# 스티칭 영상의 객관적 영상화질의 평가 방법

*미어 사데크 빌라흐, *타이 탄 투안 *안희준
*서울과학기술대학교, 전기정보공학과
{meer, thaithanhtuan, heejune}@seoultech.ac.kr

# Objective Quality Assessment for Stitched Image and Video

*Meer Sadeq Billah, *Thai Thanh Tuan, *Heejune Ahn
*Dept. Electrical and Information Eng. Seoul National Univ. of Science and Technology

## 요 약

Recently, stitching techniques are used for obtaining wide FOV, e.g., panorama contents, from normal cameras. Despite many proposed algorithms, the no objective quality evaluation method is developed, so the comparison of algorithms are performed only in subjective way. The paper proposes a 'Delaunay-triangulation based objective assessment method' for evaluating the geometric and photometric distortions of stitched or warped images. The reference and target images are segmented by Delaunay-triangulation based on matched points between two images, the average Euclidian distance is used for geometric distortion measure, and the average or histogram of PSNR for photometric measure. We shows preliminary results with several test images and stitching methods for demonstrate the benefits and application.

## 1. Introduction

Wide FOV (Field of View) contents are becoming more and more popular these days with the advancement and availability of capturing devices. To capture the landscapes people now tend to use the panorama mode feature on smartphone or digital cameras. These wide imageries are stitched from multiple or continuous snapshots with the help of image stitching methodologies.

Image stitching [1] is done at hardware level in the omni view cameras available to the consumers having multiple wide-angle fish-eye lenses or rotating pods. Post-processing on the captured images are required if multi-camera rigs are used in lieu. Both the Direct and Feature-based image stitching methodologies are well studied in the academia so far and several methods are widely used in the available solutions. There are existing proprietary and open-source software suites like Autostitch, Hugin, Panorama Maker, Ptgui, Panorama Tools, Microsoft Research Image Composite Editor and CleVR Stitcher etc. Despite its commercial success and acceptance in users, the stitched images usually suffer in quality degradations due to the parallax problem, imperfect seam selections, and color/illumination mismatches, and needs further research efforts.

Despite many algorithm proposals [1, 2], the quality evaluation method remains in primitive or subjective stages. The study of Qureshi et al. is only published work to our knowledge. Their work state the geometric and photometric quality based on frequency separation, but could not properly handle structural and photometric distortion. And they compared the stitched with pre-stitched images, not with the ground truth one. This paper proposes a Delaunay triangulation based method for evaluating the geometric and photometric distortions of stitched or warped images.

## 2. The proposed assessment method

The reference and target image are segmented by Delaunay-triangulation based on matched points between two images, and the average Euclidian distance is used for geometric distortion measure, and the average or histogram of PSNR (Peak Signal to Noise Ratio) for photometric measure.

### 2.1 Delaunay triangulation image matching

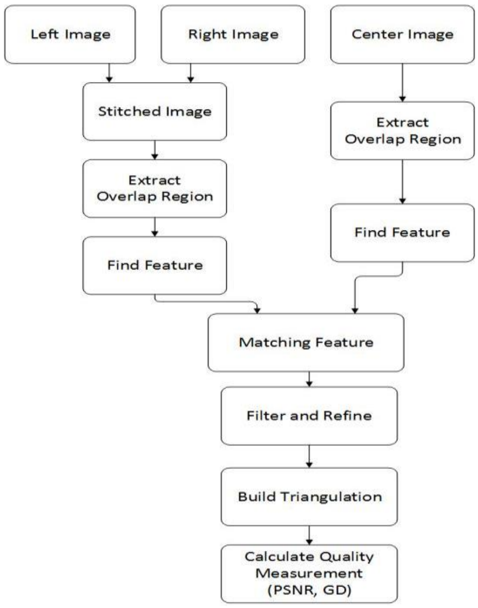
Our method uses another warped image as ground truth image for comparison with stitched one. In the following example, we restrict to three (3) images (left, center and right), but it can be extended easily to any number of image inputs. In Fig. 1, we consider the center image as reference image and stitch the left and right ones. Notice that we apply the corresponding warping to the center image too, so that the all the 3 images are placed in same camera space.

The interest points of both stitched and reference image are extracted and matched. The matching performance is crucial for the performance. To restrict the granularity of triangle and cover all image region without overlaps, we restrict the interested points for triangulation with the following rules.

1) Two matching pairs, $\{(x_r[i], y_r[i]), (x_r[j], y_r[j])\}$ and $\{(x_s[i], y_s[i]), (x_s[j], y_s[j])\}$ should be in ordered. i.e., $(x_r[i] - x_r[j]) * (x_s[i] - x_s[j]) > 0$ and $(y_r[i] - y_r[j]) * (y_s[i] - y_s[j]) > 0$.

2) Choose the strongest and highly matched one for a given rectangle area $< \{(x_1[n], y_1[n]), (x_2[n], y_n[n])\} >$

Interest points or Features are primarily gathered using Rosten and Drumonds' FAST (Features from Accelerated Segment Test) Key Point Detection algorithm on both the images. To extract the descriptors of the interest points, ORB (Oriented FAST and Rotated BRIEF) algorithm proposed by Rublee E. et al. is used considering the good performance and low computation cost. K-Nearest Neighbor method is found to be most suitable for matching the interest points that is sensitive to the local structure of the data. To further reduce the matching points to avoid overlapping triangles and preserve Delaunay triangles property, we subdivided the image area into equal sized grids and persisted only one pair of matching points based on correlations in one block.




<Fig.1> The Workflow of proposed quality assessment

## 2.2 Performance measures

The average Euclidian distance is used for geometric distortion measure, and the average or local PSNR for photometric measure.

The geometrical distortion is defined by

$$G.D. = avg(|(x_r[i], y_r[i]) - (x_s[j], y_s[j])|) \quad (1)$$

The PSNR for each segment is calculated using well-known PSNR calculation after Affine warping from stitched image. We use this local PSNR values and average PSNR over whole triangulated area. For averaging the PSNR, we give a weighting factor to size of areas in reference images. So average PSNR of segmentations is defined as follows:

$$PSNR(i) = PSNR(AffineT(Stitched) - Reference) \quad (2)$$

$$avg(PSNR) = sum(PSNR(i) * area(i))/sum(area(i)) \quad (3)$$

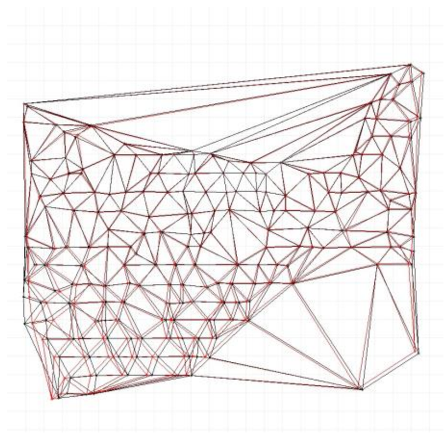
## 3. Use cases and Experiments

We present only the representative and motivation results here. Full experiments will be published elsewhere. We have prepared the following input image sets as shown in Fig 2 for the experiment sourced from the test images provided in reference academic websites.

| | | |
|---|---|---|
| Test Set1 |  |  |
| Test Set2 |  |  |
| Test Set 3 |  |  |

<Fig. 2> Test image sets (reference center and stitched)

For this preliminary study we used Brown & Lowe's auto stitching method [4] implemented in OpenCV only, but will include other methods for comparison. Fig 3 shows an example of set 1, the matched triangles between reference (center) and stitched image. The black triangles are created from the reference points and the red triangles represent the corresponding triangles in the stitched image.



<Fig. 3> Triangle matches examples between stitched (red)

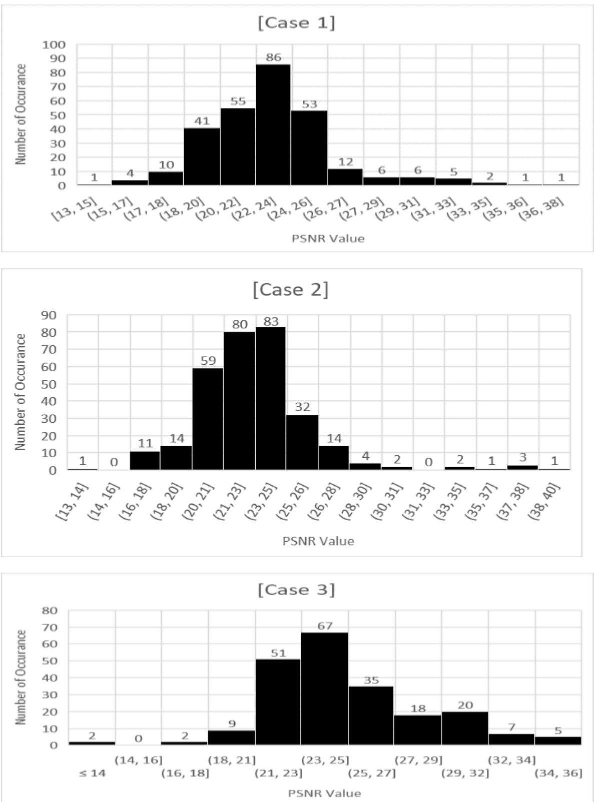
and reference (black) image.

The average G. D and average PSNR is shown in Table 1, We compare the ground truth/manual triangular segmentation with our automatic/programmed one. The accuracy of programmed segmentation and matching is over 90% for all 3 test sets. For the purpose of obtaining the PSNR values, the accuracy is considered good enough, but needs improvements in the future.

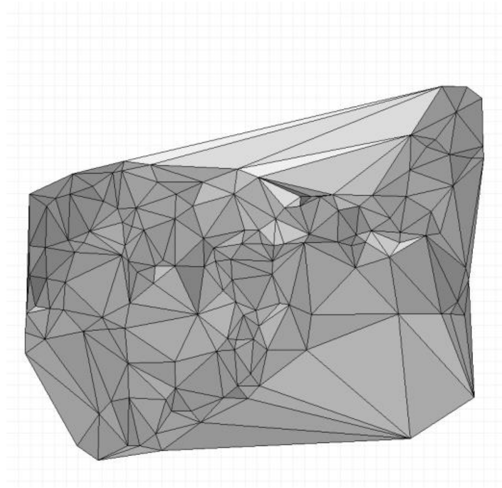
<Table 1> The performance values using the proposed assessment method

| *Test set* | *Avg G.D. (programmed) in pixels* | *Avg. G.D. (Grnd.Truth) in pixels* | *Programmatic Accuracy (%)* | *Avg.PSNR* |
|---|---|---|---|---|
| Set 1 | 3.9059 | 3.8073 | 96.15% | 24.35 |
| Set 2 | 2.5144 | 2.4176 | 97.48% | 22.79 |
| Set 3 | 0.9774 | 0.8817 | 90.21% | 25.54 |

Using our performance measure, one can examine the details of quality also. The sub-triangle PSNR histogram is in Fig. 5, and The PSNR map Fig. 6 shows the regional stitching quality performance: the darker shades refer to lower PSNR and lightens when the PSNR goes higher. One can identify and localize the regions of low stitching and warping quality. Especially, one can differentiate the main origin of low quality: from geometric transform mismatches for examples due to the parallax and photometric, e.g. color or illumination mismatches. With the histogram and maps we could understand the origin of low quality and devise solutions for them.




<Fig. 5> The sub-triangle PSNR histograms for test sets



<Fig. 6> PSNR maps for test set 1

## 4. Discussion and Conclusion

Objective quality measurement is important tools in signal and image processing technology in that without that the evaluations and strength and weakness comparison of proposed techniques. The proposed and developed triangular matching and comparison technique was applied to image stitching performance measurement. The experiment results is now limited to only single stitching algorithm, but we are working towards the comparison study with other state-art techniques.

## Acknowledgement

본 연구는 과학기술정보통신부, 정보통신기술진흥센터, 방송통신산업기술개발사업의 지원을 받았음. (시청자 이동형 자유시점 360VR 실감미디어 제공을 위한 시스템 설계 및 기반기술 연구(2016-0-00144).

## Reference

[1] Ghosh, D., & Kaabouch, N. (2016). A survey on image mosaicing techniques. Journal of Visual Communication and Image Representation, 34, 1-11.

[2] Szeliski, R. (2006). Image alignment and stitching: A tutorial. Foundations and Trends® in Computer Graphics and Vision, 2(1), 1-104.

[3] Qureshi, H. S., Khan, M. M., Hafiz, R., Cho, Y., & Cha, J. (2012). Quantitative quality assessment of stitched panoramic images. IET Image Processing, 6(9), 1348-1358.

[4] Brown, M., & Lowe, D. G. (2007). Automatic panoramic image stitching using invariant features. International journal of computer vision, 74(1), 59-73.