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THE DYNAMIC MOTION ESTIMATION OF A LUNAR LANDER USING OPTICAL NAVIGATION

Abstract

Optical navigation for a lunar lander is to estimate a lander's 3D relative dynamic motion with respect to a preselected landing site using a passive 2D video image sequence. Lunar landing missions require that a lander performs an autonomous accurate landing with simple mechanical structure, low power consumption and low cost. These have motivated the need for the development of an advanced navigation system with respect to these constrains. Existing navigation systems tend to balance the tradeoffs between simplicity, accuracy and cost. High accuracy navigation comes to complexity and high cost. In this paper, we consider a scenario where the descending phase starts at 10km with an off-the-shelf camera, which has less than 500g in mass and 10frames/second frame rate. A novel method for lander's motion estimation is described with a new method for digital video motion estimation.

Initially, the image motions consist of translation, scaling, rotation and shearing motions which are a 2D affine transformation. Each of these motions represents a 3D dynamic motion of the lander: 1) Image translation motion indicates the lander has a horizontal velocity; 2) Image scaling motion is caused by the lander's vertical velocity; 3) Image rotation motion is the representation of the lander's yaw rotation; 4) Image shearing motion illustrates the lander' pitch or/and roll rotation.

The 2D image motions are extracted using continuous wavelet transform (CWT) from the 3D digital image block. CWT for video image processing is to scale, translate and rotate a basis function in spatio-temporal domain. In a block of images, 1) Image translation motion is represented by the translation in spatial-temporal domain of the CWT with constant scaling parameters; 2) Image scaling motion is indicated the scaling parameter changing with no translation in spatial domain; 3) Rotation motion of the images corresponds to the rotation of a CWT basis; 4) Shearing motion of the images is the combination of scaling, translation and rotation of a basis function in all direction of the video block.

We describe an optical navigation system for a lunar lander, which includes the 2D image motion formation, the correspondence between these image motions and the 3D lander's dynamic motions. A computer simulation of this algorithm is performed and the result shows that this algorithm can estimate the lander's dynamic motion with less than 1