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SOLAR THERMAL ENERGY RESEARCH GROUP

Estimating a Drone's Pose Using Computer Vision Techniques

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Background

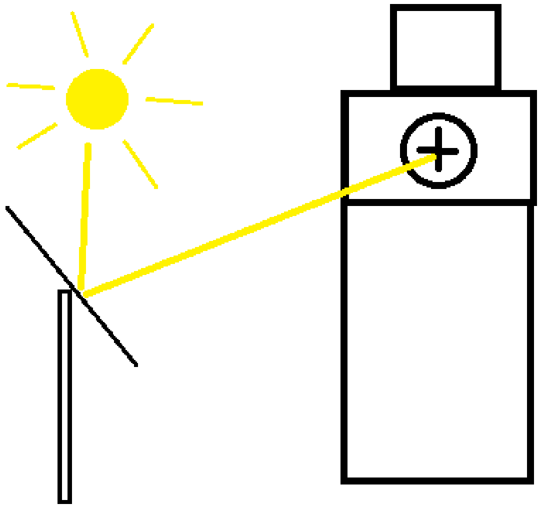
Drones

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

Background

Current Procedure

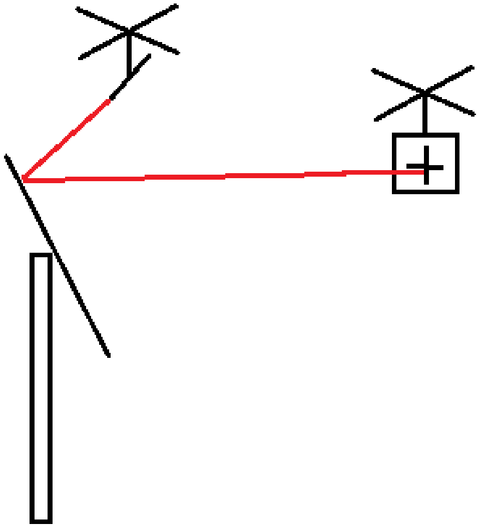
- Manually aim heliostat to target below receiver
- Downsides
  - Limited to daytime
  - Takes very long
  - Loss of accuracy over time
- External loadings compensated for with heavy frames



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 is hold its pose?
  - Required by calibration model



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Methodology

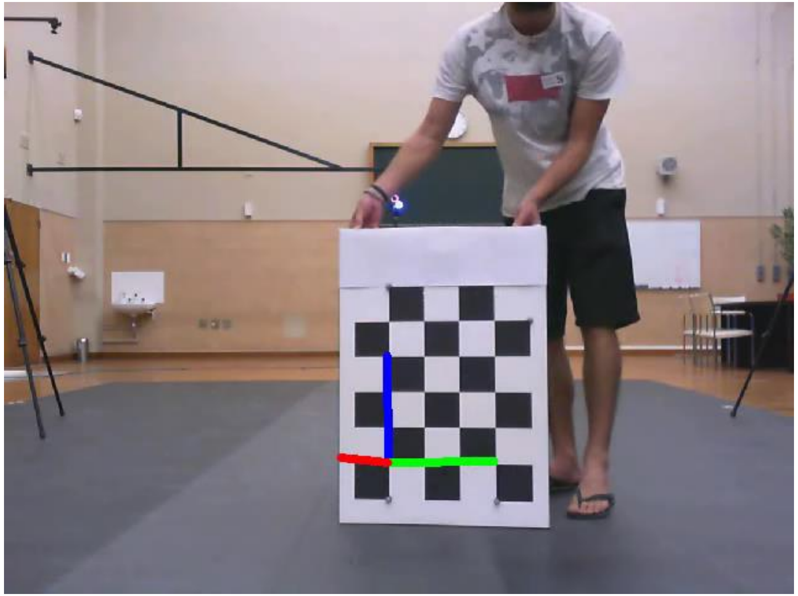
Measurement System

- 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



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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: $F(f_x, f_y) = (\boldsymbol{P}_b - \overline{\boldsymbol{P}}_b) - (\boldsymbol{P}_c - \overline{\boldsymbol{P}}_c) + \epsilon$
- Find errors by comparing Vicon with camera data
- Check for interdimensional dependence with covariance matrix

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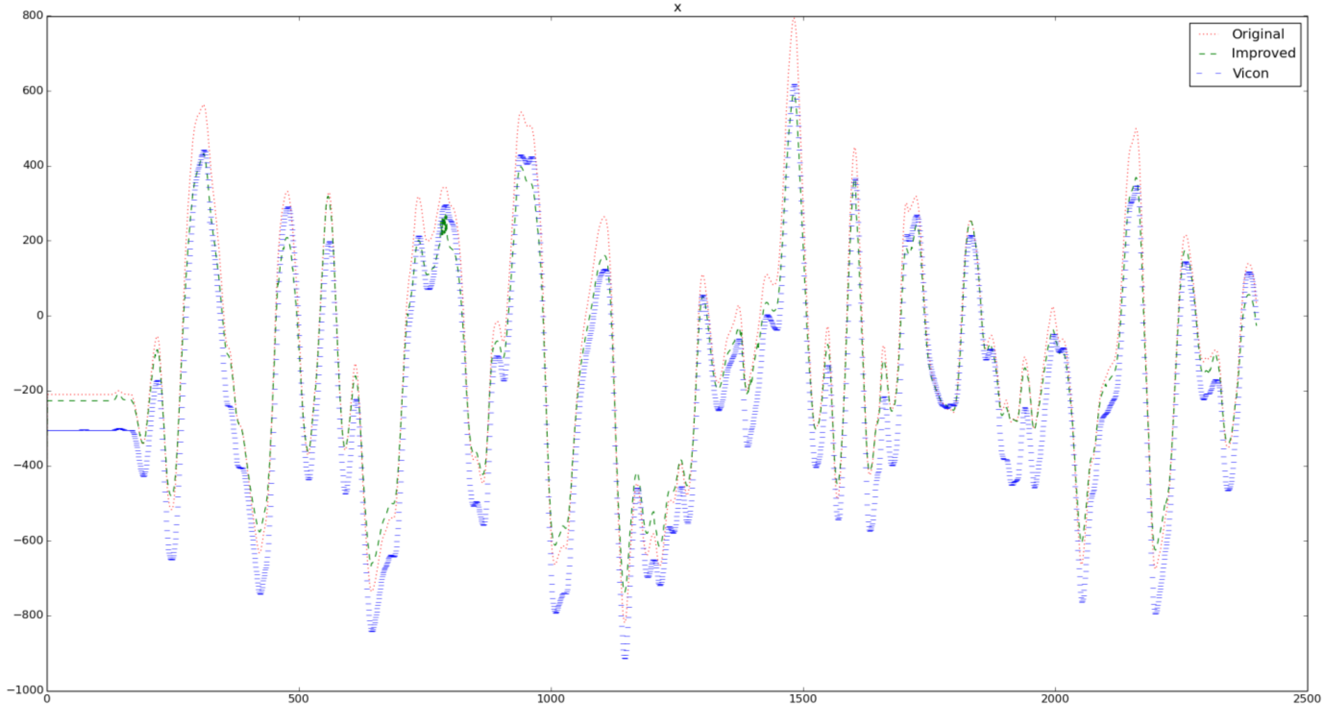
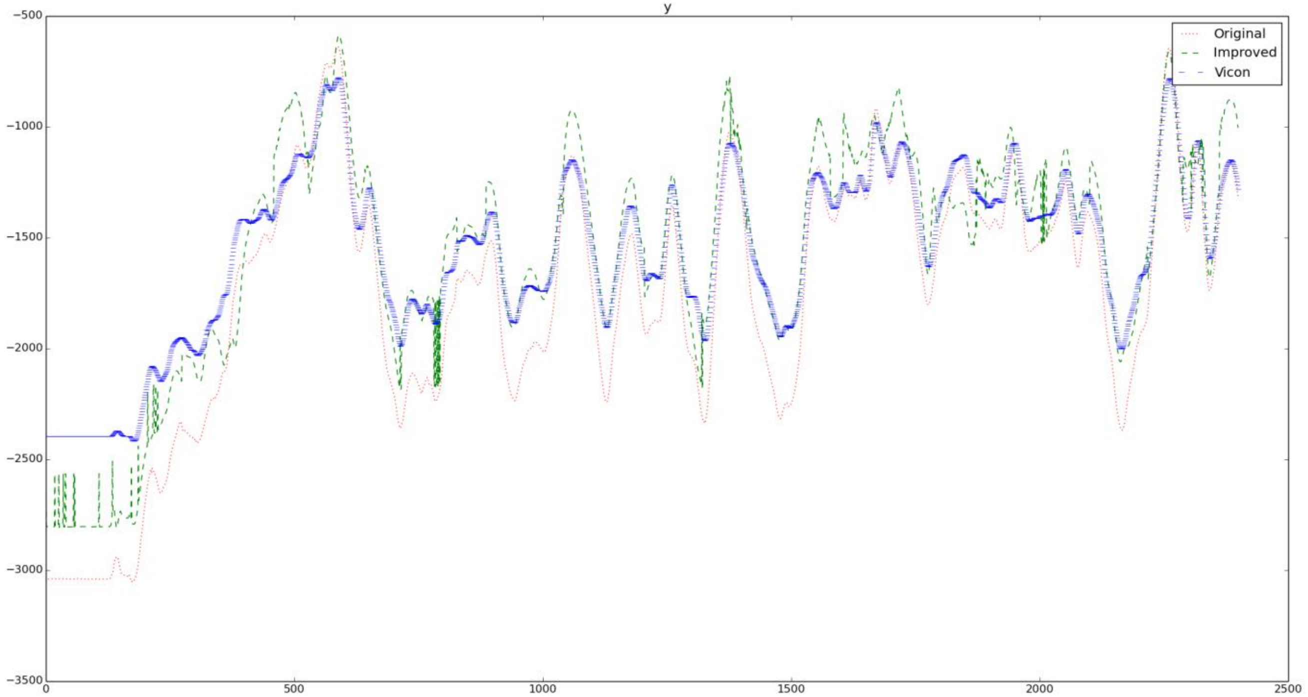
Results

Camera vs. Vicon: x



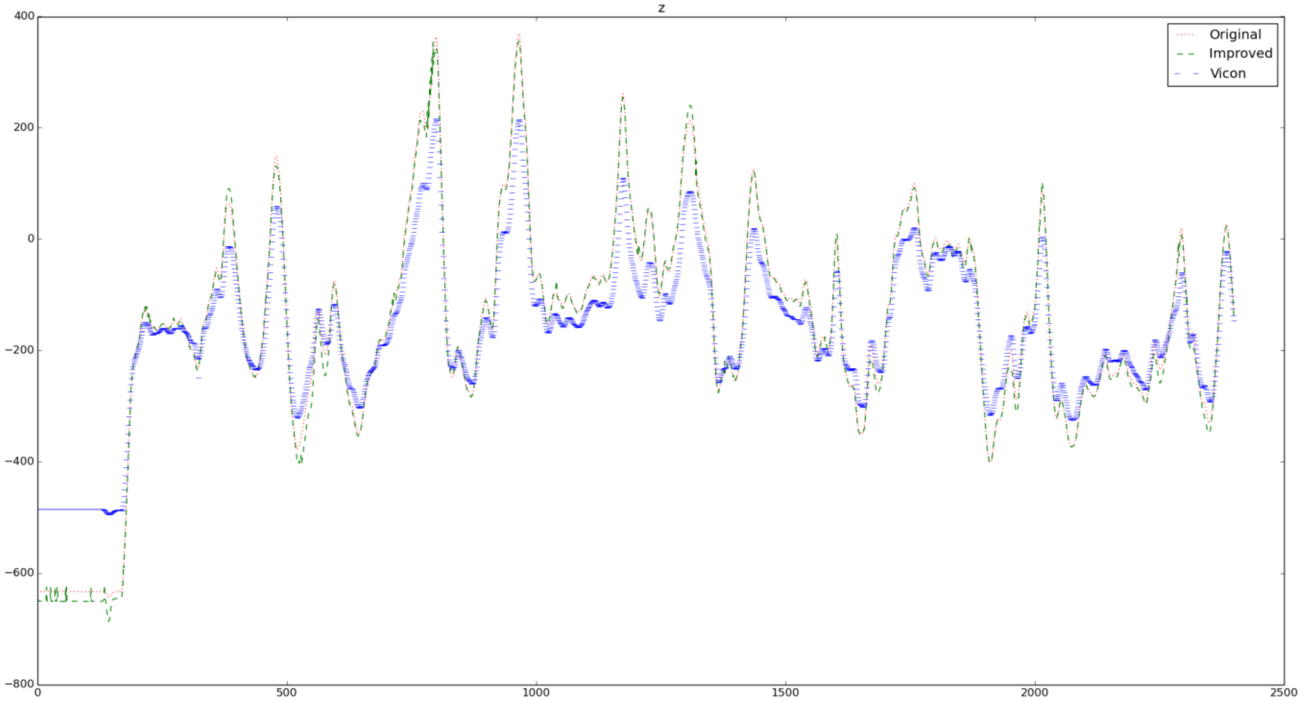
Results

Camera vs. Vicon: y



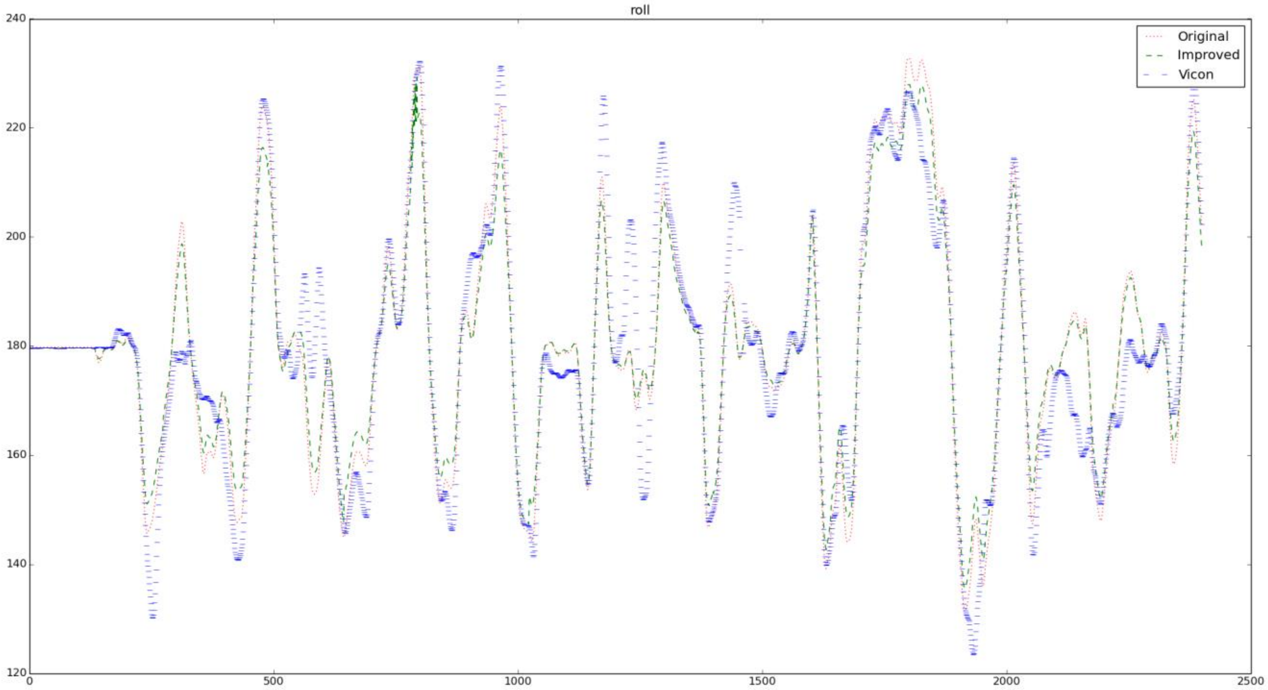
Results

Camera vs. Vicon: z



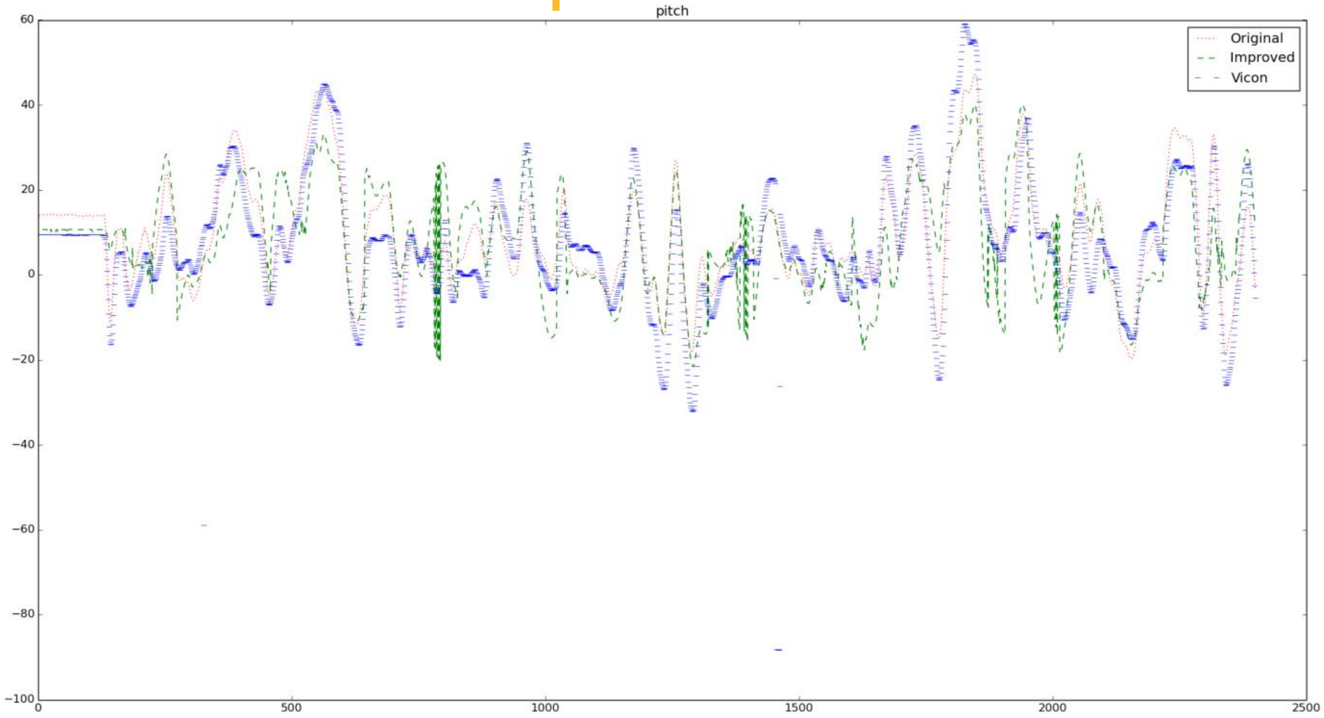
Results

Camera vs. Vicon: roll



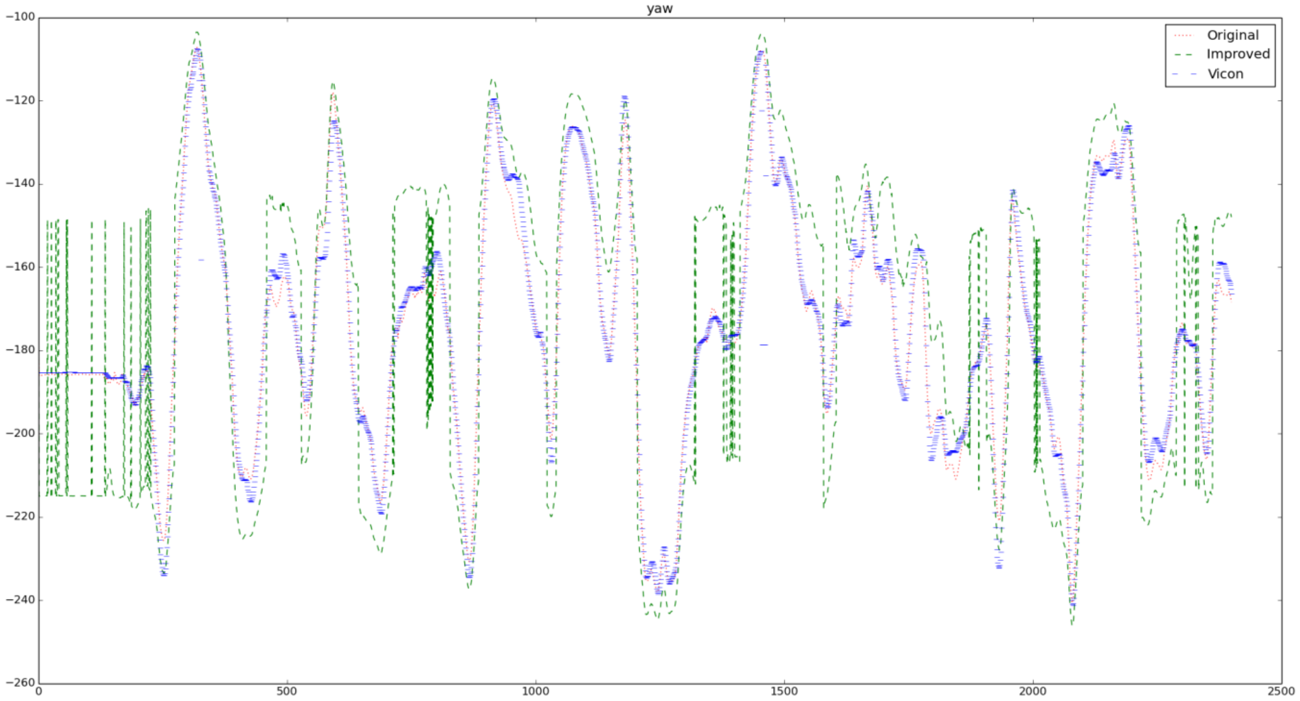
Results

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

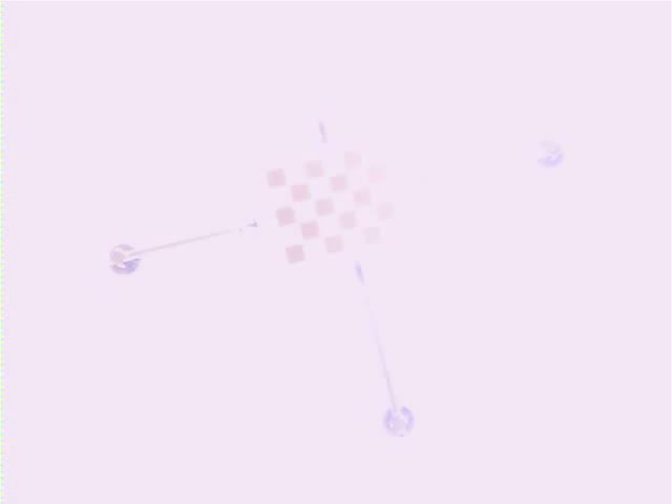
	x	y	z	roll	pitch	yaw
x	**26244.789**	-2502.109	1828.222	232.743	-355.309	975.763
y	-2502.109	**33398.392**	4938.953	-150.693	-9.425	711.815
z	1828.222	4938.953	**4390.198**	-146.195	-16.773	280.497
roll	232.740	-150.693	-146.195	**64.747**	13.696	2.104
pitch	-355.300	9.425	-16.773	13.696	**75.867**	-30.413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

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