3D Visualization of Aurora from Optional Viewpoint at Optional Time

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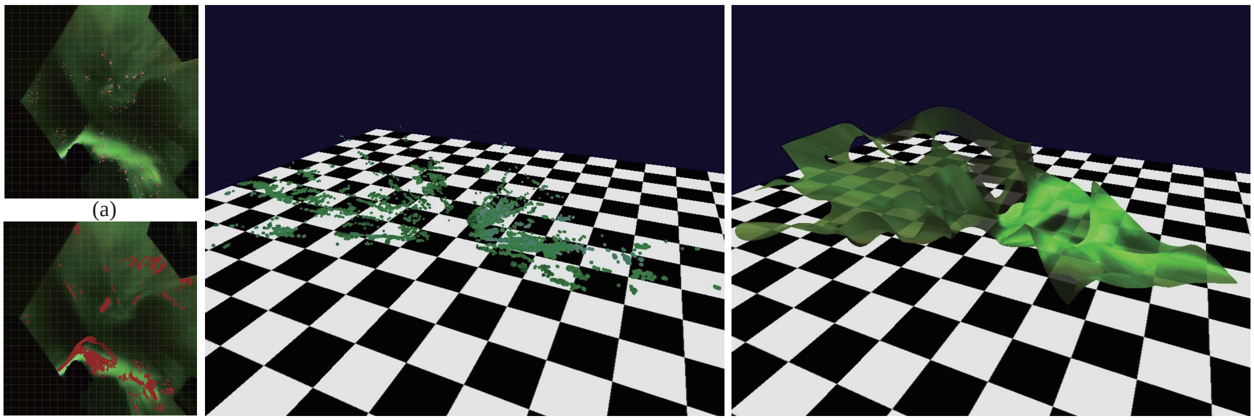

Figure 1: *Aurora 3D measurement and visualization. (a): Detected corresponding points by the previous method* [Fujii *et al.* 2014]. *(b): Detected corresponding points by the proposed method after eliminating unreliable points by tracking feature points. (c): Aurora 3D visualization result by putting the detected points on 3D space. (d): Aurora 3D visualization result by using NURBS surface.*

1 Introduction

Three-dimensional analysis of the aurora is significant because the shape of aurora depends on solar wind which influences electric equipment such as satellites. Our research group set two fish-eye cameras in Alaska, U.S.A and reconstructed the Aurora's shape from a pair of stereo images [Fujii *et al.* 2014]. However, the method using the feature-based matching cannot detect dense enough feature points accurately since they are hard to detect from the aurora image whose most parts are with low contrast. In this paper, we achieved both increasing the detected feature points and improving accuracy. Applying this method, the 3D shape of aurora from optional view point at optional time can be visualized.

2 Approach and Implementation

In Alaska, two fish-eye cameras were installed at the distance of about 8.1 km to get a vision disparity. First, the images captured by the cameras are converted so as to be treated as a parallel stereo image by using GPS information and a star map.
Second, to obtain dense corresponding points from a pair of aurora images, template matching that evaluates the texture pattern similarity between the areas is used because aurora images don't have clear feature due to its transparency and nonrigidity. Next, to improve the accuracy of the matching, the reliability of the corresponding points is investigated by tracking them toward the next frame image. The tracked points must be associated with the corresponding tracked points as the same points by template matching again. If the points are not associated with each other, the corresponding points are eliminated as the unreliable points. The results of feature points detection of a previous feature-based method using SIFT [Fujii *et al.* 2014] and this proposed method are shown in Figure 1-(a), Figure 1-(b). The figures show that by proposed method the number of the detected points in one frame increased largely in comparison with the previous method. On 4 frames average, 28,651 points were detected in the proposed method and 1,169 points are in the previous method. Furthermore the ratio of the accurate correspondence of the feature points also increased drastically. In a certain range of the aurora image, 87.2% of the detected points (1,419 of 1,619 points) were accurate in the proposed method, and 21.8% (21 of 96 points) were in the previous method.
Finally, the shape of the aurora was visualized. The three-dimensional positions were calculated based on corresponding points and fish-eye camera model. From Figure 1-(c), by putting the detected feature points on a 3D space, it was confirmed that the corresponding points were detected densely. By using NURBS surface fitting for the detected point group, aurora shape was visualized smoothly as shown from Figure 1-(d). Since a large number of feature points were detected accurately, this method can visualize the 3D shape of aurora from optional viewpoint at optional time.

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3 Conclusion and Future Work

In this paper, a methodology for accurate 3D measurement and visualization of aurora were proposed. By using this method, a large amount of feature points were detected with accuracy from a pair of aurora's images, and were visualized in 3D space. To analyze the shape of aurora more accurately, increase of the setting point of the camera is considered in future research.

Acknowledgements

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References

FUJII, H., KUBO, T., YAMASHITA, A., TAKEUCHI, A., TANAKA, M., KATAOKA, R., MIYOSHI, Y., OKUTOMI, M., AND ASAMA, H. 2014. Aurora 3D-Measurement and Visualization Using Fish-Eye Stereo Camera. In *Proceedings of ACM SIGGRAPH Asia 2014 Posters*, Article No.24.