Intelligent Dash Cam

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"Travelapse" Videos Are Jerky

Road trips are a beautiful subject for a timelapse, and Garmin's dash cams implement a "Travelapse" feature which uses a fixed frame rate to condense hours of footage into a short, but choppy, video. Regardless of whether you're stopped at a traffic light, driving through a Kansas prairie, rock crawling off-road, or winding through a scenic canyon, the frame rate remains constant, yielding a video with more boring, choppy sections than smooth, interesting ones. Storing raw footage for manual post-processing is time consuming and impractical due to storage constraints. This project demonstrates a method of producing shortened videos with a variable frame rate for smoother output over changing conditions

Variable Frame Rate Makes Smoother Videos

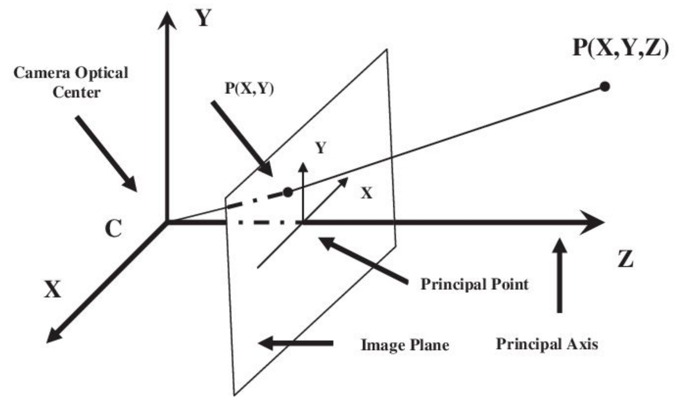
Appropriate frame rate can be determined based on many different inputs: GPS location, accelerometer, and/or gyroscope inputs, to name a few, which can be used to determine velocity. Alternatively, computer vision can be used to interpret and decide how "interesting" a scene is. This requires less finicky hardware and provides more valuable data; **the goal is to create a timelapse that is smooth and interesting!**

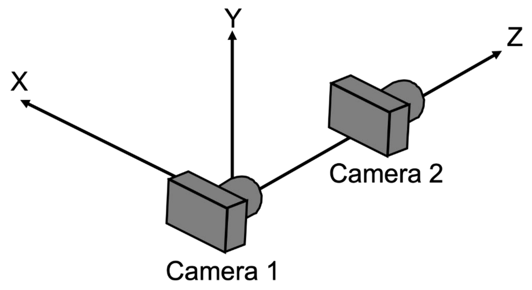
OpenCV Feature Detection and Matching

OpenCV provides a variety of feature extraction primitives, and ORB (Oriented FAST Rotated BRIEF) Feature Detection is the most efficient of the free subset of the library. Paired with Brute Force Matching using Hamming distance, it yields a fast and space efficient matcher which provides a degree of scale and rotation invariance. 256 points are used for the descriptor, and a "good" match is one with a Hamming distance less than 35, where Hamming distance is the sum of the XOR'd bits of two feature descriptors.

Interpreting Matched Features/Stereo Cameras

The diagrams below show the 2D image plane formed by the camera from the real world, and a representation of the dash cam traveling forward between time 1 and time 2. Features will be detected on the image planes of the camera at both times, then matched, producing data for us to interpret. The features should have moved outward radially in the x-y plane, away from the camera, and determining how much, and in which direction, features have moved should yield a rate of change. In practice, this is incredibly noisy and difficult to use. Alternatively, the essential matrix can be estimated from the matched correspondences, then decomposed into the rotation vector and translation vector. This would give information on whether the vehicle is turning. The translation vector would be useless, since most translation will be in the z direction, and only a scale can be estimated without knowing the depth or size of any real world objects.





More Bad Matches Mean Interesting Changes!

When ORB is unable to detect many good matches, this means the surrounding image is changing rapidly, so more frames should be saved for the video to be smooth, and will likely be more interesting. This can be measured as the mean of Hamming distance between matches, but worked better as the proportion of good matches to overall matches.

Future Work

- Real-time implementation on Jetson Nano with CUDA acceleration
- Add video processing to further decrease vibration and jitter between frames
- Ignore vehicles on road

Jetson Nano

The Jetson Nano was chosen for this project because it has an embedded GPU, making it well suited to image processing tasks. It integrates directly with the 136° field-of-view (FoV) Leopard Imaging Camera, which provides wide-angle HD video. The system bring-up was successful, but the algorithm has not yet tested in a real-time environment, since algorithm development was a higher priority.

Results

On-Road Sample

218 Good matches 1 frame apart

65 Good matches 5 frames apart

44 Good matches 10 frames apart

12 Good matches 30 frames apart

Off-Road Sample

19 Good matches 1 frame apart

3 Good matches 5 frames apart

1 Good matches 10 frames apart

0 Good matches 30 frames apart

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