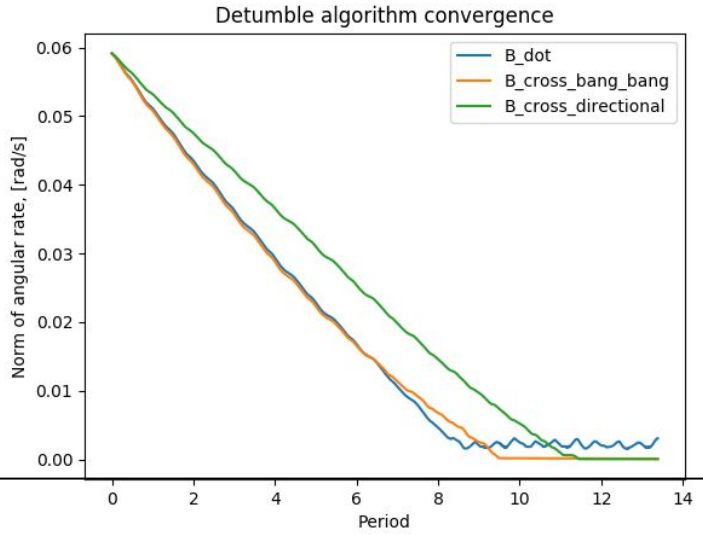
GNC / FSW

Week 2, Spacecraft Design Lab 2019-2020



Detumbling algorithms with dipole saturation

Interfaces

- Mechanical
  - Updated inertia properties
- Sensors/actuators
  - Updated magnetorquer properties

Requirements

Updated Key Milestones (past + present)

- Implemented detumble with dipole saturation - 1/6
- Demonstrated Eigen calls from C - 1/13
- Wrap all GNC algorithms in C/CircuitPython -TBD
- Full estimator in SIL -TBD
- Run controller based on the estimator
- Estimator on hardware
- Control algorithms on hardware
- Integrate GNC algorithms into state machine
- Extended spacecraft test

Weekly Results

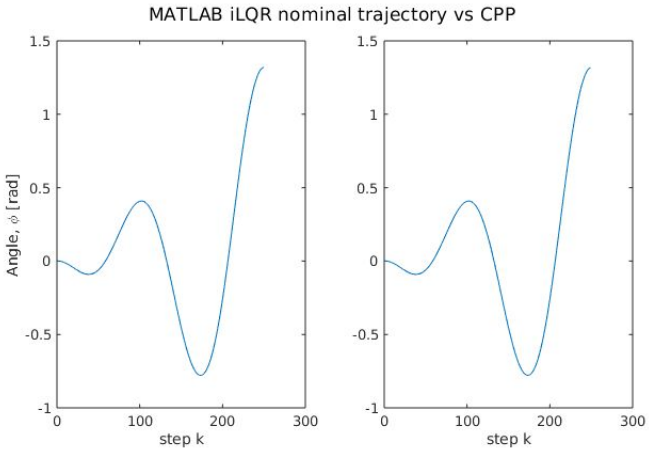
- Eigen callable from C
- First interactions with hardware
- Implemented more unit tests
- Began implementation of iLQR in C++
- Dipole saturation added to control laws

Next Week

- Fix ground truth/GNC sim discrepancies
- Begin wrapping GNC algorithms in C
- Begin taking measurements from sensors
- Test MEKF in simulator

GNC / FSW

Week 3, Spacecraft Design Lab 2019-2020



Updated Key Milestones (past + present)

• Wrap all GNC algorithms in C/CircuitPython	-TBD
• Full estimator in SIL	-TBD
• Run controller based on the estimator	-1/6
• Estimator on hardware	-2/19
• Control algorithms on hardware	-2/19
• Integrate GNC algorithms into state machine	-2/26
• Extended spacecraft test	-3/4

Interfaces

- Mechanical
  - Updated inertia properties
- Sensors/actuators
  - Updated magnetorquer properties
- Max
  - Discuss memory

Requirements

Weekly Results

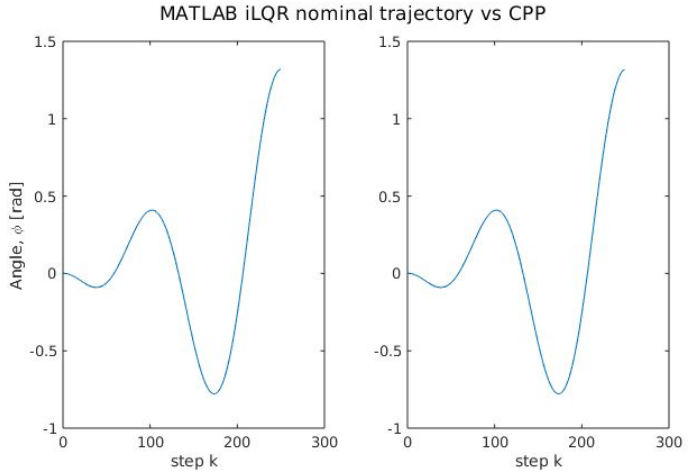
- Sim verified against Andrew's code & GNC propagator
- Sim profiled & tidied, random walk implemented
- Digital sun sensor measurements <-> vector implemented, unit tests written
- B_dot callable from C
- iLQR CPP results match MATLAB and python

Next Week

- Continue writing C wrappers for GNC functions
- Write tests for C wrappers
- Test calling C wrappers from CircuitPython
- Begin taking measurements from sensors
- iLQR control limits, quaternion maths started

GNC / FSW

Week 4, Spacecraft Design Lab 2019-2020



Updated Key Milestones (past + present)

• Wrap all GNC algorithms in C/CircuitPython	-TBD
• Full estimator in SIL	-TBD
• Estimator on hardware	-2/19
• Control algorithms on hardware	-2/19
• Integrate GNC algorithms into state machine	-2/26
• Extended spacecraft test	-3/4

Interfaces

- Mechanical/Testing
  - thermal modeling equations/properties for sim
- Sensors/actuators
  - Updated magnetorquer properties
- Electrical/Avionics
  - battery charge/discharge modeling for sim

Requirements

Weekly Results

- Began work on state machine - working on getting basic four states functional in HITL
- Finished sun vector calculation code (for both sim side and board side)
- Progressing on C from CircuitPython calls
- Progressing on C testing in PyTest using Cython

Next Week

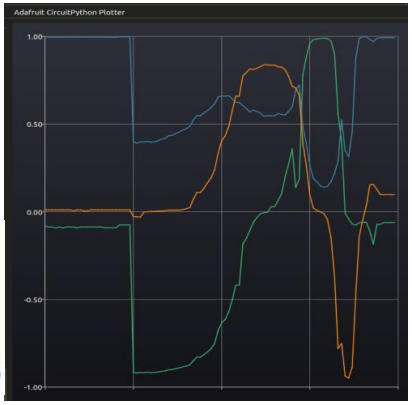
- Continue work on state machine to add functionality and integration with sim
- Call a C function from CircuitPython
- Create an archetypal C wrapper PyTest
- Detumble estimate with updated inertia and ejection properties

GNC / FSW

Week 5, Spacecraft Design Lab 2019-2020

```
>>> C = np.array([[4,0],[0,4]])
>>> L = np.array([[0,0],[0,0]])
>>> C.cholesky(L)
array([[2.0, 0.0],
       [0.0, 2.0]], dtype=float)
```

CircuitPython Linear Algebra



Sun vector creation

Updated Key Milestones (past + present)

• Wrap all GNC algorithms in C/CircuitPython	-2/19
• Full estimator in SIL	-2/26
• Integrate GNC algorithms into state machine	-2/26
• Estimator on hardware	-3/4
• Control algorithms on hardware	-3/4
• Extended spacecraft test	-3/4

Interfaces

- Mechanical/Testing
- Sensors/actuators
- Electrical/Avionics
  - battery charge/discharge modeling for sim

Requirements

- Need new flex cable/revised y- board (connected to ⅝ sensor boards currently

Weekly Results

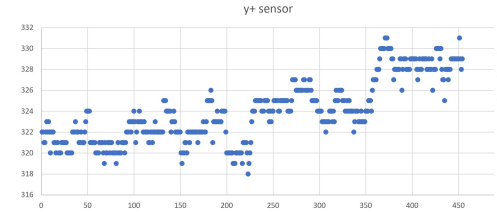
- Establishing handshake communication for HITL
- Hardware testing-build up of solar boards, running vector composition code on boards
- Called C Cholesky from CircuitPython
- iLQR for satellite dynamics & cost function
- iLQR pendulum C/Mex test successful
- BMX160: accel+temp+clock are online

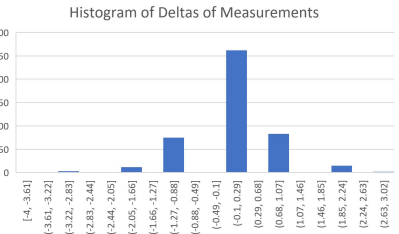
Next Week

- Continue work on state machine to add functionality and integration with sim
- Document archetypal C/CircuitPython interface
- Convert all GNC to C
- Hardware testing with MEKF
- BMX160 gyro + mag

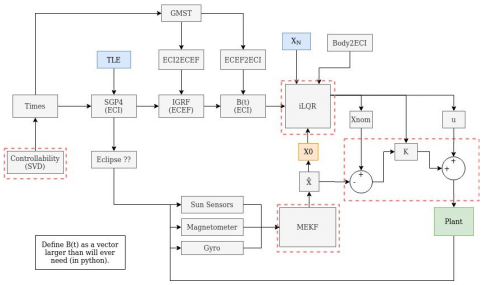
GNC / FSW

Week 6, Spacecraft Design Lab 2019-2020





Sensor Hardware Testing



Attitude Control Block Diagram

Updated Key Milestones (past + present)

• Wrap all GNC algorithms in C/CircuitPython	-2/26
• Full estimator in SIL	-2/26
• Integrate GNC algorithms into state machine	-2/26
• Estimator on hardware	-3/4
• Control algorithms on hardware	-3/4
• Extended spacecraft test	-3/4

Interfaces

- Mechanical/Testing
- Sensors/actuators
- Electrical/Avionics
  - battery charge/discharge modeling for sim

Requirements

- Need new flex cable/revised y- board (connected to ⅝ sensor boards currently

Weekly Results

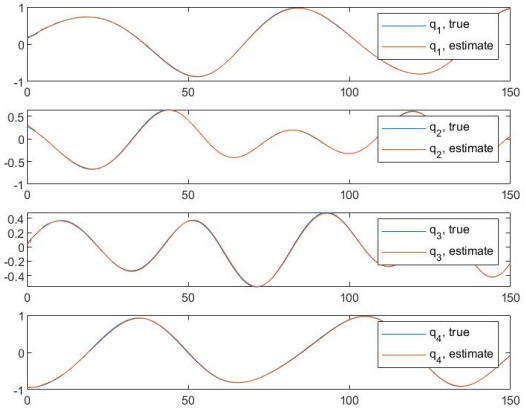
- Handshake communication completed
- Sun Sensor Characterization
- Utility function python numpy-less conversion
- Established C/CircuitPython boundary
- iLQR control-lims/regularization/restructure started
- BMX160: all sensors working

Next Week

- Continue work on state machine
- Write pytests for new utility functions
- Document archetypal C/CircuitPython interface
- Convert all GNC to C
- Autocode MEKF
- BMX160: document existing (maybe expose more functionality)

GNC / FSW

Week 7, Spacecraft Design Lab 2019-2020



Updated Key Milestones (past + present)

- Full estimator in SIL -2/26
- MEKF in C/CircuitPython -3/4
- Integrate GNC algorithms into state machine -3/11
- Control algorithms on hardware -3/4
- Extended spacecraft test -3/11

Interfaces

- Mechanical/Testing
- Sensors/actuators
- Electrical/Avionics
  - battery charge/discharge modeling for sim

Requirements

- Need new flex cable/revised y- board (connected to ⅝ sensor boards currently

Weekly Results

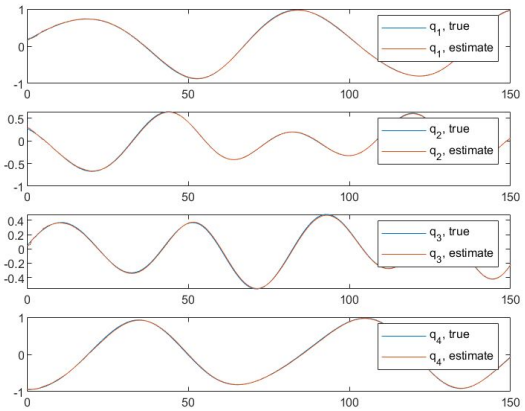
- Conceptualized baseline state machine
- Pytests written for python utility funcs
- Utility function python numpy-less conversion
- MEKF works in MATLAB
- MEKF callable from CircuitPython (doesn't work)
- iLQR tested on bicycle parking. Begun autocoding
- BMX160: Re-recorded calibration data / basic documentation written

Next Week

- Continue work on state machine
- Record Player Sensor Testing
- Document C/CircuitPython interface
- Debug CircuitPython MEKF

GNC / FSW

Week 8, Spacecraft Design Lab 2019-2020



Updated Key Milestones (past + present)

- Full estimator in SIL -2/26
- MEKF in C/CircuitPython -3/4
- Integrate GNC algorithms into state machine -3/11
- Control algorithms on hardware -3/4
- Extended spacecraft test -3/11

Interfaces

- Mechanical/Testing
- Sensors/actuators
- Electrical/Avionics
  - battery charge/discharge modeling for sim

Requirements

- Need new flex cable/revised y- board (connected to ⅝ sensor boards currently

Weekly Results

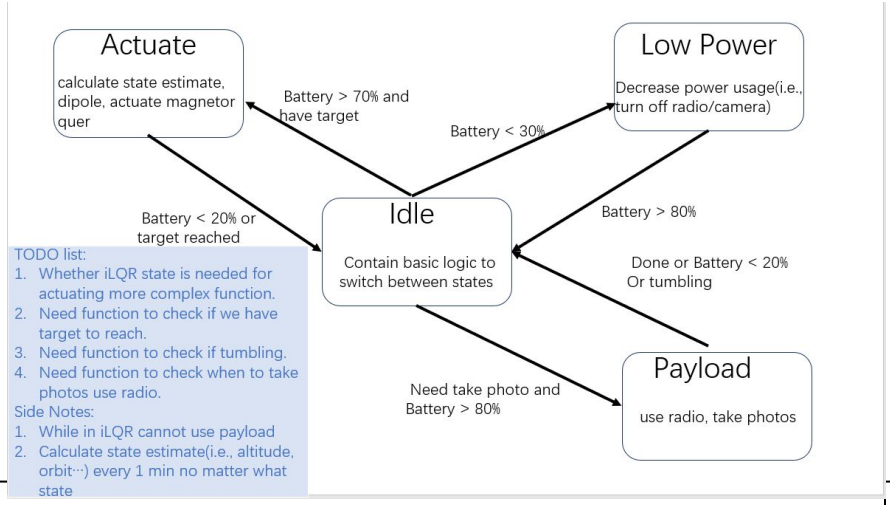
- Populating state machine with logic
- Bug fixing MEKF running on CircuitPython
- Pytests written for python utility funcs
- iLQR tested on bicycle parking. Begun autocoding
- IMU calibration/noise parameters
- Record Player test setup complete, data collected

Next Week

- Get results from CircuitPython MEKF
- Finish (baseline) state machine and begin testing
- Document C/CircuitPython interface

GNC / FSW

Week 10, Spacecraft Design Lab 2019-2020



Interfaces

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Requirements

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Updated Key Milestones (past + present)

• Full estimator in SIL	-2/26
• MEKF in C/CircuitPython	-3/4
• Integrate GNC algorithms into state machine	-TBD
• Control algorithms on hardware	-TBD
• Extended spacecraft test	-TBD

Weekly Results

- Documented MATLAB->C->CircuitPython pipeline
- Fixture for IMU testing

Next Week

- Debug hardware MEKF issues
- Integrate sensor noise characteristics into sim/covariance matrices
- New approach to IMU calibration (treated as optimization problem)