Estimation of Stereo Image Pairs from using Single Camera View for A Rotating Spherical Object covered with Smoothly Varying Surface

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February 15, 1999

Keywords: stereo vision using single camera, stereo views from rotations, morphological processing, affine transform.

In the field of astronomy, there is a need for the method to get three-dimensional information of 'corona' from X-ray solar image taken by observation satellite 'Yohkoh' as a clue about studies of solar activity.

Two or more images taken from different view angles are necessary in stereo vision method. There are two way to obtain different view angles, the first way uses two or more fixed cameras, the other way uses a moving single camera or a fixing a single camera with the rotating object. 'Yohkoh' have a fixed single camera. we can obtain different view angles from the rotation of the sun. Stereo vision using a single camera has the advantage of no camera calibration, compared with the case which uses two or more cameras. However, in the case of changing texture like the sun's surface, the error caused by changing texture between stereo image pair and stereo image lose the stereoscopic effect.

In this paper, in order to display accurate stereoscopic images, we propose the method of correcting error between the image pairs which includes varying surface using morphological processing and affine transform. Then we apply the method to model images which are made by Computer Graphics (CG) to evaluate availability of the method. Finally, we apply the method to X-ray solar image taken by observation satellite 'Yohkoh'.

Modeling of deformation of textures on the surface of the sun

The true colors of textures deforming as time passed is X-ray which radiated from the outside layer of sun's atmosphere which is called a 'corona'. The shape of 'corona' changes

largely by the influence of the magnetic field inside of sun. Beside, we can observe the explosion phenomenon called 'flare' while active term of sun. This phenomenon is that the energy conserved in the magnetic field of the corona is discharged in a short time.

In order to correct the deformation of textures, we model the deformation. First of all, separating the deformation of appearance by rotation and the deformation of texture itself, then modeling the deformation of texture itself by a morphological processing and a affine transform.

About the deformation of texture itself, We assumed that the deformation is constituted a combination of three deformations, the parallel displacement, the expansion-reduction, and the rotation. The correction is done by combining the correction of each deformation. Here, we don't assume the appearance of textures and the disappearance as the deformation, because the stereo image pair cannot be made.

In this paper, it is difficult to describe simply the deformation by the processing like the affine transform, because the pixel which composes textures does not correspond to one-to-one before and later deforming. So, using morphological processing defined by the set operation, we can describe the parallel displacement and the expansion-reduction only by changing a structuring element. But, it is not possible to describe the rotation with morphology, so the rotation is described by the affine transform.

Extraction and correction of deformation

We process in the following order.

1. Preprocessing (extraction of texture pairs)
2. Estimating the deformation of appearance by rotation
3. Correcting the deformation of texture itself

Each couple of textures is corrected. Therefore, it is necessary to make manually a right and left image of each corresponding texture pairs from the stereo image pair where two or more textures exists first of all as a preprocessing.

Next, estimating the deformation of appearance by rotation. The deformation of appearance by rotation and the deformation of texture itself exist together in the deformation. So, in order to separate them, we estimate the deformation of appearance by rotation before correcting, then correct only the texture itself.

The deformation of texture itself corrected by a searching the best combination of the basic deform operator.

Experimental results

The model image is made by CG. The correction experiment is done according to the procedure explained in the foregoing paragraph. The model image is 512×512 gray scale image (8[bit/pixel]). We experimented with displacement, expansion, reduction, rotation,

and displacement+rotation, each deformation of texture. And the correction rate R [%] was obtained as an evaluation value which shows how was the deformation able to be corrected.

As a result, our method selected the combination of the basic deform operator denies the each deformations. We obtained the correction rate of 80% or more about each corrections excluding some exceptions. Beside, stereoscopic effect is improved compared with before correcting.

Finally, we experimented with X-ray solar image taken by observation satellite 'Yohkoh'. As a result, in the experiment with X-ray solar image, the correction rate was lower than the experiment with the model image.

In order to improve this, we must examine expanding the range of the searching space of the correction processing and permitting the more complex combination of basic transformation operation. Beside, the improvement of stereoscopic effect after correction was worse than the experiment with the model image.