Independent Bi-ocular Active VIO

Project Proposal

Anton Pozharskiy

Computer Science
University of Maryland
United States
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1 Goals

This projects has several goals, to be completed in the following order

1. Build a test platform with two rotational 2-dof mounts, high-fov cameras, and IMUs.
2. Develop a tightly integrated VIO on each eye.
3. Develop a loosely integrated stereo VIO
4. Develop a Loop closure system to act on both eyes.
5. Develop a huristic decision making system to recalibrate scale between the two cameras.
6. Develop a gaze control system to improve VIO/SLAM performance

This is all in an attempt to allow for what is essentially a two loosely connected monocular SLAM system to combat scale drift by being able to actively convert to a stereo system.

This project would aim to develop the logic for actively tracking and exploring feature rich areas. It would also develop a heuristic method to readjust the scale factor by taking advantage of stereo images across the two cameras.

2 Motivation

Often natural systems are an inspiration for engineers. In this case the chameleons ability to independently operate its two eyes in order to traverse trees and search for interesting targets, and have effective depth preception.

It is a well documented feature of VSLAM that the larger the field of view the better quality the tracking tends to be. Generally, cameras with high fields of vision come with downsides, primarily in the form of high levels of distortion. In general this is solved with expensive arrays of cameras or mirrors. This approach is an attempt to take advantage of the already explored avenues of activeSLAM, a technique that uses information metrics inherent in SLAM systems to plan exploration and paths through an environment. That will be combined with the active tracking of feature landmarks using an image salience technique in order for the system to automatically attempt to improve its tracking performance.

3 State of the Art

3.1 Active Gaze Control

There exist several approaches to active gaze control that have been explored. They are primarily used to identify where in an image the algorithm should search for feature matches under loop closure. This approach is used in [1] which Newman and Ho use it to improve loop closure detection. It is also used in the field of “active SLAM” where it is used to guide the camera in which direction to go in order to maximize feature overlap [2]. As far as I can tell there is not a lot of research into active gaze control for stereo systems.

3.2 Visual Inertial odometry

There is also no state of the art for independent pairs of cameras. However, stereo visual odometry is a well known technique as is monocular visual odometry. As for visual-inertial odometry there are several known aproaches. They broadly fall into two seperate categories: Loose coupling and tight coupling. Loose coupling often involves cascades of kalman filters in order to combine IMU readings with the visual odometry readings. Tightly coupled approaches on the other hand pair imu measurements with camera frames in order to gain an advantage from getting estimated ego-motion at the time of the frame capture. Both of these have their pros and cons, depending on hardware type of motion etc. As stated before there is no research on how to link two independent cameras together with a tight coupling, however many kalman filter based approaches have been used to combine multiple noisy pose estimate in the past.

4 Tentative Plan

As stated above there are several major parts to this project:

- Physical hardware:
  - Cameras
  - IMU’s
  - Gimbals
- Independent monocular VIO
- Loop closure system
- Scale realignment system.
- Gaze control system

The current timeline is to have the physical system done by the end of spring break. After that in the next 3 weeks the independent VIO and loop closure system should be completed. In the final 4 weeks of the semester the scale realignment heuristic and gaze control system should be implemented.