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Camera View From Crane Payload: Video Stabilization

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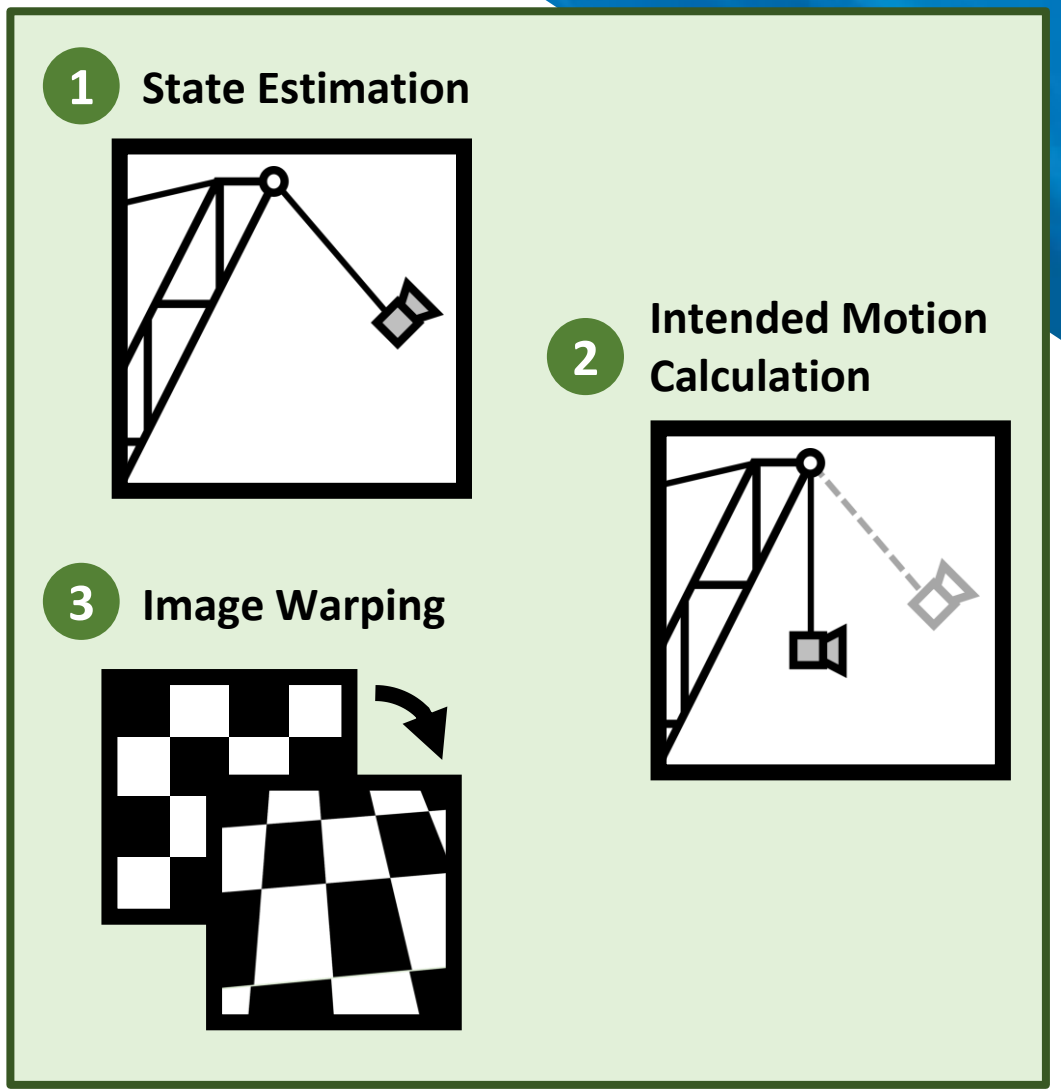
INTRODUCTION

- Cranes operations
  - Unsafe
  - Slow
- Solution
  - Provide visual feedback
- Consideration
  - Payload swinging is disorienting

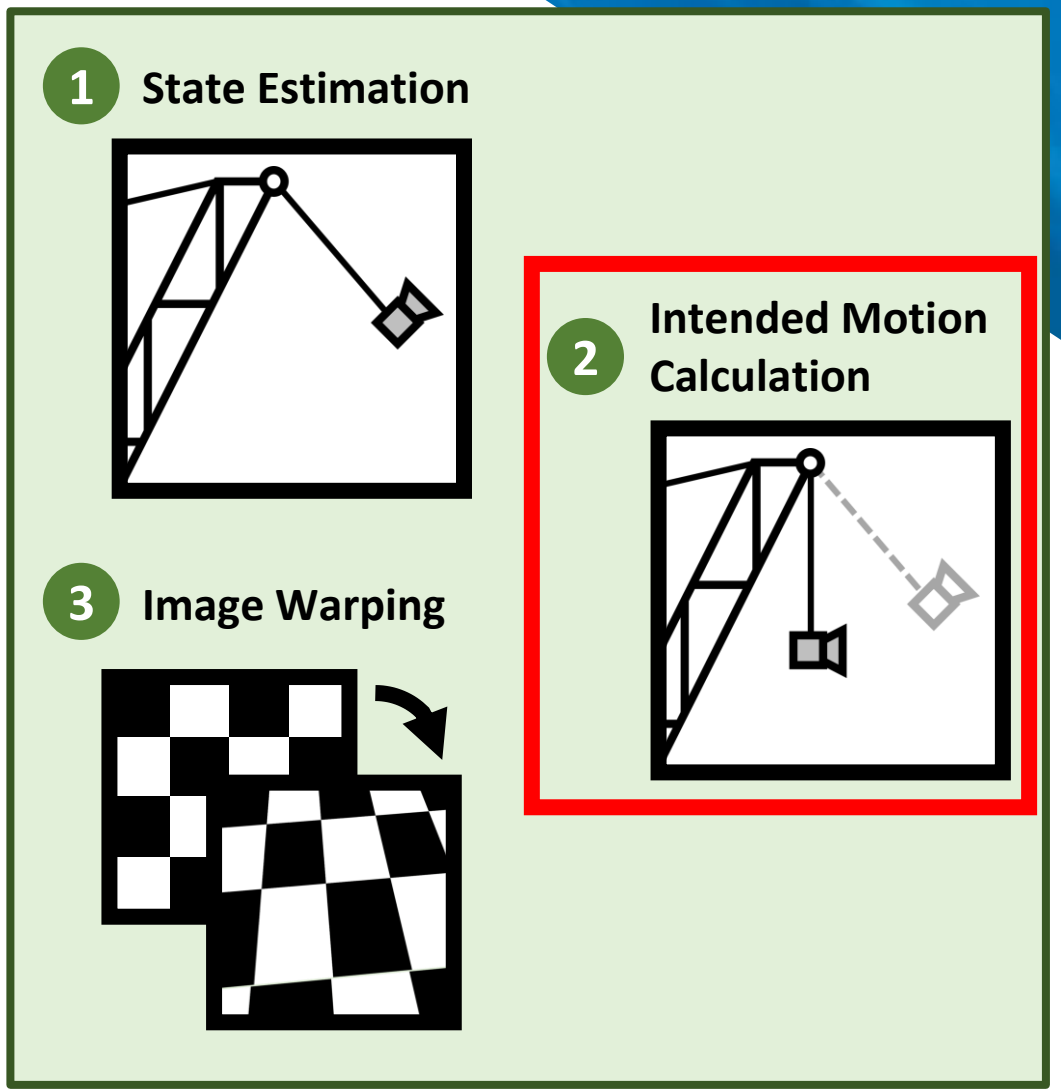
DIGITAL VIDEO STABILISATION

1. Global motion estimation
   - Camera trajectory
2. Intended motion estimation
   - Noise-free camera trajectory
3. Motion compensation
   - Warp image into intended motion frame

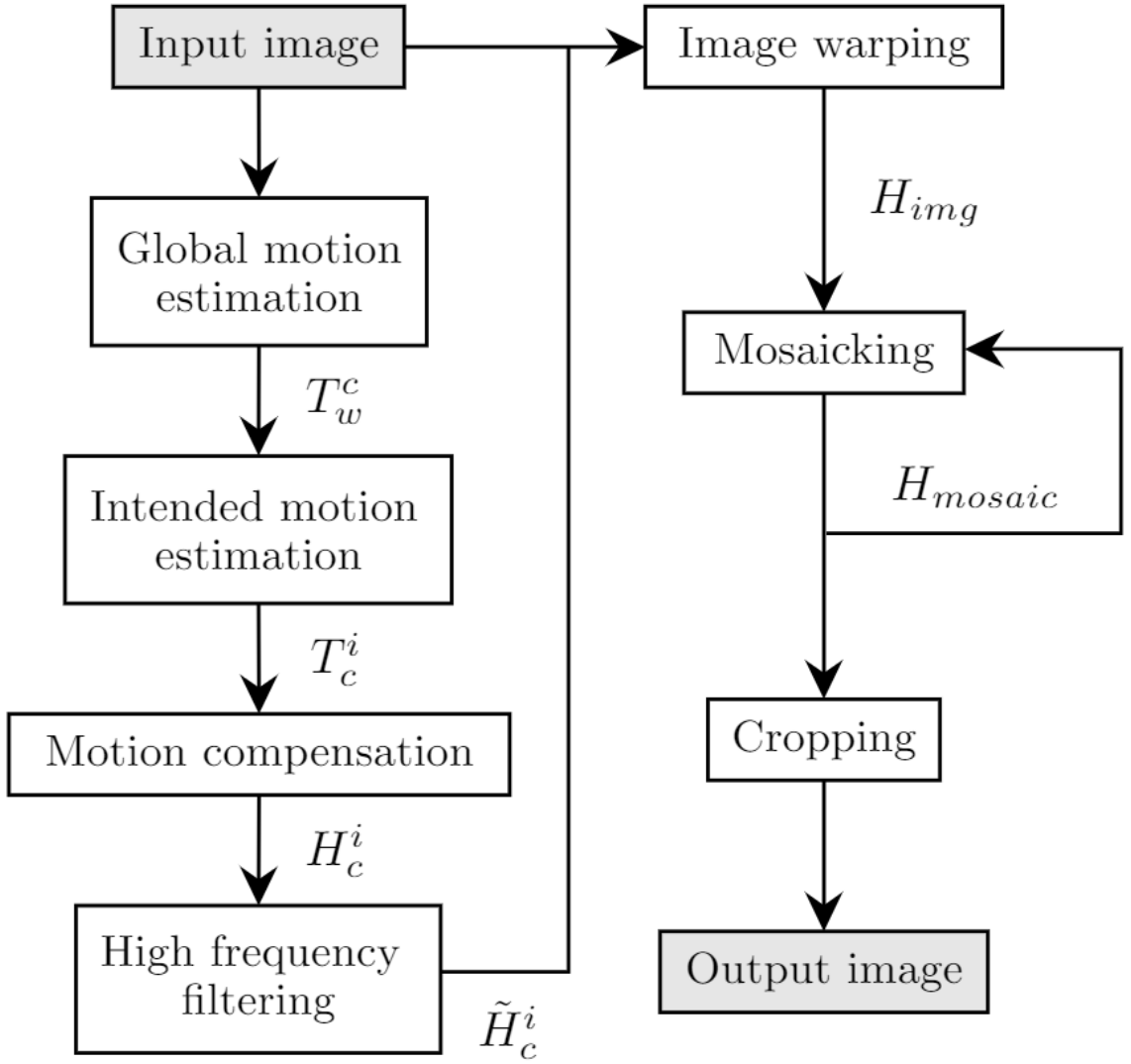


CONVENTIONAL INTENDED MOTION ESTIMATION

- Low-pass filtering (Litvin *et al*., 2003)
  - But Crane payload swinging is
    - Low-frequency
    - High-amplitude
- Offline curve fitting (Grundmann *et al*., 2011)
  - But we require real time stabilisation



METHODOLOGY



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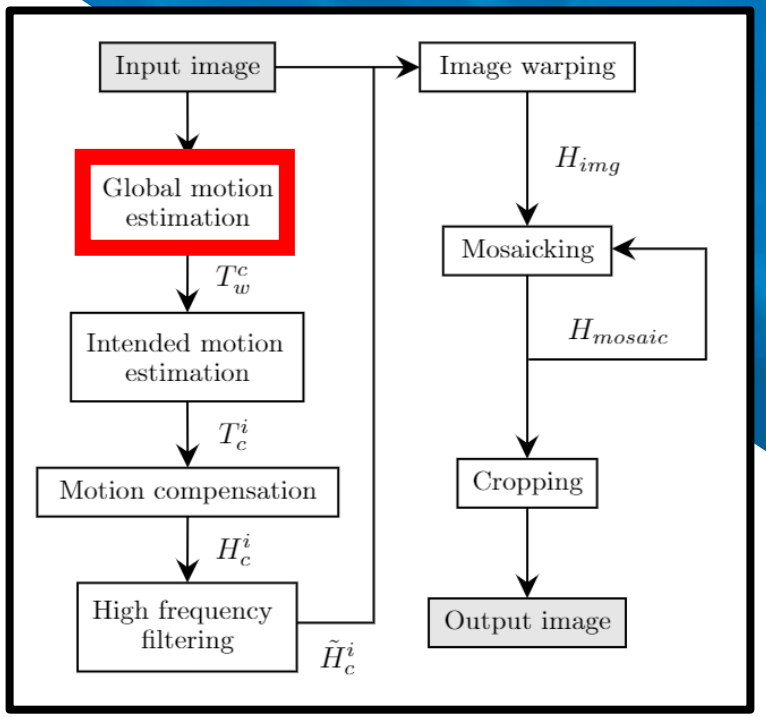
GLOBAL MOTION ESTIMATION

- Estimate Homography transformation
  - AprilTag Markers (Olson, 2011)
  - RANSAC Filtering
- Decompose into Euclidian transform
  - (Simon *et al*, 2000)



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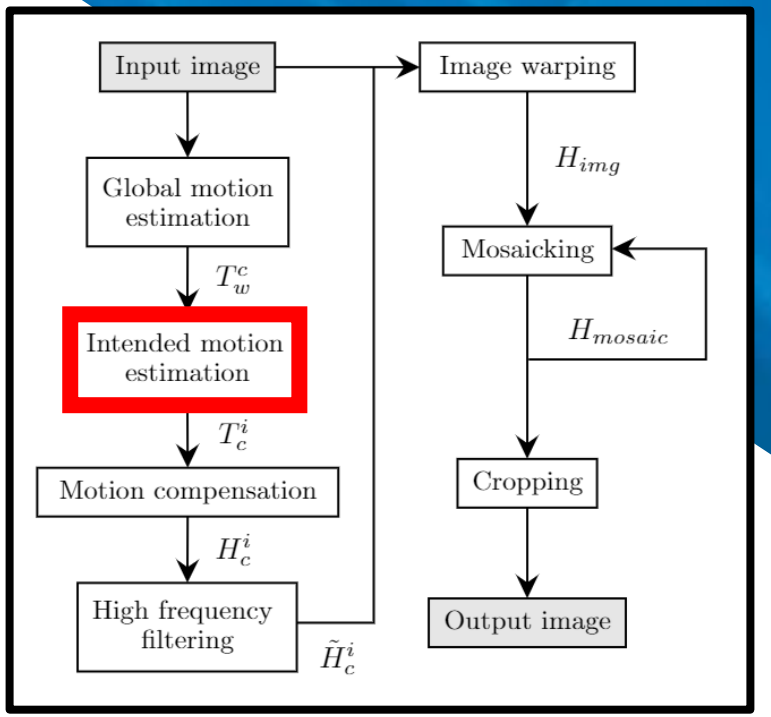
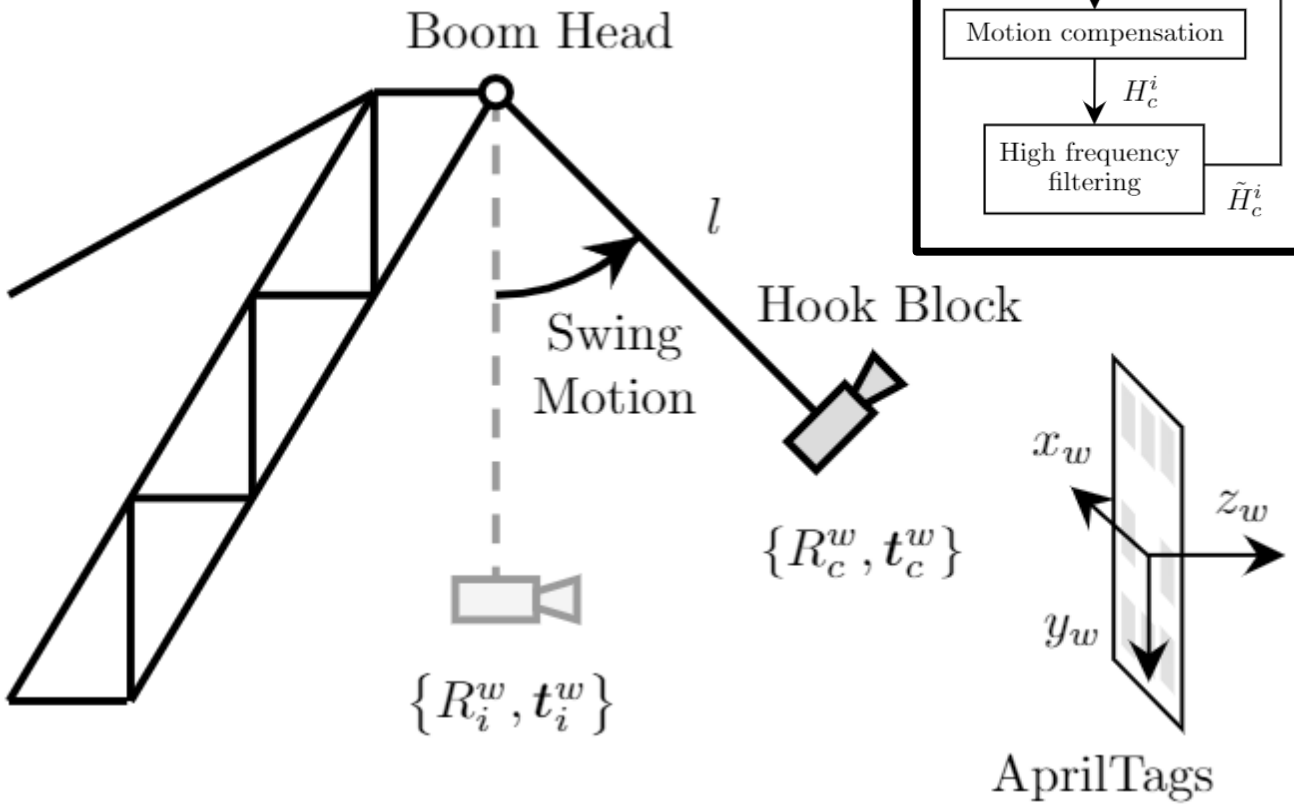
INTENDED MOTION ESTIMATION

- Intended motion
  - = Rope not swinging
  - = Directly under boom head
- How to find
  - Motion model based
    - Need a good model
  - Model-less
    - Need more sensors





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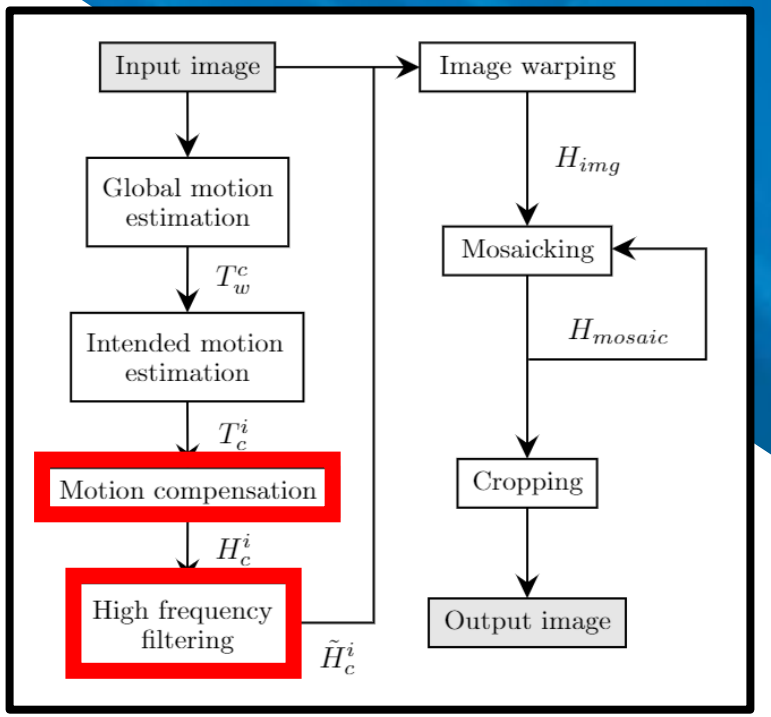
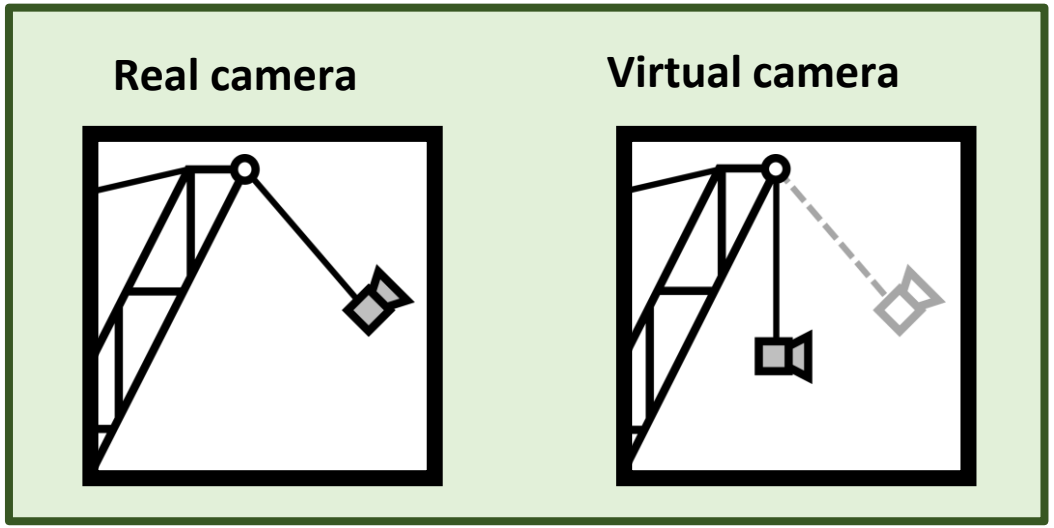
MOTION COMPENSATION

- Compensation
  - Transformation: true frame -> intended frame
- Convert
  - Euclidian transformation -> homography transform
  - (Malis and Vargas, 2007)
- Remove high-frequency noise
  - Kalman filter





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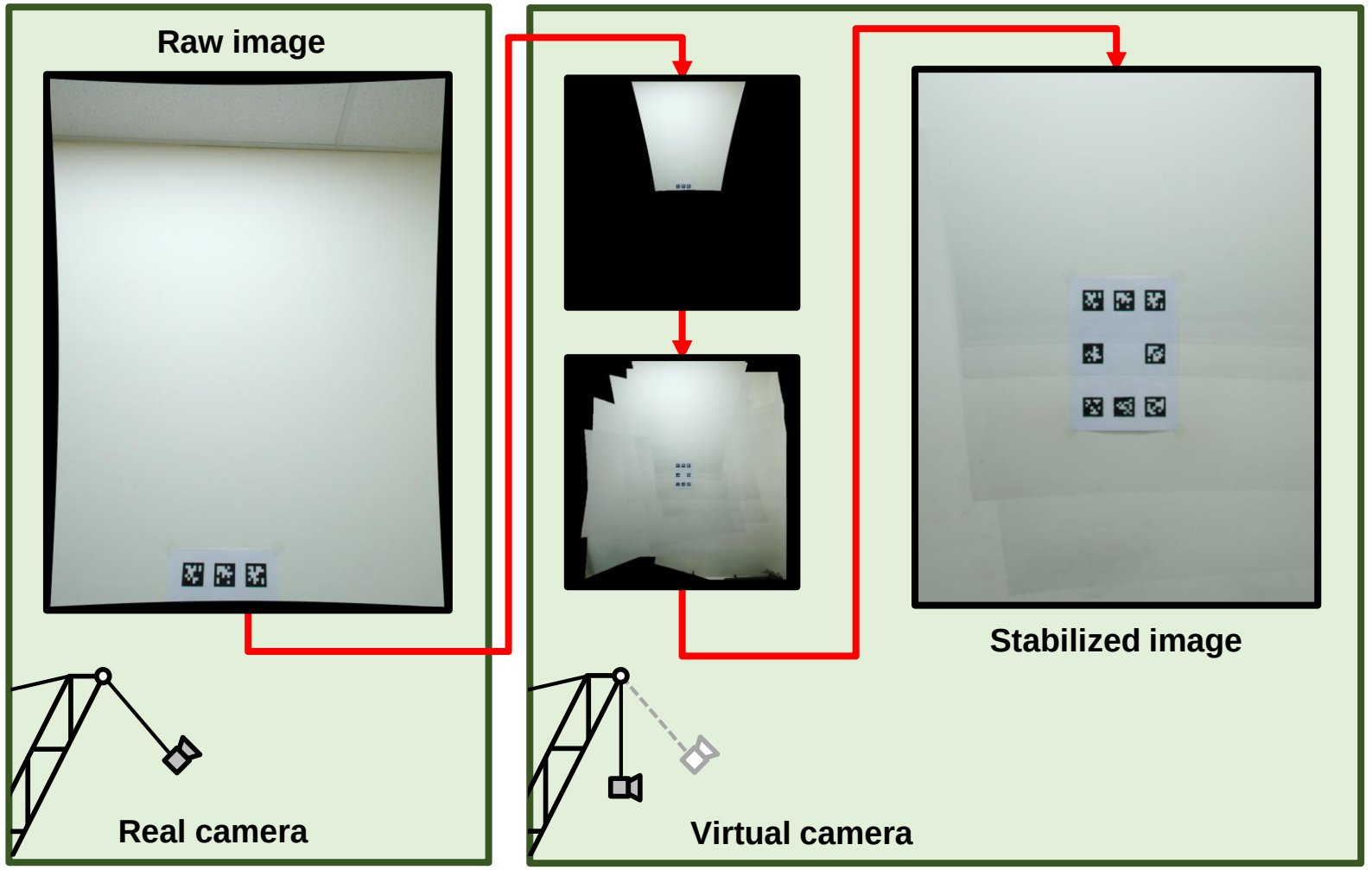
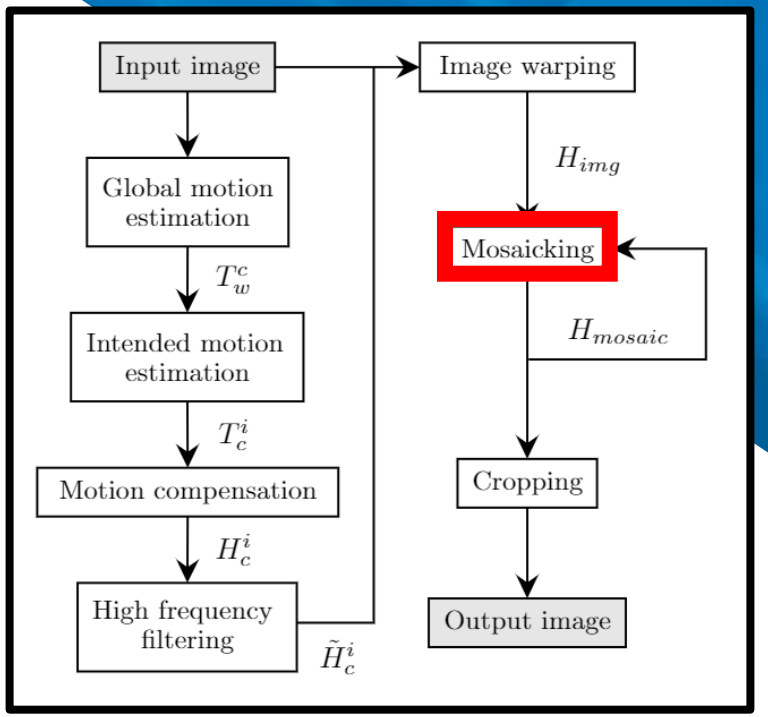
MOSAICKING





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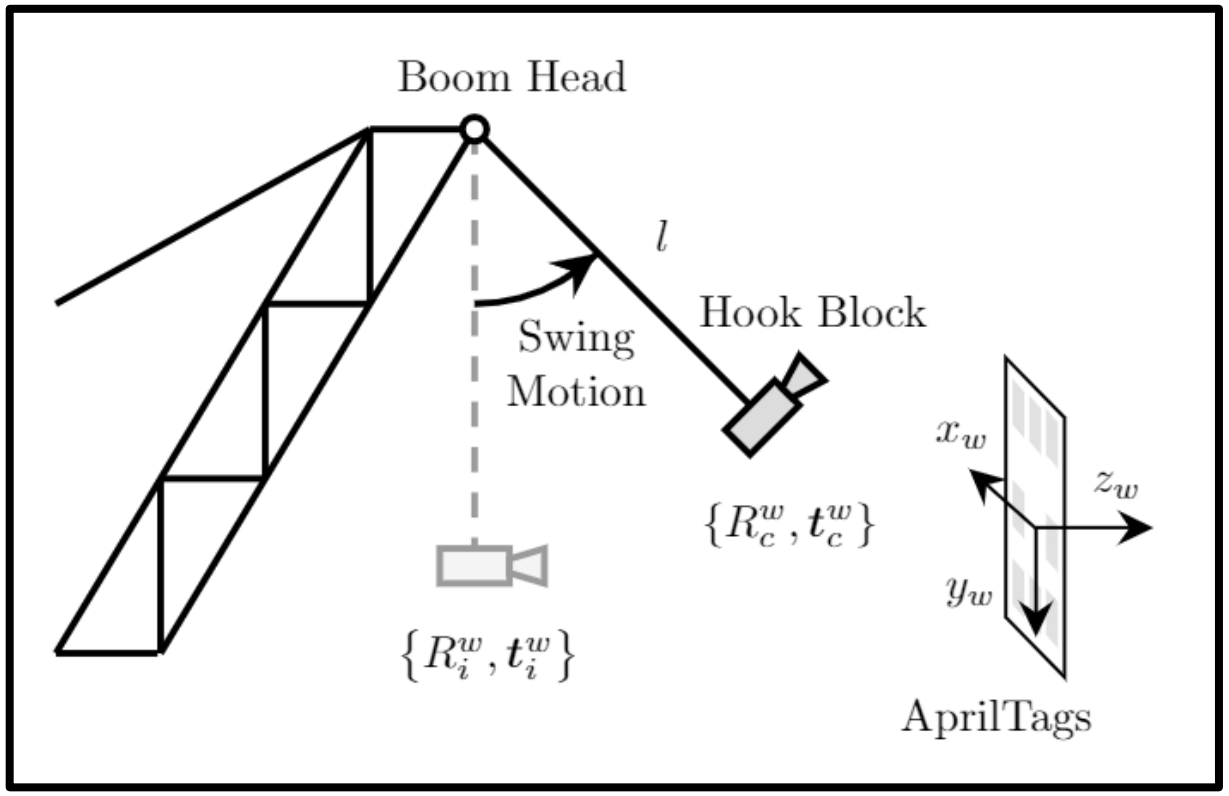
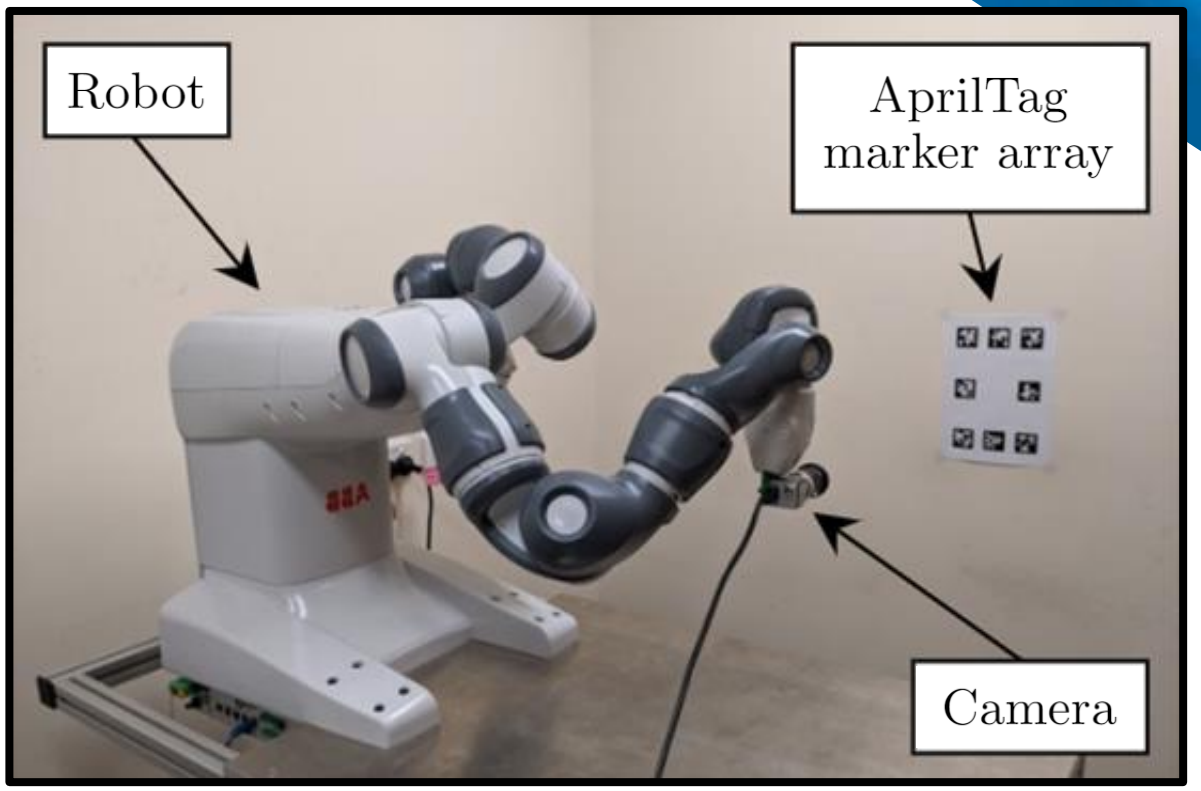
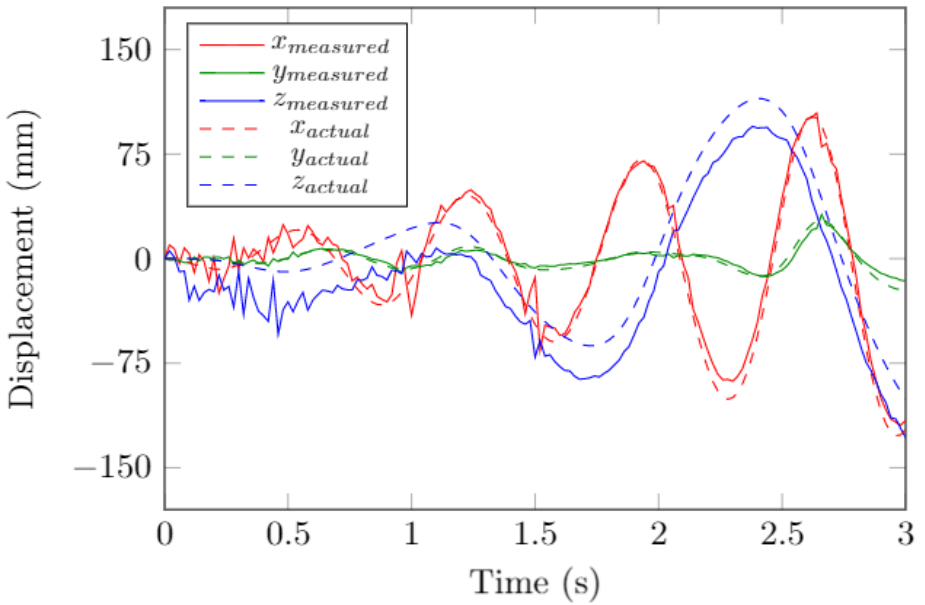
EXPERIMENTAL METHOD

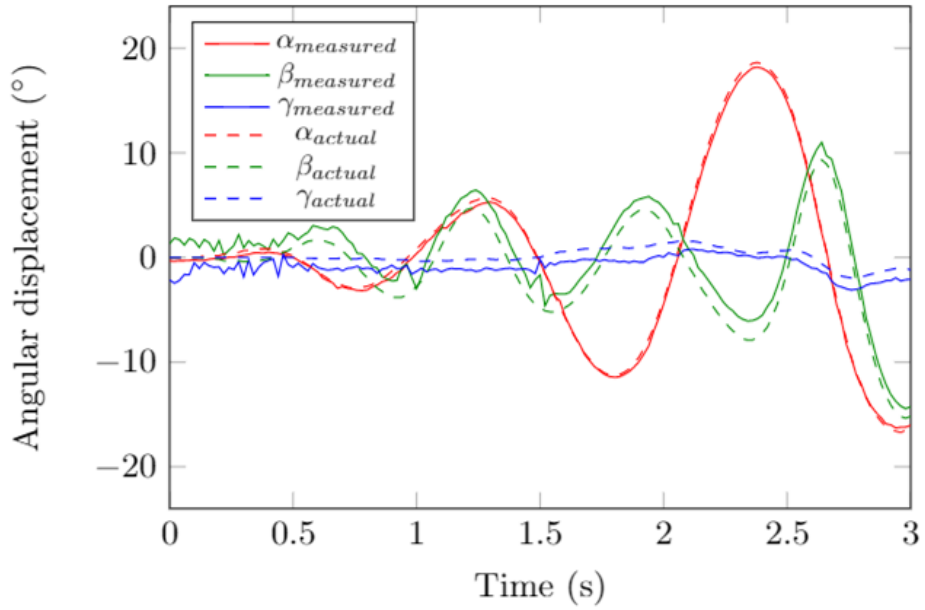




POSE ESTIMATION

- Camera pose as measured with
  - AprilTag detections (measured)
  - YuMi robot (actual)
- Induced motion
  - 3D Double pendulum
- RMS error
  - 3 mm
  - 0.8°





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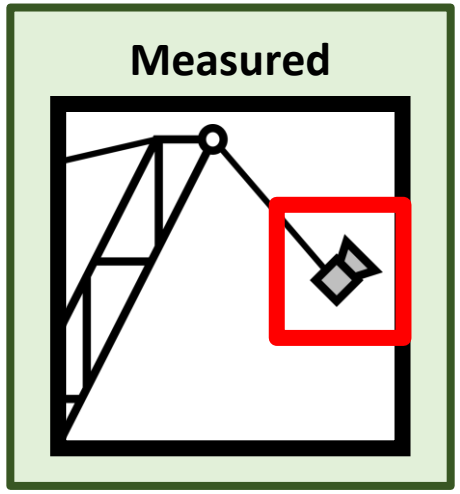
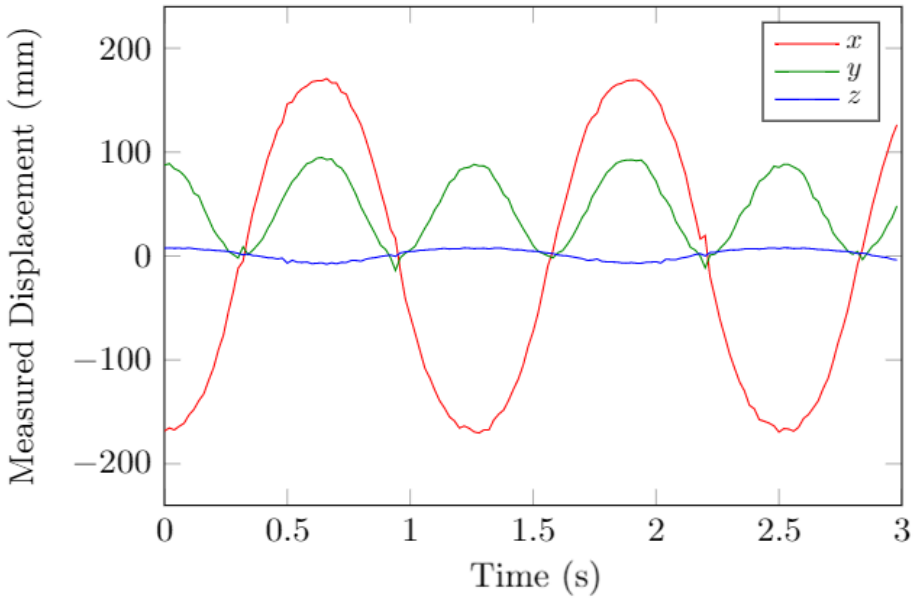
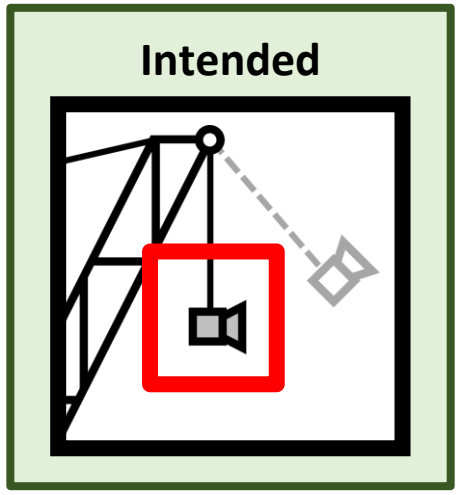
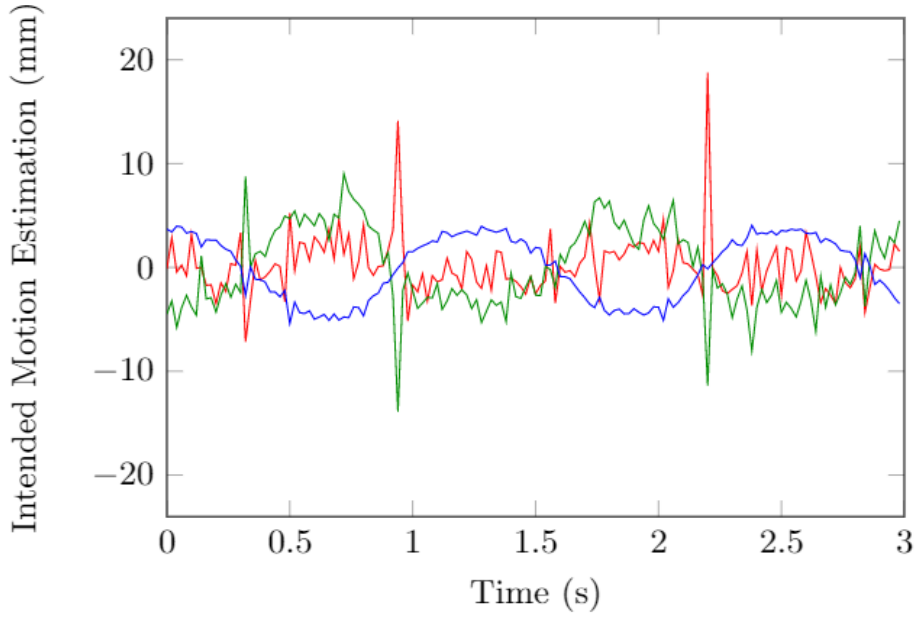
INTENDED MOTION ESTIMATION (1)

- Induced motion
  - 2D Single pendulum
  - Stationary boom head
- Intended motion estimation
  - Model-based single pendulum
  - Oscillations reduced by a factor of 36



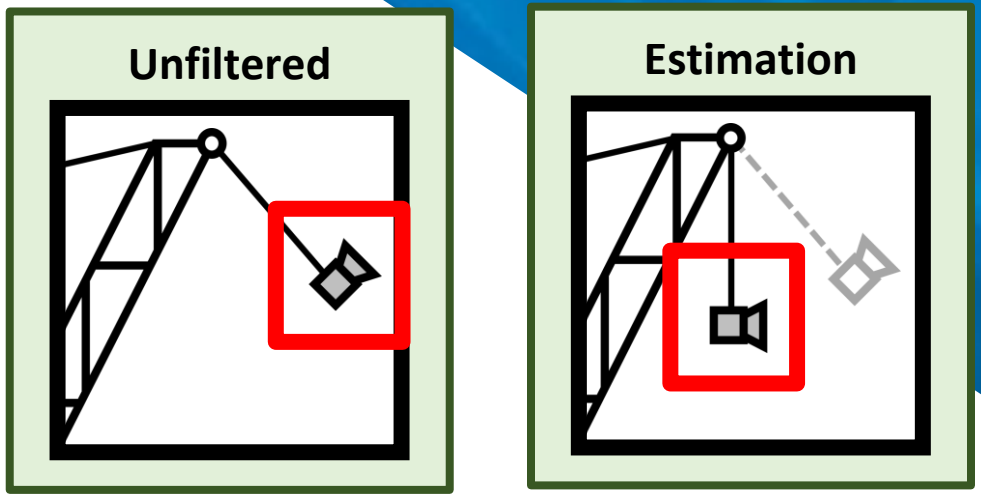


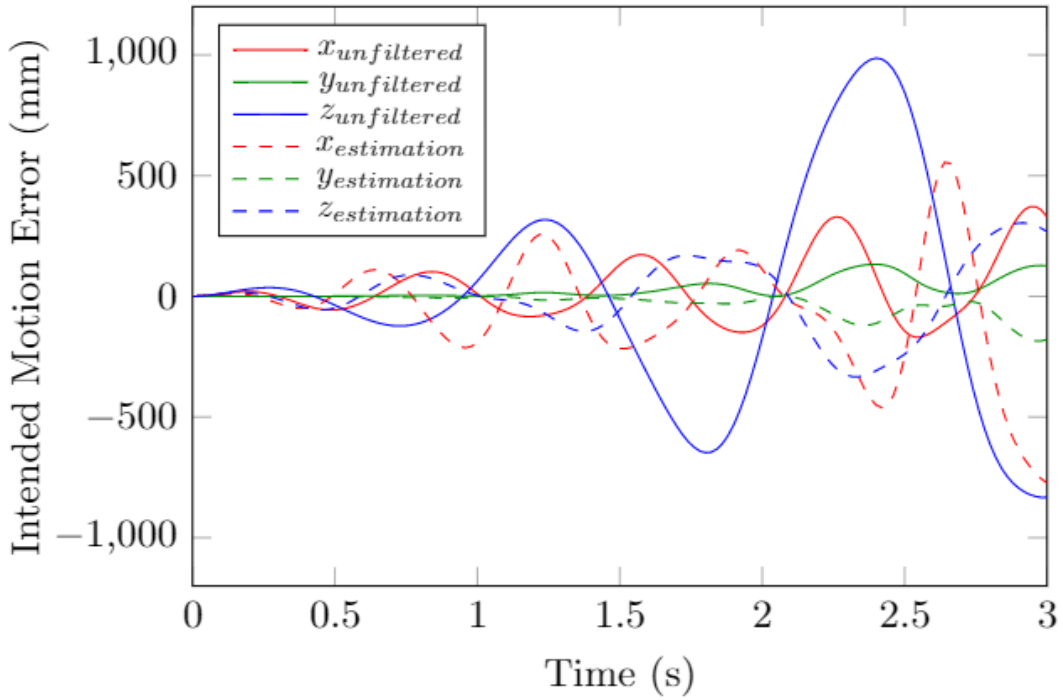




INTENDED MOTION ESTIMATION (2)

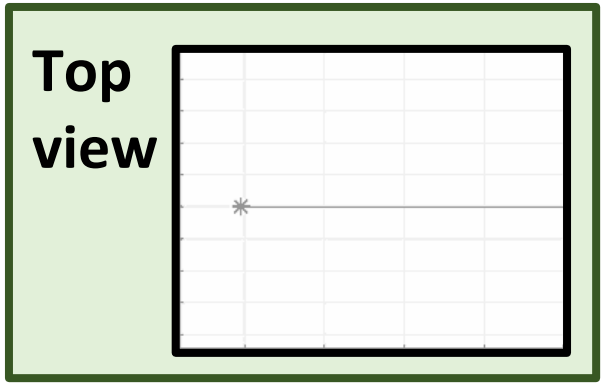
- Induced motion
  - 3D Double pendulum
  - Moving boom head
- Intended motion estimation
  - Model-based single pendulum
  - Oscillations reduced by a factor of 1.6

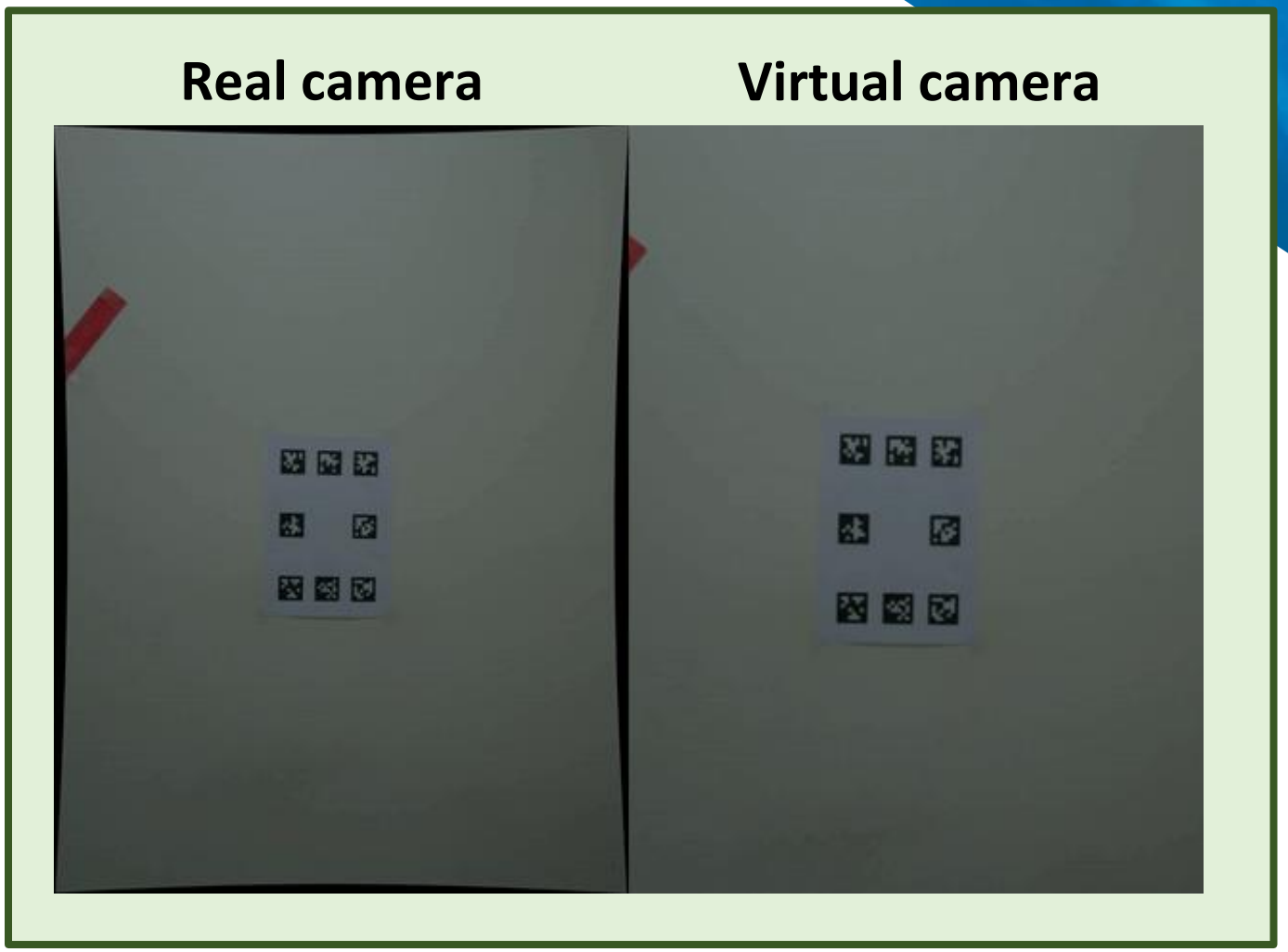




FINAL STABILIZATION RESULTS

- Induced motion
  - 3D Double pendulum
  - Moving boom head
- Intended motion estimation
  - Model-less (known boom head pose)
  - Camera resolution: 1024 x 768 pixels
  - Mosaic resolution 2000 x 2000 pixels
  - 7.5 fps





CONCLUSION

- Contributions
  - Visual feedback to improve crane safety
  - Online stabilization of crane swinging
    - high-amplitude
    - low-frequency
  - Scaled experimental validation
    - Desired results with model-less intended motion estimation
- Future Work
  - Full scale experiments
  - User studies
  - Integrate algorithm with markerless pose estimation