Particle Filter Localization for Autonomous AUVs Using Augmented Reality Tags

Ed Kelley, 2013
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aka

Where is the

Quadcopter?

Motivation

This statue is cool

http://www.asergeev.com/pictures/archives/2007/572/jpeg/05.jpg

I want a 3d model

http://www.asergeev.com/pictures/archives/2007/572/jpeg/05.jpg

Video Games
Virtual Reality
Movies
Archeology
Architecture
Maps
Crash Scenes

Manual Modeling?

Laser Scanner?

Multi-View Stereo?

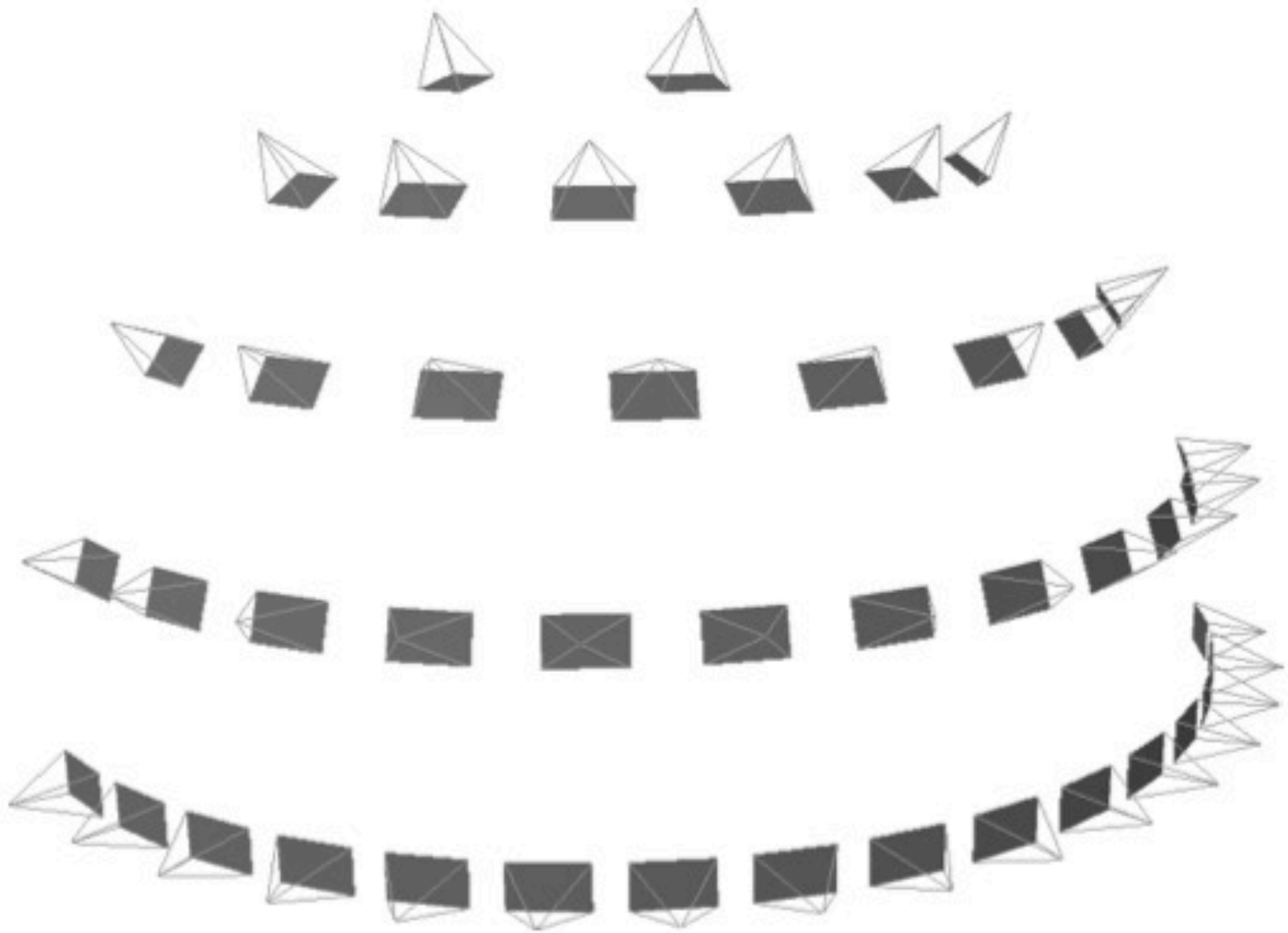
Microsoft Kinect?

Manual Modeling?

Laser Scanner?

Multi-View Stereo?

Microsoft Kinect?



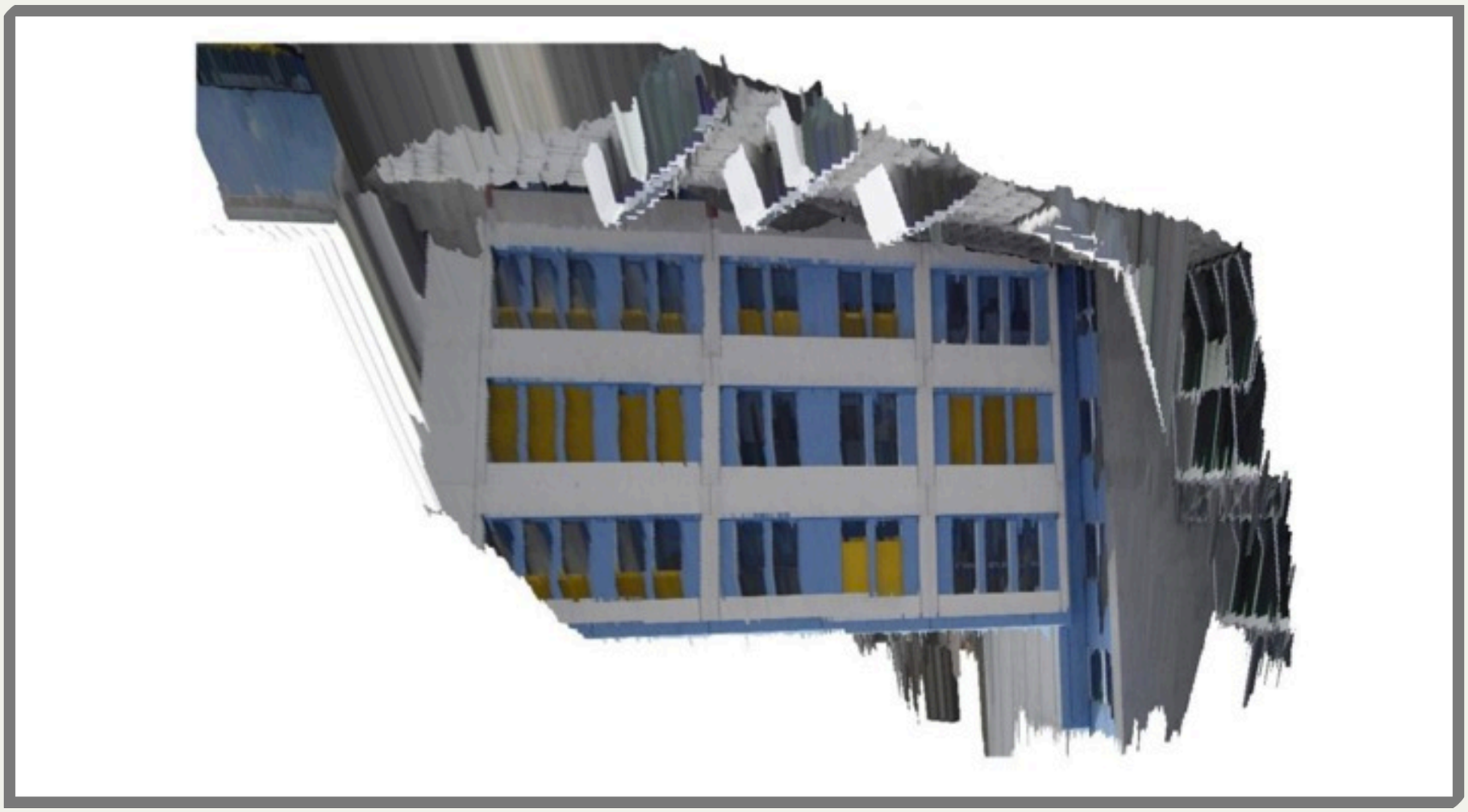
Irschara et al. 2010

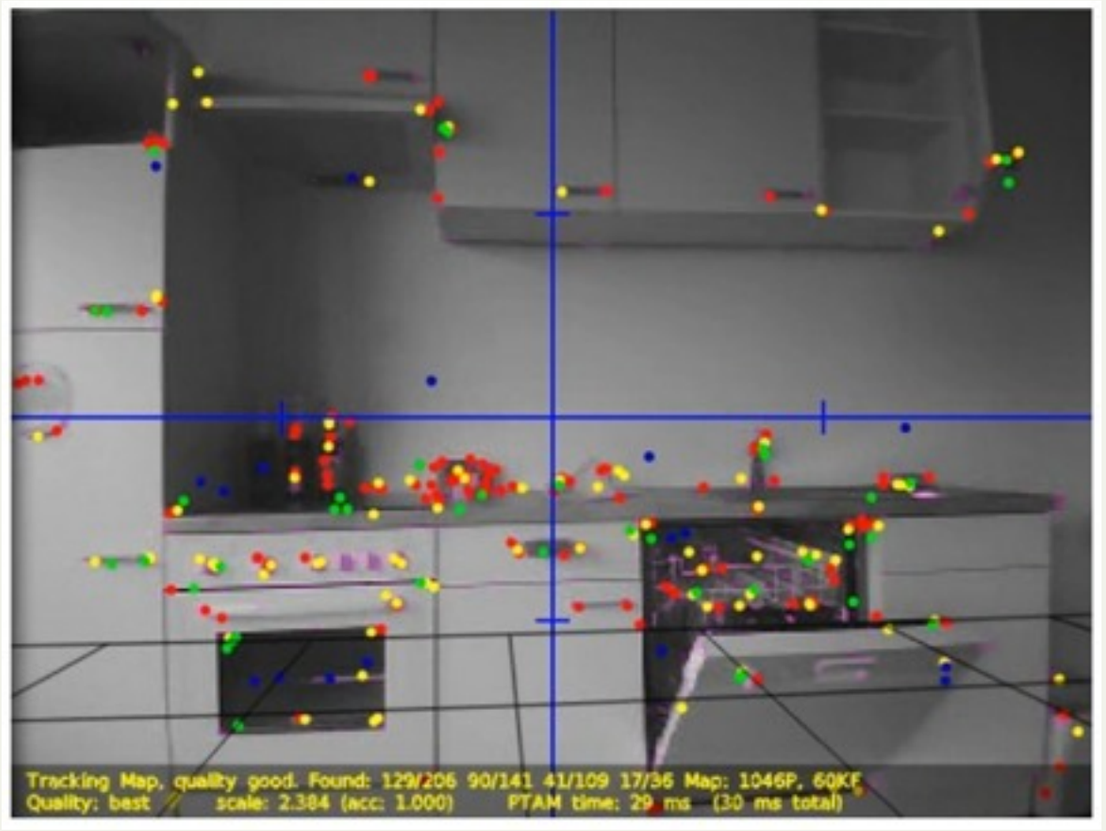
Easy
Cheap
Complete
High Quality

Quadcopters!

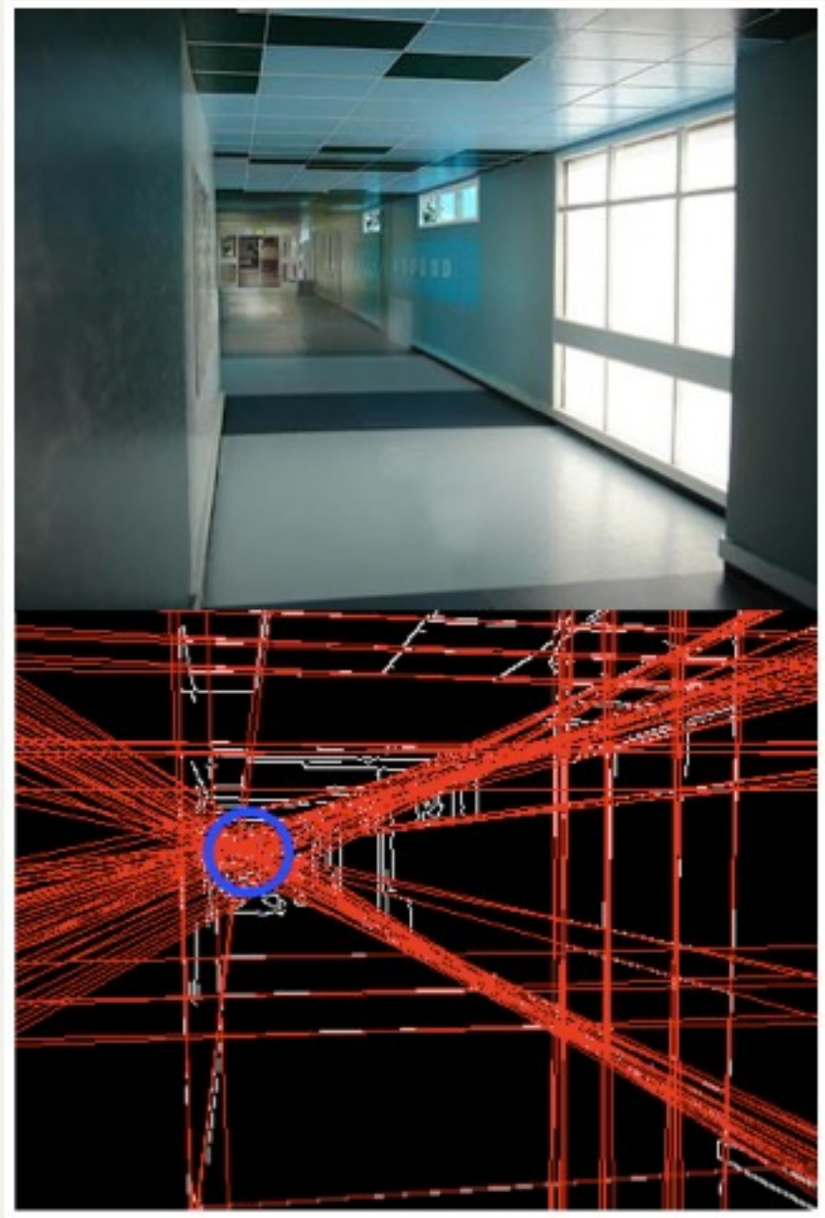
Related Work

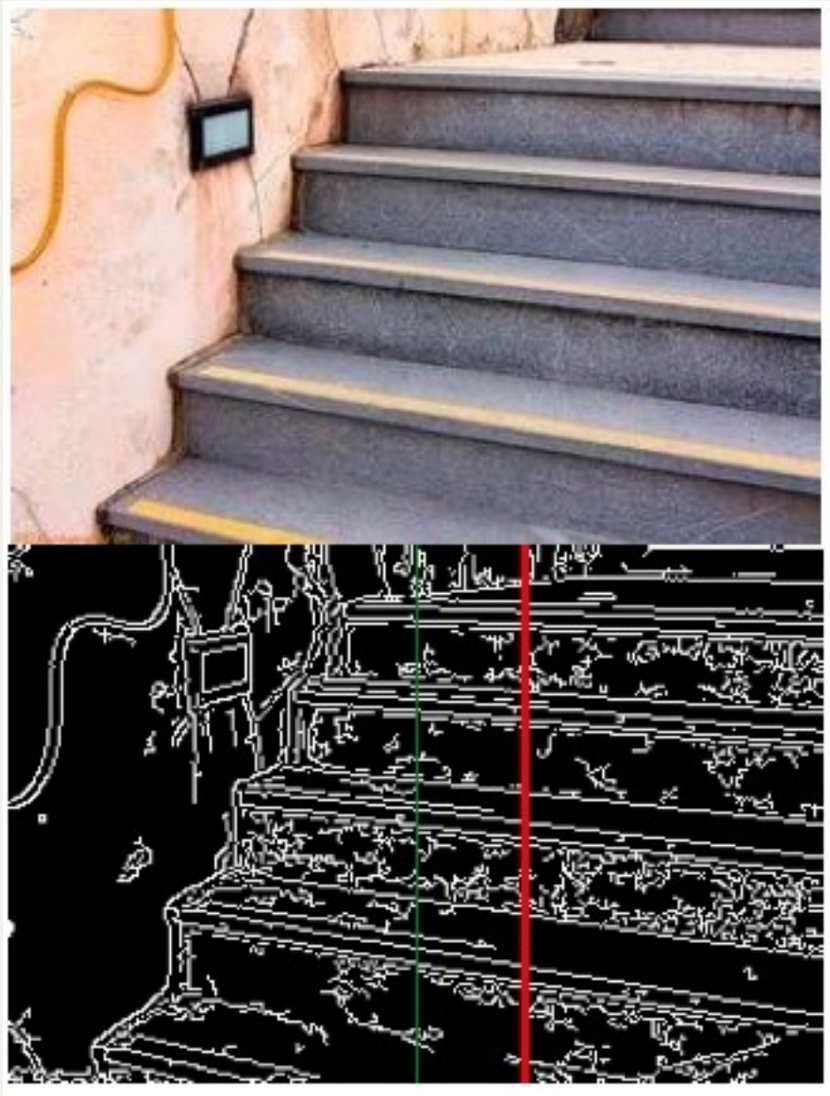
Irschara et al.




Tracking Map, quality good. Found: 129/206 90/141 41/109 17/36 Map: 1046P, 60KF
Quality: best scale: 2.384 (acc: 1.000) PTAM time: 29 ms (30 ms total)

Engel et al.



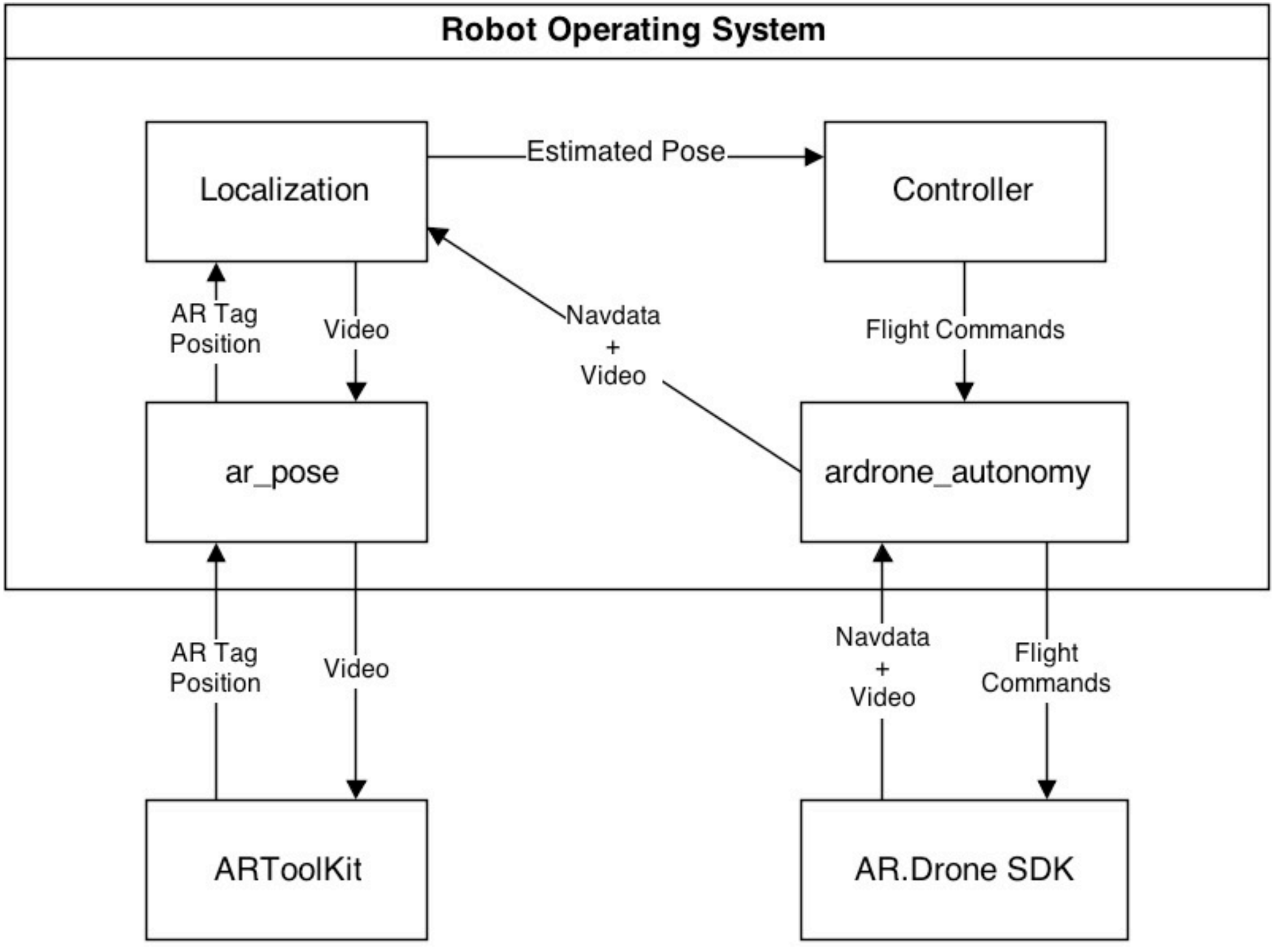


Bills et al.

System Design

AR.Drone 2.0

http://ardrone2.parrot.com/photos/photo-album/


Robot Operating System
Localization
Estimated Pose
Controller
AR Tag
Position
Video
Navdata
+
Video
Flight Commands
ar_pose
ardrone_autonomy
AR Tag
Position
Video
Navdata
+
Video
Flight
Commands
ARToolKit
AR.Drone SDK

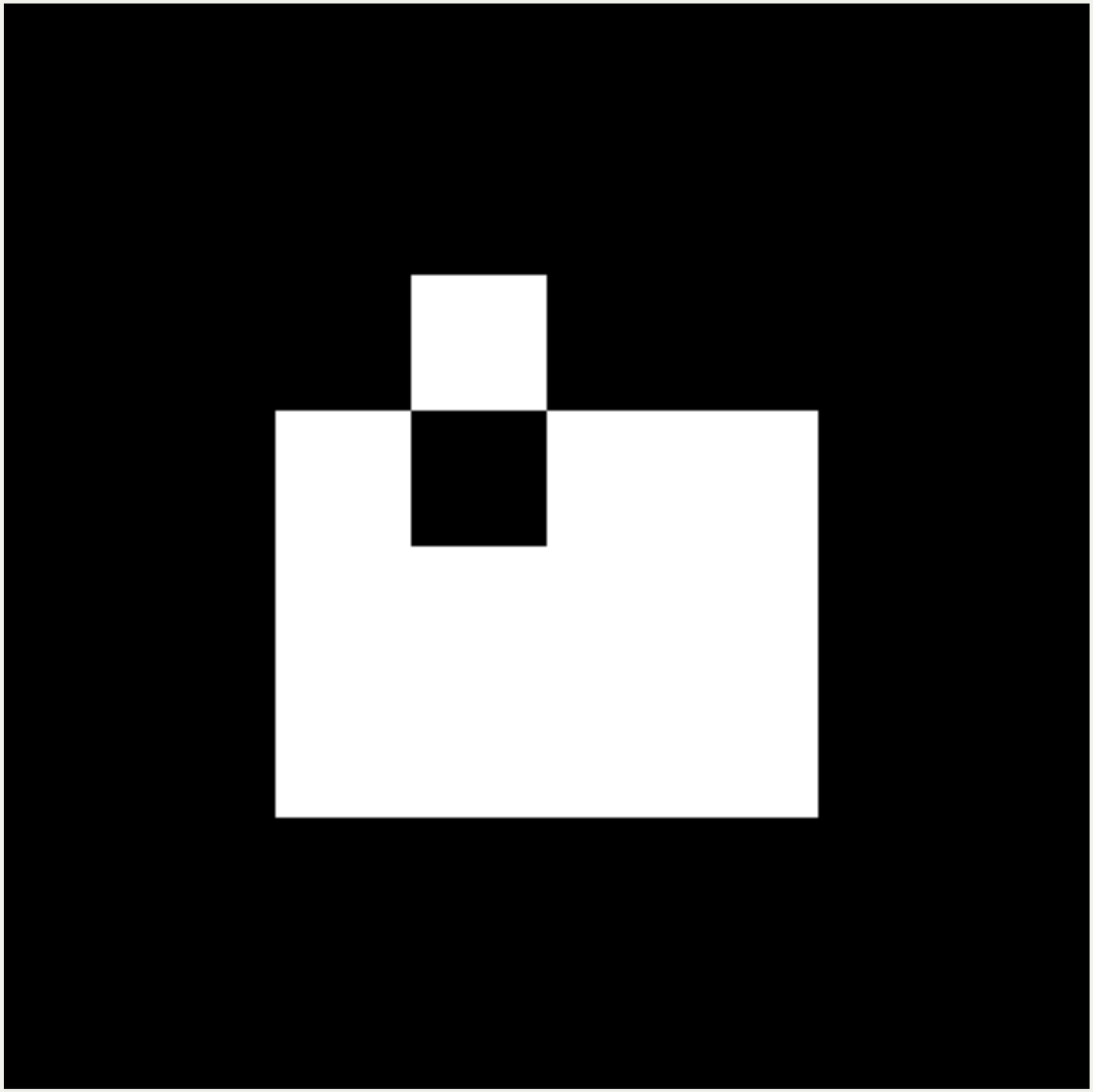
Localization + Controller = Autonomy

Localization

Local measurements tend to drift.

No GPS

No rangefinders



Kalman Filter?

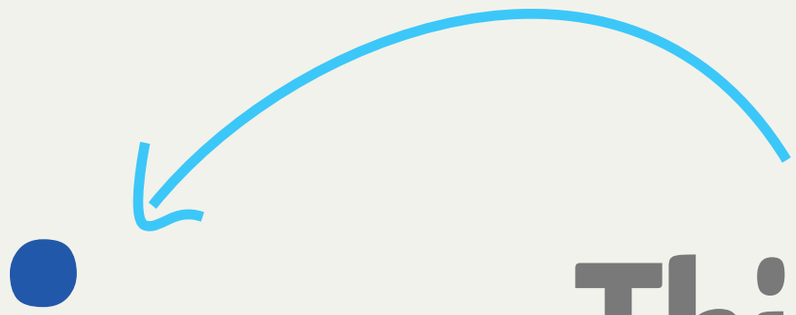
Grid Based Markov?

Particle Filter?

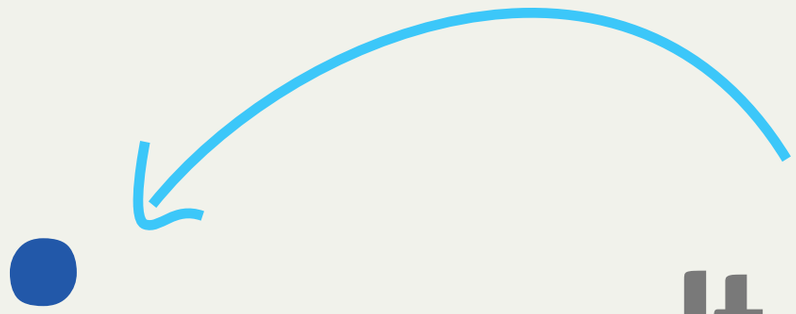
Kalman Filter?

Grid Based Markov?

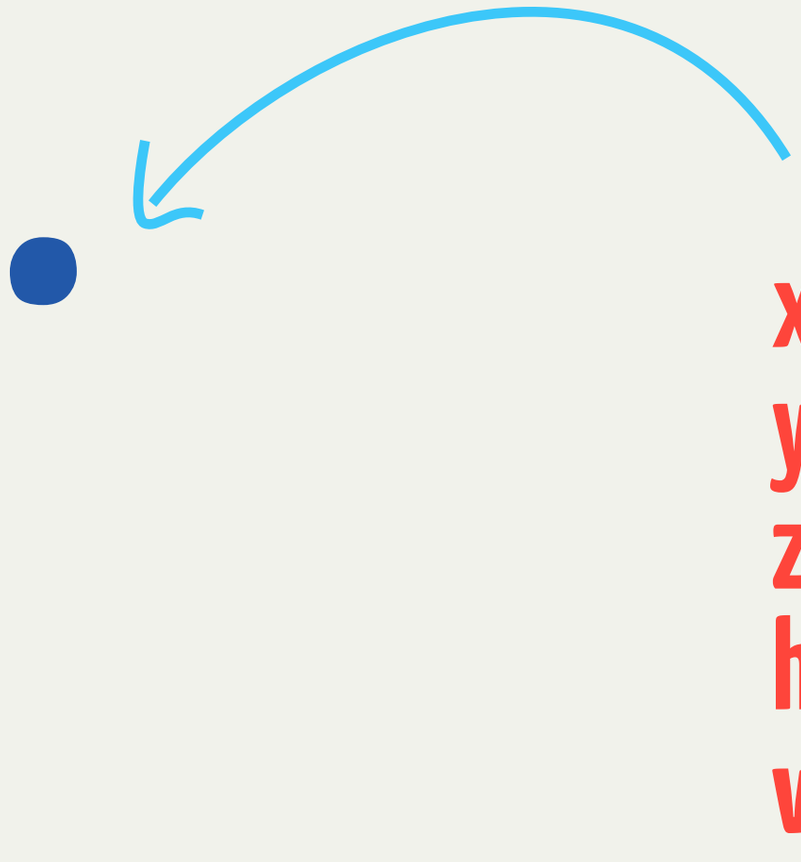
Particle Filter?



This is a particle



It represents a possible pose


x
y
z
heading
weight

Prediction Step

Update the position of each particle using noisy velocity and gyroscope readings.

Correction Step

1. Check for an augmented reality tag.
2. Calculate transformation from camera to tag.
3. Use known coordinates of the tag to calculate the position of the quadcopter.

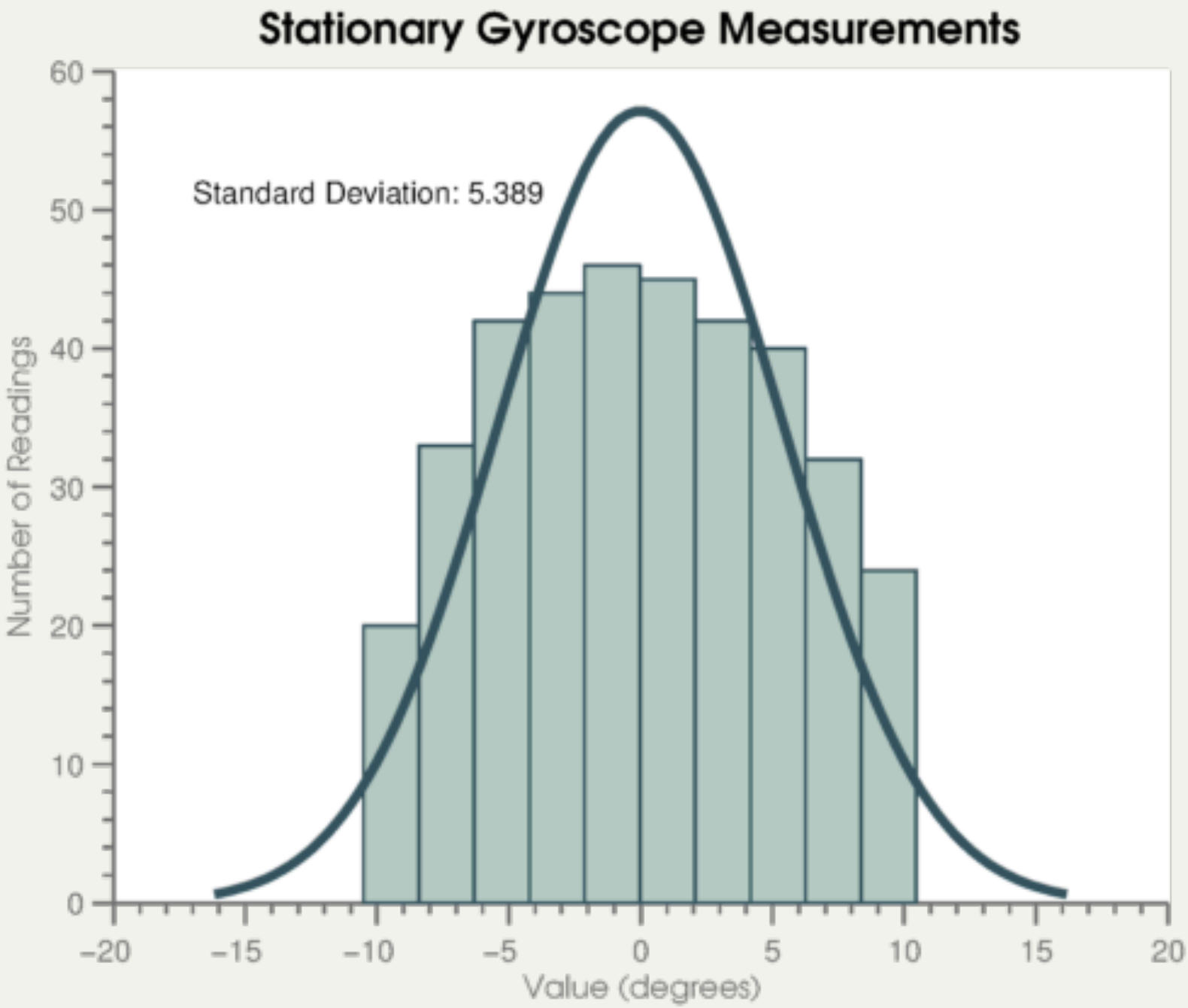
Correction Step

4. Weight the particles using their similarity to this calculated position.
5. Perform weighted resampling of the particles.
6. With some probability, replace particles with this calculated position.

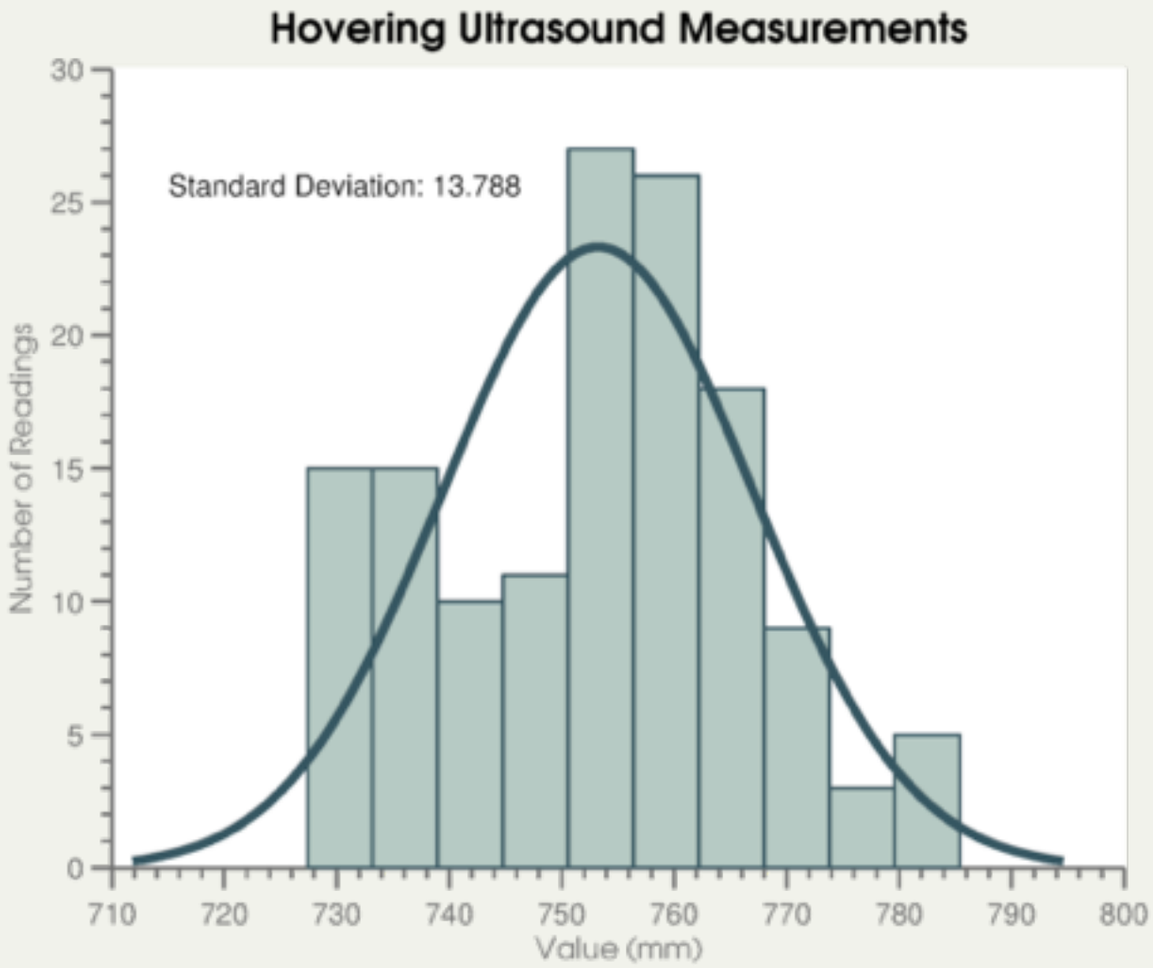
Estimate

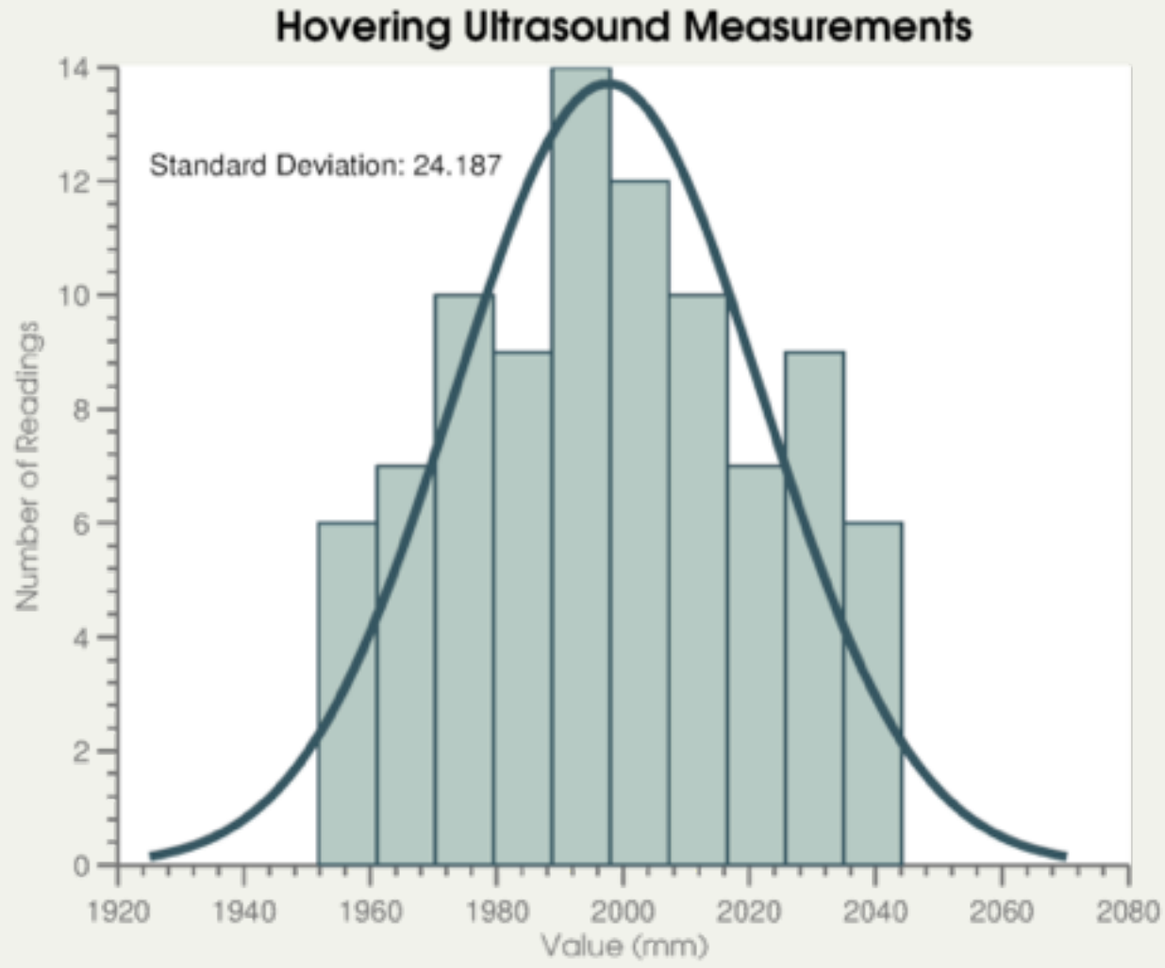
Use a linear combination of the particle values to create an estimated pose.

Testing


Stationary Gyroscope Measurements
Standard Deviation: 5.389
Number of Readings
60
50
40
30
20
10
0
−20
−15
−10
−5
0
5
10
15
20
Value (degrees)

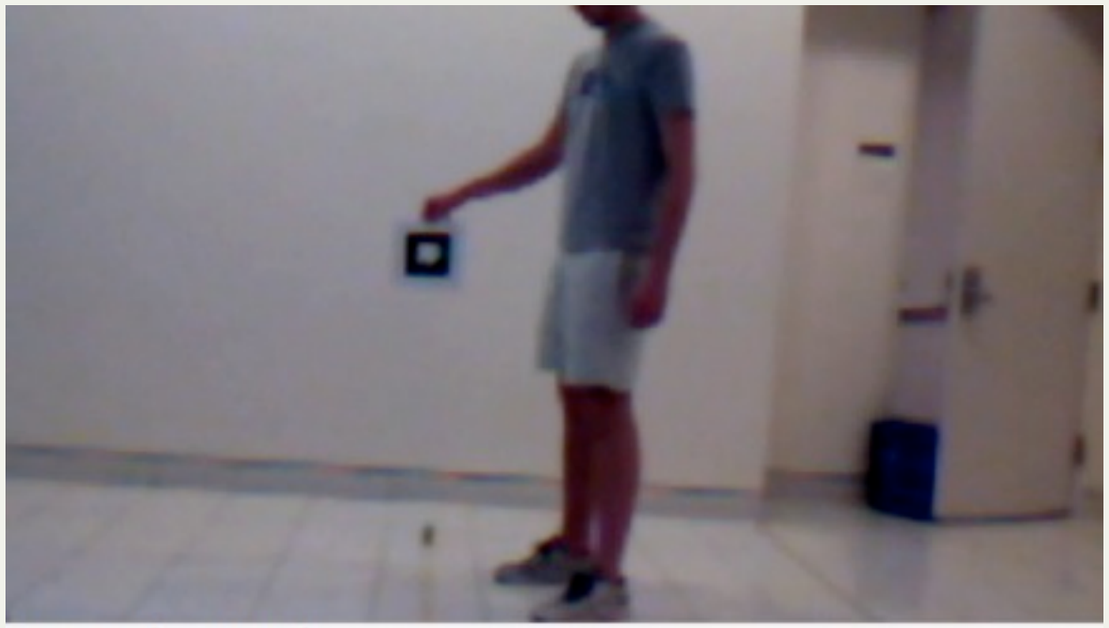
Gyroscope


Hovering Ultrasound Measurements
Standard Deviation: 13.788
Number of Readings
Value (mm)
0
5
10
15
20
25
30
710
720
730
740
750
760
770
780
790
800


Hovering Ultrasound Measurements
Standard Deviation: 24.187
Number of Readings
Value (mm)
0
2
4
6
8
10
12
14
1920
1940
1960
1980
2000
2020
2040
2060
2080

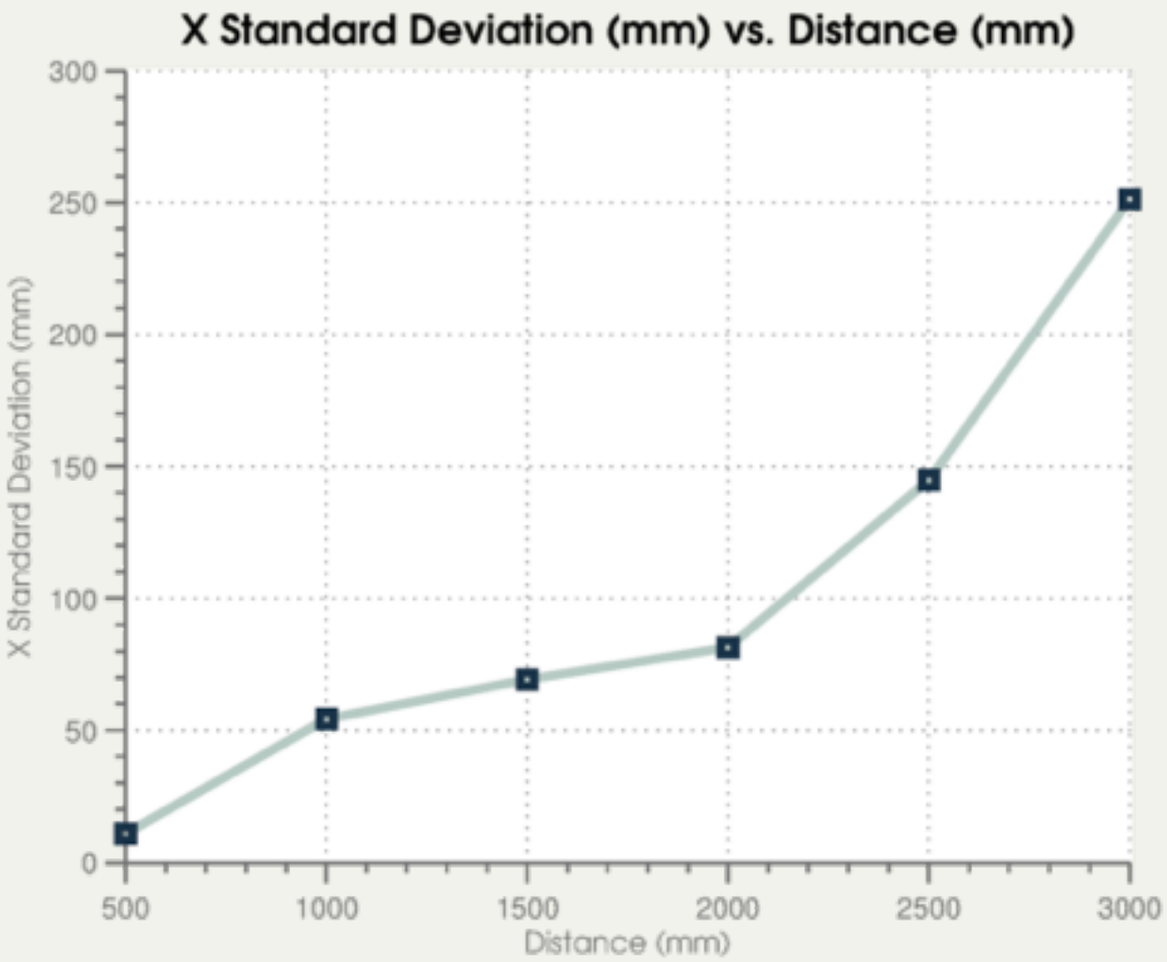
Ultrasound

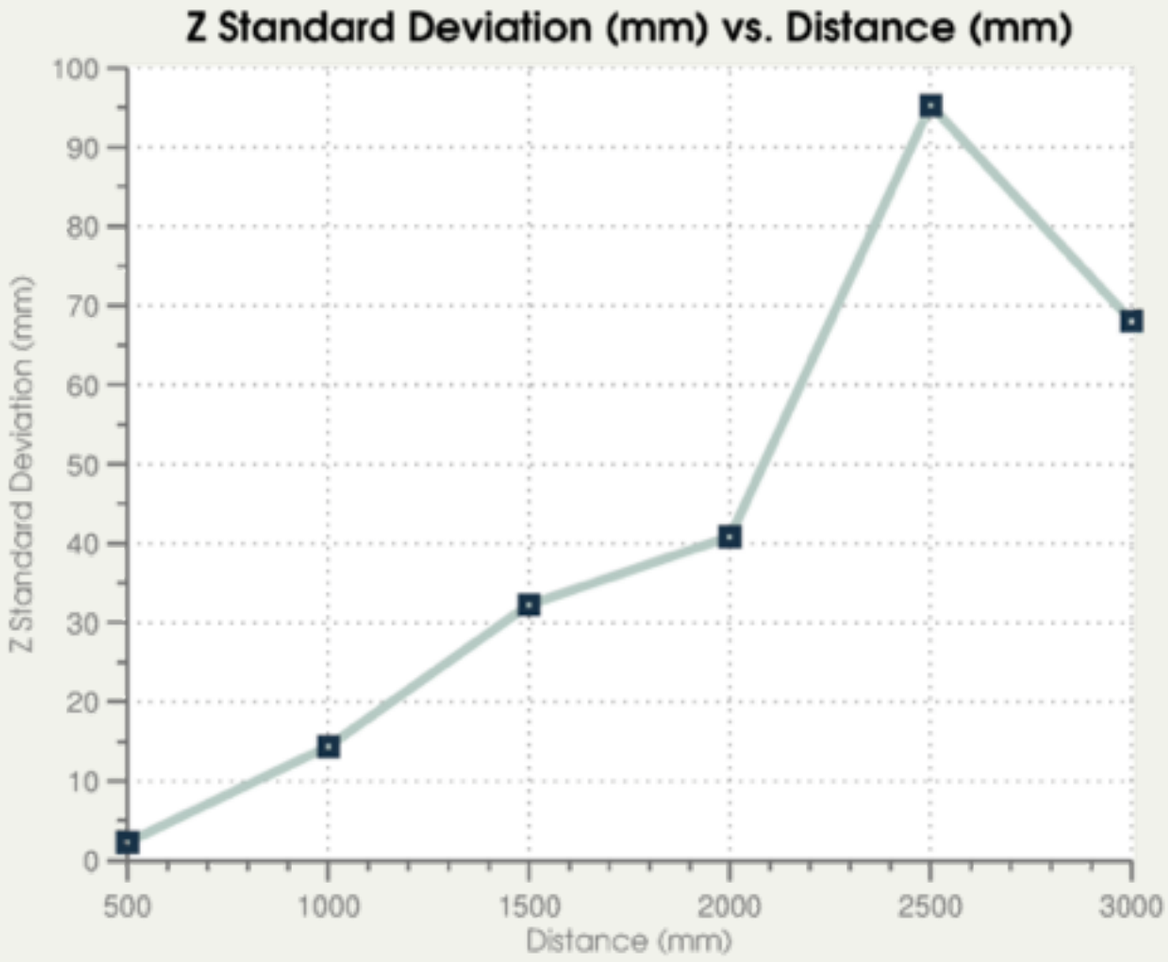
Emergency (Battery: 80%)



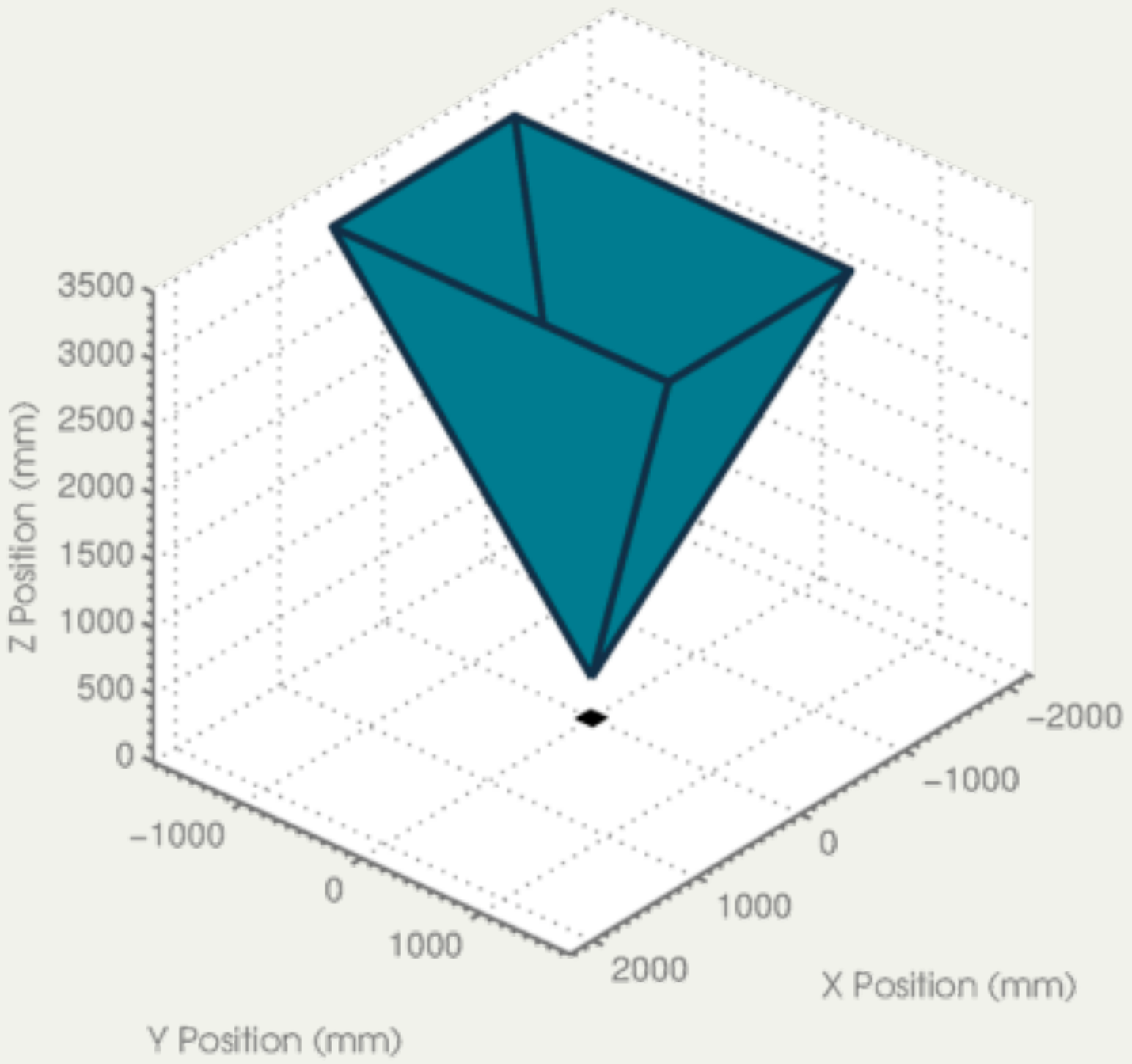
Emergency (Battery: 78%)

AR Tag

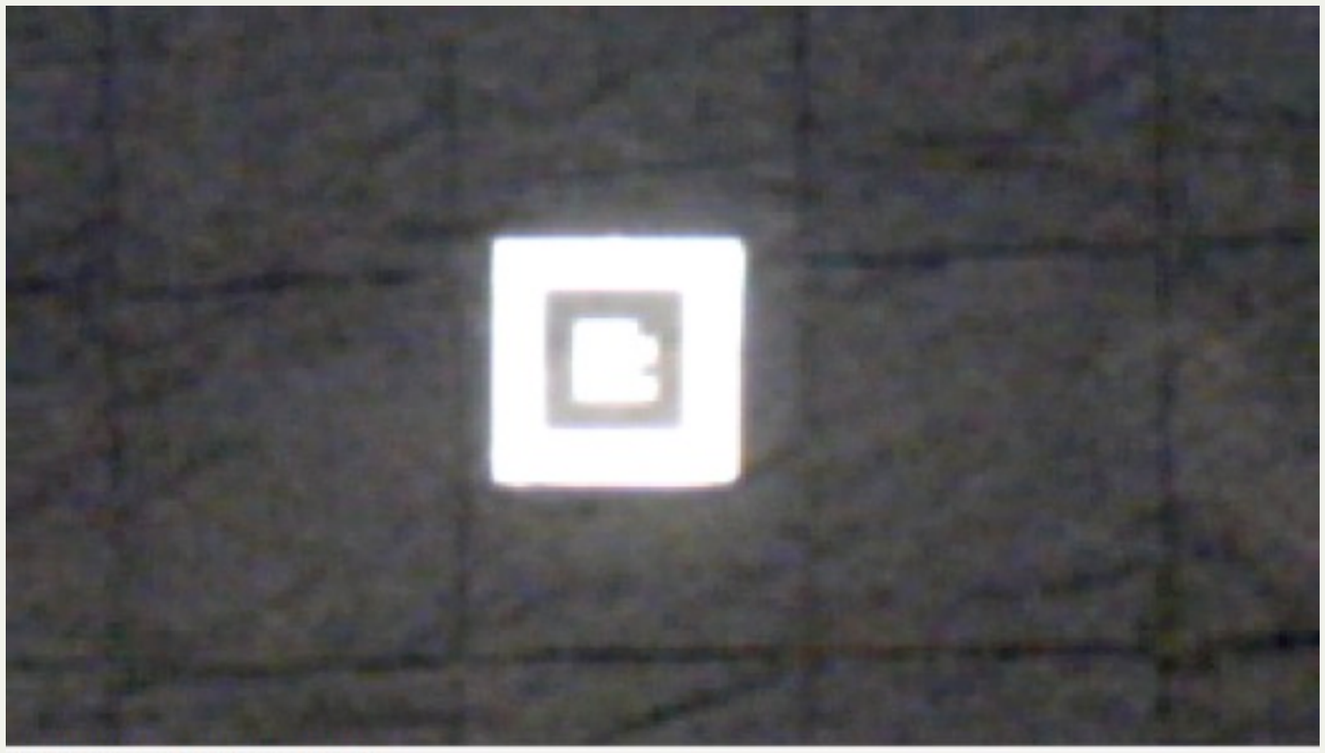

X Standard Deviation (mm) vs. Distance (mm)
X Standard Deviation (mm)
Distance (mm)
0
50
100
150
200
250
300
500
1000
1500
2000
2500
3000


Z Standard Deviation (mm) vs. Distance (mm)
Z Standard Deviation (mm)
Distance (mm)
0
10
20
30
40
50
60
70
80
90
100
500
1000
1500
2000
2500
3000

AR Tag

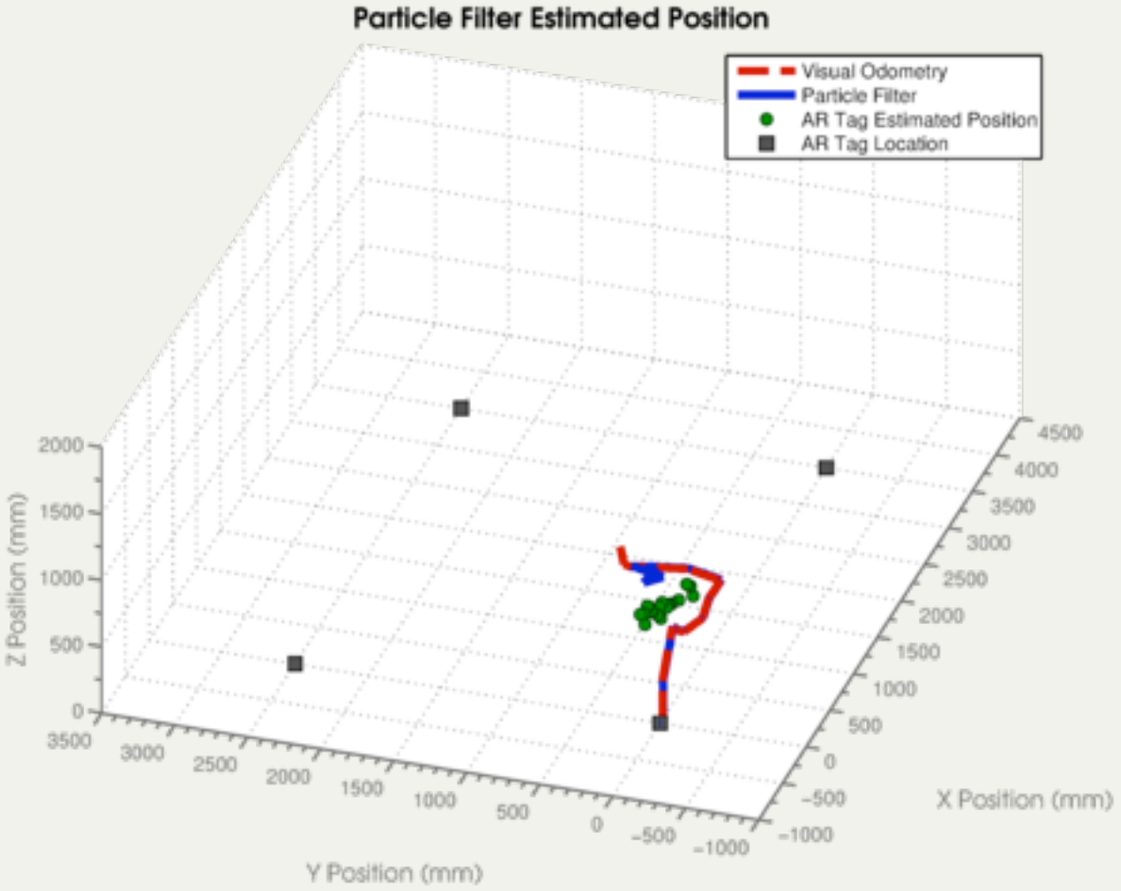

Tag Detection Space
Z Position (mm)
3500
3000
2500
2000
1500
1000
500
0
−1000
0
1000
2000
Y Position (mm)
−2000
−1000
0
1000
X Position (mm)

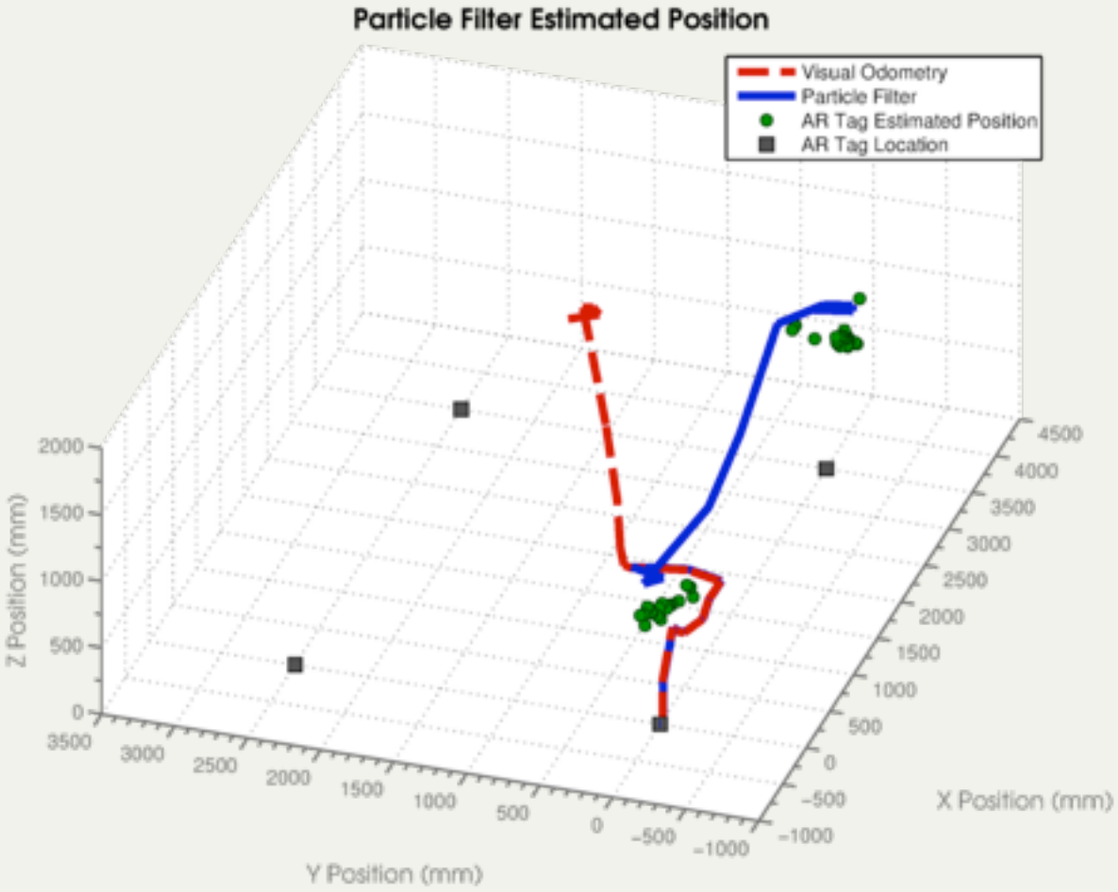
AR Tag

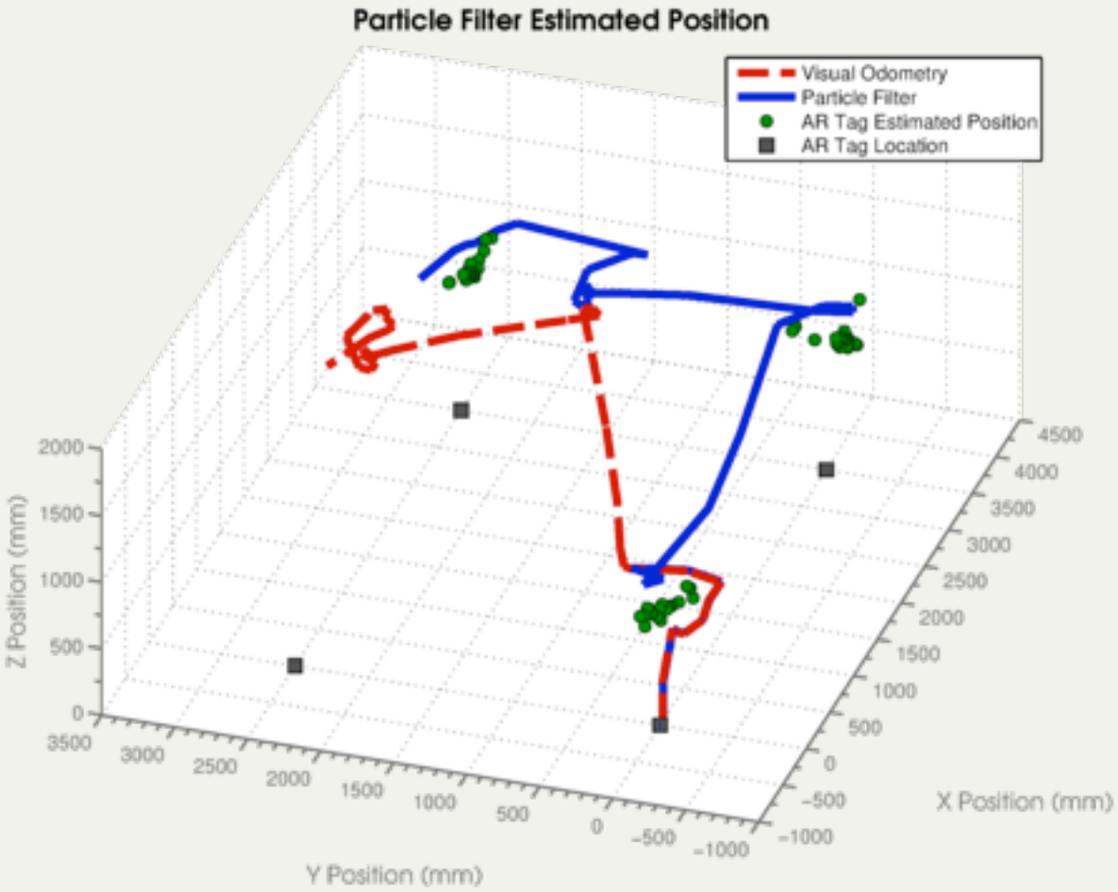


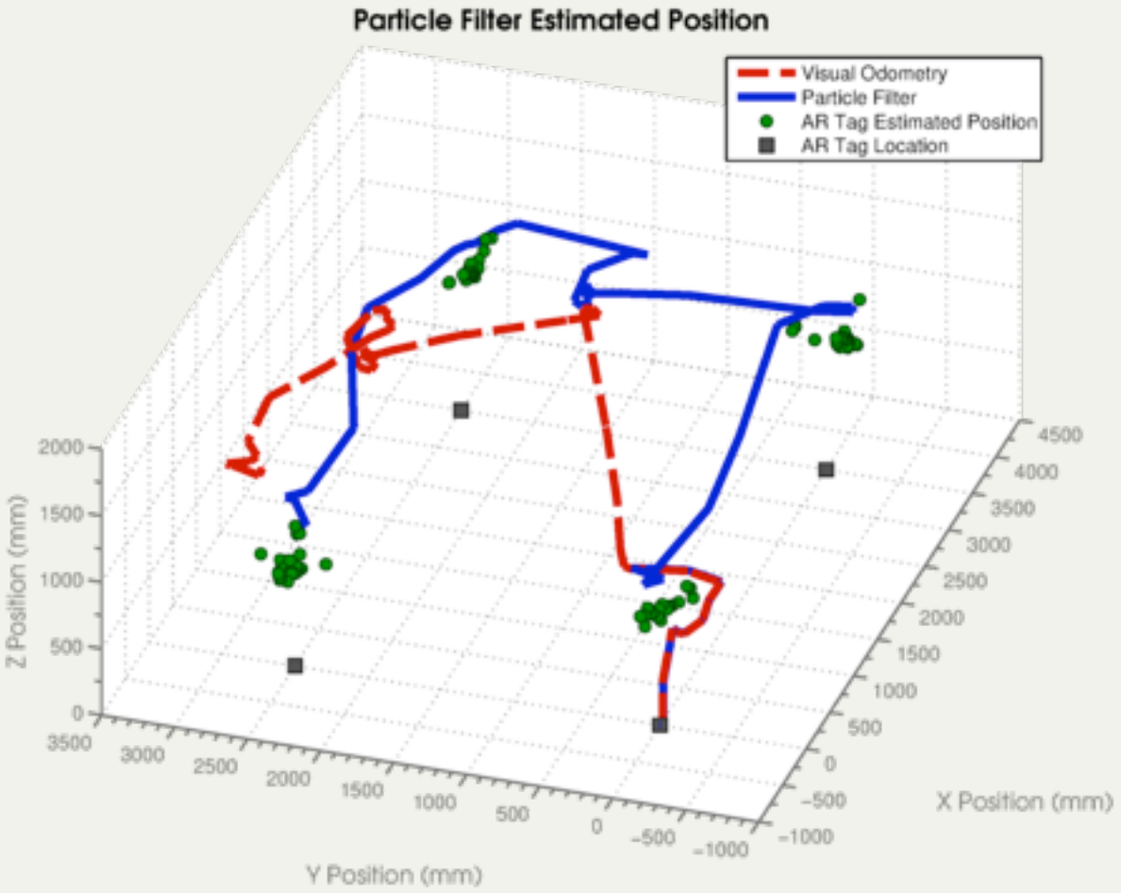
AR Tag

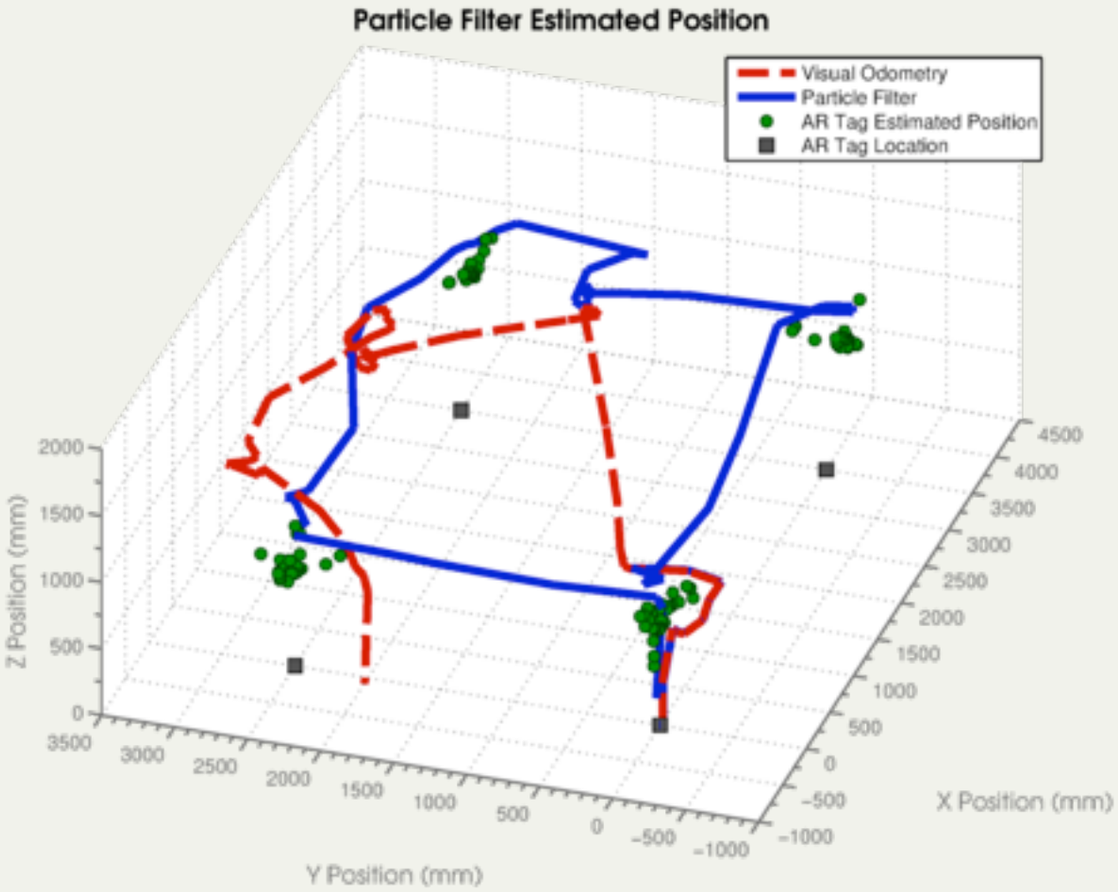
Manual Flight Test


Particle Filter Estimated Position
Visual Odometry
Particle Filter
AR Tag Estimated Position
AR Tag Location
Z Position (mm)
Y Position (mm)
X Position (mm)


Particle Filter Estimated Position
Visual Odometry
Particle Filter
AR Tag Estimated Position
AR Tag Location
Z Position (mm)
2000
1500
1000
500
0
Y Position (mm)
3500
3000
2500
2000
1500
1000
500
0
−500
−1000
X Position (mm)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
−500
−1000


Particle Filter Estimated Position
Visual Odometry
Particle Filter
AR Tag Estimated Position
AR Tag Location
Z Position (mm)
2000
1500
1000
500
0
3500
3000
2500
2000
1500
1000
500
0
−500
−1000
Y Position (mm)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
−500
−1000
X Position (mm)


Particle Filter Estimated Position
Visual Odometry
Particle Filter
AR Tag Estimated Position
AR Tag Location
Z Position (mm)
2000
1500
1000
500
0
3500
3000
2500
2000
1500
1000
500
0
−500
−1000
Y Position (mm)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
−500
−1000
X Position (mm)


Particle Filter Estimated Position
Visual Odometry
Particle Filter
AR Tag Estimated Position
AR Tag Location
Z Position (mm)
2000
1500
1000
500
0
3500
3000
2500
2000
1500
1000
500
0
−500
−1000
Y Position (mm)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
−500
−1000
X Position (mm)

Conclusion

Particle filter localization using augmented reality tags

performs **substantially better** than integrated velocity alone.

AR Tags are highly dependent on lighting.

Its called Hardware

for a reason.

Next steps...

Full integration with controller.

Modeling objects.

Thanks!