KudanCV features

SLAM

Input support

- **Monocular camera**
  - Small motion monocular initialisation
- **Stereo camera**
  - Passive stereo
  - Active stereo
- **RGB-D camera**
  - Structured light
  - Time of flight
- **Third party sources of depth**
  - LiDAR,
  - Laser scanned
  - Future methods that can produce per-pixel depth estimates
- **Non-stereo multi-camera**
  - Multiple cameras covering larger field of view
  - Provides greater tracking stability and robustness
- **Large range of fields of view**
  - Zoom
  - Wide-angle
  - Fisheye
- **Different shutter types**
  - Global shutter camera
  - Rolling shutter camera with different rolling speeds
- **IMU support**
  - Fully optional
  - Gyroscope, accelerometer, magnetometer.
- **GPS support**
  - Improves accuracy with large outdoor maps
  - Assists relocalisation

Mapping

- **Multiple mapping modes**
  - User selectable mapping modes with different performance characteristics
  - Map decoupled from tracking allows tracking with a different method than was used for map creation
- **Patch based mapping**
  - Lightweight tracking suitable for embedded

    - Denser point cloud with high accuracy
- **Descriptor based mapping**
    - Lightweight mapping
    - Sparser pointcloud
    - Small memory and disk footprint for map
    - Strong robustness to occlusion
- **Unique hybrid of descriptor and patch mapping**
    - Takes strengths from both patch and descriptor mapping
    - Improved accuracy for descriptor mapping
- **Multi-device mapping**
    - Map created by one device can be expanded by a completely different device
    - Map can represent data gathered from multiple different cameras
- **Map tidying**
    - Redundant keyframes and points are continuously removed
    - Bad points are continuously removed
    - Results in a tidier, more efficient map
- **Loop closing**
    - Multiple methods of loop closure depending on size of loop
    - Ability to manually specify loops in postprocessing
- **Map saving and loading**
    - Maps can be saved to disk in a lightweight format
    - Maps can be shared between different devices
    - Saved map can be used by external processing
- **Server-side mapping**
    - CPU intensive tasks like bundle adjustment can be performed on the cloud
    - Map streaming for memory sensitive devices means only relevant parts of the map are loaded
- **Post-processing map densification**
    - Map can be further densified (dense or semi-dense) offline
    - Works with both kinds of mapping
- **Multi-sample maps**
    - Parts of a map can be captured at multiple points in time
    - Allows robustness to extreme changes in lighting condition or environment

Tracking

- **Multiple tracking modes**
    - User-selectable depending on conditions
    - Hybrid mode available
- **Descriptor tracking**
    - Strong robustness to occlusion
    - Strong robustness to non-static environments
- **Patch tracking**
    - Lightweight tracking
    - Strong robustness to motion blur

- **Low latency**
    - Low latency mode/settings available
    - Control over number of tracked points
    - Control over pose refinement parameters
- **No-expansion mode**
    - Tracker can run entirely from an existing map
    - Patch tracking can work with very sparse maps
    - Patch tracking allows the camera to track large distances from the existing map
    - Reduces power consumption
    - Results in the most precise trajectories
- **Power-saving mode**
    - Tracker switches to lighter weight algorithms during easy trajectories
    - Reduced computational load results in reduced power consumption
    - Worst-case the same as no power-saving mode, no drawbacks
- **Tracking feedback system**
    - Query whether points were successfully tracked
    - Information on pose confidence
    - Ability to mask out points from tracking based on external logic (eg. hand tracker)

Image & object tracking

- **Multiple target types**
  - Image
  - Cube
  - Cylinder
  - 3D Object
- **Supports all cameras**
  - Tracking method insensitive to rolling shutter
- **No upper limits**
  - Unlimited detectable targets
  - Unlimited number of simultaneously tracked targets
- **API for target generation**
  - Build custom tools for creation of targets
  - Command line tools for batch target creation
- **Recovery mode**
  - Allows re-detection beyond the limits of normal detection
  - Completely transparent to user
- **Extended detection and tracking**
  - 2D SLAM builds a map surrounding the image, allowing for detection and tracking beyond normal limits
- **Compact target format**
  - Defaults to approximately 50KB per marker
  - User configurable size
  - Automatic image analysis transparently removes parts of the image that don’t contribute to detection/tracking

Portability

All Kudan computer vision technology is designed to be hyper portable. We achieve this through multiple design decisions:

- **Pure C++ codebase**
    - Strict C++14 code
    - No operating system calls
    - Assembly language optimisations are all optional over a pure C++ version
- **C++ API**
    - Trivial to wrap with other languages (including C)
    - Compact API makes hook-up easy
    - API accepts multiple data formats and performs necessary conversions internally
    - API has rich error checking and warning messages to prevent misuse
- **No hardware access**
    - Hardware access is the responsibility of the caller, meaning we support anything that can produce camera data
    - Doesn't interfere with management of hardware interfaces
    - User can pre-process sensor data prior to calling KudanCV

Optimisation

- Multiple ways to optimise components
    - SIMD instruction sets
    - GPU
    - FPGA
    - DSP
- Modular design allows selective optimisation
- Can utilise optimised OpenCV version

Use-cases

- Head-tracking
    - Low jitter
    - Ability to track pre-made maps
    - Low latency
    - High accuracy/precision
- Mobile AR
    - Monocular rolling shutter
    - Mobile CPU friendly
    - Easy to combine with additional computer vision or other trackers
- Drones/robotics
    - Ability to make large maps
    - Ability to provide dense reconstructions for additional processing
    - Supports wide variety of sensors found on such devices
- Autonomous driving
    - Ability to make very large maps
    - Ability to utilise GPS data
    - Ability to utilise LiDAR data
    - Can utilise pre-made maps