International Journal of Hybrid Information Technology
Vol.9, No.1 (2016), pp. 31-40
http://dx.doi.org/10.14257/ijhit.2016.9.1.04

Study on the Matching Algorithm and 3D Virtual Reality System Based on SilverLight

Hou Zhenjie[1], Lu Zhongqiu[1] and Yuan Dezheng[2]

[1]*College of Information Science and Engineering, Changzhou University, Changzhou 213164, China*
[2]*School of Mathematics and Physics, Jiangsu University of Technology, Changzhou, 213000, China*
Email:hhderek@163.com

Abstract

Silverlight technology is a new generation of rich internet application technology. The paper proposes a new solution based on the Silverlight technology to achieve a 3D virtual reality system which takes the pictures around the objects with 360 degree displaying in the local computer or a web page. The 3D visual sense and image matching of this system are the key technical problems. The automatic matching technology in image synthesis field plays a very important role in the system. Based on the SURF algorithm, this paper takes strategies of density threshold suppression to reduce the number of matched feature points; using the quasi Euclidean distance to complete the feature points matching process, the improved algorithm also greatly reduces the matching time of feature points and improves the matching accuracy. Through theoretical analysis and experimental contrast, demonstrates the reliability and validity of the algorithm.

***Keywords**: 3D virtual reality, SilverLight, Image Matching, SURF*

1 Introduction

Desktop virtual reality technology, also be called the Window of the World, use a conventional computer monitor to display the virtual world. Compared to the "immersive" virtual reality technology, desktop virtual reality system has the advantages of low costing and easy to promote [1]. On the basis of the widely use of desktop virtual reality, the rapid developments of the panoramic view technology become novel and popular visual technologies. By suturing or processing the picture, it can achieve the tasks of looking around landscape or dragging objects in the three-dimensional space freely [2]. It is called 3D Object rounding photography systems through accessing to the object image of 360 degree and processing the points or zooming the images.

In the early Object photography production, due to the shortage of photography precision, production efficiency and application method, it has become the difficulties to large-scale promote. With the development of rich internet applications, 3D Object rounding photography used in large quantities are a low-cost, high efficiency and simple three-dimensional imaging modalities. Rich internet applications take full advantage of the hardware capabilities of the client to improve their abilities, enhance interactivity and presentation layer logic to improve the user experience that is to fill the usability gap between local applications and internet applications [3-14]. Web development trends and directions have become a carrier of 3D Object rounding photography system-wide dissemination and application. 3D Object rounding photography system as a business application development achieve its main work based on action scripting programming and simulating three-dimensional interactive flash applications. There are also other implementations, such as the dynamic GIF images and QuickTime rounding photography

ISSN: 1738-9968 IJHIT

file. In recent years Silverlight technology as the main products of Microsoft Corporation in the rich internet applications has developed rapidly and completely met the demand of 3D Object rounding photography system development.

Compared to the other technologies, silverlight technology not only developed 3D Object rounding photography system in maintaining small file size and compositing operation simply, but also has the ability in processing control and system scalability.

2. Silverlight-based 3D Object Rounding Photography Systems

3D Object rounding photography system are based on group photos of the object in 360 degrees which can be spliced into a panoramic image or dynamic picture and displayed on a computer. Visitors can change the direction and distance with the mouse or keyboard control to meet the requirements of interactive desktop virtual reality technology. In the rapid dissemination of the internet, 3D Object rounding photography system is more popular.

Silverlight technology is a new generation of rich internet application technology contributed to its cross-browser, cross-platform implementation of the Net Framework which has extremely superior vector graphics, animation, and multimedia and rich network communication function. As opposed to traditional WPF, Java Swing or Delphi, silverlight has more lightweight of runtime environment and better supports of background language framework. Therefore, it is a completely new system solution and great practical value for user to develop 3D Object rounding photography system by siliverlight technology.

2.1 System Analysis

3D Object rounding photography system is an image processing and display system, including image processing, image storage, and web presence. The design of the system will be shown in the internet browser, so the current speed of internet connection must be considered, a small size and file format are the significant requirements of the entire system. Secondly, a group of pictures taken by professional equipment needs to go through the process of image processing. The synthesis of specific file format needs real-time storage, therefore, the system requires to create an image database. In the later steps, rendering process need to access image data from the database and can be interactive played in the play-side. The web presence is part of the vision and interactive that the 3D Object rounding photography system users experience and need the clear playback control logic. After analyzing requirements of the above system, there are many solutions can be considered. For example, any language supported by Windows system can realize the image processing, just meeting the requirement of file format and communicating with the database. Similarly, it has considerable freedom to choose the database. For example, if choosing direct storage of image data, we can use the SQL Server, the Oracle, etc. The rich internet applications are used mainly in the final step: rendering. Rich Internet applications mainly include Java FX, JavaScript / Ajax, the Microsoft ActiveX, Silverlight, Flash, *etc*.

2.2 System Design

In order to achieve 3D image rendering capabilities, we use silverlight to develop rich internet applications in 3D Object rounding photography system. The system developed the local image processing clients and established a database based on SQL server for data storage and data communication, the file format of the image information is swf.

The system’s operation and transmission of image data based on SQL Server database have functions of real-time image storage and interaction between web client and database. Contribute to the Linq to control database, the local database is simple and convenient to operate. This system has a very strong capability of process and control and potential for extensions. Due to text-based XAML format used in the Sliverlight, it can be found easily by search engines.

2.3 Interactive Features

The interactive features of the 3D Object rounding photography system refers to the vision and interactive of 3D object on the client. How to realize the functions that user can see the objects left or right, near or far, zoom freely is the client application logic that must be addressed. Based on the interactive features of the Silverlight technology, 3D Object rounding photography system is a client application that uses the C# language to meet the system logic requirements on the .Net frame. Different from the current widespread use of embedding logic directly into the Swf file, our system realizes the interaction logic in the playback side. These methods we used will greatly reduce the quantity of network data transmission. The experimental data shows that a nearly 900k Swf file with logical data can be decreased to below 500k after extracting required picture materials from our system. It is also testify directly that the system can reduce the network burden efficiently.

3. Studies on the Matching Algorithm Based on SURF

Image matching is a significant task in the field of computer image processing especially in the navigation, the terrain matching and information prediction, environmental studies, pathologic studies, fingerprint identification and other fields. The technology aligned same scene of two or more images obtained by different sensors in different or the same imaging conditions to determine the relationship between them, such as translation or rotation [15].

Under the different imaging conditions, the imaging results will be different, even to the same object, the captured image also can have differences in different time, Angle etc. The purpose of image matching is to correct the differences through the space registration. The matching algorithm based on image gray level matrix judge the results by matching similarity measure through such steps: first define a real time image window and do some search and matching calculation on the reference image. Therefore, similarity measure, window size, as well as the search strategy to these three factors will greatly affect the match result. When matching the image grayscale distortion is larger or geometric distortion, the matching algorithms tend to fail. Stefano proposed a bounded part matching algorithm. The algorithm is obtained by Cauchy-Watts inequality, using a new lower-bound correlation function to reduce the calculation in the process of matching [16-20]. Based on sequential similarity algorithm, Takahito use a triangle inequality distance to get lower bounds on the child window of the registration window and the target window, and by setting threshold to determine whether to skip the search. The algorithm also reduces the quantity of calculation of matching algorithm. Luo Zhongxuan proposed a matching algorithm combining the wavelet variation [21-25].

3.1 The SURF Feature Points Matching Algorithm

SURF called the Speed - Up Robust Features, not only is a kind of scale invariant algorithm for feature point extraction but also is a feature points description algorithm. It is an improved SIFT (Scale Invariant Feature Transform) algorithm proposed by Bay. The performance of SURF algorithm in illumination and perspective changes invariant is close to SIFT algorithm, its speed has improved greatly than SIFT algorithm.

Integral image is an original image, it computes a rectangular region pixels and integral image calculation chart is as follows:

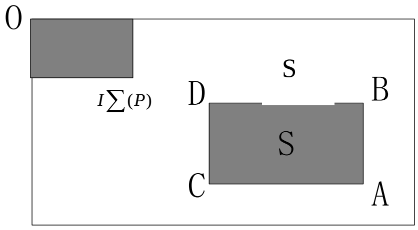

Figure 1. Integral Image Calculation Diagram

As shown in Figure 1, set P (x, y) is a point on the integral image, the point value of images is a integral value on the rectangular area from the origin to the point. Integral formula is as follows:

$$I\sum(P) = \sum_{i=0}^{i<x}\sum_{j=0}^{j<y} I(i, j) \quad (1)$$

The I (I, j) is the pixel value at the point (I, j), $I\sum(P)$ is P (x, y) value on integral image

After integral calculation, only need the addition and subtraction operations to get the pixels sum of any piece of rectangular area in the original image and does not need to calculate the integration. Compared with ordinary integral operation, by using the integral image arithmetic, the greater the rectangular area, the more computation time can be save. Area of the pixel can use B and C subtractions and D addition to represent:

$$S = A - B - C + D \quad (2)$$

SURF use approximate Hessian matrix to test point of interest, and use points chart to improve the efficiency of interest point detection.

3.2 Improved SURF Algorithm

Compared to SIFT, by using of the integral image strategy, the computing result of SURF algorithm is greatly enhanced, but the description of the feature point still take up a larger operation time. At the same time there will still be some phenomenon of mismatch. Therefore, this paper proposes a SURF algorithm based on the strategy of density threshold suppression for the feature point extraction to decrease the burden of the feature points extraction. Besides, the algorithm uses standard Euclidean distance instead of Euclidean distance to increase matching speed and considers the difference scale of the feature points to enhance the accuracy of the matching algorithm.

The feature points is very large in terms of quantity and its distribution is uneven. The algorithm will need a lot of useless calculation time for the computation of the feature point since the matching area is very small between two images. So a strategy of the density threshold is used to decrease the number of the feature point extraction in this paper.

Figure 2. Feature Points Extraction Spot Response Threshold

Specific steps of the image feature point extraction are as follows:

(1) positioning the features of point

After creating the scale space, the scale of the point (x, y) is σ, its corresponding Hessian matrix is defined as follows

$$H(x,\sigma)=\begin{bmatrix} L_{xx}(x,\sigma)\, L_{xy}(x,\sigma) \\ L_{xy}(x,\sigma)\, L_{yy}(x,\sigma) \end{bmatrix} \tag{3}$$

Hessian determinant of a matrix can be expressed as:

$$\det(Hessian)=D_{xx}D_{yy}-(\omega D_{xy})^2 \tag{4}$$

The ω is a weight coefficient of a fixed value. Experiments have shown that taking ω= 0.9 didn't affect the result. Until the determinant of a matrix is better than the specified threshold, it comes to the next step. Selecting points as special points of requirement comes to the current layer, the pre-layer and the next layer of each 3*3 neighborhood of the points which adopt maximum suppression, and are larger than other 26 response values. Finally interpolate the scale space so as to determine the position of the feature points

(2) Selecting the feature point

In the previous step, feature points was determined, we will filter the feature points. First of all, divide the whole image into several small square areas, and set a threshold value. When the area of feature points approach specified threshold, remove all other feature points in that area. The feature point density of that small square area is ρ, calculating formula is ρ =N/S.

N is the number of existing feature points in square area, S is the number of the square area pixel points. It is effective to decrease the number of feature points by using the strategy of density threshold suppression to extract feature points. At the same time, the algorithm makes the distribution of feature points relatively uniform. Because of the less number of feature points, the improved algorithm can effectively reduce the computation of SURF.

(3) The main direction

Set s is the scale of the current feature point, then the main direction of calculation method is as follows: first, calculate Haar wavelet of all feature points in the x, y direction in 6s circular neighborhood. Wavelet sampling step size is s. Second, do a Gaussian weighting processing. Interests points as the center demanded by the weighted operation, use Gaussian function (σ=2s) to weight all of the response. Third, to angle for л/3 fan, around the point of interest for a cycle, every 5 degree calculation again. Each calculation required adding response in the fan area. For established circular neighborhood, traverse a circle can get 72 new vectors. Fourth, select the longest vector to be the main direction of the feature points among the previous 72 vectors.

(4) Vector description

The description vectors are divided to operate independently in the 16 sub-regions of the square neighborhood. Like the main direction methods, child vector description of SURF also need to calculate haar wavelet of all feature points in the x, y direction of the response. Therefore, each feature points in each area can be calculated to get its response dx and dy. all child area have the same center Gaussian weighted (σ =3.3) to the feature point after the response calculation of feature points. Furthermore, so as to describe the haar wavelet in the x, y direction, the absolute value of dx and dy need to be added. So, for positive direction of neighborhood, each area has 4 quantities and each child area obtained four dimensional feature vector:

$$v=(\sum d_x, \sum d_y, \sum |d_x|, \sum |d_y|) \tag{5}$$

(5) Finally, merging vectors of 16 sub-areas will get a 64-dimensional feature ve Because the normalization processing of the 64-dimensional feature vector is required, the characteristics of child description method has characteristics of luminance and scale invariance.

Two-dimensional plane of the Euclidean distance between two points is as follows:

$$D = \sqrt{(x - x_0)^2 + (y - y_0)^2} \quad (6)$$

Quasi Euclidean distance use quasi european-style matrix in the form of a block of Euclidean distance estimation:

$$D_0 = |x - x_0| + (\sqrt{2} - 1)|y - y_0| \quad (7)$$

Using SURF, the size of each feature point vector is 64D and 128D. There will be 64 computing multiplication and square root operations to calculate the Euclidean distance between two feature points at a time. So the quasi Euclidean distance is used to replace the Euclidean distance. The quasi Euclidean distance only needs one time of multiplication, effectively decreasing the matching time. Meanwhile, the quasi Euclidean can reduce the calculation deviation and improve the matching accuracy because the quasi Euclidean distance is smaller than Euclidean distance.

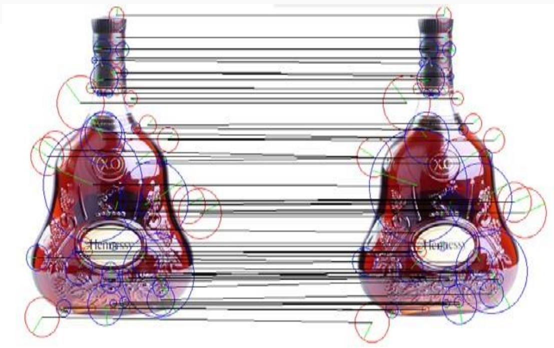

Figure 3. **Feature Points Matching**

4. Experiments and Results Analysis

4.1 Extracting Feature Points Based on Density Threshold Suppression Experiments

As is shown in Figure 4, the experiments are based on the density threshold suppression of feature points extraction. In Figure 4, the parameter N is the number of feature points in the small square area, the parameter S is the number of the pixel points in small area. Feature points as shown in Table 1.

It is demonstrated by experiments that due to the strategy of density threshold suppression, the number of feature points and the description time of the feature points can be decreased obviously by the extraction algorithm. The algorithm effectively improves the computing efficiency.

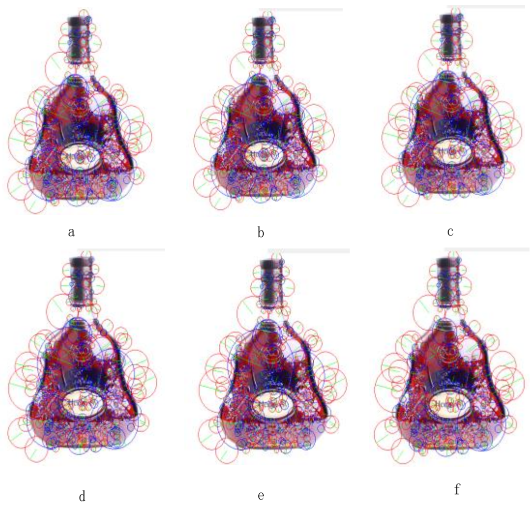

Figure 4. **Extracting Feature Points Based on Density Threshold Strategy (Spot Reaction Threshold Value: 0.0001 f, N: 1) Normal Extracting; b. S=4; c. S=9; d. S=25; e. S=64; f. S=100)**

Table 1. Extracting Feature Points based on Density Threshold Strategy (N = 1)

S	Number of feature points	time(ms)
Normal	359	450
4	349	442
9	337	429
25	315	409
64	277	374
100	258	350

Table 2. Experiments based on the Quasi Euclidean Distance

Matching image	**Original algorithm(error match number)**	**Improved algorithm(error match number)**	**Original matching time(ms)**	**Improved matching time(ms)**
bottle	70(9)	25(1)	110ms	90ms
building	66(10)	25(1)	105ms	85ms
desert	59(2)	50(0)	167ms	133ms

4.2 Experiments Based on Quasi Euclidean Distance

Experiments based on quasi Euclidean distance are shown in Figure 5:

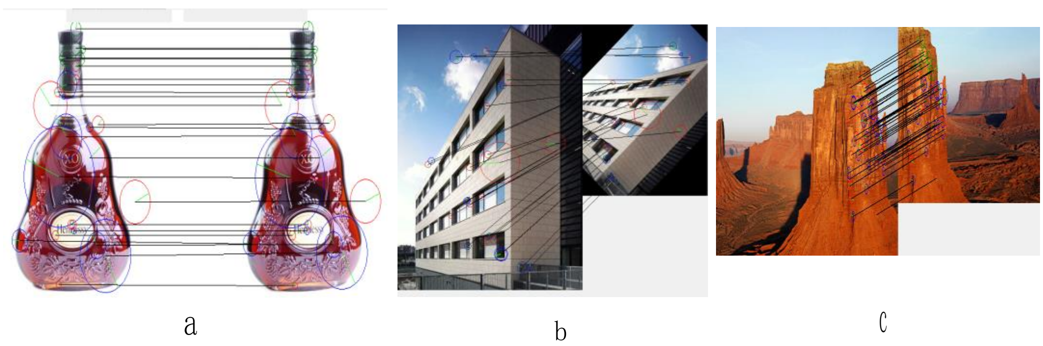

Figure 5. **Experiments based on the Quasi Euclidean Distance (Quasi Minimum Euclidean Distance/Quasi Minimum Euclidean Distance = 0.64)**

The Table 2 shows that using the quasi Euclidean distance can decrease the error rate of matching points and the time of computation, but at the same time it will decrease the total number of matches.

5. Conclusions

3D Objects rounding photography system is very popular in the industry of e-commerce, virtual tour, virtual museum etc. With the development of 3D technology and rich internet applications, 3D Object rounding photography system will surely reach more excellent achievements. This paper proposed a scheme based on Silverlight technology that has good capabilities of process control and potential of expansion. At the same time, the scheme based on the SURF algorithm uses density threshold suppression strategies which can decrease the number of matched feature points to improve the speed of the computation and uses the quasi Euclidean distance to deal with the feature points matching process. Contribute to the only one time of the multiplication calculation and the decrease of distance calculation deviation, the improved algorithm surely decreased the matching time of feature points and increased the matching accuracy. Through theoretical analysis and experimental contrast, the algorithm is reliability and validity.

Acknowledgements

This work is supported partly by the National Natural Science Foundation of China under Grant No.61063021, No.61272367.

References

[1] S. Peleg and M. Ben-Ezra, “Omnistereo: Panoramic Stereo Imaging”, IEEE Trans. Pattern Analysis and Machine Intelligence, vol. 3, no. 23, **(2001)**.
[2] D. Gledhill and G. Y. Tian, “Panoramic Imaging - A Review”, Computers & Graphics, vol. 27, **(2003)**.
[3] B. W. Benson and D. J. Flint, “Advances in Diagnostic Imaging for Pathologic Conditions of the Jaws”, Head and Neck Pathology, vol. 4, no. 8, **(2014)**.
[4] J. Hao, “A novel hybrid optimization algorithm and its application in solving complex problem”, International Journal of Hybrid Information Technology, vol. 2, no. 8, **(2015)**.
[5] F. Okura and M. Kanbara, “Aerial Full Spherical HDR Imaging and Display”, Virtual Reality, vol. 4, no. 18, **(2014)**.
[6] Aditi, “A hybrid approach for dehazing images”, International Journal of Hybrid Information Technology, vol. 3, no. 7, **(2014)**.
[7] D. Anguelov and C. Dulong, “Google street view: capturing the world at street level”, IEEE Comput Mag, vol. 6, no. 43, **(2010)**.
[8] D. G. Lowe, “Distinctive Image Features from Scale-invariant Keypoints”, International Journal of Computer Vision, vol. 2, no. 60, **(2004)**.
[9] M. Raed, “A novel hybrid gabor filter based on automatic wavelet selection with application to fingerprint enhancement”, International Journal of Hybrid Information Technology, vol. 4, no. 8, **(2015)**.
[10] M. A. Goodrich and B. S. Morse, “Supporting Wilderness Search and Rescue Using a Camera-equipped mini UAV”, J Field Robot, vol. 1, no. 25, **(2008)**.
[11] Y. Tyagi, “A hybrid approach to edge detection using ant colony optimization and fuzzy logic”, International Journal of Hybrid Information Technology, vol. 1, no. 5, **(2012)**.
[12] F. Okura and M. Kanbara, “Fly-through Heijo Palace Site: Augmented Telepresence Using Aerial Omnidirectional Videos”, Proceedings of ACM SIGGRAPH’11 Posters, Vancouver, BC, Article No. 78, **(2011)**.
[13] G. Ward, “Fast Robust Image Registration for Compositing High Dynamic Range Photographs From Hand-held Exposures”, J Graph Tools, vol. 2, no. 8, **(2003)**.
[14] A. Zomet and D. Feldman, “Mosaicing New Views: the Crossed-slits Projection”, IEEE Trans Pattern Anal Mach Intell., vol. 6, no. 25, **(2003)**.
[15] L. Zhao and Z. Hou, “An Improved Image Registration Method of SIFT”, Computer Engineering, vol. 12, **(2010)**.
[16] S. Liu, “Research on image retrieval technology based on fast wavelet transform”, International Journal of Hybrid Information Technology, vol. 4, no. 8, **(2015)**.
[17] L. Di Stefano and S. Mattocia, “ZNCC-based Template Matching Using Bounded Partial Correlation”, Pattern Recognition, vol. 14, no. 26, **(2005)**.

[18] P. Tribikram, "Implementation of machine part cell formation algorithm in cellular manufacturing technology using neural networks", International Journal of Hybrid Information Technology, vol. 2, no. 8, **(2015)**.
[19] L. Zhongxuan and L. Chengming, "Fast Algorithm of Image Matching", Journal of Computer Aided Design & Computer Graphics, vol. 17, **(2005)**.
[20] Z. Hou, "Research on 3D Object Rounding Photography Systems and Technology", Lecture Notes of 0Computer Science, vol. 7473, **(2012)**.
[21] Z. Hou, "Research on Genetic Segmentation and Recognition Algorithms", Lecture Notes of Computer Science, vol. 7473, **(2012)**.
[22] H. Bay and A. Ess, "Speeded-up Robust Features Using SURF", Computer Vision and Image Understanding, vol. 3, no. 110, **(2008)**.
[23] C. Ford and D. Etter, "Wavelet Basis Reconstruction of Nonuniformly Sampled data", IEEE Trans. Circuits and Systems II, vol. 8, no. 45, **(1998)**.
[24] Z. Hou, "Study on Traditional Camera Calibration", Journal of Information, vol. 11, no. 15, **(2012)**.
[25] W. K. Carey and D. B. Chuang, "Regularity-preserving Image Interpolation", IEEE Transactions on Image Processing, vol. 8, **(1999)**.

Authors

Hou Zhenjie, He is a Professor in the College of Information Science & Engineering of Changzhou University, China. He obtained his PhD in Computer Science from the Inner Mongolia Agricultural University in 2005. His research work has centered on computer vision systems.

Lu Zhongqiu, He is a Master degree candidate in the school of Information Science and Engineering, Changzhou University. His research work has concentrated on computer vision systems.

Yuan Dezheng, He is a Professor in the School of Mathematics and Physics of Jiangsu University of Technology, China. He obtained his PhD in Computer Science from the Inner Mongolia Agricultural University in 2005. His research work has centered on mathematics.