Lidar fusion using image space transformations and focal planes

Abstract

Light detection and ranging (lidar) provides unprecedented information about object shape and structure while aerial imaging gives explicit measurement of surface reflectance. Combined, lidar and imagery are perfunctory to object recognition and classification; however these applications require precise spatial registration, which is obfuscated by the different underlying coordinate systems. This paper provides a methodology for the accurate fusion of lidar and aerial imagery assuming certain flight trajectory, spatial and temporal knowledge.

The methodology employs two transformations to and between focal planes, which conjoined is an orthorectification mapping the image to the lidar point cloud. The first projects a radiometric model from the space of the point cloud onto a pseudo-focal plane while the second is a deformation between the model's projection and the image lying on the true focal plane. Radiometry is modeled from geodetic shadow and topographic incidence which are functions of solar position. The projection is determined from flight trajectory and spatial location; due strictly to instrument inaccuracy, the focal planes lay on disparate geometries and therefore have objects with similar but deformed coordinates. This deformation is mapped by matching similarly textured patterns using an area-based approach, probabilistic filtering and interpolation. Continuous deformation is interpolated using a spline and discrete observations made from regional Fourier transformation and phase correlation. A new form of metadata called "rectification strength surface" is introduced and shown to be highly correlated with spatial accuracy.

The methodology is applied to a series of color aerial photographs taken of Yellowstone National Park, WY. Spatial accuracy is assessed using a statistical sample and found to be high for moderately textured surfaces. Finally, the rectification strength surface is applied to an image mosaiking problem.

Keywords

Fusion, orthorectification, lidar, aerial imagery, mosaic