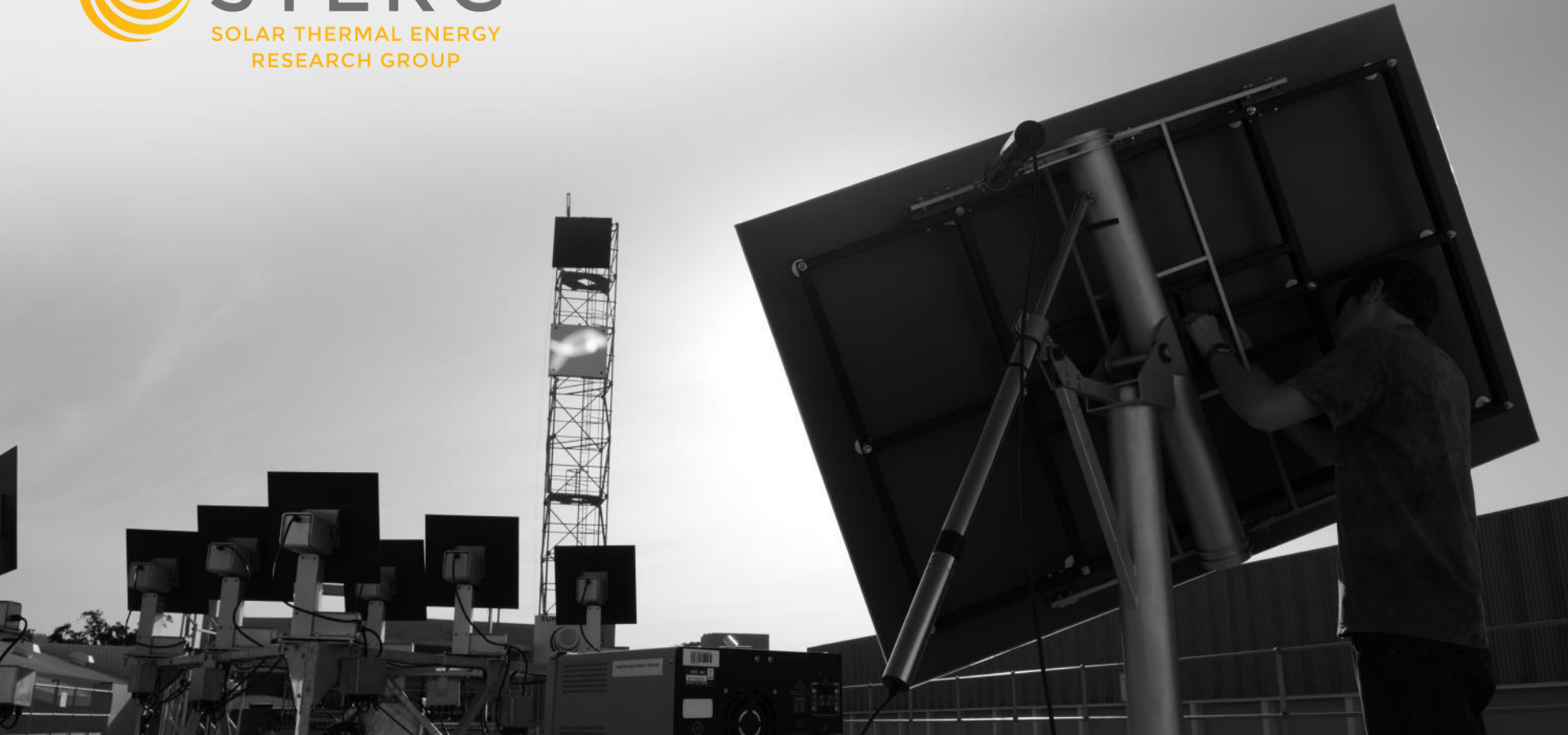




STERG

SOLAR THERMAL ENERGY
RESEARCH GROUP



Estimating a Drone's Pose Using Computer Vision Techniques

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Background



Drones

- Autonomous or manually controlled
- Small, light, manoeuvrable, cheap
- Various applications
 - Geomapping, photography, delivery
- Possible uses in CSP plant setting

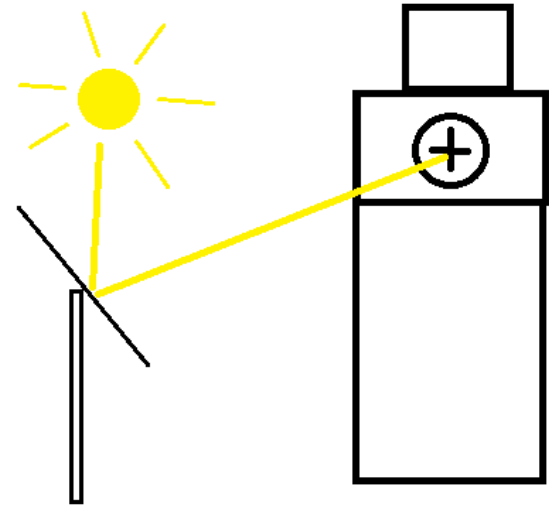


Background



Current Procedure

- Manually aim heliostat to target below receiver
- Downsides
 - Limited to daytime
 - Takes very long
 - Loss of accuracy over time
- External loadings compensated for with heavy frames

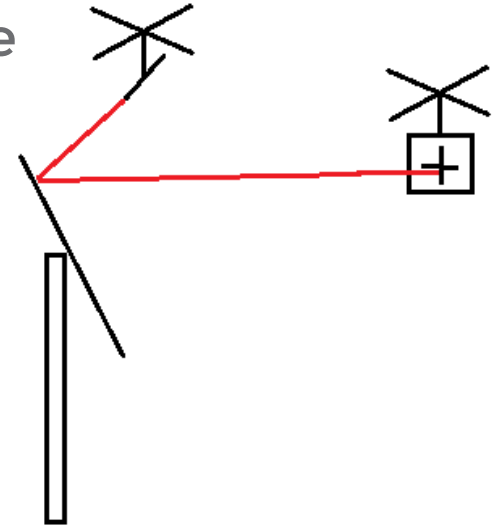


Background



Advantages and Problems of Using Drones

- Teams of dedicated drones means more frequent calibration
 - Lighter, cheaper frames = lower cost of plant
- One drone receiver, other source
- Drones don't hold position accurately
 - Wind, model, GPS errors, etc.
- How accurately does it hold its pose?
 - Required by calibration model



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Methodology



Measurement System

- Has been done for indoor systems
 - Uses sophisticated camera system in control loop
 - Current methods not applicable to outdoor measurement (requires GPS lock)
- Use CV-based system
 - Lasers + Radar unavailable and expensive
 - CV system uses any camera + OpenCV = very cheap

Methodology



Measurement System (Cont.)

- Estimates pose by tracking corners on chessboard
- Some errors involved
 - Need to determine those errors before it can be used

Methodology



Error Measurement

- Error determined by comparing with state-of-the-art Vicon indoor camera measurement system
- First optimise camera matrix's focal lengths to improve pose estimate
 - Find f_x, f_y by minimising error and constant offset bias
 - Cost Function: $F(f_x, f_y) = (P_b - \bar{P}_b) - (P_c - \bar{P}_c) + \epsilon$
- Find errors by comparing Vicon with camera data
- Check for interdimensional dependence with covariance matrix

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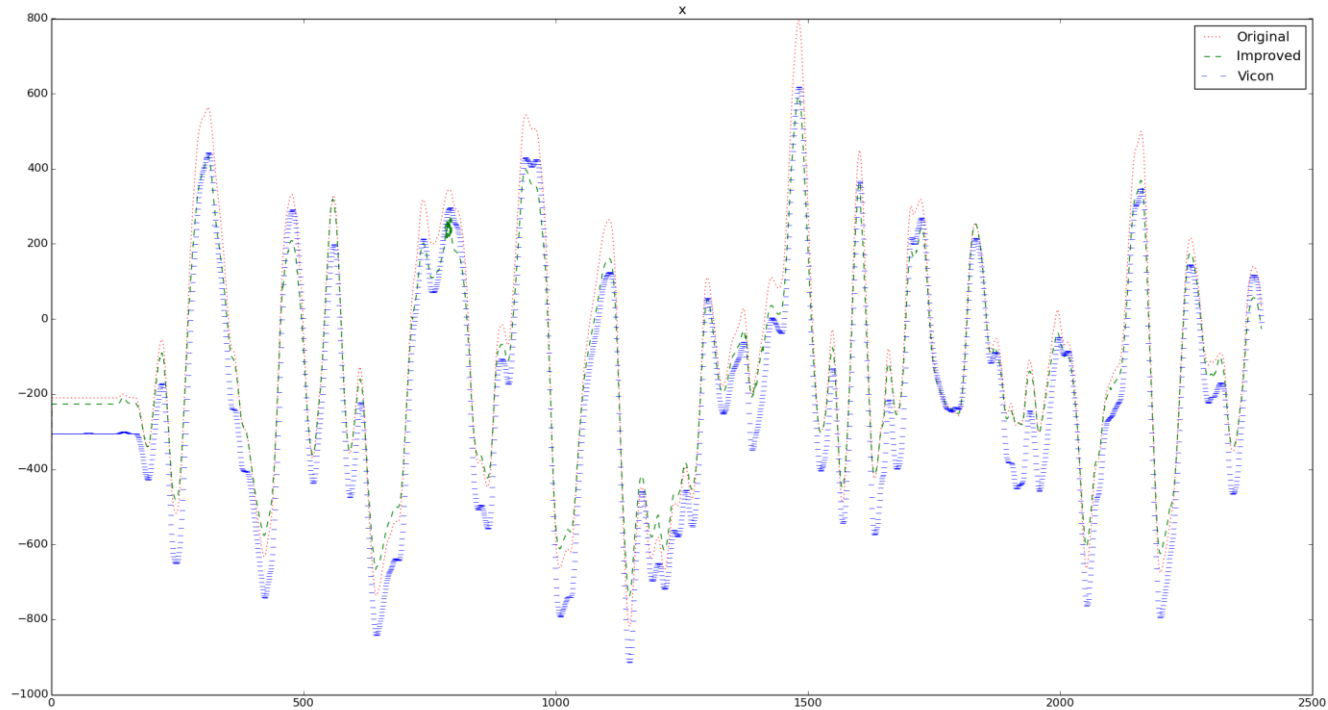
Future Work

Acknowledgements

Results



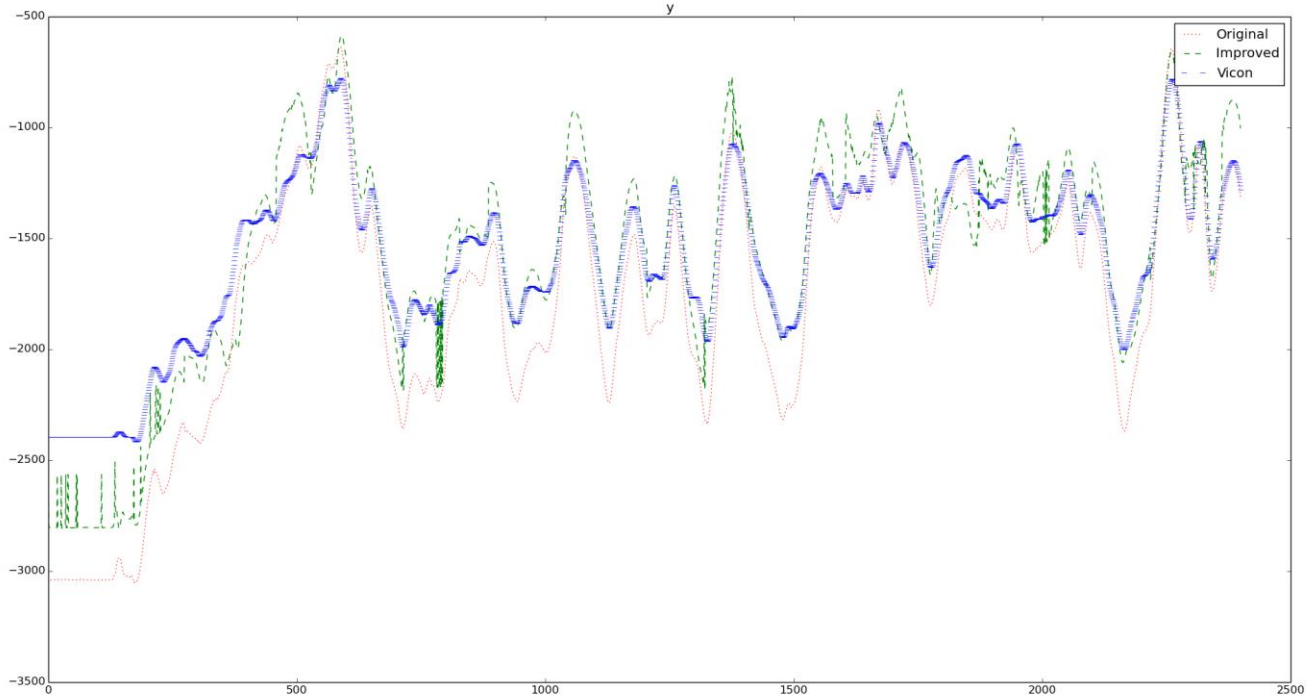
Camera vs. Vicon: x



Results



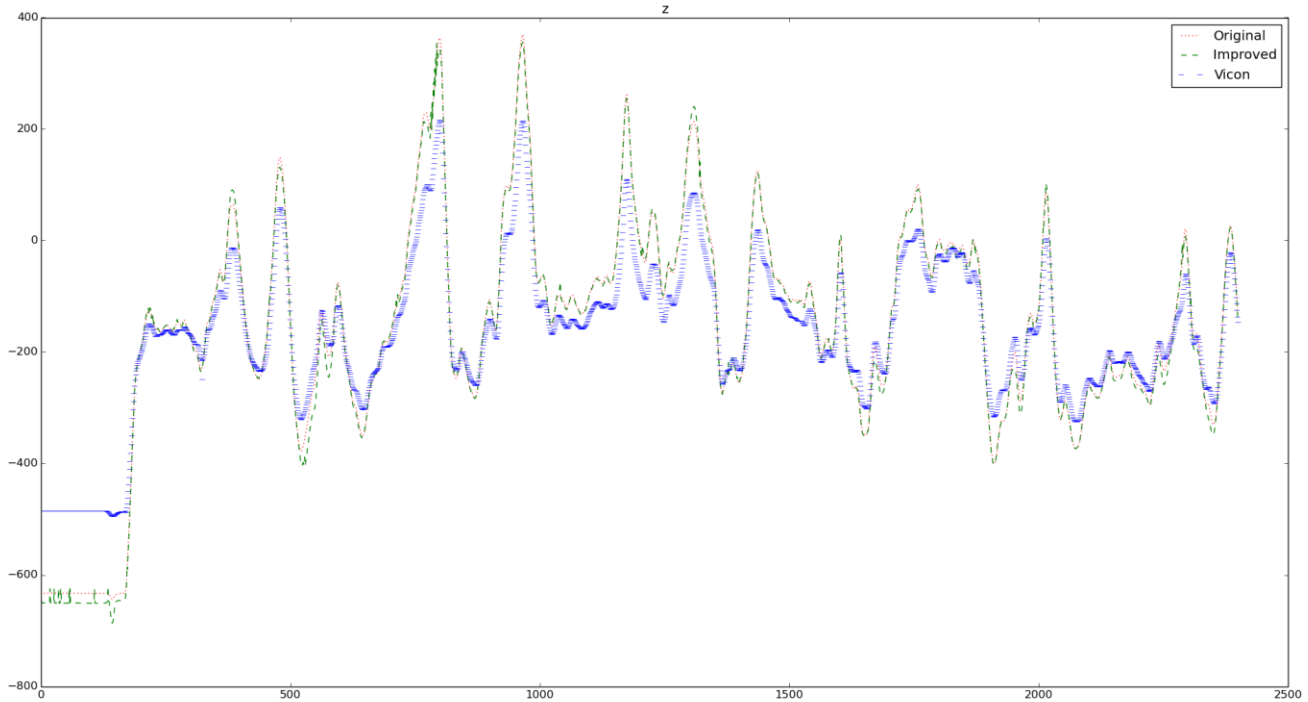
Camera vs. Vicon: y



Results



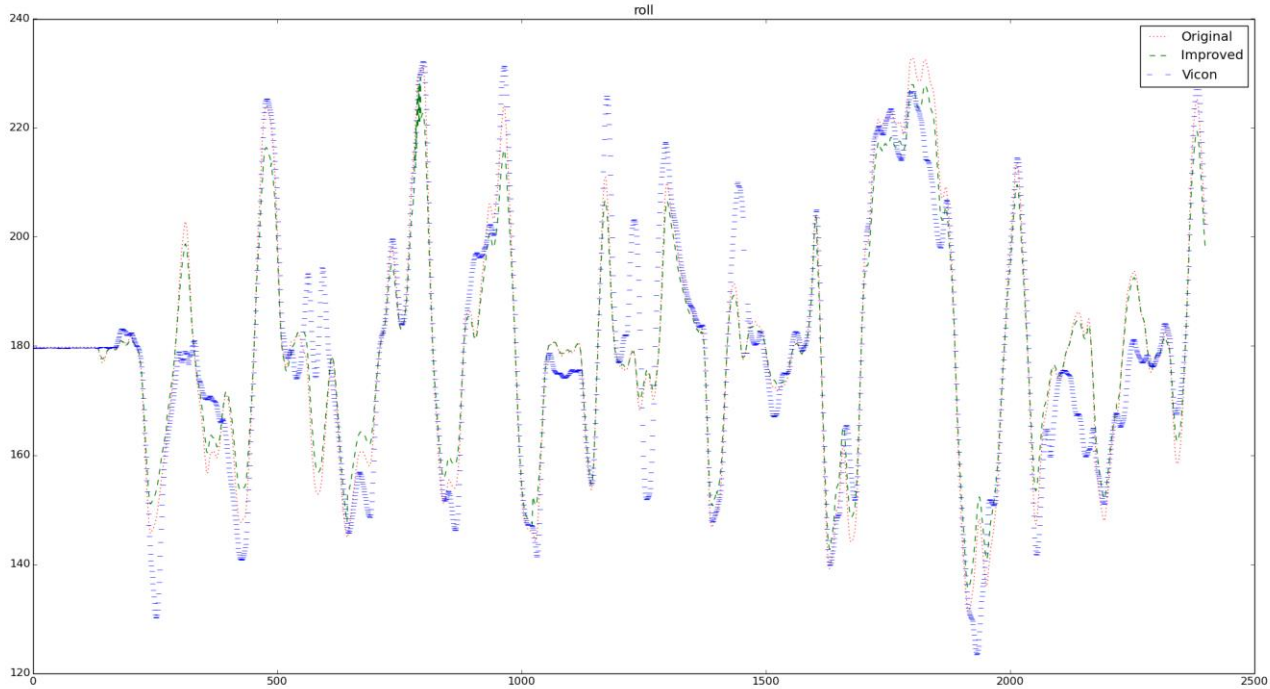
Camera vs. Vicon: z



Results



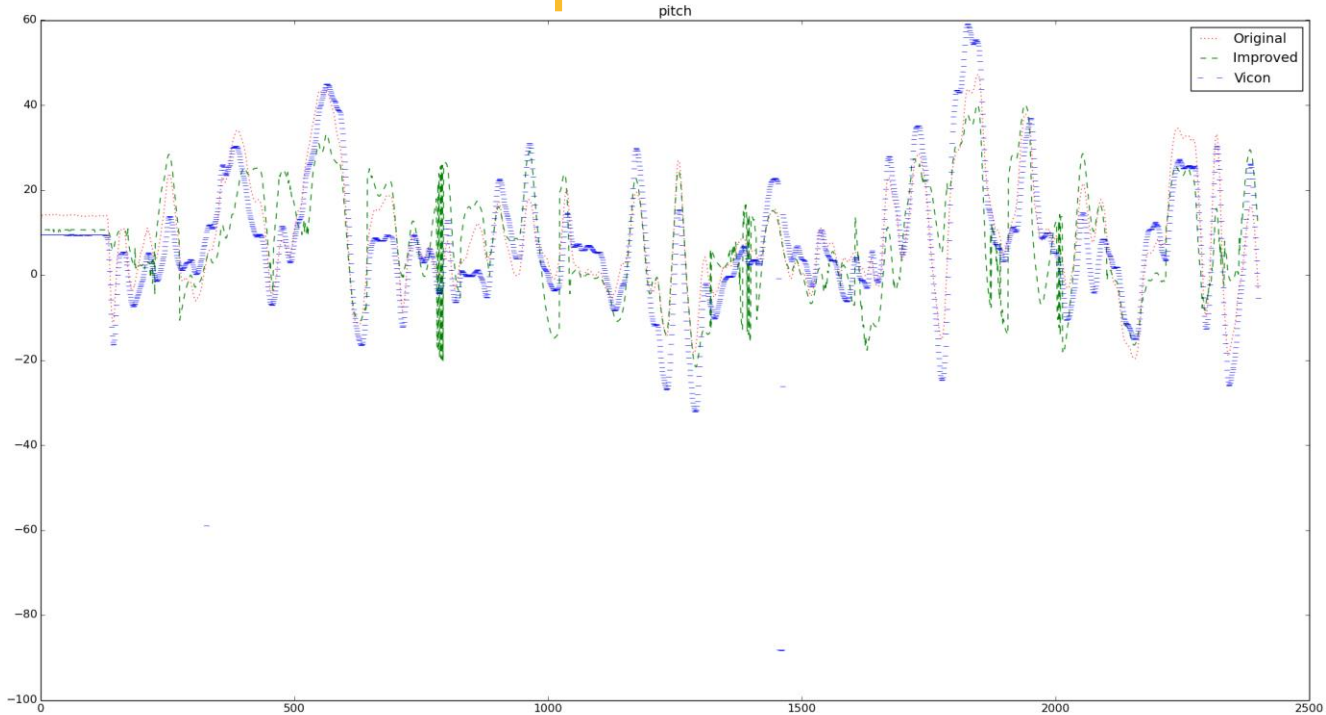
Camera vs. Vicon: roll



Results

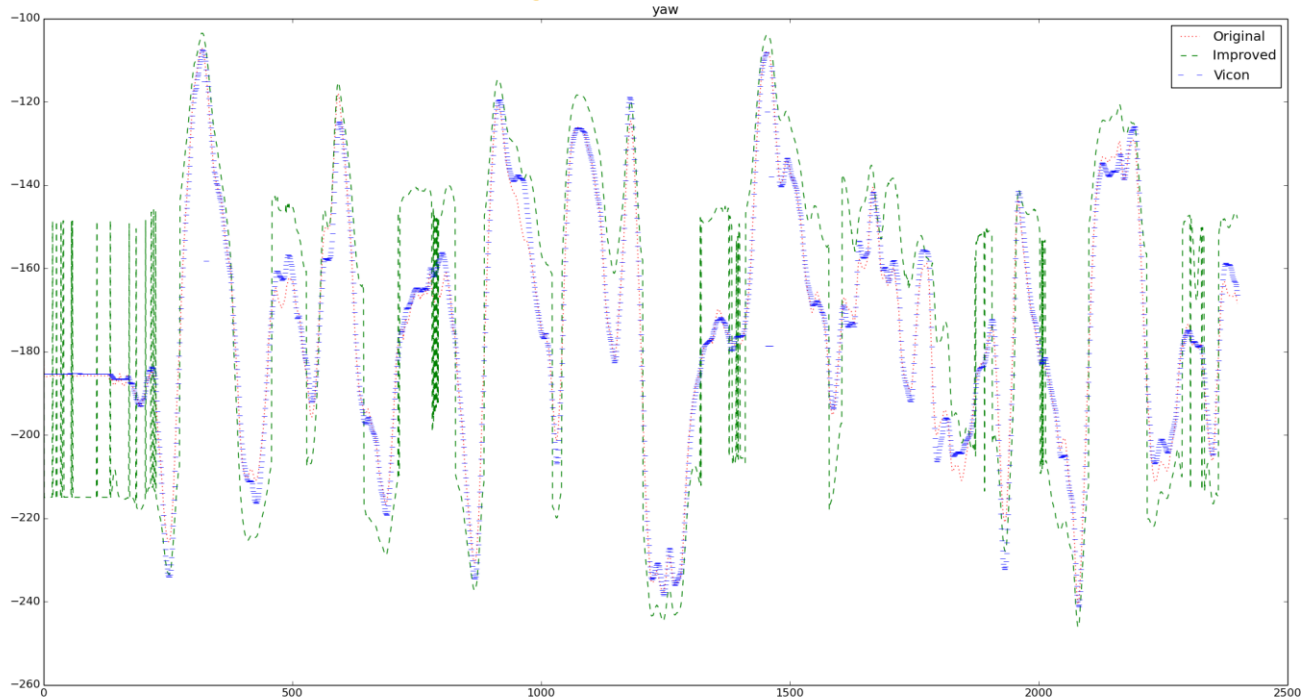


Camera vs. Vicon: pitch



Results

Camera vs. Vicon: yaw



Results



Pose error

- Indicates strong interdimensional dependence
 - Implies that measurement error depends on distance from camera for eg.
- Not an optimal result, but still a useful one

	x	y	z	roll	pitch	yaw
x	26244.789	-2502.109	1828.222	232.743	-355.309	975.763
y	-2502.109	33398.392	4938.953	-150.693	-9.425	711.815
z	1828.222	4938.953	4390.198	-146.195	-16.773	280.497
roll	232.740	-150.693	-146.195	64.747	13.696	2.104
pitch	-355.300	9.425	-16.773	13.696	75.867	-30.413
yaw	975.760	711.815	280.497	2.104	-30.413	239.816

Conclusion



- Camera-based outdoor measurement system designed, tested, optimised
- Results compare well with Vicon measurements
- Found error covariance matrix that can be used in the future
- System ready for tests with a drone

Current and Future Work



- Currently performing tests with real drone
 - Busy with processing and analysis
- Implement measurements into calibration model

Thank you

ACKNOWLEDGEMENTS:

NRF, CRSES, STERG, M&M Engineering

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