A Study of Terrain Feature Matching for Lunar Landing Navigation

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Recently, future lunar landing mission has been considered in many countries. Various lunar surface data, such as soil distribution, topography and so on, was gathered by previous lunar remote sensing orbiters. And some candidates of landing site were assessed from the perspectives of science and engineering. To achieve automatic pinpoint landing, new precise landing system will be required and proposed. An accurate position estimation of the lunar lander during orbiting and descending to the landing point is crucial technology in this system.

There is much work for the lander position estimation system. Especially, the navigation system based on the landmark matching is mainly studied in recent years. The following two methods are major navigation system for precise lunar landing.

First, the crater detection and matching approach is one of typical visual based navigation system. In this way, the craters detected from obtained image by lander camera are regarded as the landmarks on the lunar surface. The crater's shape has a strong invariance feature against rotation, scaling and sun position changes. Certainly, this method is invalid in case of no-crater region and very low and high sun position situation.

Next, the digital elevation map (DEM) matching approach is a practical navigation with the field tests. The distance image obtained by 3D scanner, e.g. Imaging LIDAR, is referred to the terrain elevation map. This method can be applied for any landing site, because the active 3D scanner is not affected in any illumination condition. The active range of the 3D scanner is short, so this navigation can be only worked on low altitude.

We proposed a new navigation, which is based on terrain feature matching between an image obtained by lander camera and an image synthesized from lunar DEM information. Our synthesized image of the Moon is precisely made by using the high resolution DEM of lunar surface, e.g. SELENE or LRO, and the sun position of the landing time. This high quality synthesized image could achieve our idea, that versatile precise navigation system. The local pattern feature, similar example is SIFT (Scale-Invariant Feature Transform) or SURF (Speeded Up Robust Features), of lunar image was employed to the landmark navigation. The feature points of the rendering image have 3D position information of the selenographic coordinates, so we can directly calculate the position and pose of camera, i.e. lunar lander by computer vision geometry. The matching is based on the similarity of feature vector and employed robust method. This process is basically same as the estimation of the fundamental matrix of the stereo vision. In this pater the outline of our approach is explained with some results and some accuracy of lander position and pose estimation with computer simulation are shown.