



# Robust Targeting for the Smartphone Video Guidance Sensor (SVGS)

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CREATING THE NEXT®

# OUTLINE



- Background
- Changes made
- Results
- Difficulties faced in implementation
- Additional Improvements
- Conclusion

# BACKGROUND: WHAT IS SVGS?



- Cube-sat Autonomous Rendezvous and Docking Sensor
- Cheap
- Small form factor
- Self-contained
- Low mass and energy req.

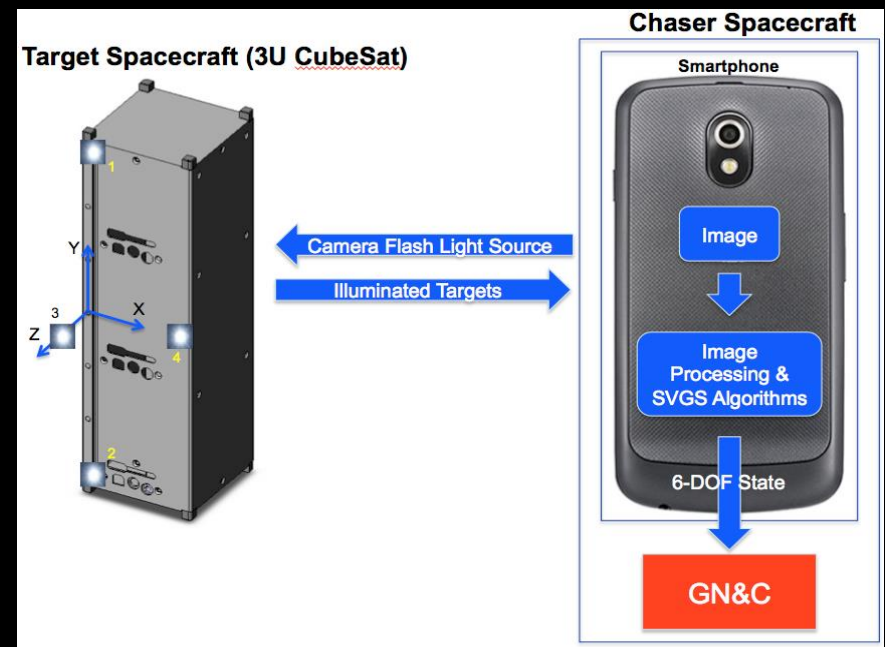


Figure 1: SVGS Concept of Operations

## BACKGROUND: CHALLENGES FACED



- Target difficult to distinguish from background, especially with reflections
- Slow refresh rate, difficult to implement into a control loop

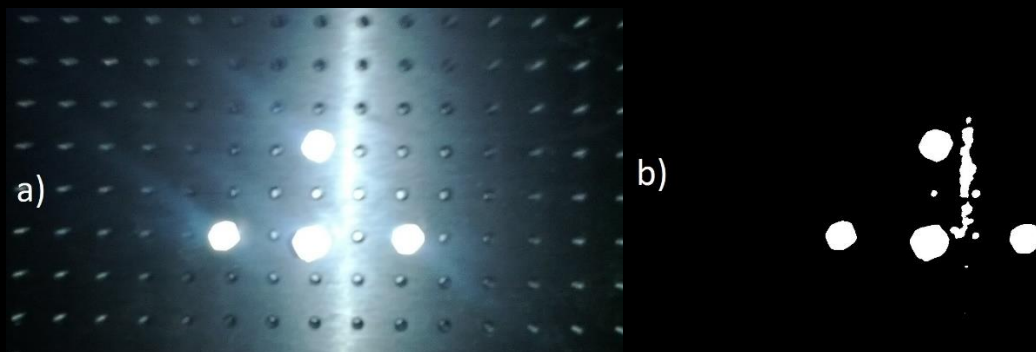


Figure #: a) Retro-reflector captured image b) Retro-reflector processed image

# PROPOSED SOLUTION



- LED Targets
  - Color selectivity
- Persistent tracking
  - Less Image Processing

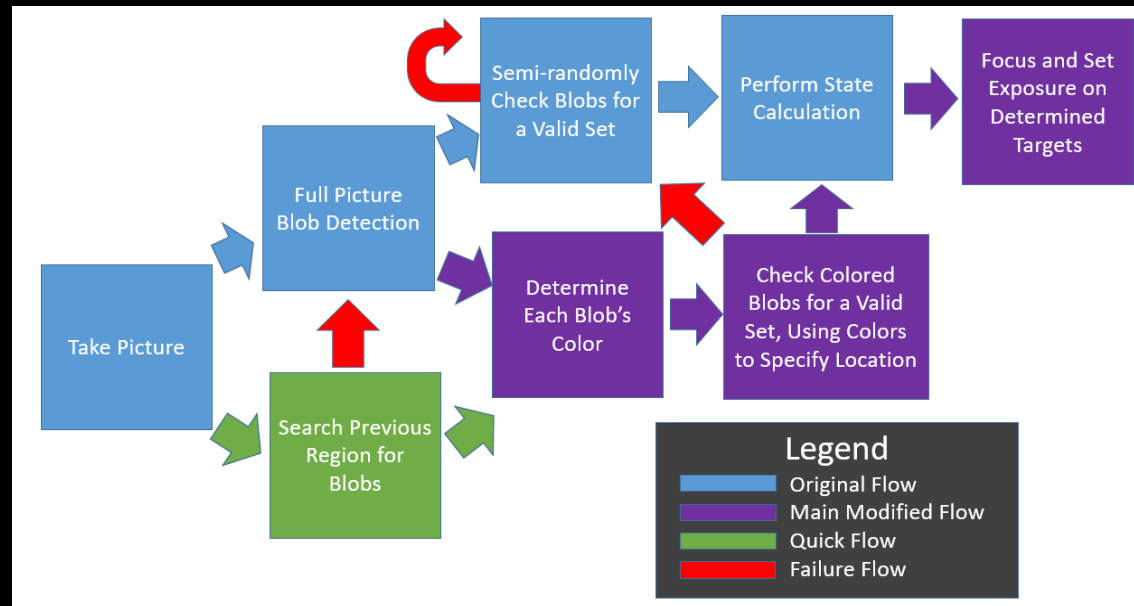


Figure #: Original and Proposed Modified Solution

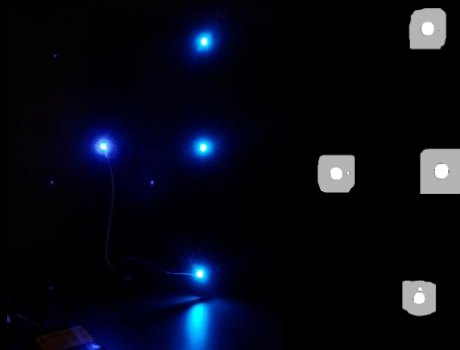


Figure #: LED Target captured and processed images

## RESULTS: TEST SCENARIO



- Target Positioned 2m from camera at a slight rotation
- Extraneous LED light source introduced to ensure plenty of reflections
- Steady-state measurements taken using the LED and retro-reflector targets



Figure #: Test Setup with LED and retro-reflector targets

## RESULTS: RELIABILITY

- Retro-reflector target was unable to be uniquely determined
- LED target was uniquely determined by using color, despite lots of background noise

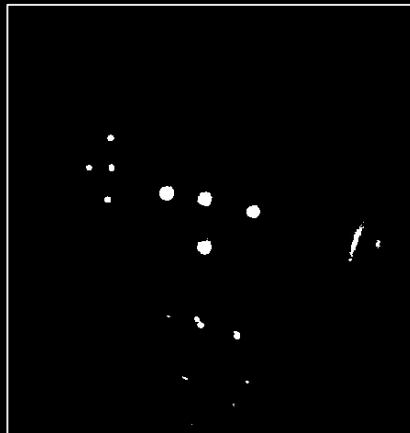
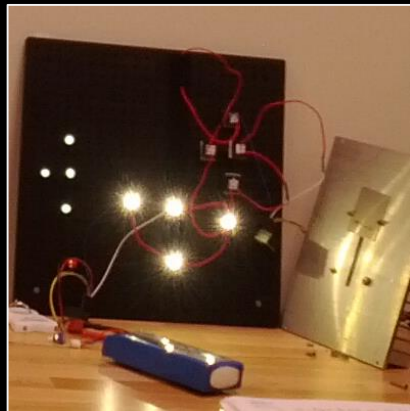


Figure #: Retro-reflector target captured and processed images

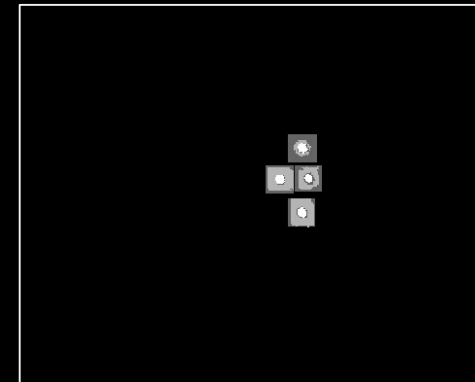
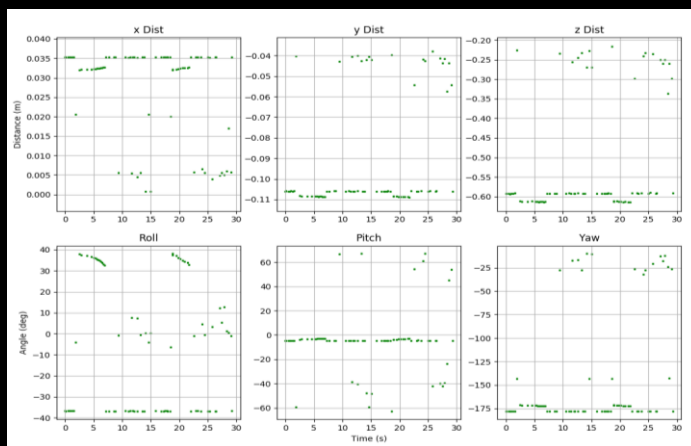


Figure #: LED target captured and processed images after successful "target lock"

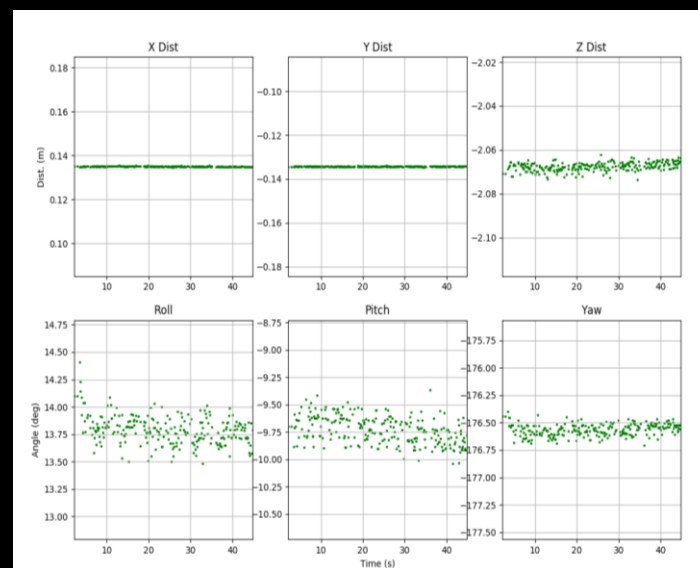
# RESULTS: SENSOR PROPERTIES



- The LED target allowed for much greater selection
- Targeting algorithm significantly increased speed



6DOF output state using retro-reflectors



Output state using LED targets + persistent targeting algorithm



# DIFFICULTIES FACED



- Colors mixed at range
- Using only color to determine regions of interest was slow and ineffective
- With an extremely dark background, the LEDs merged together



Figure #: LED target at 6m in a dark room

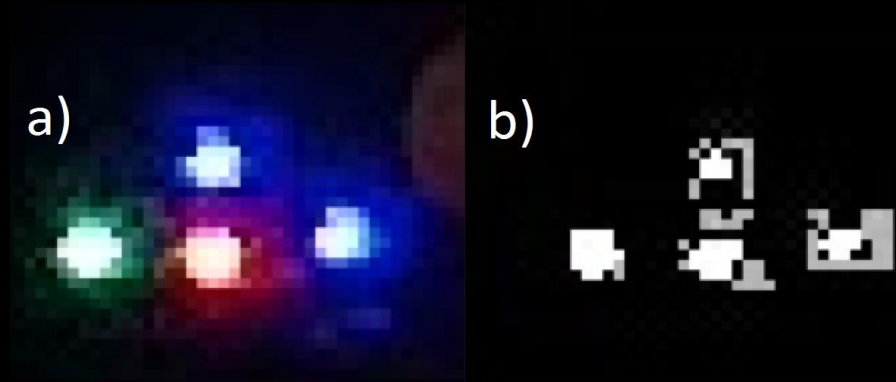


Figure #: a) 12 meter Image Capture and b) Resulting Blobs and Color Selection

# ADDITIONAL IMPROVEMENTS



- Demonstrated the modified SVGS to close a 3DOF control loop using the robust targeting system
- Demonstrated ability to find the target at very high refresh rates even while the relative position was changing rapidly

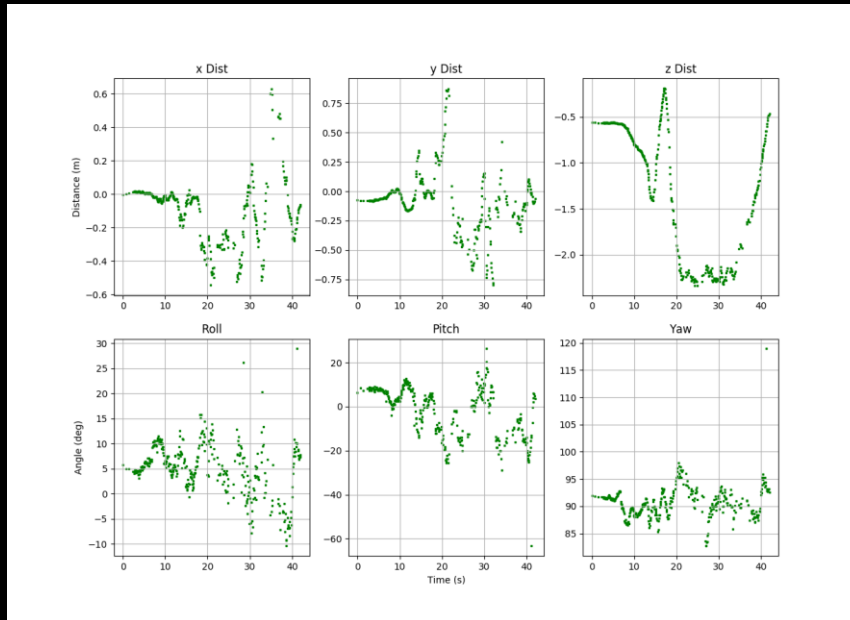


Figure #: 6DOF scatterplot during rapid changes in all 6DOF

# CONCLUSION



- The proposed solution was effective
  - Increased speed by 3x by retaining previous state, 10x through combination of various factors
  - Increased reliability and the sensor's ability to choose the correct target
- Target should be mono-chromatic to increase sensor range
- The sensor needs a more thorough test of accuracy to be fully characterized
- The sensor is ready to prove its capability in a 6 DOF test rendezvous and docking simulation

## ACKNOWLEDGEMENTS



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