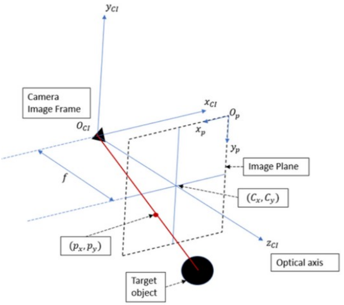
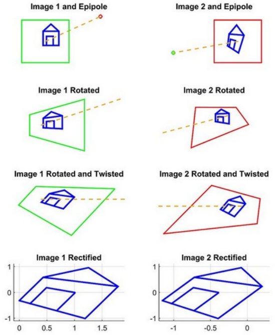
Computer Vision Pipeline

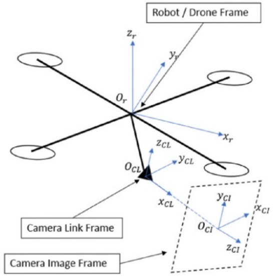
Camera Geometry (Intrinsic) :
- focal length, field of view, resolution
- principal point (on optical axis)
- image plane coordinate system

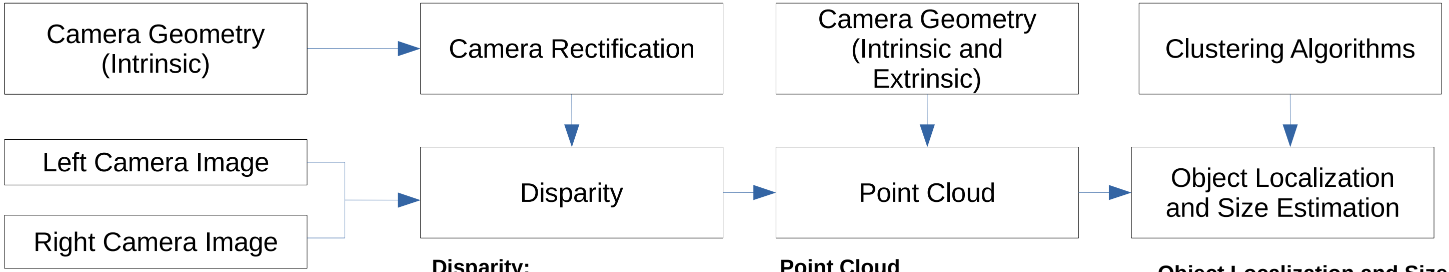


Rectification:
- Both images are warped so that they share the same coordinate system. Facilitated using OpenCV



Camera Geometry (Extrinsic) :
- Camera Position and orientation relative to Drone





Camera Geometry (Intrinsic)

Camera Rectification

Camera Geometry (Intrinsic and Extrinsic)

Clustering Algorithms

Left Camera Image

Right Camera Image

Disparity

Point Cloud

Object Localization and Size Estimation

Disparity:
- Matrix of size (height x width, from resolution).
- Each element in the matrix, disparity[u,v] is horizontal pixel distance between pixel (u,v) on left image and the best matching pixel on the right image.
- Pixel matching using OpenCV

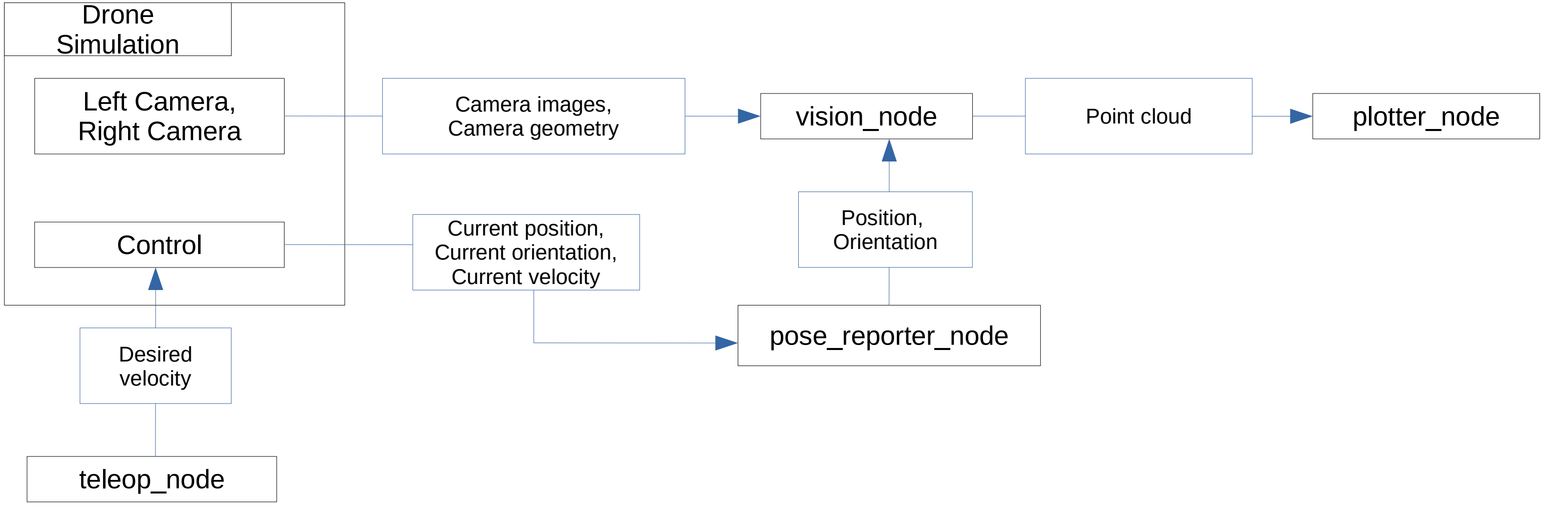
Point Cloud
- Array of 3D coordinates. Each element from disparity matrix is transformed into a 3D coordinate through the following operations
1 - Convert disparity to physical distance (depth map) using camera geometry.
2 – convert pixel coordinate into direction.
3 – Combine physical distance and direction to generate vector in camera image frame.
4 – Apply extrinsic geometric to express vector in drone reference frame.

Object Localization and Size Estimation
- Points from point cloud are clustered.
- C enter of each cluster is used as object location.
- Extent of each cluster (maximum and minimum coordinate values) are used to estimate size.

Image sources:
Camera geometry: master’s thesis, page 79 - Figure 4.9

Image rectification: wikipeida

Software Description



Components

teleop_node : Facilitates manual flight control of drone by enabling users to send control inputs as command velocity

vision_node : Executes the computer vision pipeline in real-time, up to the point of point cloud generation, fusing information from left and right camera, as well as camera geometry to generate point clouds for visualization.

pose_reporter_node : Reports on the drone's position and orientation.

plotter_node : Processes point clouds and applies clustering algorithms to identify, localize and estimate the size of objects. Visualizes the point cloud and detected objects

Key Technologies

ROS2 : Overall data processing / communications and drone control

Gazebo : Facilitates manual flight control of drone by enabling users to send control inputs as command velocity

OpenCV : Image processing and calculation of disparity.

Numpy: Used for matrix operations (reference frame transformation and data transformation)

Sci-kit Learn: Used for clustering algorithms to detect objects.

Matplotlib : Used for point cloud visualization