An Improvement of Motion Estimation on Sequential Fisheye Images

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1. Introduction

Applying motion estimation technique directly on sequential fisheye images still become a challenging to be implemented. Because of the distortion characteristic of the fisheye lens, the movement of objects captured by the camera seems to be displayed inconsistent. Additionally, shapes of the objects also deform freely while they are moving throughout the fisheye domain. This condition causes the implementation of former motion estimation concepts must be modified.

In this research, enhancing the performance of motion estimation on a sequential fisheye image is proposed by extending the calculation of Lucas and Kanade's optical flow concept (LK).

2. Proposed Method

Firstly, the motion estimation that occurs between each two successive images is calculated by using original LK. This first calculation produces vector flows that can be used for reconstructing the second image. The term of the second image means that in the forward motion estimation the vectors are defined to flow from first image to the second image for each calculation upon two successive images. The reconstruction image then can be used to evaluate the performance of the motion estimation by calculating PSNR (peak-to-peak signal to noise ratio) between the second image and the reconstructed one. This method is very useful for obtaining the performance since it is difficult to find a suitable ground truth for a sequential image captured by a fisheye camera.

Due to an assumption used to define the brightness constancy constraint of the optical flow approximation through Tylor series and in the fact that the optical flow basically is interfered by complex illumination, the motion vectors, which are obtained in the first calculation, will not too satisfying, especially when the object move larger than one pixel [1,2,3]. In the case of images taken from fisheye camera, this situation occurs more significant since the movement of an object seems to be slower at the peripheral areas of fisheye domain and it became faster at the central. Therefore, the first calculation of optical flow gives a better performance (PSNR) at the peripheral site, while this becomes worst at around the central area.

To increase the performance, the calculation of motion estimation can be done several times until the number of PSNR reaches a maximum. Therefore, after the first optical flow calculation and obtaining the first PSNR calculation, the first reconstructed image is used with the second image for calculating optical flow in the second time and building the second reconstructed image for calculating the second PSNR calculation. If the PSNR increases, then the third optical flow calculation applies by involving the second reconstructed image with the second image. The same calculation process will continue until the last PSNR calculation remain the same. The final motion vectors are an accumulation of motion vectors obtained from each motion estimation calculation process. The mechanism is basically similar to the idea of Lucas and Kanade interim of image registration, but in this case the number of PSNR obtained from comparing the reconstructed image with the second image in each calculation became a constraint. Table 1, shows the algorithm of the proposed method. We develop this algorithm based on Matlab [4].

Table 1. Experimental Algorithm

Algorithm for motion estimation calculation and the performance evaluation
Input: 126 one side of fish-eye images
Output: reconstructed image, vector flows (u & v), motion compensated, & PSNR
1: ***for*** *each two successive images,* ***do***
2: $im1_{st}$ & $im2_{nd}$ ← convert the two images to grayscale
3: $im1_{st}$ & $im2_{nd}$ ← smooth the two grayscales images
4: u & v ← calculating vector flows
5: im1R ← $im1_{st}$ moved by u & v
6: im_prediction ← subtract $im2_{nd}$ with im1R
7: PSNR ←10 log_{10} im_prediction
8: $im1_{st}$ ← im1R
9: Do 2 to 7
10: if the new PSNR < previous PSNR Do 2 to 9
11: else end
12: ***end for***
13: ***return***

In the above image reconstruction phase, image transformation mechanism is applied. This means that the original image (the first image) is transformed to the prediction image by using motion vectors as a transformation parameter. Since the process of transformation remains blank pixels or there are arrival pixels on non-integer pixel areas, the bilinear interpolation process is applied to solve these problems.

The proposed method is compared by other method that use motion model, such as Affine and Dioptric motion models.

3. Results

In this research, one side fisheye camera (Ricoh Theta S) is used to capture a single moving object [5]. This object is a hand moving from the left to right side of fisheye image display. The video consists of sequential 126 images with resolution of 640x640 pixels including black area outside the fisheye domain.

It can be seen from Fig. 1, our method (multiple) reaches a maximum of PSNR at around 51 dB and a minimum at around 36 dB. These numbers are better around 6 to 13 dB than we use Dioptric motion model. Our method also leads by around 7 to 15 dB to affine motion model. In addition, there is a gain around 10 to 15 dB when we compare our method with the original LK.

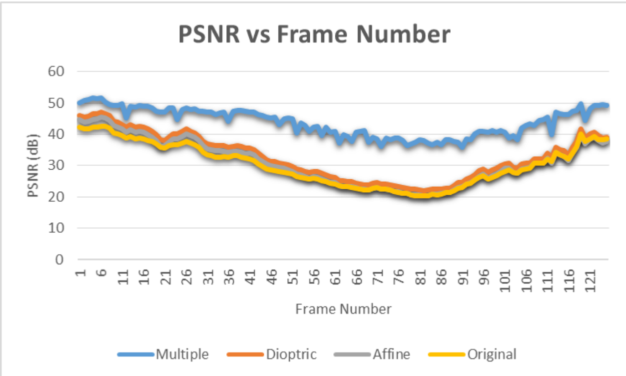
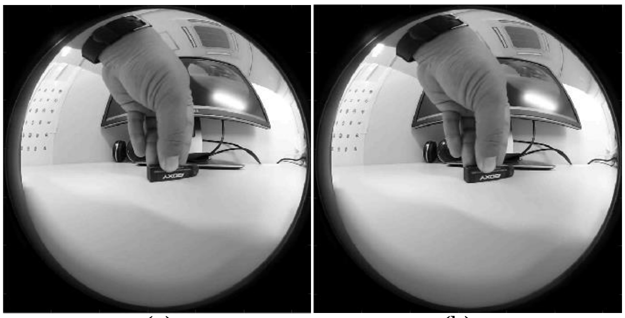
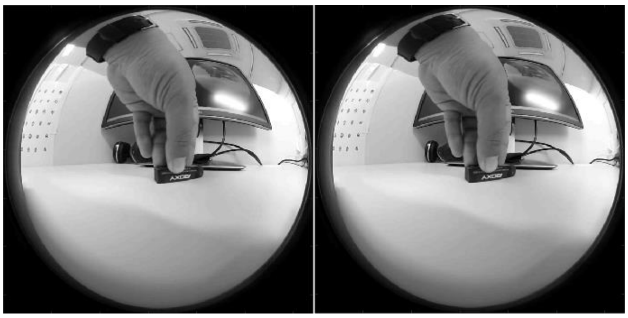


Fig. 1 PSNR for Every Pair Image



(a) (b)



(a) (b)

Fig. 2 (a) is the first image, (b) is the second image, (c) is the first reconstructed image, and (d) is the final reconstructed image.

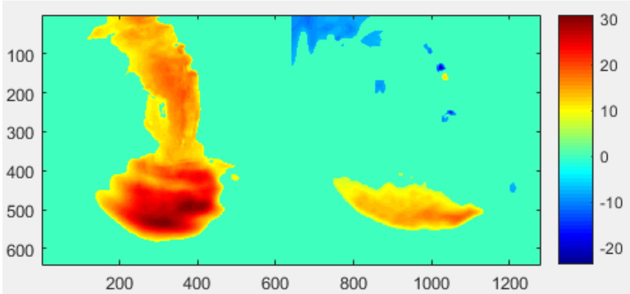


Fig. 3 The optical flow result for horizontal vectors (left) and vertical vectors (right)

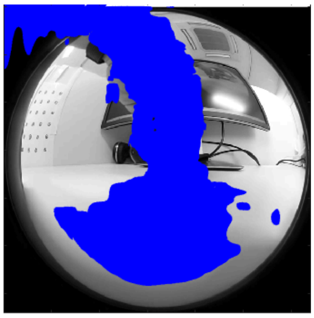


Fig. 4 The optical flow result

Visual performance of this experiment can be seen from Fig 2. While (a) and (b) show the first and second images, (c) and (d) show there is improvement in the performance of reconstructed image from the first calculation to the final calculation.

On the other hand, it can be seen from Fig. 3 and 4, which most of motion vectors occurs around the moving object.

4. Conclusion

Enhancing the performance of motion estimation on sequential fisheye image can be done very well by extending the calculation of LK's optical flow. Each calculation process will evaluate the PSNR number obtained from comparing the reconstructed image with the second image. By using this approach, the PSNR is about 15 dB better than using only original LK's approach.

5. References

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