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City2BA: Tools for creating synthetic bundle adjustment problems

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Software

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Summary

Bundle adjustment is a global nonlinear optimization step used in structure from motion (SfM) and simultaneous localization and mapping (SLAM). It is usually formulated as a nonlinear least-squares problem where the goal is to minimize the error between the projected location of 3D points in each camera and the actual observed location of the point in the camera frames. Triggs, McLauchlan, Hartley, & Fitzgibbon (1999) provides a good overview of the formulation and uses of bundle adjustment. For SLAM, the bundle adjustment problem is small, but for SfM, problem sizes can grow very large. Ideally, developers of new bundle adjustment algorithms would like to test against real world data. However, not many datasets are available (the authors only know of 1DSFM (Wilson & Snavely, 2014) and Bundle Adjustment in the Large (Agarwal, Snavely, Seitz, & Szeliski, 2010)), and these datasets are limited in size and structure. We know large datasets exists and are in use (see Klingner, Martin, & Roseborough (2013)), but these datasets are not available to the public. To facilitate the development of bundle adjustment algorithms, we developed the **City2BA** package which can generate large, synthetic bundle adjustment datasets.

City2BA provides two main features: generation of synthetic datasets from models, and tools to add noise to existing datasets. Synthetic dataset generation can either use an existing 3D model (in `.obj` format), or can operate on an implicit model of a grid or a line. The user can specify the problem size as well as parameters like number of 3D points and maximum distance between a camera and an observed point. The user can also modify problem structure by using different 3D models or placing different camera paths. Cameras can either be generated in a streetview-like scenario where cameras are placed along a path, or placed in random locations in the geometry. Synthetic datasets have zero error and so are useful in testing the accuracy and correctness of different methods. To test different algorithms, the ground truth datasets need some form of added error. The tools we provide can add a variety of different types of error to simulate different inaccuracies in SfM methods. For example, we provide long range drifting effects that mimic error from accelerometer noise. These features allow users to test the scalability of their algorithm over a variety of scenarios and types of noise.

City2BA is provided both as a set of command line tools (for convenience) and as a library (for extensibility). Currently, **City2BA** ships with a single camera model commonly used in the literature (see Agarwal et al. (2010)), but the user can add their own camera model if they so choose. It is optimized and can generate very large models (100,000 cameras, 1,000,000) in less than an hour.

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