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Enhanced Techniques 3D Integral Images Video Computer Generated

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ABSTRACT

The main purpose of this paper is to introduce some techniques to overcome 3D missing information visual artefacts problem, holes and blank regions between 3D integral images (holoscopic images) frames encountered with the computer generated 3D integral image, pixel-tracing styles is proposed to achieve a higher performance of generating 3D integral images in terms of execution time, Z-buffer and correct occlusion scheme is also introduced to overcome visual artefact. The methods are based on a 3D integral images ray-tracer containing 3D integral images parser, 3D integral camera model, a 3D integral images renderer and scene transformations. Consequently, fast sequences of 3D integral image frames for animations purposes are generated, experimental results show validation of the strategies to fill in the 3D missing pixels and test on different scenes, improvement in terms of execution time depends on the complexity of the scene is achieved.

Index Terms— Computer graphics, Integral images, Interpolation, Animation, 3D TV

1 INTRODUCTION

Software which takes advantage of the temporal coherence between successive 3D holoscopic image frames (animation) is developed. It is based on an interpolation process in order to overcome the missed pixels problem between 3D integral imaging frames. Consequently, 3D missing pixels are mapped.

The 3D missing information is normally produced by ray tracing them again. Although, very good results in terms of filling in the black holes with correct pixel information have been achieved but the drawback of the strategy is that it time consuming. Therefore, In this paper, an interpolation algorithm is developed to compute the 3D missing information without the need of ray tracing them again the interpolation scheme are used information from the neighboring still 3D integral image frames each side of the current still 3D integral image frame. This will avoid the need to ray tracing all of the missed pixels in new still 3D integral image frame and that has noticeably resulted in the reduction of the number of computations and hence in acceleration of execution time.

In this paper, a complete software tool that implements the application programming, interpolating 3D missing pixels in the environment of object-oriented in C++, C programming languages is developed and the second based ray tracer parallel system tool is adapted.

2 ADVANCED INTEGRAL IMAGING SYSTEMS

Integral imaging is attracting a lot of attention in recent year and has been regarded as strong candidate for next generation 3D TV [1-4]. A fair amount of research work has concentrated on the development of optical and digital techniques to convert the pseudoscopic image to an orthoscopic image [5-25].

The 3D camera model used for each microlens is the pinhole approximation. Each micro-lens acts like a separate camera. The result is a set multiple cameras. Each of them records a sub-image of the virtual scene from a different angle. Primary rays pass through the centre of the micro-lens and the image plane. The scene image straddles the micro-lens array. Therefore there are two recording directions, in front and behind the micro-lens array Figure 1.

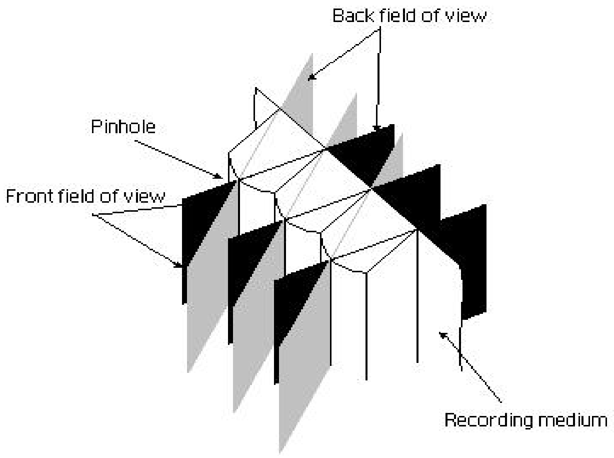


Figure 1: Lenticular sheet model in integral ray tracer [24].

An optical configuration necessary to record one stage orthoscopic 3D integral images has been proposed [6-13] and is shown in figure 2. This employs a pair of microlens arrays placed back to back and separated by their joint focal length, which produces spatial inversion. The arrangement allows a pseudoscopic image to be transferred such that it can straddle a separate microlens recording array (close imaging). The recording micro-lens array can be put anywhere in the transferred image space to allow the desired effect to be achieved freely: The object can be entirely inside of the display, outside of the display, or even straddling the display. The space transfer imaging scheme offers the flexibility of recording the object at a desired depth.

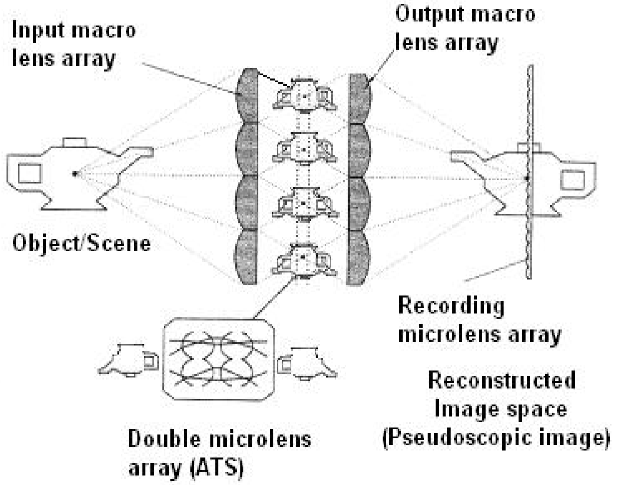


Figure 2: An advanced Integral Imaging system [23].

The system uses an additional lens array, which images the object space around the plane of the microlens combination. This arrangement has been termed a two-tier optical combination. Effectively the first macro array produces a number of pseudoscopic, laterally inverted, images around the double integral microlens screen. This image is transmitted effectively negating the sign of the input angle such that each point in object space is returned to the same position in image space. The arrangement performs pseudo phase conjugation, i.e. transfer of volumetric data in space. The image is transmitted with equal lateral longitudinal magnification, and the relative spatial co-ordinates, are preserved i.e. there is no inversion in the recorded image and no scale reduction in depth.

The system will record live images in a regular block pixel pattern. The planar intensity distribution representing an integral image is comprised of 2D array of $M \times M$ sub-images due to the structure of the microlens array used in the capture and replay. Unidirectional integral images (UII) are obtained by using a special case of the integral 3D imaging system where 1D cylindrical microlens array is used for capture and replay instead of a 2D array of microlenses. A section of a cylindrical and micro lenses array is shown in Figure 1. The resulting images contain parallax in the horizontal direction only.

The replay of the 3D Integral images is achieved by placing a microlens array on the top of the recoded planar intensity distributions. The microlens array has to match exactly the structure of the planar intensity distribution.

3 3D INTEGRAL IMAGES MISSED PIXELS

Pixels with no points mapped onto them are called 3D missed pixels. They appear as holes or blank regions in the still 3D integral image frame and its status is (-1) which means no point is projected onto this pixel. 3D missed pixels are the result of: (1) occluded areas in the previous still 3D integral image frame that should appear in the new still 3D integral image frame which are missing. This is illustrated in Figure 3. (2) The new still 3D integral image frame shows an area that has not been covered by the previous still 3D integral image frame. In example of this occurrence is shown in Figure 4. To overcome this problem the missed pixels are interpolated in order to generate their intersection points and to produce their colour.

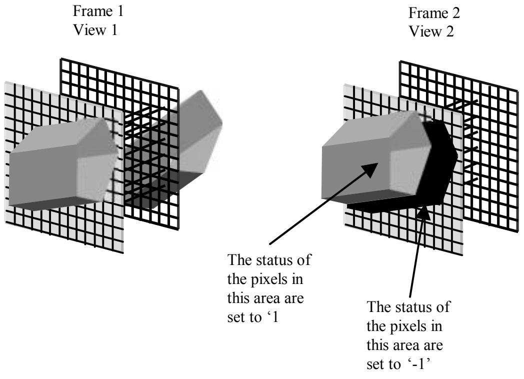
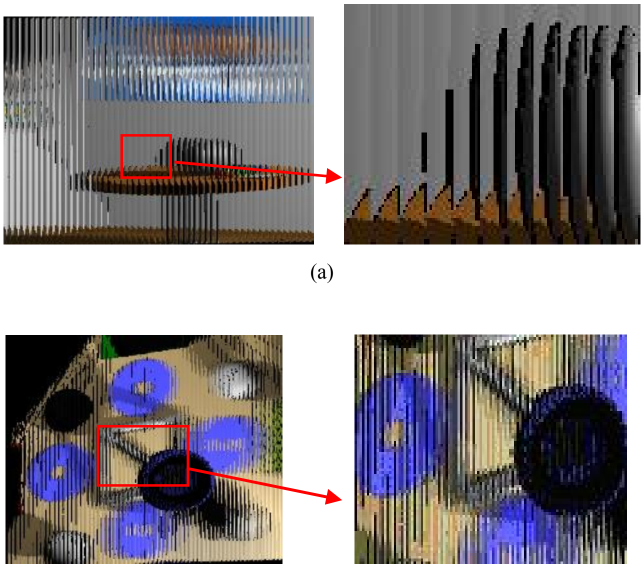


Figure 3: occluded areas in the previous frame.



(a)

(b)

Figure 4: Areas are not covered in previous frame, is coloured black (a) room scene (b) primitives scene.

4 ENCHANCED 3D INTEGRAL IMAGING RAY TRACER

The interpolation algorithm is used to fill in 3D missing pixels and to speed up the generation of a sequence of frames. In this case the temporal coherence between successive frames is taken into account and the missing information is obtained by generating two point arrays. The first point array is to store the point image of the previous frame and the second point array is to save the point image of following frame. Taking the average of point image colour components (*R, G, B*) of the odd point image arrays. In order to generate the associated new point image colours of even frames are recorded onto the new image plane.

The recursive operation is then continued, using the image points of the previous and following frames to generate the new refreshed frame. An example of filling in the missing information is shown in Figures 5 and 6.

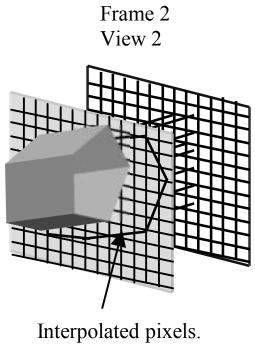


Figure 5: Interpolated missed pixels.

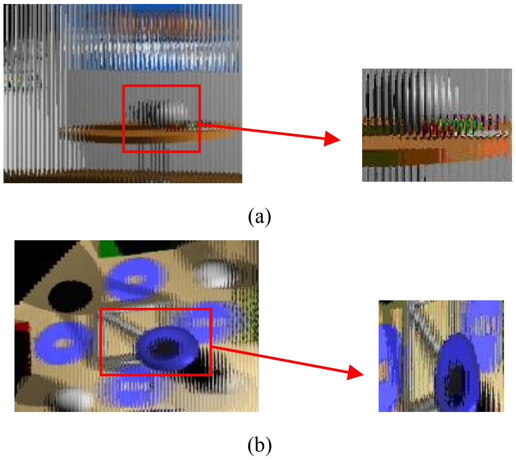


Figure 6: After overcome the missed pixels in figure 4: (a) room scene (b) primitive scene.

5 Z-BUFFER AND CORRECT OCCLUSION

Incorrect occlusion problems occur when more than one point in the point image of the first frame map onto the same pixel position in the new frame as shown in figure 7.

The solution to this problem is to build a *z-buffer* for each pixel. The *z-buffer* ensures that the closest point to the image plane is the one to be mapped onto the pixel. The *z-buffer* first tests the z-component of the point considered against the stored value in the buffer if the value is smaller than the one stored, the *z-buffer* will store the new value and allow the point to be mapped onto the pixel, and if the value is larger than the one stored then the point is discarded. Figure 8 shows the result of adding the *z-buffer* to the 3D integral interpolation and to parallel integral ray tracer software [27].

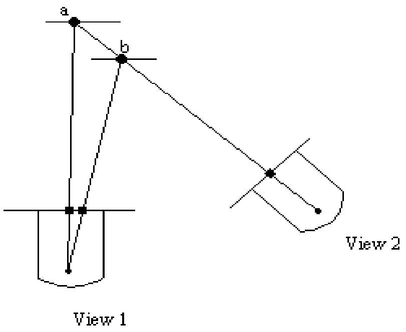


Figure 7: Incorrect occlusion.

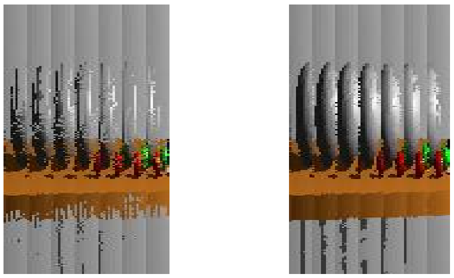


Figure 8: (a) Incorrect occlusion. (b) Correct occlusion due to the z-buffer.

6 PIXEL-TRACING STYLES

In order to achieve a higher performance of generating 3D integral imaging in terms of execution time two different pixel-tracing styles [27] have been adapted separately in order to find out the optima; pixel-tracing style of generation fast 3D integral imaging, from the table 3.

It can be seen no significant savings in the execution time is achieved using pixel-tracing styles for *Teapot*, *Room*, *Small-balls*, and *Primitives* scenes, due to the simplest of the scenes. But there is a respectful reduction in execution time is complex scenes such as *Tree*, and *Gears* scenes.

6.1 Horizontal Pixels Style

Simply, the pixels in the first cylindrical lens of frame are produced by using integral Ray-tracing algorithm in the horizontal direction, row by row.

6.2 Vertical Pixels Style

The same technique has been used in order to produce the pixels of the first cylindrical lens of frame by using integral ray algorithm but in the vertical direction, column by column.

7 EXPERIMENTS AND RESULTS

The calculations that have been presented, to measure the 3D integral imaging quality and amount of image distortion between frames are adopted for testing. The method most commonly used for comparing the similarity of two images is to compute the peak signal to noise ratio (*PSNR*). The first 3D integral imaging frame $f(i, j)$ is generated by using the fully integral ray tracing algorithm, and the second 3D integral imaging frame $g(i, j)$ is obtained by using 3D integral imaging interpolation algorithm discussed above. Figures 8 are illustrated enhanced 3D integral imaging frames that have been obtained using 3D integral imaging interpolation algorithm.

$$PSNR_{AVR} = \frac{379.7031}{11} = 34.5185 \; dBs \qquad (1)$$

The results tabulated in Table 1, clearly show the significant reduction in execution time reduction is achieved as against using the fully integral ray tracing, from table 1. It can also be noticed that more significant reductions in execution time is achieved by using the 3D integral interpolation algorithm. Saving up to (59 % - 78 %) as compared to the ray tracing time of different process. The approach adopted saved up to 5345 second (59 %) of the *Tree* scene computation time.

Table 1: Measurements of 3D integral imaging animation quality of teapot scene.

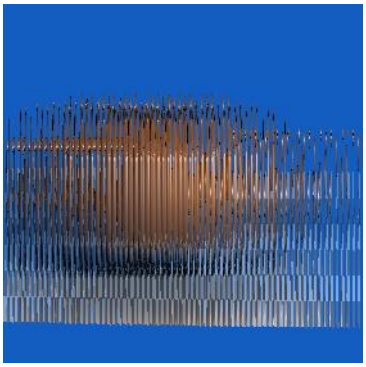
Scene Teapot	*RMSE Red*	*RMSE Green*	*RMSE Blue*	*RMSE Average*	*PSNR (dB)*
Frame 103	24.1023	20.0936	20.1222	21.439367	34.8187
Frame 104	28.2723	23.3329	22.6439	24.7497	34.1951
Frame 105	24.3423	20.4135	20.2650	21.6736	34.7715
Frame 106	28.7464	24.0092	23.2379	25.3311	34.0943
Frame 107	24.7025	20.8879	20.6101	22.0668	34.6934
Frame 108	29.1157	24.5675	23.6282	25.7705	34.0196
Frame 109	25.4550	21.8205	21.4098	22.8951	34.5334

Table 2: Timings for rendering the frames using different rendered algorithms.

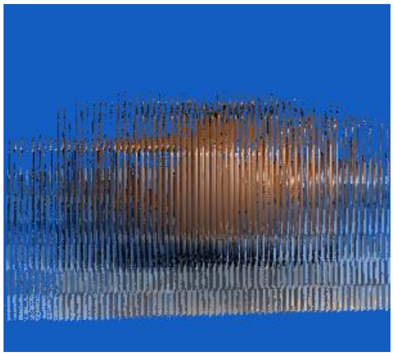
Scene	*Number of frames*	*Total time for rendering the frames using fully integral ray tracing (in seconds)*	*Total time for rendering the frames using 3D integral interpolation algorithm (in seconds)*	*Total saved time using 3D integral interpolation algorithm (in seconds) & (%)*
Teapot	612	1836	520	1316 sec (72 %)
Room	634	1268	496	772 sec (61 %)
Small-balls	421	842	189	653 sec (78 %)
Primitives	512	1024	333	691 sec (68 %)
Tree	612	9017	3672	5345 sec (59 %)

Table 3: results of pixel-tracing styles.

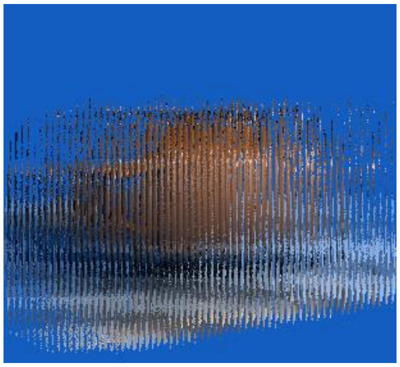
Scene	*Total Ray-tracing time for rendering first lens in the vertical direction*	*Total Ray-tracing time for rendering fist lens in the horizontal direction*
Teapot	0.046	0.046
Room	0.016	0.016
Small-balls	0.016	0.016
Primitives	0.015	0.016
Tree	0.156	0.230
Gears	0.062	0.078



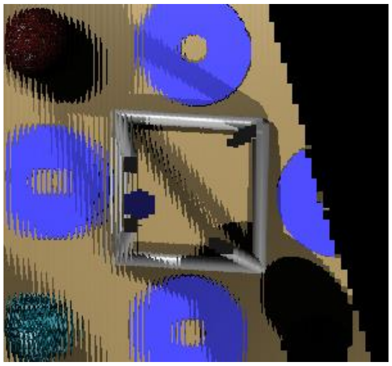
(a)Teapot scene frame 0000



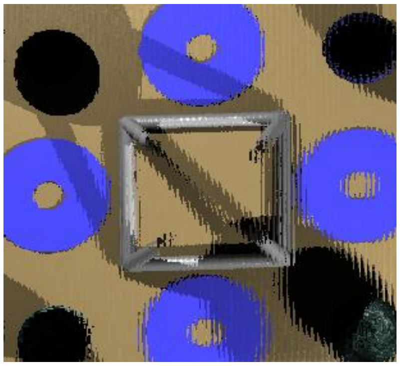
(b) Teapot scene frame 0101



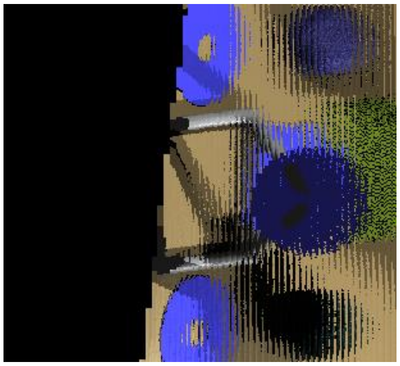
(c) Teapot scene frame 0303



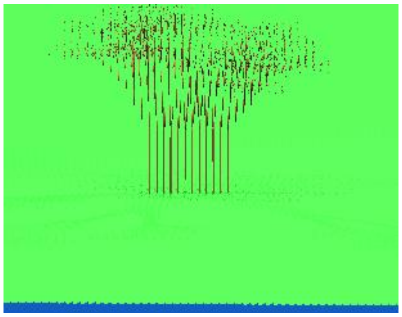
(a) Primitives scene frame 0000



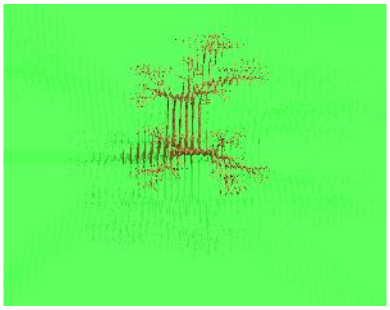
(b) Primitives scene frame 0099



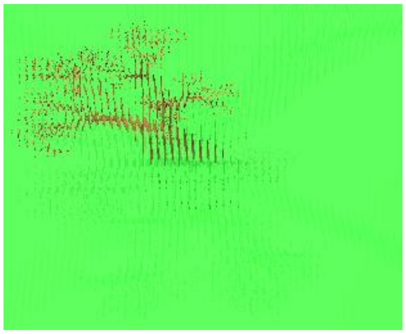
(c) Primitives scene frame 0550



(a) Tree scene frame 0000



(b) Tree scene frame 0101



(c) Tree scene frame 0402

Figure 9: illustrated interplated 3D integral Image animation.

8 CONCLUSION

This paper presents techniques that can accelerate generation of 3D integral imaging frames, using interpolation algorithm. Z-buffer and correct occlusion is proposed to overcome incorrect occlusion problems occurred. Pixel-tracing styles are introduced and compared in order to produce the optimal pixel-tracing for speeding up the generation of 3D integral imaging. The vertical pixels style takes advantage of the spatial coherence information within the integral imaging micro-images to enhance the processing speed. Both subjective and objective images quality assessment are reported and it is found out that the significant reduction in processing time is achieved without any visible degradation in image quality. Sequences of 3D integral imaging frames of several tested scenes have been produced such as teapot, room, primitives, small-balls, tree scenes.

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