Orthorectified Mosaicking of Images from Small-scale Unmanned Aerial Vehicles

Unmanned aerial vehicles (UAVs) have been recently deployed in various civilian applications such as environmental monitoring, aerial imagery, and surveillance. Small-scale UAVs are of special interest for first responders since they can rather easily provide bird's eye view images of disaster areas. For such UAVs the number of images and the positions where to capture them are predefined due to limitations in flight time, communication bandwidth and local processing. The main goal of this thesis is to develop methods for mosaicking of individual aerial images taken from homogeneous or heterogeneous sensors on small-scale UAVs. The mosaicking of images taken in such scenarios is challenging as compared to panoramic construction or other mosaicking methods such as satellite image mosaicking. When flying with UAVs at a relatively low altitude (below 100m), non-planar objects on the ground make the feature matching and image registration more difficult. In addition other artifacts such as dynamic scene, lens distortion, and heterogeneous sensors make the mosaicking procedure more difficult.

In this thesis we focus on producing orthorectified and incremental mosaics from low-altitude aerial images. The orthorectification is important in order to preserve the relative distances in the mosaic. On the other hand, the incremental mosaicking means to update the real time mosaic while individual images are being added. We present two methods to construct such mosaics. The first method combines the metadata of the images such as GPS positions and the UAV orientations with the image processing techniques to construct the mosaic. The second method does not exploit any metadata and only uses the images. By this method we find and mitigate the sources of errors, in the process of incremental mosaicking, to achieve an orthorectified mosaic. Unlike some other mosaicking approaches we avoid any global optimization because of the high computational complexity. Furthermore, the global optimization methods require all images at once while in our incremental mosaicking we do not reposition any of the previously mosaicked images.

Eventually we demonstrate some novel methods for multispectral aerial imagery with thermal and visual (also referred to as RGB) cameras. We show how to register the images of different spectrums and how to improve the quality of this interspectral registration. The contribution of this part includes (i) the introduction of a feature descriptor for robustly identifying correspondences in images of different spectrums, (ii) the registration of image mosaics, and (iii) the registration based on depth maps.