Aurora 3D-Measurement and Visualization Using Fish-Eye Stereo Camera

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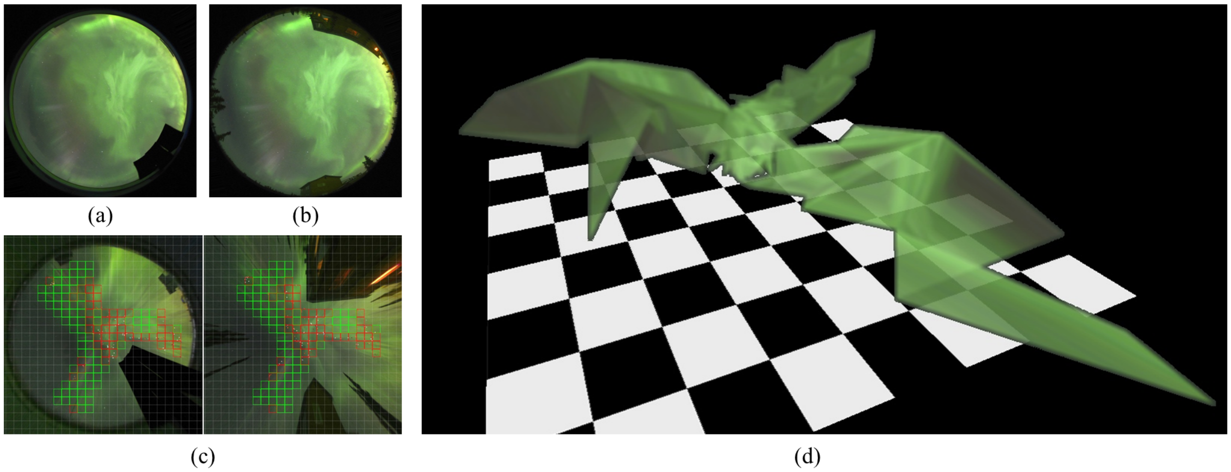

Figure 1: *Aurora 3D-measurement and visualization. (a), (b): Input images captured by fish-eye cameras whose distance from each other was about 8.1km in Alaska. (c): Undistortion and corresponding point extraction. Distortion of fish-eye image was corrected and aurora areas were detected (shown as areas with red and green). Characteristic areas shown with red were detected using variance of pixel values, and in the area corresponding points were extracted using SIFT. (d): Result of aurora visualization in 3D.*

1 Introduction

Three-dimensional analysis of the aurora which is an atmospheric phenomenon is significant because the shape of aurora reflects the electromagnetic relationship between the Earth and the Sun, which can influence electric equipments such as satellites. To analyze a number of auroras, our research group set two fish-eye cameras in Poker Flat Research Range (PFRR), Alaska [Kataoka et al. 2013]. However, shape reconstruction of aurora from a pair of stereo images is highly difficult problem because corresponding points are hard to detect automatically due to its transparency and nonrigidity. In this paper, a methodology of 3D-measurement of aurora and visualization of its shape from a pair of stereo images is proposed.

2 Approach and Implementation

Two fish-eye cameras were used to capture wide range of aurora, and these cameras were installed at the distance of about 8.1km to get a vision disparity. First, the images are transformed using stars location to treat both cameras as a parallel stereo system. Input images are shown in Figure 1-(a), (b).

Second, distortion of the fish-eye images is corrected based on its lens model (equisolid angle projection). This is because, in a parallel stereo image, corresponding points can be found efficiently by using epipolar geometry restriction. A pair of images is divided into rectangle areas which correspond in both images. The areas where green aurora exists are classified according to spatial variance of pixel values in the area. The larger variance indicates that feature points of the area can be detected with higher confidence. The areas of large variance are shown as the red rectangle in Figure 1-(c). In this research, corresponding points are detected by SIFT (Scale-Invariant Feature Transform), which is widely used due to robustness against change of illumination and local affine distortion. The three-dimensional positions are calculated based on corresponding points and fish-eye camera model. Because green auroras exist in the altitude from 50km to 200km [Kataoka et al. 2013], the points which are out of the range are eliminated as outliers.

Finally, the three-dimensional points are triangulated, and visualized in 3D space. A result is shown in Figure 1-(d). It became possible to get a overview of the spatial distribution of the aurora by visualizing in 3D space.

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3 Conclusion and Future Work

In this paper, a methodology for 3D-measurement and visualization of aurora were proposed. The feature points were detected from a pair of images captured by fish-eye cameras, and were visualized in 3D space. To analyze the transformation of aurora, several points must be considered in future research: increase of density of the corresponding points, and continuous-tracking of the feature points.

Acknowledgements

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References

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