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A Study of Generating Depth map for 3D Space Structure Recovery

Kyeong Jin Ban†, Jong Chan Kim††, Eung Kon Kim†††, Kim Cheeyong††††

ABSTRACT

In virtual reality, there are increasing qualitative development in service technologies for realtime interaction system development, 3- dimensional contents, 3D TV and augment reality services. These services experience difficulties to generate depth value that is essential to recover 3D space to form solidity on existing contents. Hence, research for the generation of effective depth-map using 2D is necessary. This thesis will describe a shortcoming of an existing depth-map generation for the recovery of 3D space using 2D image and will propose an enhanced depth-map generation algorithm that complements a shortcoming of existing algorithms and utilizes the definition of depth direction based on the vanishing point within image.

Key words: line, Edge extraction, Depth-map

1. INTRODUCTION

The development of computer graphics has shown the most brilliant advancement than any other areas in computer industry. Its effect has caused a huge change on information delivery methods and cultural assets. The demands for multimedia data with more improved solidity are higher than ever before. Specifically, as the interests in visualization and communication methods on the Internet and the needs of realtime interaction services for the communication in virtual space increase, technologies for computer vision are proposed as solutions for these demands[1].

One key issue in computer vision area is the acquirement of 3D information of real world. When 3D information projects to 2D image, the depth information of 3D information is lost. However, as applied areas such as bio engineering, computer science and medical engineering develops applied technologies using depth information, the importance of vanished depth information recovery is being increased. As the interests in visualization and communication methods and the services for realtime interaction system, 3D contents and augment reality technology increase, the thesis introduces an enhanced depth-map generation algorithm that extracts a valid vanishing point from monocular image to generate depth value for the recovery of 3D space for its solidity on 2D content and use the point to improve the accuracy of depth-map based on the vanishing point extraction.

2. DEPTH RECOGNITION ELEMENT AND MATCHING ALGORITHM

2.1 Depth recognition element

To create 3D image, it is essential to understand

※ Corresponding Author : Kim Cheeyong, Address : (614-714) Eomgwang-no, Jin, Busan, Dept. of Visual Infor. Eng., Dong-Eui University, TEL : +82-51-890-2270, FAX : +82-51-890-2265, E-mail : kimchee@deu.ac.kr
Receipt date : Dec. 10, 2010, Revision date : Dec. 28, 2010
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†††† Department of Computer Science, Sunchon University Jeonnam, Korea
(multwave@sunchon.ac.kr)
†††† Department of Computer Science, Sunchon University Jeonnam, Korea
(kjc7026@gmail.com)
†††† Department of Computer Science, Sunchon University Jeonnam, Korea
(kek@sunchon.ac.kr)
†††† Department of Visual Information Engineering, Dong-Eui University Busan, Korea

a human depth recognition element. Perception process that determines size, distance or depth of an object utilizes various clues. These clues are categorized as monocular clue and binocular clue. Monocular clue is a case to utilize information that is from one eye as one clue and binocular clue is a case to utilize information that is from both eyes and is combined as one clue.

Monocular clues that affect depth recognition are overlap, linear perspective, Atmospheric perspective, density change of quality and shadow. Other monocular clues that are important to depth recognition are motion parallax and accommodation. Overlap is to perceive when one object covers a part of another object, the object is perceived as being in the front of the other. Linear perspective is to perceive two parallel edges of a road being converged to one point by becoming narrow. Atmospheric perspective is to perceive an object to be blur and unclear if it is at some distance and height of shape is to perceive an object as if it looks far away when the object is below the viewpoint and vice versa when the object is above the viewpoint. Shadow has an effect to make an object look solidified. Motion parallax which is a powerful depth clue is to perceive the speed of an object's movement as if the speed of an object is moving faster with an inverse proportion between the observer and the distance.

2.2 Matching algorithm

In computer vision, there are many ways to measure the distance and one method which estimates time difference between right and left images that calculate the distance information has been renowned as easy to use. However, this type of stereo adjustment is difficult to extract accurate and reliable disparity map[2-3]. Depth information in image industry is the distance from the observation point to the object and if real world information will be presented in 2D image, the depth information will be lost. As depth information-based applied technologies such as bio engineering, computer science and medical engineering researches are prevalent in daily life, recovery of vanished depth information becomes a key issue. [Fig 1] shows an example of applying depth information recovery to image data.

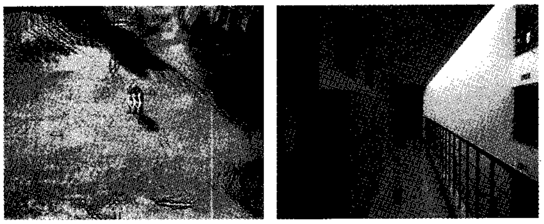

Fig. 1. An example of practice : 3D image using depth information.

2.2.1 Stereo image model

Imitating distance recognition capability of human vision system, Stereo image model is a method to calculate disparity, the distance between each corresponding point of two images that are from different view points.

General process to acquire distance information from stereo image by camera is shown in [Fig 2]. Acquired image will take a process for deleting errors and noises from camera lens then will be transferred to extraction process for features of adjustment. From these processes, it conducts image adjustment. For disparity from image adjustment process has various errors, it takes substantial 3D distance information by post process [6,7].

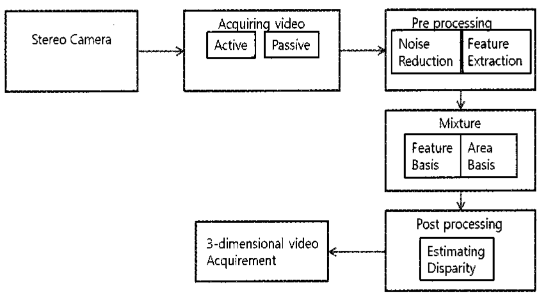

Fig. 2. General processes of 3D image adjustment.

Difficulties on stereo adjustment process are feature abstraction process, mutation and conjunction process of features for adjustment, similarity estimation process of restructured features, establishment of search range for adjustment and post process for relaxation after adjustment.

2.2.2 3D laser model and monocular image model

3D laser model is a method using 3D digitizer that it directly acquires 3D information of real object using laser equipment. After reducing 3D information to appropriate size, it generates a model by triangulation method.

In monocular image model, a real world point U(X,Y,X) is reflected to a point u(x,y) in image. The point U in reflected image again become reflected to u'(x', y') according to the movement of camera. At this moment, it estimates depth information from geometric structure of two points, u and u'[3]. [Fig 3] illustrates geometric structure for 3D structure recovery in monocular image model[11,13,14].

The merit of this monocular image model is to create model only using one input image sequence when it extracts depth information from the acquired image by single camera. From input image, it generates 3D model by estimating depth from brightness information or from geometric structure. Current TV or movie contents are monocular image. If it extracts depth information from this monocular image as an input, it enables application of the depth information to those areas that apply solid image as it can recover 2D image to

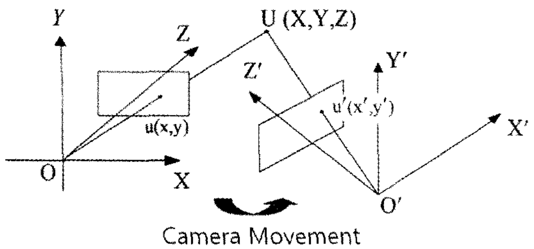

Fig. 3. Monocular image model.

3D one with a short time. Geometric relation among continuous frames in monocular image sequence is the same as non-parallel axis stereo geometry.

3. DEPTH GENERATION USING VANISHING POINT

Perceiving depth in indoors or in outdoors with artificial structure utilizes vanishing point, a powerful depth recognition clue. Vanishing point corresponds to the point at the farthest distance. Human estimates vanishing point using geometric components that monocular image possesses and it can conduct relative depth recognition based on the location of vanishing point and viewpoint of the observer. Vanishing point is one of depth clues that are used to recover 3D space structure from 2D image.

Parallel straight lines in 3D space becomes narrow as they have more distance in perspective image of 2D then meet each other at the end point. This end point is called as vanishing point and the lines that meet at the vanishing point are called as vanishing lines. In images for indoor structure such as floor and room and images for outdoors that include building and road, vanishing point is a very strong depth clue. Gaussian sphere method is proposed for extraction of vanishing point using straight lines[4,5,8,10,15].

Depth map is a map that demonstrates the difference of 3D distance among objects in a image. It is presented as a value from 0 to 255 in each pixel and it represents farther when the value becomes close to lower value(black). As vanishing point is located on the horizon in general, it represents the farthest point based on the lower face of image. Therefore, it is possible to estimate relative depth using vanishing point. In case when vanishing point is present within image, it illustrates depth step by step toward right/left direction and upper/bottom direction from the vanishing point. However, this method should consider different formula for calculating depth based on the location of vanishing point within image.

4. DEPTH-MAP GENERATION ALGORITHM

In this thesis, we introduce an enhanced depth-map generation method that improves mutual immersion based on object augmentation by estimating relative depth information of objects using geometric features that 2-dimensional monocular image.

A representative method of estimating depth using geometric feature is one that utilizes vanishing point. Again, it requires different formula for depth calculation based on the location of vanishing point. This paper proposes an enhanced depth-map generation algorithm based on the location of vanishing point within a image. Our proposed algorithm applies median filter to remove noise in image before extraction of edges. It traces edges on noise removed image using Canny edge extraction method and vanishing lines through Hough conversion and designates vanishing point by gathering intersection points of vanishing lines. As depth-map values should be differentiated based on the location of vanishing point within image, we defined corresponding range of the location of vanishing point toward between image and vanishing point. From the defined range of vanishing point location, it generates standard depth-map to the range and creates proposed depth-map algorithm by linear interpolation adjacent vanishing lines.

[Fig 4] is a diagram for proposed depth-map generation algorithm. Edge extraction, first step of the algorithm, is a pre-step for input image that it reduces noise by median filter then extracts geometric feature by applying Canny edge. In vanishing lines and vanishing point generation, second step of the algorithm, it extracts straight lines by applying Hough conversion, calculates lines' intersections and estimates the location of vanishing point thru defined range of vanishing point location. In vanishing point location calculation and depth-map generation, final step of the algorithm, it calculates the location of vanishing point by the range of vanishing point location, sets the steps of depth and generates depth-map based on the location of vanishing point.

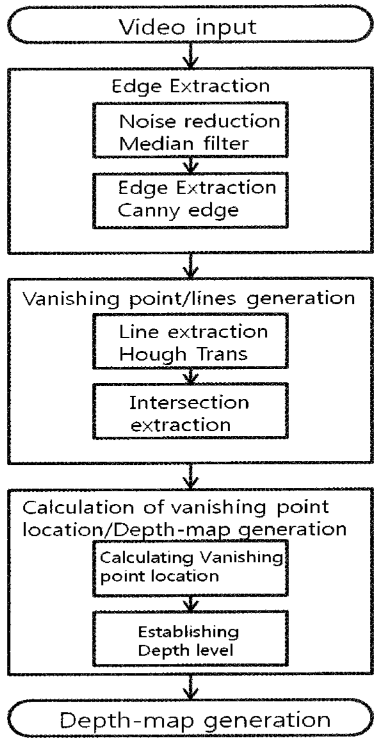

Fig. 4. Diagram for proposed depth-map generation method.

Depth-map generation algorithm is as below.

① Based on the vanishing point, setup the farthest place among the outer borderline of image as the standard dimension.

② For the standard dimension, setup the brightness value of the vanishing point as 0 and the value of the border line as 255.

③ generate depth level of the standard dimension by linear interpolation between vanishing point and the borderlines.

④ create depth-map by conforming the depth value which is adjacent to the standard dimension with depth level to the depth level.

[Fig 5] shows entire processes of depth-map generation from the original image which is gathered by proposed depth-map generation algorithm.

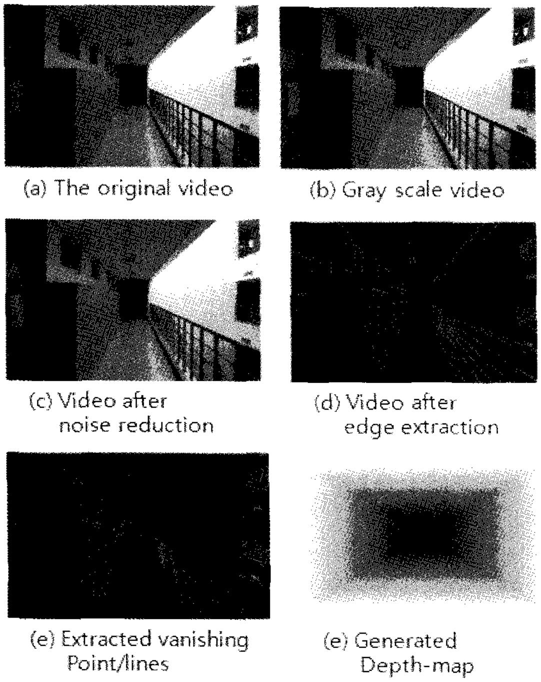

Fig. 5. Depth-map generation processes.

5. ESTABLISHING DEPTH-MAP STANDARD BASED ON THE LOCATION OF VANISHING LINES

As vanishing point is the point that extension of straight lines meet each other, it indicates the farthest point from the location of camera to 3D direction while the points located in edges of image illustrate the closest distance. Therefore, the distance from vanishing point to the outer borderline can present relative depth within image. Based on image, there are cases that need to set different depth value on the outer borderline. [Fig. 6] demonstrates generation of the relation of locations between vanishing points.

With the perspective described above, this paper defines the depth standard direction in regard to the location range of vanishing point within image

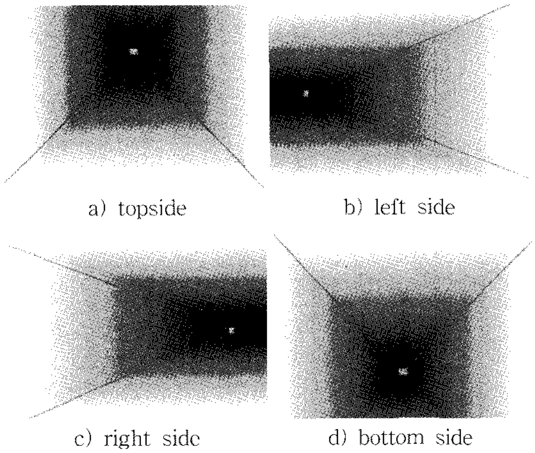

Fig. 6. Generation of the relation of locations between vanishing points.

for the presentation of depth-map that is related to the location of vanishing point. Let's assume that (X_{VP}, Y_{VP}) is the vanishing point and that H and W presents height and width of image. The location range of vanishing point and the depth that correspond to the relation between image and vanishing point are shown in [Table 1].

Table 1. Establishing depth-map standard according to the location of vanishing point

left side
▪ $0 < X_{VP} < W/2$
▪ $0 < Y_{VP} < W - X_{VP}$
▪ *right* ⇒ *left*
right side
▪ $W/2 < X_{VP} < W$
▪ $0 < Y_{VP} < X_{VP}$
▪ *left* ⇒ *right*
topside
▪ $0 < X_{VP} < H - Y_{VP}$
▪ $0 < Y_{VP} < H/2$
▪ *bottom* ⇒ *top*
bottom side
▪ $0 < X_{VP} < Y_{VP}$
▪ $H/2 < Y_{VP} < H$
▪ *top* ⇒ *bottom*
(X_{VP}, Y_{VP}) = Vanishing point coordinates
H is the height of video
W is the width of video

5.1 processing steps of each process

The input image is converted to gray scale image before edge extraction executes and noise reduction for the input image is conducted in pre-process using median filter. The image after pre-process will go to Canny edge extraction step. edge points from Canny edge extraction will trace lines by Hough conversion. Among the traced lines, those whose slope is close to perpendicular or horizontal are excluded. In general, vanishing point on indoor space is stopped when it meets the front wall. In the line extraction process, this feature looks as if vanishing line is cut at the point where the line meets the wall. Therefore, it is impossible to create intersection to generate vanishing point. To solve this, it is required to extend the lines. Based on the standard point, it estimates vanishing point and generates depth-map using our proposed depth generation algorithm according to the location of estimated vanishing point. [Fig 7] and [Fig 8] is the creation of depth-map for a image whose vanishing points are present at right and left side of the indoor image using the proposed depth-map generation algorithm. With the generation of depth-map using proposed depth-map generation algorithm which creates depth-map based on defined depth direction in relation to the location of vanishing point within image, we confirm that the proposed algorithm created accurate depth-map compared to the original image.

[Fig 9] is the comparison of outdoor images.

Fig. 7. Proposed Depth-map : in case of vanishing point located in the right place on the image(indoor).

Fig. 8. Proposed Depth-map : in case of vanishing point located in the left place on the image(indoor).

Fig. 9. Proposed Depth-map : in case of vanishing point located in the right place on the image(outdoor).

outdoor image is hard to conduct line element extraction based on the proportion of artificial structures in the image and on the environment of the image. Specifically, natural structures such as trees are hard to extract line element from them. Although it can reduce unnecessary edges through controlling edge extraction critical point for noise reduction that can occur during the process of line extraction, quality of the extracted line elements from artificial structure also decreases. As such, a outdoor image which has too much noise from natural lighting or natural structures is hard to create depth-map.

6. CONCLUSION

Recently, the mixture of various media causes the demand for a more solid multimedia data. It also causes advanced technologies for multimedia data which mix the existing data to text, audio and image that become the core of media industry as a result. Specifically, services for visualization and communication methods on the Internet, realtime interaction system, 3D content and augment reality are highly demanded. However, they services are in difficulties on generating depth value that is required for the recovery of 3D space structure to conform solidity within existing content. Therefore, researches for the generation of depth-map using 2D image are imperative.

This thesis complements a shortcoming of an existing depth-map generation algorithm that is required to recover 3D space structure from 2D image and proposes an enhanced depth-map generation algorithm that defines depth direction based on vanishing point within image. Proposed depth-map generation algorithm takes three steps to create depth-map for 2D image; edge extraction for the recovery of indoor space, vanishing lines or vanishing point generation and calculation of vanishing point location or depth-map generation. In edge extraction for the recovery of indoor space, it creates basic data for vanishing point extraction using noise reduction and Canny edge extraction algorithm. In vanishing lines or vanishing point generation, it removes line elements that are close to horizontal and vertical among the lines from edge extraction and extracts representative vanishing lines and vanishing point of each line. In calculation of vanishing point location or depth-map generation, it defines depth direction according to the location of vanishing point and establishes depth level and creates depth-map thru vanishing point location calculation by the defined depth direction.

Our future research is to develop an algorithm to apply to outdoor image and apply it to high-quality 3D content development.

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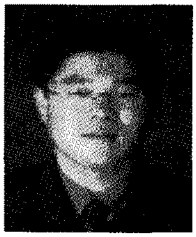

Kyeong-Jin Ban

He received his B.S. degree from Sunchon National University in 2003, his M.S degree from department of computer science, Sunchon National University in 2005, his Ph.D degree from department of computer science, Sunchon National University in 2010.
His current research interests are computer graphics, image processing, HCI, VR and AR.

Jong-Chan Kim

He received his B.S. degree from Sunchon National University in 2000, his M.S degree from depart-ment of computer science, Sunchon National University in 2002, his Ph.D. degree from department of computer science, Sunchon National University in 2007.
His current research interests are image processing, computer graphics, AR, games and HCI.

Eung-Kon Kim

He received B.E. degree Cho-sun University in 1980, his M.E. degree from depar-tment of computer engineering, Hanyang University in 1986, his Ph.D degree form depart-ment of computer engineering, Chosun University in 1994, In 2010, he joined department of computer science, the Sunchon National University, where he is a professor.
His current research interests are image processing, AR, computer graphics, multimedia and HCI.

Kim Cheeyong

Received his MS and PhD degrees in Computational Physics from Inje University, Republic of Korea, in 2000. He worked at Inje University, Busan College from 1991~2002 and at Dongseo University from 2003-2005. In 2006, he joined the DONG-EUI University, where he is an associate professor.
His research interests are in 3D Character Animation, Multimedia Design and VR, Web 3D Contents Design, Fractal & Chaos Design, & Conceptual Design.