Probabilistic Models for Visual Odometry

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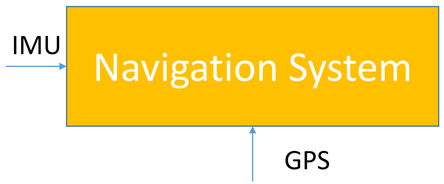
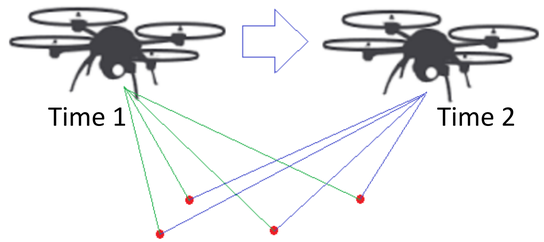
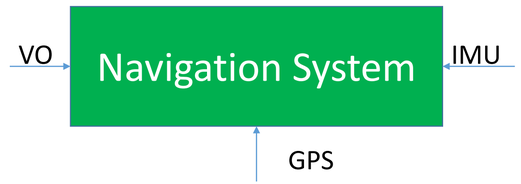
MEMS IMU Failure Modes:
- Vibration
- Temperature
- Humidity
- Magnetic Interference
- Bias/Drift



An IMU or GPS malfunction will disrupt the navigation system



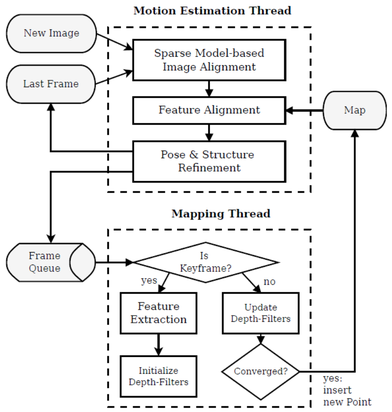
Visual Odometry estimates the position and pose using features and pixel intensity obtained by an onboard camera



Visual Odometry provides redundancy against an IMU and/or GPS malfunction

GPS Failure Modes:
- Jamming
- Spoofing
- Selective Availability
- Multipath
- Solar Flare
- Indoor

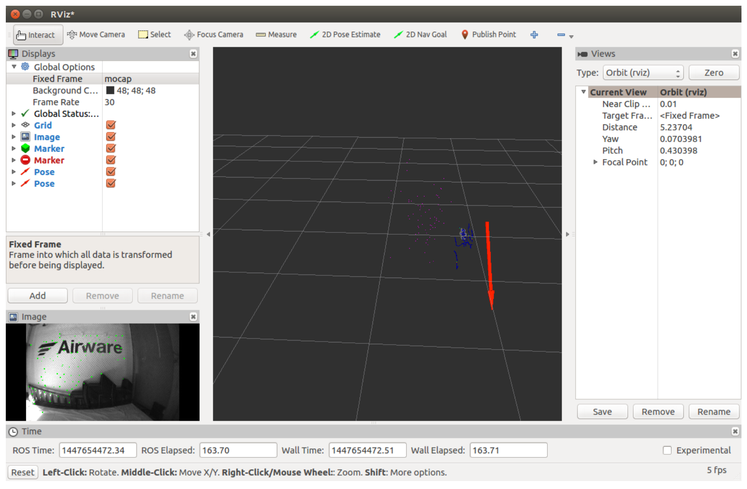
SVO – an open source visual odometry software package



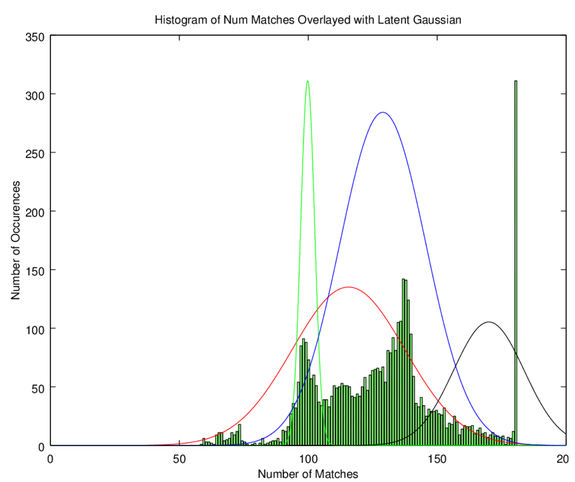
Credit: Forster, Pizzoli, Scaramuzza

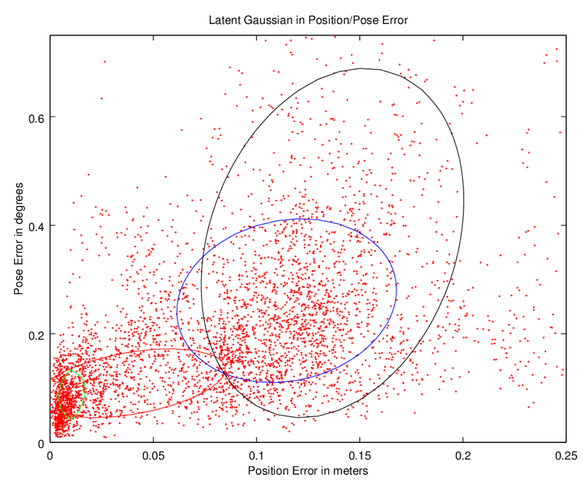
SVO Output:
- position estimate in x, y, and z
- pose estimate as a quaternion
- number of matches (estimate quality)
- indicator (estimate unavailable)

Experiment Setup: perform visual odometry in an enclosed motion capture system to obtain both the estimated and the true position and pose. The motion capture system has millimeter level accuracy, and is source of truth. 8834 data points are captured in 180 seconds.



Key Results: Model the likelihood of position error, pose error, and number of matches using mixture of gaussians. Furthermore, it was found that fewer number of matches was correlated with lower error.





Interpretation: When IMU, GPS, and VO are simultaneously available, the position error between the GPS and the VO, the pose error between the IMU and VO, and the number of matches from the VO is applied to the Gaussian distributions to calculate the probability that the measurements are in agreement. When GPS is unavailable, the pose error between the IMU and VO is used to estimate the VO position error using the pose/position error covariance matrix and the number of matches. A similar calculation is made when the IMU is unavailable. When both the IMU and GPS are unavailable, the number of matches from the VO indicates the precision of the VO position and pose estimate.