the object. While someone wants to measure objects from these panoramic images, each two panoramic images which both contain the object can be chosen to display on ArcMap. Then we calculate correlation coefficient of the two chosen panoramic images so as to calculate the coordinate of object. Our study test different patterns of panoramic pairs and compare the results of measurement to the real value of objects so as to offer the best choosing suggestion. The article has mainly elaborated the principles of calculating correlation coefficient and multichip matching.

## 1. Introduction

Three dimensional viewing and mapping is in great demand for various applications. There is a general study on 3D city based on panoramic images which are presented along with traditional 2D map, for example: Google street map. The Google Street view gives us a great example of the application of panoramic images while it doesn't offer the function of measurement. At the time the ESRI company shows great advantages on large map data processing and ArcGIS offer multiple application development toolkits which help solving this problem.

In this research, we propose a mapping toolkit plugged in ArcGIS, which makes inventories and measurements based on panoramic images possible. With the help of our toolkit, you can measure heights and distances, and make complete asset inventories of the public domain in x-y-z coordinates from panoramic images. These inventories can be stored directly in a standardized Access databank or in your own ESRI Geo-database (for which an API has recently been published). From within ArcGIS, we can now also display GIS data, such as utility network or development plans, with the panorama images. This will provide an accurate and natural perspective on our data. Therefore this toolkit is ideal for applications such as measuring tree heights and frontage or for making an inventory of parking spaces and public parks.

The experimental data used in this article is obtained by the vehicle laser scanning and modeling measurement system developed by Capital Normal University, which is named after SSW, which is



show in Figure1. The system mainly consists of laser scanner, panoramic camera, GPS and IMU. With this platform we can get panoramic images and the camera file at the same time. Besides we can also test and verify the accuracy of the point that we measured from panoramic with the point-cloud data obtained by the laser .



**Figure 1.** Experimental Platform.

The SSW carries Ladybug3 structure, before measuring the panoramic images we should study the panoramic camera calibration method and coordinate measurement of three-dimensional object point. Ladybug3 panoramic vision system is a good example of panoramic technology application. Because it has six fisheye lens composition, distributed in different sides and on the top, we can get six camera views, which cover the entire 360 panorama sphere and offer more than 75% coverage of adjacent views. After right calibration of Ladybug3 panoramic vision system, we can obtain foreign element of each camera. In this paper ,we discusses the control points under the circumstance of only a whole scenery party point coordinates the solution method.

The digital camera is used to obtain color texture. IMU and GPS provide the attitude and position of the system during the movement. The equipment like laser scanner, digital camera, IMU and GPS, are rigidly fixed on the same platform in the space. And in time the equipments are unified by the GPS time. With the experimental field calibration and a series of data fusion process, the laser point-cloud and images can registration accurately. In this article the system is equipped with Ladybug3 panoramic camera so as to obtain panoramic images (Figure 2) directly. With the registration between panoramic images and laser point-cloud, we could get the correspondence between the pixels in the image and the points in the point-cloud.



**Figure 2.** Ladybug 3 image data.

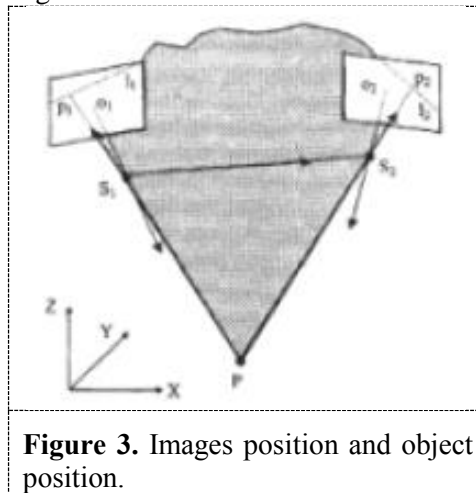
In this paper, on the basis of the registration between panoramic image and GPS mark, we

introduce a method to generate measurable images from series of panoramic images.

color point-cloud from laser point-cloud and panoramic image, with the collinear principle that the center of the omnidirectional multi-camera system, image point on the sphere and object point are in line. The method takes full advantage of the 360 degree panoramic image and laser point-cloud. In the end, the experimental results show that the proposed algorithm and formulae in this paper are correct.

## 2. Principle

As showed in Figure3, the undefined point P is covered in the field of image2 and image 0. So we can use forward intersection equation to calculate the position of point P. From universal knowledge we know that there are six exterior orientation parameters of the camera, or laser, with respect to the IMU, namely three linear offsets ( $X_1, Y_1, Z_1$ ) and three rotations ( $\Omega, \Phi, \kappa$ ). But if we want to decide the relative position of two panoramic sphere, there is only one set of relative orientation parameters. Once the relative position between the two main sensors is fixed, it's only necessary to record the posture of the first image.



**Figure 3.** Images position and object position.

All original data is unified through Geodetic coordinate system, which is an absolute coordinate system. The center position of panoramic image0 is  $S_0(X_0, Y_0, Z_0)$  and the center of panoramic image is  $S_2(X_2, Y_2, Z_2)$  and we also can get the three attitude angles of the panoramic images and focal length  $f$  from the camera file.

Besides, by choosing point from the two views of object, we get the plate position of  $P_0(x_0, y_0)$  and  $P_2(x_2, y_2)$  and the photo center of two images  $P_0'(x_0', y_0')$  and  $P_2'(x_2', y_2')$ , which are in plate coordinate system. We defined geodetic coordinate of object point as  $(X, Y, Z)$ .

According to the collinear equation we can drive to the following linear equation

$$\begin{bmatrix} Lx \\ Ly \\ Lz \end{bmatrix} = \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} \cdot \begin{bmatrix} L1 & L2 & L3 \\ L4 & L5 & L6 \end{bmatrix} \quad (1)$$

where  $(X, Y, Z)$  is the geodetic coordinate of object point and  $L_n$  is the correlation coefficient which can be calculated by following Formula

$$\begin{aligned} L1 &= f * a1 + (x - x') * a3, & L2 &= f * b1 + (x - x') * b3, \\ L3 &= f * c1 + (x - x') * c3, & L4 &= f * a2 + (x - x') * a3, \\ L5 &= f * b2 + (x - x') * b3, & L6 &= f * c2 + (x - x') * c3 \\ Lx &= f * a1 * Xs + f * b1 * Ys + f * c1 * Zs + (x - x') * a3Xs + (x - x') * b3Ys + (x - x') * c3Zs, \\ Ly &= f * a2 * Xs + f * b2 * Ys + f * c2 * Zs + (x - x') * a3Xs + (x - x') * b3Ys + (x - x') * c3Zs, \end{aligned} \quad (2)$$

where  $(a1, a2, a3, b1, b2, b3, c1, c2, c3)$  is the parameters of the rotation matrix, determined by the three attitude angles of the panoramic sphere:  $\varphi$  (Roll angle),  $\omega$  (Pitch angle),  $\kappa$  (Heading angle), as Formula 3

$$\begin{bmatrix} a1 & a2 & a3 \\ b1 & b2 & b3 \\ c1 & c2 & c3 \end{bmatrix} = \begin{bmatrix} \cos \varphi & 0 & -\sin \varphi \\ 0 & 1 & 0 \\ \sin \varphi & 0 & \cos \varphi \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos \omega & -\sin \omega \\ 0 & \sin \omega & \cos \omega \end{bmatrix} \cdot \begin{bmatrix} \cos \kappa & -\sin \kappa & 0 \\ \sin \kappa & \cos \kappa & 0 \\ 0 & 0 & 1 \end{bmatrix} \quad (3)$$

with one object point and its two photo points, we can get four equations and solve the unknown number  $(X, Y, Z)$  through least square method.

When we choose more than two panoramic images to measure the object, we only get more big equation set and also can solve through least square method, with which we can also add weight value according to different intersection angle.

### 3. Result

Following the mathematic principle of section2, we developed the panoramic image toolkits with the help of application development toolkits offered by ArcGIS. In this experiment, the accuracy of the measurement is mainly affected by the following factors: the calibration precision of the panoramic vision system, resolution and accuracy of the GPS registration between images. Ladybug 3, resolution of which is  $2048 \times 1024$ , is the panoramic camera used in the experiment, its error in 10 m distance is 1 cm, and in 50 m the error is 5 cm. When the object is far from the Center of Photography, a pixel may correspond to many neighboring points. So the higher the resolution of the panorama image has, the higher the accuracy of measurement we get.

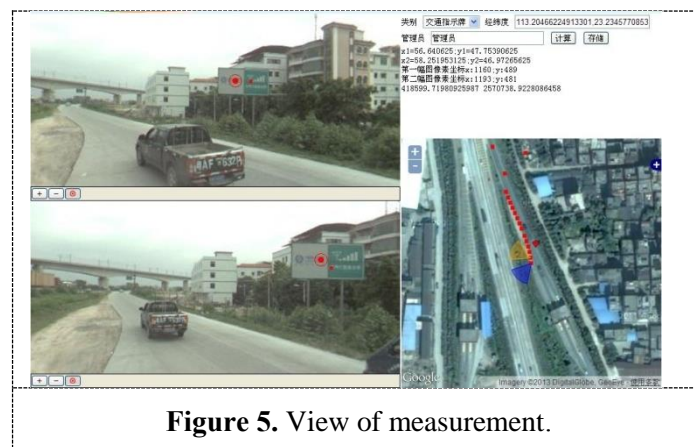


Figure 5. View of measurement.

The experiment data used in this paper is collected in a viaduct section of Guangzhou by the vehicle laser scanning and modeling measurement system developed by Capital Normal University. Measuring interface shown in Figure5, measuring example shown in Figure 6.

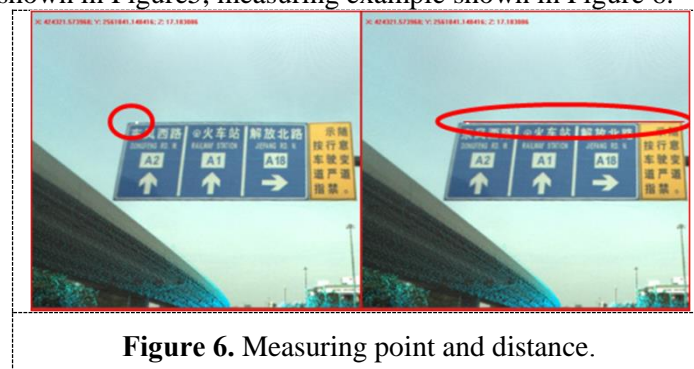


Figure 6. Measuring point and distance.

We also carried out research on the accuracy of measurement via our tools by comparing the measurement result from panoramic images to the result from laser data. It is confirmed that, taking some basic principles into account, the accuracy reached is at least ten centimeters.

#### 4. Conclusion and future work

This paper developed a toolkits plugged in ArcGIS, which can view panoramic photographs at street level directly from ArcMap and make inventories and measurements based on panoramic images possible. A series of panoramic images adjoined with absolute coordinate through GPS and IMU is demanded. It give a easier way to measure object from panoramic images and it can be intergrated in many GIS system for better user experience. With this toolkit, each two panoramic images which both contain the object can be chosen to display on ArcMap. Then we calculate correlation coefficient of the two chosen panoramic images so as to calculate the coordinate of object. The study tested different patterns of panoramic pairs and compare the results of measurement to the real value of objects and find the error is greater when the intersection angle is smaller to a certain degree and it seems when the intersection angle is around 60 degree the result is the most accurate. What caused this result maybe is the data precision digit and calibration of panoramic camera and it will be found out in future work.

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