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ICS 683

Project Proposal

Title
Motion Correction in Astronomical Images

Overview

Camera and scene motion is a big problem in amature astronomy. While big telescopes, such as Gemini and Keck, are secured via a mounting structure and inertial dampeners which eliminate the effects of vibrations, amateurs are faced with the elements armed only with a tripod. Furthermore Professional telescopes allow for star tracking, ie the telescope is moved to match the motion the earth, in order to remove the effects of earth's rotation. On the other hand amature astronomers rely on post processing in order to correct for this effect. The results of camera or star motion is a "smeared" image of the sky, where each star is followed by a tail as shown in Figure 1.

Figure 1: Night sky shot from Haleakala crater with Milky Way in the background. The motion of the camera is clearly visible.

Project Goals

The goals of our project is to provide a set of algorithms which will perform motion correction on images of Oahu's night skies. We hope to create a data set of images which show properties of motion distortion. Motion distortion can easily be caused by both camera movement(i.e. wind) or the rotation of the earth as observed by star images with long exposures.

We hope to develop algorithms that detect and correct the distortion caused by motion. Instead of seeing streaks of stars in the image, the algorithm will show the stars as single points of light.

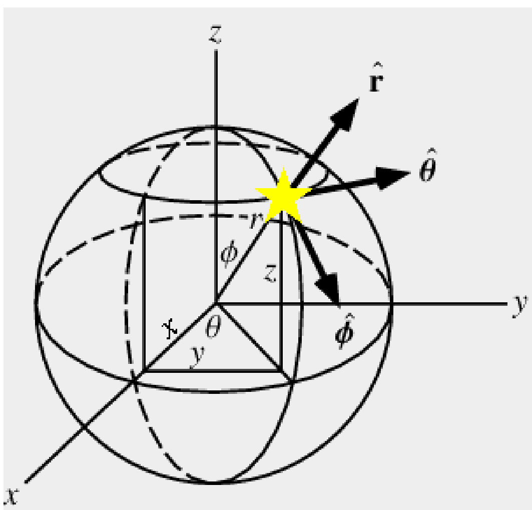
Project Outcome

The outcome of our project is the development of a set of algorithms which work together to correct image distortion of stars in Oahu's night skies. A more ambitious outcome is to create algorithms that correct motion distortion in many different types of images, and not just images of stars.

Technical and Experimental Plan

Problem statement:

Night sky photography requires use of long exposure. In the analog camera this is accomplished through keeping the shutter open for a prolong period of time. In a digital camera CCD samples are averaged across the exposure time. If the camera moves during the exposure the light will hit a different area of the sensor, resulting in a line smear. Similarly sensor position illuminated by the star will change as the earth rotates around the axis (except for the north star which is at the earth's rotational axis). At the first glance the camera motion and the scene motion are separate problems, but if we apply apply the system constraints their equivalence becomes clear. Stars, from the point of view of a camera, are essentially point sources infinitely far away. They are constrained to moving in the θ and ϕdirections, since any finite motion in the r axis will not change the scene perspective. Any synchronous motion of ALL stars in the scene is equivalent to a camera motion with the matching θ and ϕ displacement.



Exact camera path is not required for a good reconstruction. A probability(P_A) of finding a camera in a state which illuminates a set of pixels *A* during the exposure will suffice. By analyzing $P_A$values for each star we can should be able to deduce the scene motion probability density(P_s). Using these values it should be possible to correct the smearing effects due to camera or star motion.

Programming Environment

We will be developing on Linux with C++ using the standard GCC compiler tool chain along with the OpenCV image processing library.

Project Evaluation

To evaluate our algorithms, we will compare images with motion distortion to those without motion distortion. It will also be possible to correlate our final image with Google Sky Map to ensure that the stars found and their locations match known stars and locations.

Data Sets
We will be collecting a large set of images of Oahu's night sky from various locations on the island. It will be correlated with the google sky map for star identification.

We hope that our data set will show motion caused by both camera movement and the rotation of the earth. Our project hopes to provide motion correction on these images.

Timeline

Mid-October	Finish collection of data.
End of October	Selection of algorithms and initial implementation.
Mid-November	85% of the total code base implemented.
End of November	Completed software and initial evaluation.
December	Revisions and polishing.

Literature Review and Bibliography

Image stabilization problem has been largely solved in regard to video. Features extracted from a single frame are compared against the neighbouring frames in order to estimate the camera motion. On the other hand approximating the camera and the scene motion in a static image has received less attention. There are many papers on image stabilization in videos such as:

Vella, Filippo, et al. "Digital image stabilization by adaptive block motion vectors filtering." Consumer Electronics, IEEE Transactions on 48.3 (2002): 796-801.

Censi, Alberto, Andrea Fusiello, and Vito Roberto. "Image stabilization by features tracking." Image Analysis and Processing, 1999. Proceedings. International Conference on. IEEE, 1999.

Ertürk, Sarp. "Real-time digital image stabilization using Kalman filters." Real-Time Imaging 8.4 (2002): 317-328.

Chang, et al. propose a method of correcting image motion by using optical flow techniques for removing both transmotional and rotational image distortions.

Chang, Jyh-Yeong, et al. "Digital image translational and rotational motion stabilization using optical flow technique." Consumer Electronics, IEEE Transactions on 48.1 (2002): 108-115.

Irani et al. show provide a method for computing the 3D camera motion (the ego-motion) in a static scene, which is based on computing the 2D image motion of a single image region directly from image intensities.

Irani, Michal, Benny Rousso, and Shmuel Peleg. "Recovery of ego-motion using image stabilization." Computer Vision and Pattern Recognition, 1994. Proceedings CVPR'94., 1994 IEEE Computer Society Conference on. IEEE, 1994.

Morimoto and Chellappa evaluate several electronic image stabilization techniques based of their fidelity, displacement range, and performance.

Morimoto, Carlos, and Rama Chellappa. "Evaluation of image stabilization algorithms." Acoustics, Speech and Signal Processing, 1998. Proceedings of the 1998 IEEE International Conference on. Vol. 5. IEEE, 1998.