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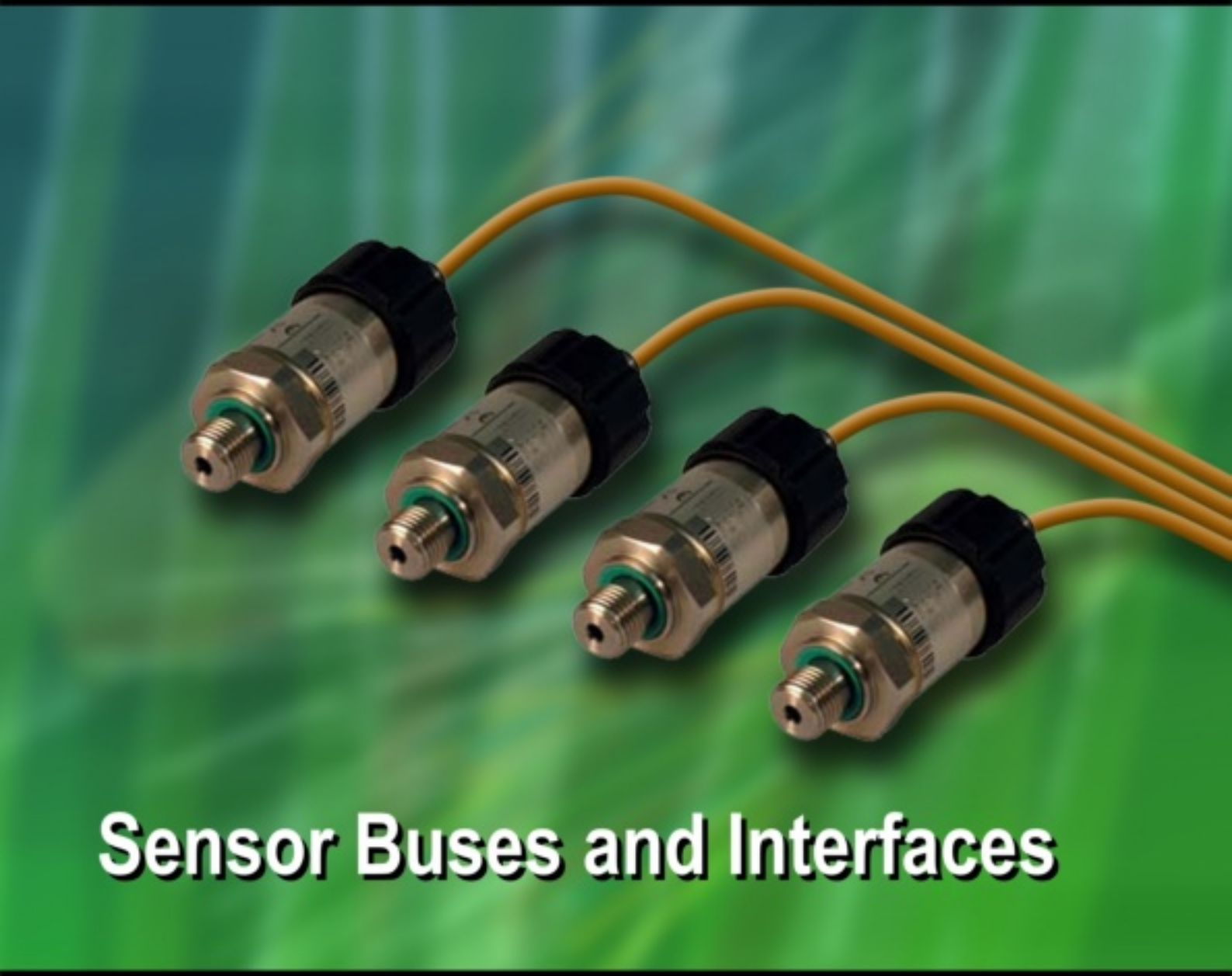

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Designing Binocular Stereo Omni-Directional Vision Sensors

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Abstract: A new type of binocular stereo Omni-Directional Vision Sensor (ODVS) is designed, in which the mirror of catadioptric is designed by using secondary catadioptric imaging principle. Then solution of the catadioptric mirror is obtained by the fourth order Runge-Kutta algorithm. Finally the two ODVS with the same parameters of the average angle becomes a binocular stereo ODVS which is composed by back-to-back manner. To avoid conversions of coordinates during three-dimensional measurement and reconstruction, Gaussian coordinates is used during the processing of the video data capturing, information processing and presentation. ODVS can align the azimuth of feature point easily. Through this character, ODVS can simplify camera calibration, feature points matching, and other cumbersome steps easily. The results of experiment show that the device can simplify computing complexity of three-dimensional visual measurement and facilitate three-dimensional image matching.

Keywords: Stereo vision, ODVS, Average angle resolution, Stereo image matching

1. Introduction

According to theory [1] of computer vision presented by David Marr in the 1970's, inputs of computer vision system are 2D image sof the real world, and the outputs should be qualitative or quantitative understanding of the scene which is based on 3D representation. In addition, the following four different representations of image data and information are proposed [1]:

(1) The input of 2D image data;
(2) Primal sketch which extracts information of obvious contours and edges;
(3) 2.5D sketch that extracts depth information in 3D world and direction information on surfaces for

objects;
(4) 3D representation that obtains the 3D geometry information of the scene.

The hardest problem in the above representations is to forming 2.5D from primal sketch, which are usually realized by various shape from X, such as shape from shading, shape from contour, shape from texture, shape from motion, shape from stereo, and more. Most of these processes are ill-posed problems. Even if they are well-posed, the results are prone to noise interference easily. As Harallick R. M. stated [2]: "Basic problem of computer vision is a robustness problem, if we don't consider about the problem of robustness, almost all the problems of computer vision are resolved." 2.5D sketch is related to stereopsis, optic flow, and motion parallax. The 2.5D sketch represents that in reality we do not see all of our surroundings but construct the viewer-centered three dimensional view of our environment. 2.5D Sketch is a paraline drawing and often referred to by its generic term "axonometric" or "isometric" drawing and are often used by modern architects and designers [1].

Stereo vision is based on binocular parallax principle of the human eyes [3-6] to perceive 3D information, which imitates the method used by human being to apperceive distance in binocular clues. Distance between objects is obtained from binocular parallax of the two images respectively captured by two eyes for the same object, which makes a stereo image vivid as depth information is include in the image... There are two main shortcomings in the stereo vision technology. One is that camera calibration, matching, and reconstruction are still not resolved perfectly. The other lies in that it is not able to capture panoramic view and to make people feel being in the scene personally since it is object-centered and with narrow-view, i.e., it only captures a small part of the scene. The second shortcoming is overcome by the ODVS technology [7], which is viewer-centered, eliminates narrow-view problem so that a panoramic view is gained.

Currently, in binocular stereo vision, there are some difficulties, which belong to vision ill-posed problems including camera calibration, feature extraction, stereo image matching, etc. Upon camera calibration is set, focal length is fixed. Accordingly, the depth of the captured image is only at certain range and could not be changed; otherwise, camera calibration is needed to be set again. The another disadvantage of calibration technology is that changing parameters can be avoided in a variety of movement in 3D visual measurement system [8-10], which limits the applications of the binocular stereo vision. Disadvantages in feature extraction and stereo image matching are mainly as follows. The processes of various shapes from X incur to perform coordinate transformation many times, which leads to huge calculation overhead and makes it impossible to conduct real-time processing. Besides, there exists a high mismatching probability in matching corresponding points, causing high rate of matching errors and reducing matching accuracy. Nowadays, 3D visual matching is a typical ill-posed calculation, and it is difficult to get 3D matching unambiguous and accurate [11].

Advanced in ODVS technology in recent years provides a new solution for acquiring a panoramic picture of the scenes in real-time [3]. The character of ODVS with wide range of vision can be used to compress the information of the hemispheric vision into an image, which includes a great volume of information. On the other hand, ODVS can be freely placed to get a scene image. ODVS establishes a technical foundation for building a 3D visual sensing measurement system.

It is significant to build a uniform coordinate system for 3D stereo vision so that ill-posed calculations are avoided. Motivated by this, we investigate designing binocular stereo ODVS, and building a uniform spherical coordinate system, in which computational geometry is used in object depth calculation, the 3D visual matching, and the 3D image reconstruction. The main contributions of this paper are as follows: (1) two omni-directional vision equipment without dead angle are seamlessly combined to capture objects without shelter; (2) the overlay vision area in the designed sensors, which is generated from visual fields of two ODVSs being combined in back-to-back manner, makes it possible for a binocular stereo ODVS to perceive, match and capture stereoscopic images at same

time; and (3) a uniform Gaussian sphere coordinate system is presented to for image capturing, 3D matching, and 3D image reconstruction so that computing models are simplified. All the above contributions together with features of ODVSs simplify the camera calibration and feature point matching.

This paper is organized as follows: Section 2 design of binocular stereo ODVS. Section 3 provides details of how to unwrap omni-directional image, match feature points and calculate spatial information. Finally in section 4 we provide our experiment result and conclusion (section 5).

2. Design of Binocular Stereo ODVS

2.1. Structure Design of ODVS

A new type of ODVS which without dead angle is designed in this paper. This type of ODVS can apperceive the entire object on the semi-spherical surface in real-time [11]. The structure of ODVS is shown in Fig. 1. The camera is placed behind a hyperboslic mirror which is called firstly reflection mirror. The lens of camera is on the focus of the firstly reflection mirror and obtain video information through an eyelet. The eyelet is in the middle of the firstly reflection mirror. Before the firstly reflection mirror, there is secondary reflection mirror. We embed a wide-angle lens in the middle of secondary reflection mirror. Omni-directional image is reflected by the firstly reflection mirror and afterward reflected by the secondary reflection mirror, then it obtained by the camera through the eyelet on the firstly reflection mirror at last. We called the imaging point between firstly reflection mirror and wide-angle lens the first imaging point. The object at the exact front of the firstly reflection mirror projected to its image on the first imaging point, and it projected to its image on the len of camera. By these design we eliminate the dead angle behind the secondary reflection mirror.

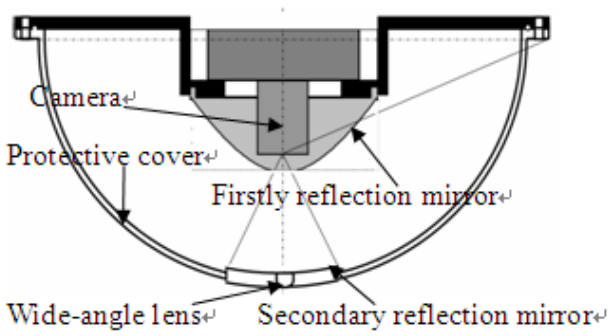

Fig. 1. ODVS with no dead angle.

Fig. 1 shows that if we want to obtain a 360°•360° large-scale Omni-directional image, two question must be resolved:1) Two omni-directional vision equipment without dead angle should be combined seamlessly in accordance with the requirements in structural design and to meet the requirements without shelter;2) The image of transition region of two ODVS should be continuous. In order to fuse the video information, transition region of two ODVS must satisfy the imaging law either.

2.2. Design of Reflection Mirror

In order to insure the image of transition region of two ODVS is continuous, ODVS is designed by using average angle. In other words, there is a linear relation between points on imaging plane and

incident angle. This is discussed further in next paragraphs.

Design the average angle solution can be summarized in how to design curve of catadioptric mirror [12]. As shown in Fig. 2, the incident light V1 from a light source P reflects on the main mirror reflection (t1, F1), the reflected light V2 reflects another time after it reflects on the secondly mirror reflection (t2, F2), the reflected light V3 enters into the camera lens with the angle of θ1 and projected to its image on the camera (CCD or CMOS).

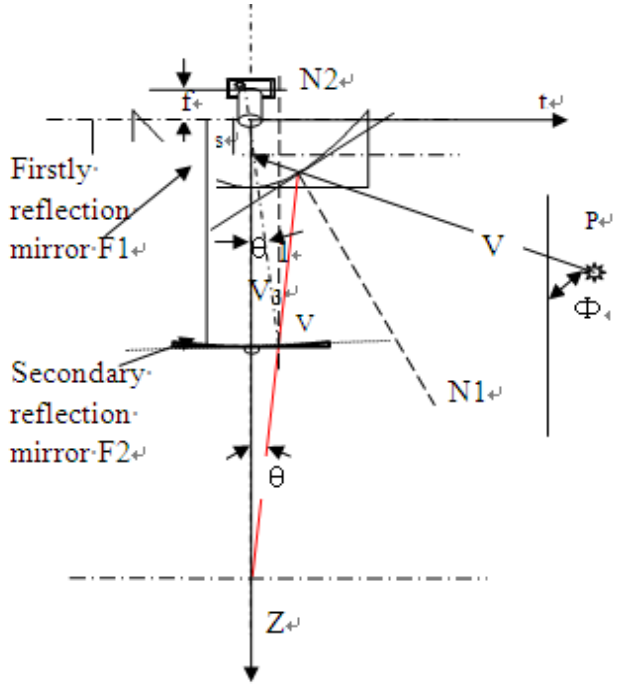

Fig. 2. Imaging principle of catadioptric of average angle resolution.

According to imaging principle, the angle between the first incident light V1 and the spindle Z is Φ, the angle between the first reflected light V2 and the spindle Z is θ2, the angle between the tangent through P1 (t1, F1) and the spindle t is σ, the angle between the normal and the spindle Z is ε ; the angle between the secondary reflected light V3 and the main axis Z is θ1, the angle between the tangent through P2 (t2, F2) and the spindle t is σ, the angle between the normal and the spindle Z is ε1. For these relations can get the equation (1):

$$\begin{cases} \sigma = 180^0 - \varepsilon \\ 2\varepsilon = \phi - \theta_2 \\ \sigma_1 = 180^0 - \varepsilon_1 \\ 2\varepsilon_1 = \theta_1 - \theta_2 \end{cases}, \tag{1}$$

Among them, $\tan\phi = \dfrac{t_1}{F_1(t_1 - s)}$, $\tan\theta_2 = \dfrac{t_1 - t_2}{F_2 - F_1}$, $\tan\theta_1 = \dfrac{t_2}{F_2}$.

In the equation: F1 is the firstly reflection mirror curve, F2 is the secondary reflection mirror curve; s is the coordinate position on the spindle Z.

Use the triangular relationship and simplify the finishing, can get equation (2) and (3):

$$F_1^{'2} - 2\alpha F_1^{'} - 1 = 0, \tag{2}$$

$$F_2^{'2} - 2\beta F_2^{'} - 1 = 0, \tag{3}$$

Among them,

$$\alpha = \frac{(F_1 - s)(F_2 - F_1) - t_1(t_1 - t_2)}{t_1(F_2 - F_1) - (t_1 - t_2)(F_1 - s)}$$

$$\beta = \frac{t_2(t_1 - t_2) + F_2(F_2 - F_1)}{t_2(F_2 - F_1) - F_2(t_1 - t_2)}$$

Solutions (2), (3) can be:

$$F_1^{'} = \alpha \pm \sqrt{\alpha^2 + 1}, \tag{4}$$

$$F_2^{'} = \beta \pm \sqrt{\beta^2 + 1}, \tag{5}$$

Among them, $F_1^{'}$ is the differential of curve F_1, $F_2^{'}$ is the Differential of curve F_2.

In order to make some certain linear relationship between a point on the imaging plane and the angle, need to build a linear relationship between the distance from the pixels P to the spindle Z and the angle, namely:

$$\phi = a_0 \cdot P + b_0, \tag{6}$$

In the equation: a_0、 b_0 are arbitrary parameters.

Use f as the focal length of the camera modules, p as the distance to spindle Z, (t_2, F_2) is the reflex points on the secondary reflection mirror. According to imaging principle, we have:

$$P = f \cdot \frac{t_2}{F_2}, \tag{7}$$

Substitute equation (7) into the equation (6), we can get:

$$\phi = a_0 \cdot (f \cdot \frac{t_2}{F_2}) + b_0, \tag{8}$$

The mirror curve meeting equation (8) can meet the requirements of average angle resolution.

According to the principle of catadioptric, by equation (8) we can get:

$$\tan^{-1}(\frac{t_1}{F_1 - s}) = a_0 \cdot (f \cdot \frac{t_2}{F_2}) + b_0, \tag{9}$$

For the equation (2), (3), (9),can get the digital Solutions of F_1 and F_2 through the four order Runge-Kutta algorithm(as shown in Fig. 3), so the firstly reflecting mirror and secondary folding mirror reflection obtained are of the average angle resolution.

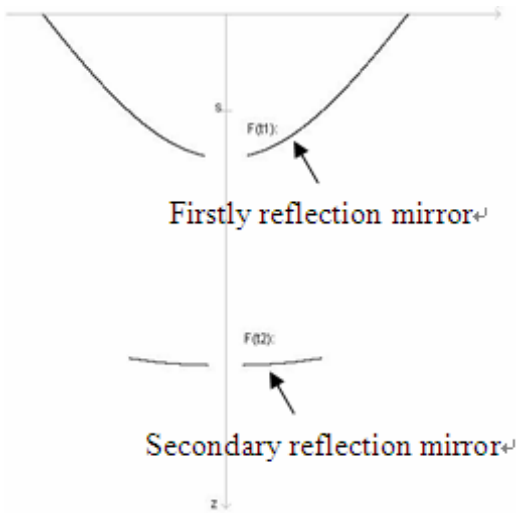

Fig. 3. Reflectors curvilinear figure.

2.3. Design of Binocular ODVS

According to the design above, each ODVS' field of view can reach 240°•360°and have the same average angle resolution. So as long as fix two ODVS back-to-back with connectors and make sure that the two ODVS' axis line overlap, we will get a binocular stereo ODVS. Specific methods are: the video cable of the two ODVS' cameras and power line extract from the connector hole and switch-into video image access unit separately. If the field of view of each ODVS designed is 240°•360°, then there are 60°overlapping field where the two can obtain images at the same time, as shown in Fig. 4.

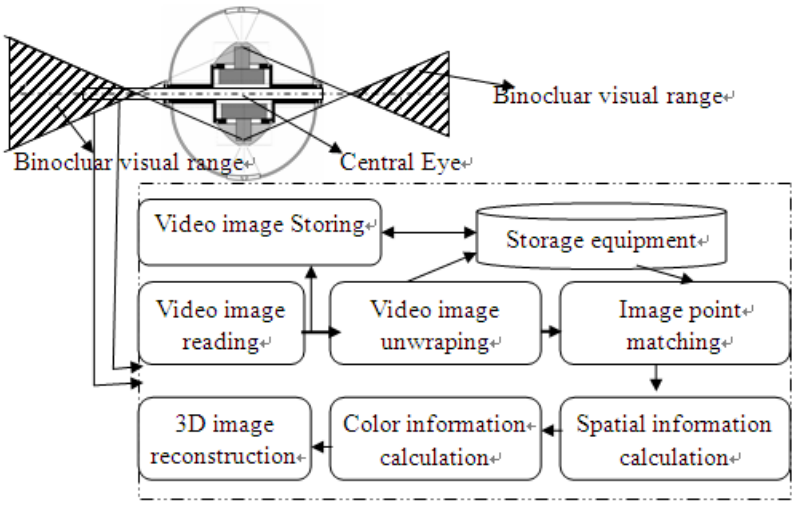

Fig. 4. Binocular stereo ODVS and its image processing flow.

Video image read unit obtain omni-directional image from two ODVS, then video image unwrap unit unwrap the omni-directional image [11]. In order to match the object point quickly and exact, azimuth angle of two ODVS unfolded image must same. Then we are using computational geometry to calculate every feature point's spatial Information and color flu information in Calculation of color flu information unit and Spatial Information calculation unit. Finally, we reconstruction 3D stereo omni-directional image in 3D image reconstruction unit.

3. Unwrap Omni-Directional Image, Match Feature Points and Calculate Spatial Information

3.1. Unwrap Omni-Directional Image

Omni-directional image unwrap algorithm unwrap all omni-directional image from ODVS, x-axis of image express azimuth angle, y-axis express incidence angle in this paper.

We needed to separate image of central part from omni-directional image. After that, omni-directional image is unwraped: the calculated step at horizontal direction in the unwrap algorithm is $\Delta\beta = 2\pi / l$; the calculated step at horizontal direction in the unwrap algorithm is $\Delta m = (\phi_{\max} - \phi_{\min}) / m$; in the equation, $\phi_{\max}$ is the scene lighting angle corresponding the biggest effective radius (Rmax) of the panorama relevant, $\phi_{\min}$ is the scene lighting angle corresponding the smallest effective radius (Rmin) of the panorama relevant; See Refs. [11] for details on omni-directional image unwrap algorithm.

The coordinate of C corresponding to the original point C (Φ, β) represented by polar coordinates is:

$$x = \beta / \Delta\beta, y = (\phi - \phi_{\min}) / \Delta m, \tag{10}$$

in equation, $\Delta\beta$ is the calculated step in the horizontal direction, β is azimuth angle, Δm is the calculated step in the vertical direction, ϕ is the scene lighting angle corresponding the effective radius R of the panorama relevant, $\phi_{\min}$ is the scene lighting angle corresponding the smallest effective radius (Rmin) of the panorama relevant.

3.2. The Match of the Image Point

Fig. 12 shows unfolded image of ODVS. In unfolded image, x-axis express azimuth angle, y-axis express incidence angle. The principle of splicing is matching the azimuth angle of two ODVS, it makes the same object from two unfolded image on the same vertical line in splicing image. If justify the longitude of the two ODVS when designing, so it realizes the condition of bound by a line in the structure, after meeting the condition of bound by a line in the structure, the problem of searching corresponding points from the entire plane has become to the problem of searching corresponding points in a vertical line, thus provides foundation for the rapid match between point-to-point; from the point of view of latitude, if there are certain linear relation between the incidence angle and the pixels on image plane of the ODVS designed, the incidence angle of the two ODVS combined can be calculated conveniently, and also can simplify the problem of searching corresponding points in a vertical line to the problem of searching corresponding points in a certain area of the vertical line. Shown as equation 11:

$$180° \le \phi 1 + \phi 2 \le 2\phi \max, \tag{11}$$

In equation, is the incident angle of ODVS's imaging point which is underneath, Φ2 is the incident angle of ODVS's imaging point which is aloft, $\phi \max$ is the maximum of ODVS imaging point called elevation.

We mark the ODVS aloft as ODVSup and the ODVS underneath as ODVSdown. Assume that the object point C is in the range of the binocular vision, its imaging point in the panorama relevant of

ODVSdown is Cdown (Φ1, β1) (shown in Fig. 5(a)),its object point in the spherical launched plans is Cdown(x1, y1) (shown in Fig. 5(b)), among, Φdown-max show the elevation when then incidence angle of ODVSdown is biggest, Φdown-90 show the value when the incidence angle of ODVSdown is 90°, Φdown-min show the depression angle when the incidence angle of ODVSdown is the smallest.

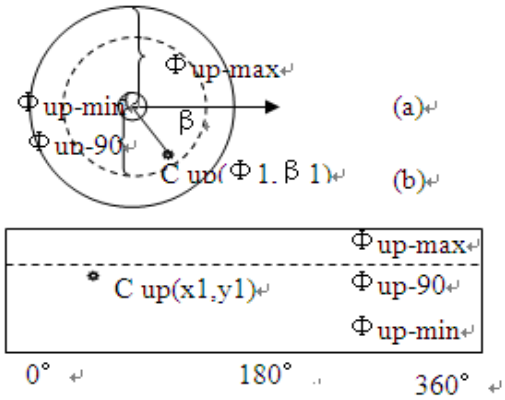

Fig. 5. Schematic diagram of panoramic vision photo graphed by upper ODVS.

We can also know that object point c's imaging point in the panorama relevant of ODVSup is Cup (Φ2, β2) (shown in Fig. 6(a)),its object point in the spherical launched plans is Cup(x2, y2) (shown in Fig. 6(b)).

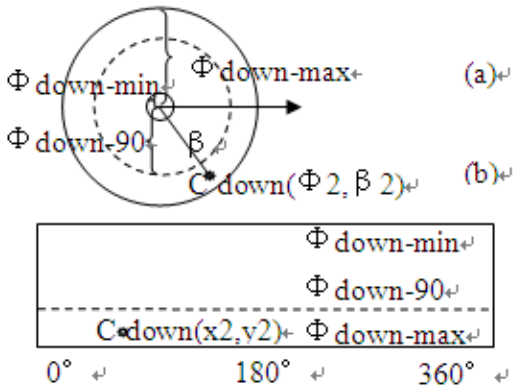

Fig. 6. Schematic diagram of panoramic vision photo graphed by lower ODVS.

The incidence angle bigger than 90°is called elevation and the smaller than 90°is depression angle. In this article, set the incidence angle of the ODVS as elevation, so it must have some area that both the two ODVS can reach, and that is named binocular vision scope (as the slash part shown in Fig. 4). For the same object point in the space, if it can be seen in the binocular vision scope, so, must have two image points Cup (Φ1, β1) and Cdown (Φ2, β2) in the panorama relevant of the two ODVS which have the same azimuth angle β, that is, β1=β2.

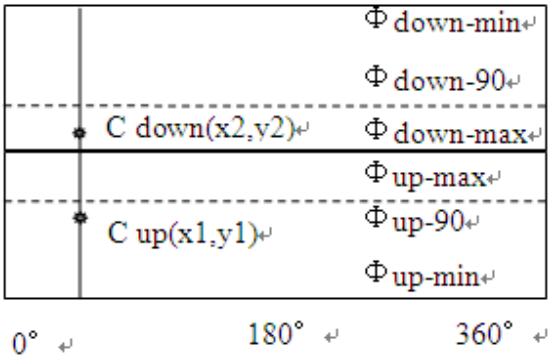

Fig. 7. Image point matching for two ODVS.

As a result, the X coordinate corresponding to the spherical launched plans is same too, that is x1=x2.So according to this principle, can justify the azimuth angle in the spherical launched plans of the two ODVS, as shown in Fig. 7. Actually, the Fig. 7 is mixture of the Fig. 5 (b) and the Fig. 6 (b), which can realize the justifying of the azimuth angle in the spherical launched plans conveniently.

3.3. The Coordinate of Gaussian Sphere and Central Eye

Human-centered stereo omnidirectional vision has high third dimension and fidelity. We call the center of binocular vision's baseline central eye (as shown in Fig. 4) which is used to describe the information of object point c (r , Φ, β , R , G , B , t) in space. The meanings of each physical parameter are shown in Fig. 8.

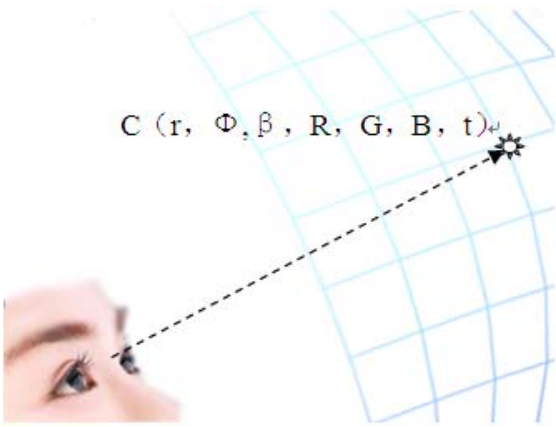

Fig. 8. Imaging point expression in Gaussian reference frame coordinates.

The coordinate of central eye is used to be the origin O of Gaussian sphere coordinate in this paper. We use seven parameters to describe the information of object point in space. r express the distance between origin O and object point; Φ express the angle between Z axes and the line connecting origin O with object point; β express azimuth angle; R is the average value of central eye's red component; G is the average value of central eye's green component; B is the average value of central eye's blue component; t is time information. The equation 12 can express any object point in space,

$$c = C(r, \phi, \beta, R, G, B, t), \tag{12}$$

We adopt a scientific and uniform Gaussian sphere coordinate in binocular stereo vision to express all object point by using seven physical parameters. It can lay a good technology foundation for model simplification and fast calculation later. It also provides convenience for the follow-up geometric calculation.

3.4. Object Point's Spatial Information and Color Information Acquisition and Calculation

The spatial information of object point is expressed by these parameters r, Φ, β in Gaussian sphere coordinate. Because we us central eye as origin of Gaussian sphere coordinate, calculate of spatial information can concluded to calculate of the position relation between object point and central eye. Among them r express the distance between origin O and object point; Compare to central eye, object point's longitude value is Φ; Compare to central eye, object point's dimensionality value is β; According to the principle of binocular vision we can estimate the object point's depth information, as shown in Fig. 9.

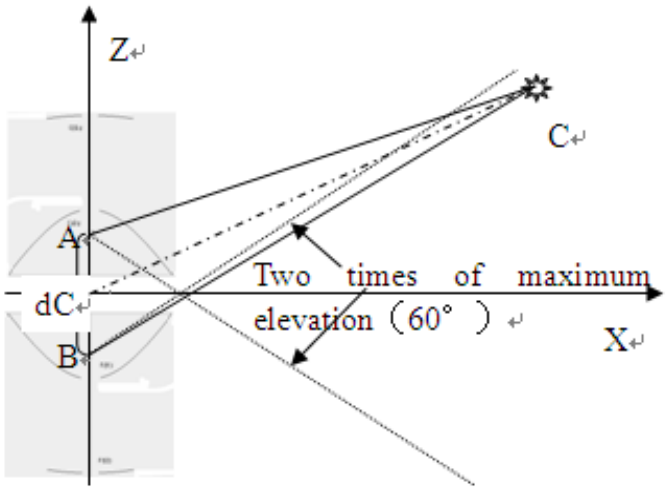

Fig. 9. The measurement principle of Binocular.

According to the imaging principle of binocular vision, we can get the distance between object point and viewpoint that is depth of field if only obtain the incidence angle of object point at two ODVS Φ1 and Φ2. Because two ODVS is composed by back-to-back manner, Φ1 and Φ2 can count by equation (13), (14):

$$\phi_1 = \phi_{\min} + (\phi_{\max} - \phi_{\min}) / m \bullet (m - y_1) , \tag{13}$$

$$\phi_2 = \phi_{\min} + (\phi_{\max} - \phi_{\min}) / m \bullet y_2 , \tag{14}$$

In the equation, m is the height of unfolded image; y1, y2 is match point's y-axis in two unfolded images; $\phi_{\min}$ is the minimum incidence angle; $\phi_{\max}$ is the maximum incidence angle.

According to the triangular relationship, we can get the distance r between origin O and point C,

$$\begin{aligned} r &= \overline{OC} = \sqrt{\overline{AC}^2 + (dc/2)^2 - 2\overline{AC}(dc/2)\cos A} \\ &= \sqrt{[\frac{dc}{\sin(A+B)} \bullet \sin B]^2 + (dc/2)^2 - \frac{dc^2}{\sin(A+B)} \bullet \sin B \cos A} \\ &= \sqrt{[\frac{dc}{\sin(\phi 1+\phi 2)} \bullet \sin \phi 1]^2 + (dc/2)^2 + \frac{dc^2}{\sin(\phi 1+\phi 2)} \bullet \sin \phi 1 \cos \phi 2} \end{aligned}, \quad (15)$$

In the equation ∠A=180-Φ2, ∠B=180-Φ1, dc is the distance between ODVSup's viewpoint and ODVSdown's viewpoint.

The incidence angle Φ can be calculated as:

$$\phi = \arcsin(\frac{dc}{2r}\sin\phi 2) + \phi 2 - 180, \quad (16)$$

Φ is the incidence angle of object point; c is the distance between point A and point B in binocular system; r is the distance between feature point and central eye; Φ2 is the incidence angle of ODVSup.

Another parameter of object point β can choose any one from two ODVS's azimuth angle. t is the time from computer system.

The average value of each color components R, G, B from matching point of two unfolded image are adopted in calculation of color information as central eye's color coding. First we obtain color components R_{ODVS1}, R_{ODVS2}, G_{ODVS1}, G_{ODVS2}, B_{ODVS1} and B_{ODVS2} from matching point of two unfolded image, then the average value of each color components is counted as central eye's color coding. The equation is shown as follows:

$$\begin{aligned} R &= \frac{R_{ODVS1} + R_{ODVS2}}{2} \\ G &= \frac{G_{ODVS1} + G_{ODVS2}}{2}, \\ B &= \frac{B_{ODVS1} + B_{ODVS2}}{2} \end{aligned} \quad (17)$$

In the equation, R is the average value of red component; R_{ODVS1} is red component of ODVS one; R_{ODVS2} is red component of ODVS two; G is the average value of green component; G_{ODVS1} is green component of ODVS one; G_{ODVS2} is green component of ODVS two; B is the average value of blue component; B_{ODVS1} is green component of ODVS one; B_{ODVS2} is blue component of ODVS two; The value range of them are 0~255.

4. Experiment Result

According to the above idea, we develop a binocular stereo ODVS as shown in Fig. 10.

The video information obtained from binocular stereo ODVS are transmited to computer through two USBs. After it computer will process the image, and match the object point, count the distance of object point. Fig. 11 is the panoramic picture of both the above frame and the below frame graphed by the Stereovision Measurement Device Based on Binocular Omni-Directional Vision Sensor, both

resolving capability are 640*480.

Fig. 10. Binocular stereo ODVS with back to back.

In order to proof the good characteristic on 3D matching of the device, in this paper, use SIFT (Scale-invariant feature transform) feature matching algorithm[13] to match the feature points for Fig. 11 and the result is shown in Fig. 12, all the connections of the matching points are almost parallel, that is to say, it is feasible to match the feature points gotton from the unwrap image on the line of the connections, and after fixing the device, use bin ocular ODVS to demarcate processing, so can get the position of these matched line and only need to find match points on the matched line in later matching processes, thus greatly reduce the complexity of the match.

(a) (b)

Fig. 11. Omnidirectional Images Captured by Binocular ODVS.

Error analyze to calculation of distance: According to the principle of binocular stereo vision the position of object can be measured exact. But the image is not continuous when it is obtained by imaging unit (CMOS). The image is discrete data which takes pixel as a unit. There is minimum resolution ratio error in measurement, because of camera's resolution. This problem can be improved by n using high resolution camera. According to result of measurement, measurement error will increases with the increase of measuring distance. The reason of this is because when measuring distance increase, the measuring point's incidence angle on two ODVS Φ1 and Φ2 is becoming small, and all of them are tends to 90°.

Fig. 12. Imaging point matching for two ODVS using SIFT.

It makes last item of the equation 6 very sensitive to the change of incidence angle. Range experiments are carried out in the range of 0.2-5 meter. The result of experiment express that the measured value of short distance measuring is close to the actual value. This is because the closer to the center of stereo ODVS, the more accurate of measuring point's incidence angle.

5. Conclusion

Imaging technology of panoramic stereo is one of the most active research topic in computer vision. A new type of ODVS is designed by using average angle and two catadioptric technologies in this paper. 360°•360° panoramic image is obtained by two symmetric ODVS. Binocular stereo ODVS simplify calculation model by using uniform Gaussian sphere coordinate system in image acquisition, 3D matching and 3D image reconstruction. We simplify camera calibration and feature points matching and so on to accelerate real-time operation by using these characteristics.

Stereo vision has always been an important issues of computer vision and video measurement, the beneficial effects of the binocular ODVS based on stereovision measurement device developed by this paper are mainly manifested in: 1) Capturing the 360°•360°omni-directional 3D video images in real time, getting the panoramic images of the entire monitoring sphere through geometric calculation, and the tracked monitoring objects will be not lost. 2) Designing the ODVS with an average angle resolution, which can get images with no distortion, thus solve the problems exist in catadioptric ODVS; Providing a complete theoretical system and model for the realization of real time tracking of fast-moving targets in large space. 3) Proposing a new omni-directional binocular vision, in the overlapping vision region of the two ODVS, binocular stereo ODVS has the same time perceiving, fusion faculty and stereo feeling. 4) Each ODVS constituting the binocular ODVS is designed with an average angle resolution, and both of the cameras employ the same criteria, which let our device achieves truly symmetry, and can capture real time video image under the spherical coordinates. As a result, we can realize rapid point to point match, which gives a great convenience for the following 3D image processing. 5) No longer need the complicated calibration work, feature extraction is very convenient, and rapid 3D image matching can be achieved. 6) There is no fixed focal length problem since ODVS is developed with catadioptric technology: the image clarity is the same in any region. 7) Double catadioptric imaging technology is employed which makes it easy to implement small or echo micro device. 8) Adopts a kind of uniform coordinates at the image gathering, 3D matching and 3D image reconstruction, to achieve 3D image reconstruction and 3D objects measuring much more easily through geometric calculation. The device designed and developed in this paper can be widely used in industrial inspection, military reconnaissance, geographical surveying, medical cosmetic surgery, bone orthopedics, cultural reproduction, criminal evidence, security identification, air navigation, robot vision, mold rapid prototyping, gifts, virtual reality, animated films, games and other application areas.

References

[1]. Marr D., Poggio T., A computational theory of human stereo vision, *Proceedings of the Royal Society of London, Series B, Biological Sciences*, Vol. 204, No. 1156, London, 23 May 1979, pp. 301-328.

[2]. Harallick R. M., Harallick S. R., Zhuang X. Image Analysis Using Mathematical Morphology, *IEEE Transaction on Pattern Analysis and Machine Intelligence*, Vol. 9, No. 4, 1987, pp. 532-550.

[3]. Gyung-Bum Kim, Sung-Chong Chung, An accurate and robust stereo matching algorithm with variable windows for 3D measurements, *Mechatronics,* 2004, Vol. 14, No. 6, 2004, pp. 715-735.

[4]. Qiu Yang, and so on, 3D visual new method based on the edge of the match, *Instrumentation Journal*, Vol. 22, No. 3, 2001, pp. 255-256.

[5]. Zhao Xunjie, Li Chengjin, The key technology of real-time distance measurement by using binocular stereo system, *Laser and Infrared*, Vol. 36, No. 9, 2006, pp. 874-877.

[6]. You Su-Ya, et. al., Stereo Vision Research and progress, *Chinese Journal of Graphic Images*, Vol. 2, No. 1, 1997, pp. 17-23.

[7]. TANG Yi-Ping, YE Yong-Jie, ZHU Yi-Hua, Gu Xiao-Kai, Research on Intelligent Omni-Directional Vision Sensors and Their Application, *Chinese Journal of Sensors and Actuators*, Vol. 20, No. 6, 2007, pp. 1316-1320.

[8]. Zhou Fu-Qiang, and so on, Field calibration technology based on binocular visual sensor, *Instrumentation Journal*, Vol. 21, No. 2, 2000, pp. 142-145.

[9]. Qiu Mao-Lin, Camera calibration Summary in computer visual, *Journal of Automation*, Vol. 26, No. 1, 2000, pp. 43-55.

[10].H. Hirscllnlulle, P. R. Innocent, J. Garibaldi, Real-time correlation-based stereo vision with reduced border errors, *International Journal of Computer Vision*, Vol. 47, No. 1, 2002, pp. 229 -246.

[11].TANG Yi-ping, Omni Directional Vision Sensors without dead angle, Chinese Patent No. 200710066757.0, 2007-07-25.

[12].Tomas Pajdla, Tomas Svoboda, Epipolar Geometry for Central Catadioptric Cameras, *International Journal of Computer Vision*, Vol. 49, No. 1, 2002, pp. 23-37.

[13].David G. Lowe, Distinctive image features from scale-invariant keypoints, *International Journal of Computer Vision*, Vol. 40, No. 2, 2004, pp. 90 -110.

Guide for Contributors

Aims and Scope

Sensors & Transducers Journal (ISSN 1726-5479) provides an advanced forum for the science and technology of physical, chemical sensors and biosensors. It publishes state-of-the-art reviews, regular research and application specific papers, short notes, letters to Editor and sensors related books reviews as well as academic, practical and commercial information of interest to its readership. Because it is an open access, peer review international journal, papers rapidly published in *Sensors & Transducers Journal* will receive a very high publicity. The journal is published monthly as twelve issues per annual by International Frequency Association (IFSA). In additional, some special sponsored and conference issues published annually. *Sensors & Transducers Journal* is indexed and abstracted very quickly by Chemical Abstracts, IndexCopernicus Journals Master List, Open J-Gate, Google Scholar, etc.

Topics Covered

Contributions are invited on all aspects of research, development and application of the science and technology of sensors, transducers and sensor instrumentations. Topics include, but are not restricted to:

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- Smart sensors and systems;
- Sensor instrumentation;
- Virtual instruments;
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