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Artificial Image Shadows Generation Algorithm Based on Augmented Reality

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Abstract: **In this paper, the key image processing technology is researched, and then a suit of commercial MAR application system is developed combined with the National Science and Technology Major Project by ZTE Corporation for the practice and exploration of the MAR industrialization. In which, the key image processing technology includes image retrieval, object registration and tracing, content rendering and image compression in the application, and then some creative methods are proposed to solve some of the related problems of image searching, image reorganization and image rendering in the MAR application.**

Keywords: Mobile augmented reality; Visual retrieval; Registration tracking; Visual lossless; Feature lossless

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1. Introduction

With the development of broadband mobile communication technology, as well as the advent of smart mobile phone such as IOS and Android, and mobile applications, the Augmented Reality (AR) that is limited in the laboratory before begins to enter the public view, and a large number of terminal location, image recognition technology-based mobile Internet application called mobile AR (MAR) applications begin to emerge, and become one of the hotspot in the industry. In 2010, the MAR is ranked in the top ten technology trends that lead the future by the US Times magazine. MAR apply the virtual augmented reality information to the real world, and change the user to observe the world. The traditional WE$ page query mode based on text input in the browser will be changed to the next generator show mode that the hotspot information captured by a variety of sensors is loaded into the real scene in the screen of the mobile, and which will enhance the user experience greatly.

Figure 1. Augmented reality typical applications.

In the multimedia field, augmented reality (AR) technology has become one of the most popular key technologies, in which illumination consistency has increasingly become the research focus. In recent years, although AR technology is widely used in entertainment, exhibition and military, it is still evolving with some shortages. For example, the virtual and real scene is not unified on visual effects. So the research on illumination consistency of AR is very necessary.

2. Technologies

2.1. Visual retrieval

Considered the problems of low accuracy and short of bitrates adaptation in visual retrieval of current MAR solution, a robust method for various bitrates with low memory used and easy to distribute deploy is proposed. By selecting feature points based on the statistics and the convergence of multiple efficient affected the performance in image visual retrieval, the linear transformation of simple descriptor and the block-based location point code method, the local feature stream is reduced effectively. Via the Fisher Vector based local descriptor convergence method, the local features are aggregated and the interference factors are removed effectively, and the binary compact descriptor used for distance calculation is generated quickly. As well as, the results are verified with geometric algorithm of DISTRACT and filtered secondly to gain a stable performance with different bitrates streams for the overall visual retrieval system. In addition, the fast linear search method shows its great advantages in the distributed processing and the incremental training to achieve rapid visual retrieval, and provides powerful support for the large-scale deployment of the MAR system.

$$P(c = 1|y \in B) = \frac{P(y \in B \cap c=1)}{P(y \in B)}$$

$$\hat{P}(y \in B \cap c = 1) = \frac{\sum_{n=1}^{N} \kappa(y_n \in B) c_n}{N}$$

$$\hat{P}(y \in B) = \frac{\sum_{n=1}^{N} \kappa(y_n \in B)}{N}$$

$$\hat{P}(c = 1|y \in B) = \frac{\sum_{n=1}^{N} \kappa(y_n \in B) c_n}{\sum_{n=1}^{N} \kappa(y_n \in B)}$$

$$\hat{P}(c = 1|y \in B_k) = \frac{\sum_{n=1}^{N} \kappa(y_n \in B_k) c_n}{\sum_{n=1}^{N} \kappa(y_n \in B_k)}$$

2.2. Registration & feature tracking

A mufti-Thread Parallel Computing method for feature matching and tracking is proposed, which optimizes traditional RANSAC algorithm with

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geometric constraint, and thus effectively solves the lack-of real time issue of existing AR system based on the unmarked registering & tracking technology. As well as, a quality evaluation function of feature tracking is added to achieve the state switching between threads and the effective screening of the homographic matrix, by which, the system can track fluently irrespective to the object rotation, scaling and occlusion. And finally, a set of AR system is implemented that is available in the mobile terminal with stable and real-time experience.

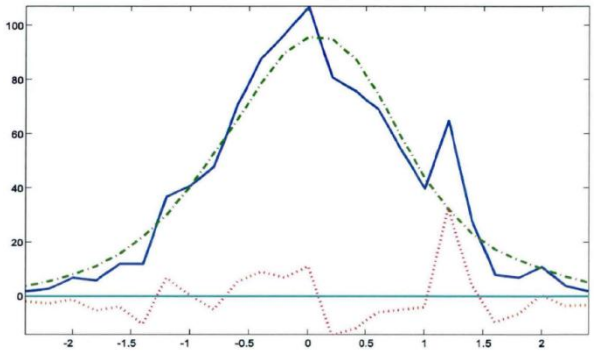

Figure 2. Consistency check.

2.3. Content rendering

The content rendering system of MAR involves key technologies such as script parsing, content loading and presentation. In the paper, to achieve the goal of light weight and high efficiency, some related configuration suggestions are given for choosing the enhanced content in different formats based on massive experimental work. Some more prospective research on the depth of field and shadow rendering algorithm are also studied, which is too complex to use on the mobile intelligent terminal with weak computing capability. For shadow rendering algorithm, the Hashtable is used to promote the efficiency of contour edge finding, besides that, Per-Object algorithm is also used to sharply reduce the number of the triangle slices. For the depth of field rendering algorithm, on the basis of the single-layer algorithm the Gaussian filters are introduced to fuzzy edge to promote the efficiency of the depth of field rendering algorithm. To further improve the operational efficiency of the algorithm, the heterogeneous GPU programming method is used to code implementation, which obtained a more substantial performance improvement.

2.4. Image compression

Firstly, a visual lossless image compression algorithm is realized under the standard JPEG framework,- and an effective and complete picture quality evaluation method is introduced for the first time, which dynamically adjusts the quality factor without degrading the user visual perception to obtain a higher compression ratio. In this method, many factors including signal to noise ratio before and after picture compression, edge and texture information are considered, to build an objective picture quality evaluation model. The dynamic adjustment range of quality factors is significantly reduced by using the priori statistical knowledge of quality and objective picture quality score; and the system efficiency is effectively improved by using the dichotomy to quickly adjust the quality.

$$P_i^t = P(z^t = z_i | x_t;\ \lambda_i) = \frac{w_i p_i(x_t|\lambda_i)}{\sum_{j=1}^{128} w_j p_j(x_t|\lambda_j)}$$

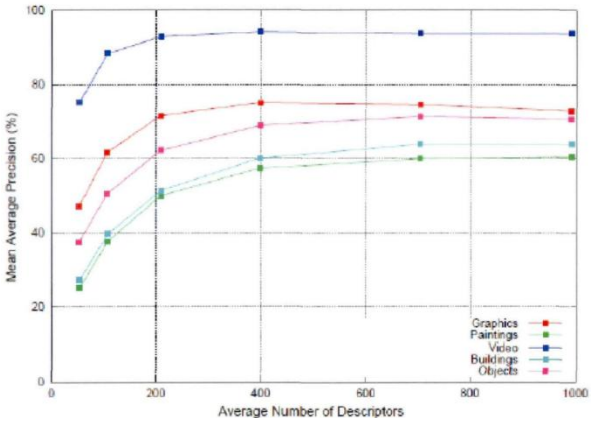

Figure 3. Change curve

Secondly, a feature lossless image compression algorithm is implemented. Under the standard JPEG framework, this adjusts the DCT coefficients to save 42.7% storage compared to the original JPEG algorithm, without losing image information. Moreover, the algorithm uses the genetic algorithms to train massive data to obtain the lossless quantization table, effectively avoiding the problem of big quantization table space, and improving the system efficiency.

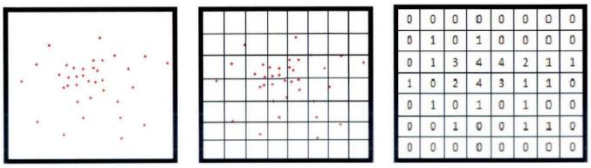

Figure 4. Image partitioning diagram.

3. Results and Discussion

In this thesis, after the domestic and abroad research status about illumination consistency of AR are summarized, as well as the main problems of the field are analyzed, the focuses then are on the studies of inverse detection of illumination and shadow generation technology.

$$I_D = I_a \cdot K_a + \boldsymbol{L} \cdot \boldsymbol{N} \cdot K_d \cdot I_L$$

Firstly, the inverse detection algorithms based on the illumination model are widely used in augmented reality, however they demand the surface of the calibration object to be purely diffuse and detection errors of the light source's position are also relatively large. To solve this problem, a two-step detection algorithm of the light source is proposed, which imports 3D features of the shadows and secular reflection. The algorithm is divided into two parts, including position

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detection of the light source and intensity detection of the light. Under the condition of having known the position of the light source, the Cook-Torrance model with the secular reflection is introduced, and such methods as random sampling partition and error handling are also adopted. Besides, the 3D features of the shadows are used instead of the plane corner features, and the position of the light source is detected according to the ray tracing. Experiment results show that the position detected by this algorithm is more accurate. Therefore, it solves the inaccuracy in detecting the position of the point light source and the limitations in the calibration objects.

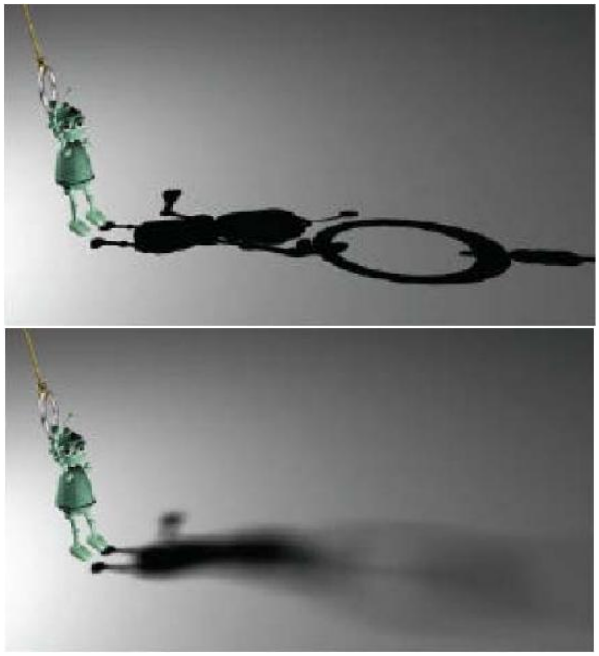

Figure 5. Shadow generation effect.

Secondly, since soft shadow achieved by existing shadow generation algorithms of AR is unrealistic, a shadow generation algorithm using adaptive sampling and background fusion is proposed. The shadow spatial location distribution of virtual objects is firstly computed by using planar shadow algorithm which takes occlusion into account. Then, to improve the procedure of soft shadow generation in swell and erode algorithm, an adaptive sampling method which gets illuminant union according to shape types is presented. Finally, since shadow color gotten by gray image method is limited, a method based on multi-channel and background fusion is presented. Experiment results show that in this algorithm the color of soft shadow is more reasonable and the method of soft shadow rendering is more effective. Consequently, the new algorithm improves the realism of soft shadow. Finally, a prototype system of AR based on marker and illumination technologies is developed. The system uses the key technologies including 3D registration and illumination consistency.

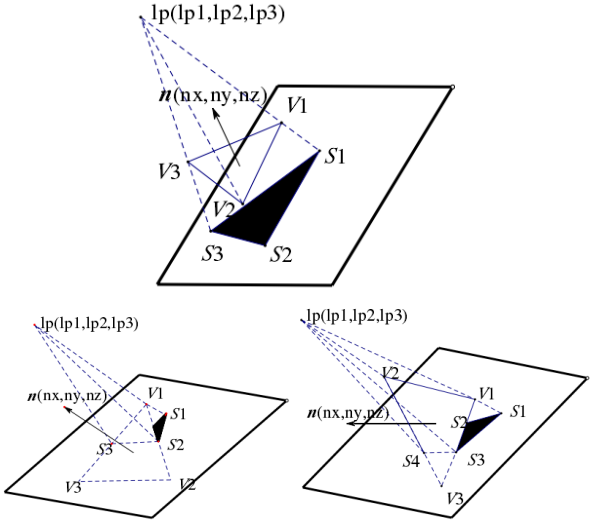

Figure 6. Shading in case of occlusion.

Shadow is a piece of dark areas which is created by the opaque object blocks the light. Shadow as the projection of object which is created by light in real life has become an indispensable part to enhance the computer graphics' rendering realism. The boundary section of shadow can help people understand the shape of objects, as well as the relative position of objects. Therefore, there is more and more study about real-time dynamic soft shadows at home and abroad. The main algorithm of shadow is shadow mapping and shadow volumes algorithm, for the expensive spending of shadow volume algorithm, the most popular algorithms is shadow mapping algorithm.

A variety of algorithms of real-time dynamic soft shadows are researched: The shadow mapping algorithm is analyzed, shadow mapping algorithm is a kind of shadow generation technology base on image space. Its basic principle is do two rendering to get the shadow. The perspective shadow mapping algorithm is analyzed, this algorithm generate the shadow mapping through perspective space, and provide high-resolution for near object when provide low-resolution for object which is far away the viewport. This algorithm solves the prelim of aliasing. The light space perspective shadow mapping is described, this algorithm merges the shadow mapping algorithm and the perspective shadow mapping algorithm.

The algorithm of laved percentage-closer filter which is based on the parallel split shadow mapping is proposed. First, the parallel-split shadow mapping algorithm is details analyzed, then the percentage-closer filtering algorithm is introduced. Finally, combine the parallel-split shadow mapping algorithm with percentage-closer filtering algorithm, laved PCF based on PSSM is proposed. And two kinds of selection method of kernel size with depth map in the algorithm of laved percentage-closer filter which is based on the parallel split shadow mapping are proposed: user select and geometric progressive based on the penumbra. Layered PCF algorithm based on PSSM can also simulate real-time soft shadows, it can

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render the shadow of more complex geometry while ensuring the quality and satisfying the efficiency for real-time rendering, providing an effective solution to generate real-time shadow in virtual environment.

In virtual scene, shadow plays a crucial role in the realism of scenes and immersion of users, and is an indispensable part to simulate the real world. However, it is often very time-consuming for accurate rendering of shadow, so that the real-time rendering of shadow is affected. Therefore, how to harmonize the problem of the shadow realism and real-time rendering, under the condition without affecting the realism improving the real-time rendering, or under the condition without affecting the real-time rendering enhancing the shadow realism, is still the key point of the shadow research in virtual scene. In recent years, with the GPU processing ability continuously increasing, the GPU applications extend from the graphics processing to the GPU general computing, many data handled by CPU can be redesigned to be processed by GPU now, the GPU powerful computing and parallel processing ability can be used to improve the efficiency. This provides a good solution for drawing the shadow with high real-time rendering and strong realism. Aiming at the above problems, this paper proposes a soft shadow generation algorithm based on GPGPU, combined with the GPU general computing technology. Aiming at the realistic need of shadow rendering, on the basis of the PCSS algorithm, this paper puts forward a soft shadow generation algorithm based on GPGPU. It samples shadow map by poison disk pattern, uses depth gradient to deal with the phenomenon of self-shadowing, uses the VSM algorithm to filter the shadow, and uses the summed area table to filter the shadow map dynamically, improving the shadow quality and rendering efficiency in a certain extent.

Aiming at the real-time need of shadow rendering, this paper gives a detailed analysis, summarizes the optimization strategies of using GPU for general purpose computing, proposes to speed up the implementation of the proposed algorithm reasonably with GPU, gives the detailed design process, and analyses the result. `The result shows that the proposed method not only enhances the shadow realism of the virtual scene, but also improves the real-time shadow rendering, which is very suitable for soft shadow rendering of the virtual scene. Finally, the real-time dynamic soft shadow effect is applied to the actual scene editor. First, the function modules of the Romans Studio Scene Editor are introduced. Second, the shadow module and the key class of the real-time dynamic soft shadow are introduced, analyzed and implemented. Then the module design and application of the real-time dynamic soft shadow in the scene editor are analyzed. Finally, the real-time dynamic soft shadow effect is applied to the scene editor and the result is analyzed.

4. Conclusion

On the basis of the research, the theoretical results are applied into the engineering practice. After completing the architecture design of the MAR system, the augmented reality service platform and application software are developed, which is a significant practice of mobile Internet value-added services and information services innovation model, and contributes to the promotion of augmented reality service, and promotes the whole industry ecology.

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