Kudan modular components

Kudan's SLAM is made up of multiple components that can be used independently of its SLAM system. Components are typically implemented to be as fast as possible, and utilising more cutting-edge algorithms.

High-level

- **Non-linear optimisation (for bundle adjustment)** - utilises unique algorithms to allow extreme parallelism across any number of cores. Highly performant implementation with support for multiple kinds of observation data.
- **Bundle adjustment** - higher level algorithms to provide local and global bundle adjustment, with different window sizes in between. Preemptable with state saving means results never get discarded while remaining highly responsive.
- **Sparse stereo matching** highly efficient approach to stereo matching allows stereo information to be used for every frame, not just keyframes. High accuracy down to subpixel level allows narrower baselines and greater ranges.
- **Pose estimation** - 6DOF pose estimation given a set of point observations. Efficient approach to hypothesis generation, non-linear optimisation and outlier filtering.
- **Camera calibration** - calibration of monocular and stereo cameras. Completely in-house approach results in superior accuracy compared to OpenCV. Intuitive GUI allows complete oversight of the process.
- **Monocular/stereo initialisation** - multiple approaches to monocular initialisation (homography and essential matrix) with automatic switching. Instant stereo initialisation when in range.
- **Epipolar expansion** - efficient matching of untriangulated points using epipolar geometry. This can be combined with a stereo system for greater efficiently and robustness.
- **Global relocalisation** - robust and fast relocalisation. Module can be used with both sparse and direct SLAM systems.
- **Loop detection** - efficiently detect loop candidates and robustly verify them. Multiple approaches work together to provide the best results.
- **Loop closure** - correct drift across a loop given a similarity transform from any source.
- **Point matching** - multiple approaches to point matching including descriptors and templates, which can be combined. Highly tuned implementation that can provide sub-pixel accuracy, resulting in more accurate tracking and mapping. High viewpoint and illumination invariance with multiple filtering criteria.
- **Coarse frame to frame tracking** - lightweight tracking method provides a highly accurate initial estimate to the main tracking methods. Camera motion need not fit a basic motion model. Multiple fallback methods to cover range of scenarios.

- **Sparse-to-dense mapping** - either real-time or post-processing densification of a sparse map. This can produce more accurate dense maps than actual dense SLAM systems.
- **Plane finding** - find the origin and orientation of the dominant plane within a pointcloud, useful for initialising a reference frame.

Low-level

- **Descriptor generation** - highly optimised feature extraction and binary feature descriptor generation.
- **Descriptor matching** - incredibly fast binary feature descriptor matching and filtering.
- **Hypothesis generation** - fast versions of RANSAC/PROSAC for both homographies and fundamental matrices
- **Camera image correction** - efficient undistortion and stereo rectification. Fast implementation with a unique algorithm resulting in a more accurate image.
- **Low-level image operations** - blurs, resizes, affine warps and more all implemented and tuned using SIMD