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A Block-based 2D-to-3D Conversion System with Bilateral Filter

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***Abstract*-- The three-dimensional (3D) displays provide a dramatic improvement of visual quality over the 2D displays. The conversion of existing 2D videos to 3D videos is necessary for multimedia application. This paper presents an automatic and robust system to convert 2D videos to 3D videos. The proposed 2D-to-3D conversion combines two major depth generation modules, the depth from motion and depth from geometrical perspective. A block-based algorithm is applied and cooperates with the bilateral filter to diminish block effect and generate comfortable depth map. After generating the depth map, the multi-view video is rendered to 3D display.**

I. Introduction

3D video signal processing has become a trend in the visual processing field. However, for existing 2D content, depth information is not recorded. Therefore, an automatic 2D-to-3D conversion is necessary. Due to different characteristics of each object, the object modeling and depth map generation require lots of visual knowledge about depth cues [1][4]. Combining with two major depth cues, our system attempts to generate comfortable depth maps from single view 2D videos.

II. Proposed System

The proposed block-based 2D-to-3D conversion system with bilateral filtering is shown in Fig. 1. The depth generation consists of two modules, depth from motion parallax (DMP) and depth from geometrical perspective (DGP). The depth fusion module fuses the depth map D(x, y) produced by DMP and the depth map produced by DGP according to weighting factors W_m and W_p. The DMP and DGP modules are all implemented by block-based algorithm to ease the hardware implementation. A cross bilateral filter [5] is then applied to remove block artifact of depth map. The DIBR renders multiple views with various view points for 3D displays [2].

A. Depth from Motion Parallax

The depth from motion parallax (DMP) module is the central core of the system. Firstly, camera motions of consecutive video frames are analyzed by block-based motion estimation. Frames are warped to form a parallel view configuration with the current frame. Then the frame with most suitable baseline is selected as shown in Fig. 2. Motion parallax is then computed by block-based matching. The depth was estimated by $W_p\sqrt{MVx^2+MVy^2}$. Using this method, the camera motion is compensated. The motion parallax can be retrieved by the moving distance from current frame to reference frame. Moreover, the motion vector of each block will be globally optimized with the consideration of neighbor block. Therefore, the smooth motion vector map will result in smooth depth map.

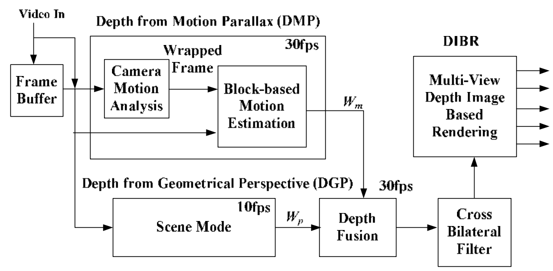

Fig. 1. Proposed 2D-to-3D conversion system

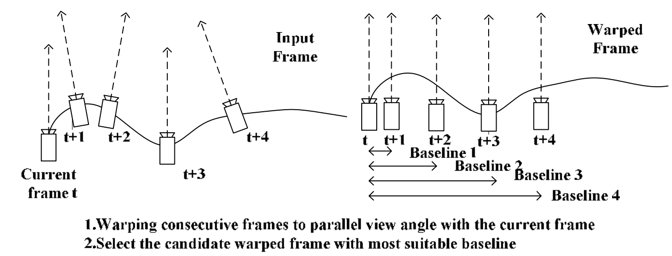

Fig. 2. Concept of depth from motion parallax

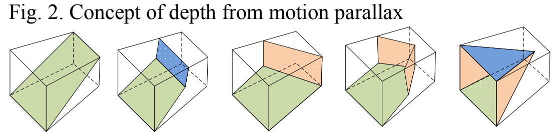

Fig. 3. Multiple scene modes using depth from geometry

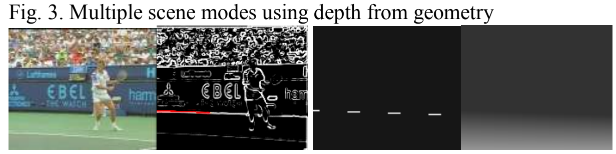

Fig. 4. Processed image in DGP module, from left to right, Stefan sequence, image after edge filter and line detection (red), dominate line, and depth map

B. Depth from Geometrical Perspective

Geometrical information is used to generate the scene depth [3]. The method we proposed classifies the scene into multiple modes by line structure detection as shown in Fig. 3. The method is an edge-based algorithm that analyzes the line structure of the scene as shown in Fig. 4. A temporal depth stabilization method is applied to prevent the depth map from flickering. The frame rate of the output of the DGP module is 10fps, and then is linearly interpolated to 30fps. This prevents depth from ringing effect and reduces computation.

C. Depth Fusion and Bilateral Filtering

Overall data flow of proposed system is shown in Fig. 5. The depth map of DMP and DGP are fused according to weighting factors W_m and W_p. The fused depth map is then filtered by the cross bilateral filter. The window size depends on the characteristic of objects. In our implementation, the kernel of the bilateral filter is larger than block size in DMP module. Bilateral filtering smoothes depth map while preserving object boundary, by means of different weighting of nearby pixel values in color image.

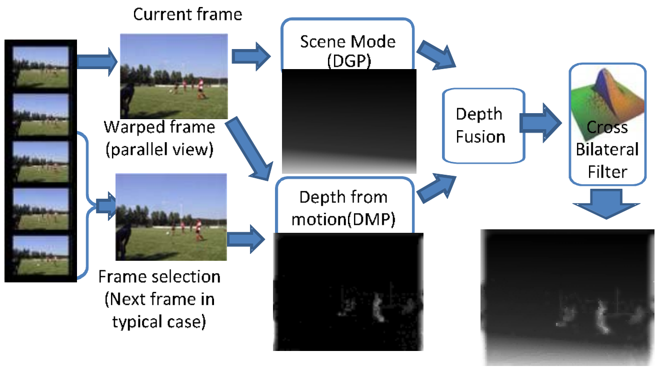

Fig. 5. Data flow of the proposed block-based 2D-to-3D system

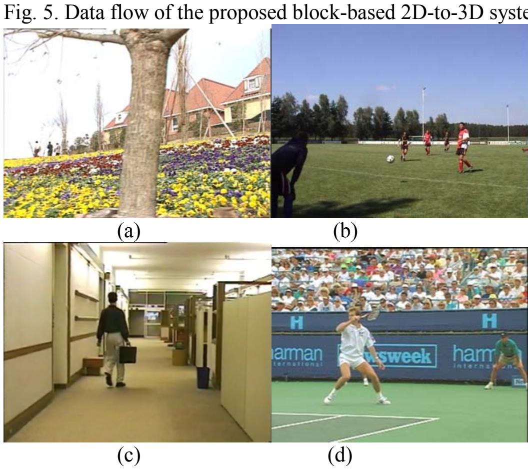

Fig. 6. Test sequence: (a) flower, (b) fussball, (c) hall_monitor, (d)stefan

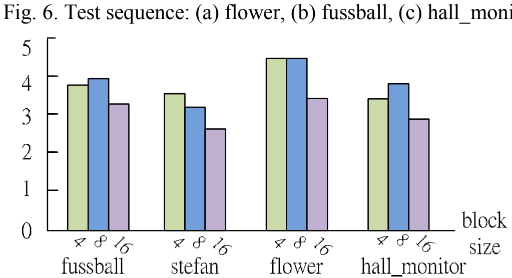

Fig. 7. Subjective view evaluation

III. Experimental Result

In our implementation, various block size and bilateral filter is tested. Four test sequences are used in this paper as shown in Fig. 6. The subjective evaluation result of different block size is shown in Fig. 7. The subjective evaluation was performed by 30 persons. Scores from 1 to 5 points are given according to three evaluation terms which are senses of stereo, reality, and comfortability. A higher score means a better visual quality. Block size 4 and 8 have better visual quality. Tradeoff between computation and quality, we select block size 8 for block-based motion estimation. The depth maps and red-cyan images are shown in Fig. 8.

IV. Conclusion

This paper presents an automatic and robust 2D-to-3D conversion system. The proposed system combines two major depth generation modules, the depth from motion parallax and depth from geometrical perspective. A block-based algorithm is applied and cooperates with the bilateral filter to generate comfortable depth map. The proposed method is a hardware-oriented algorithm and is suitable for VLSI design.

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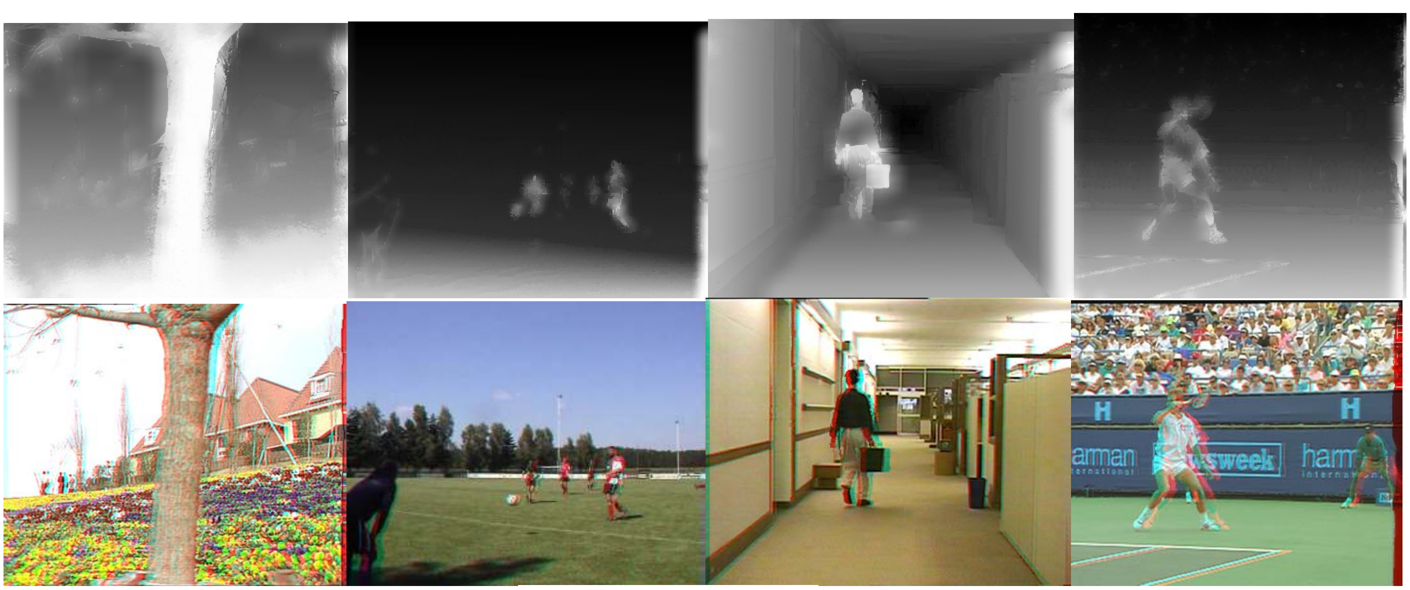

Fig. 8. Experimental result of flower/ fussball/ hall_monitor/stefan sequence