The Flying Gator: Towards Aerial Robotics in occam-π

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Summary

- **Introduction/ The Gator UAV**
- Flight
- Challenges
- Future work

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What is a UAV?

- **U**nmanned **A**erial **V**ehicle
  - Our definition: An unmanned, autonomous, aircraft capable of navigating a predetermined course, acquiring data, and safely operating within FAA regulations
- Why are these aircraft useful?
  - Agriculture
  - Oil pipeline surveys
  - Search and rescue
  - Military
- Consistent acquisition of data/images

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Why waste our time?

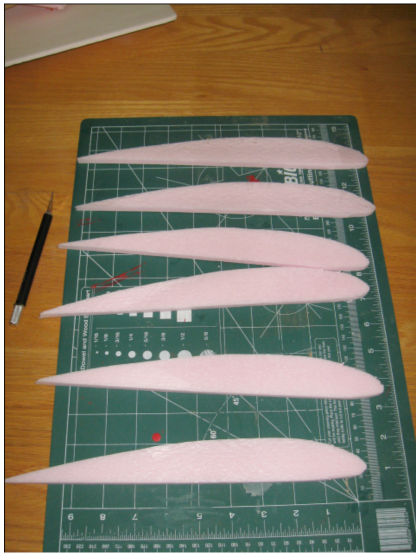
Full scale aircraft

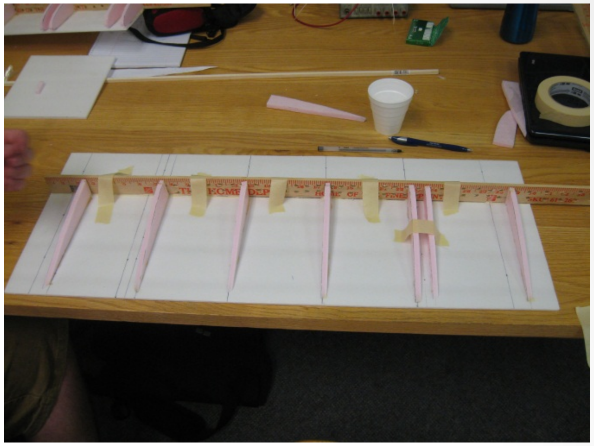
- Aviation fuel in the US = 7 - 10 USD per gallon
- Rental Prices for a Cessna 172 = 80 – 120 USD for 1 hour
- Who is going to fly it?

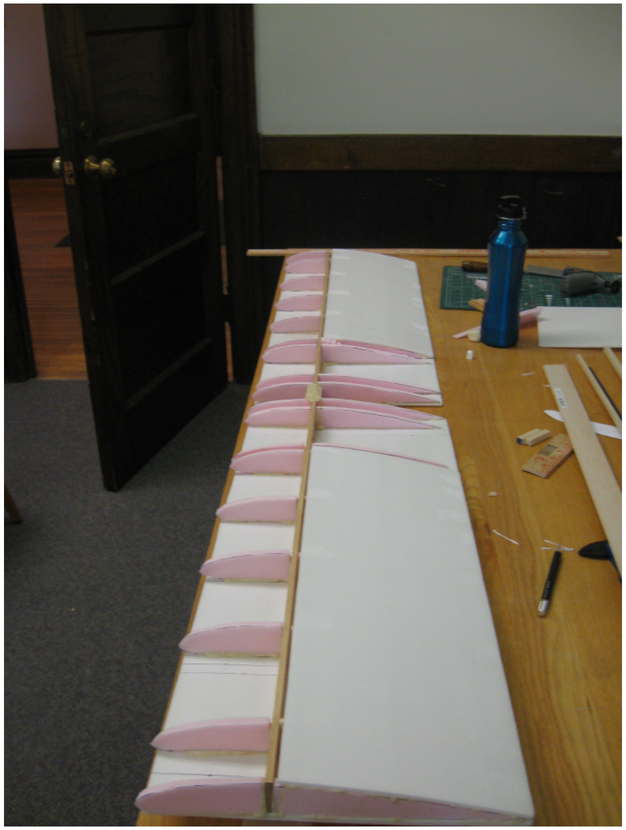
The Flying Gator

- Budget was 800 USD
- Designed and built using lightweight foam insulation
- Airframe cost is < 20 USD

Build Log







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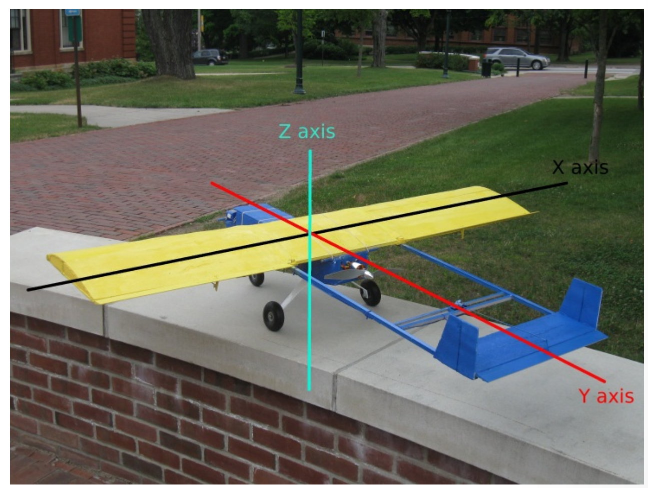
A "Crash course"

- Air moves over wing creating lift
- Pitch, Roll, Yaw (x, y, z)
- Control surfaces alter airflow over the aircraft for course adjustment
- One Control Surface linked to each axis
  - Elevator (x)
  - Aileron (y)
  - Rudder (z)
- Throttle
- **Three Dimensional Challenge**



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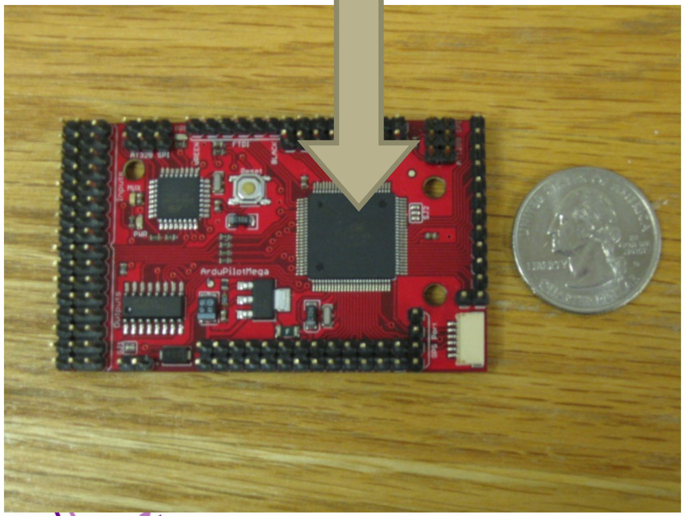
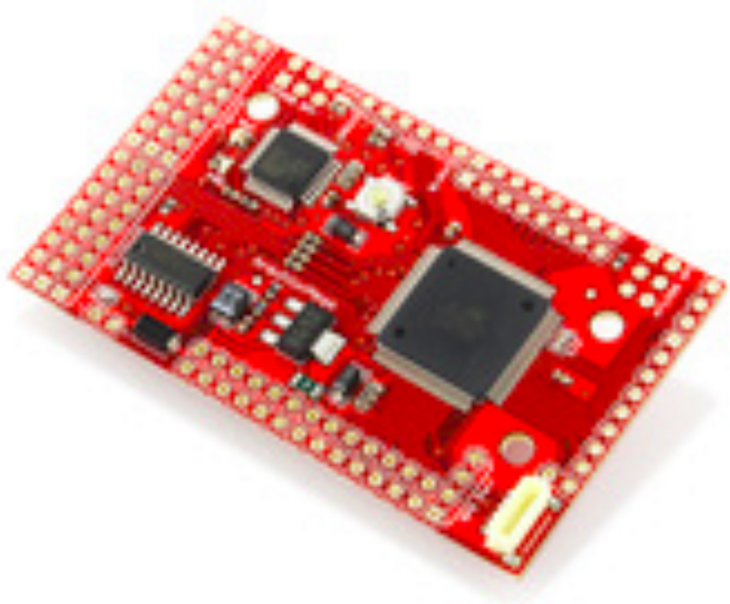
Ideally…



Our “Pilot"

- ArduPilot Mega
  - Developed for the ArduPilot project
  - 16 mHz Atmega 1280 processor
  - 128k Flash
  - 8k Ram
  - 4 serial ports
  - 16 analog pins
  - 40 digital pins



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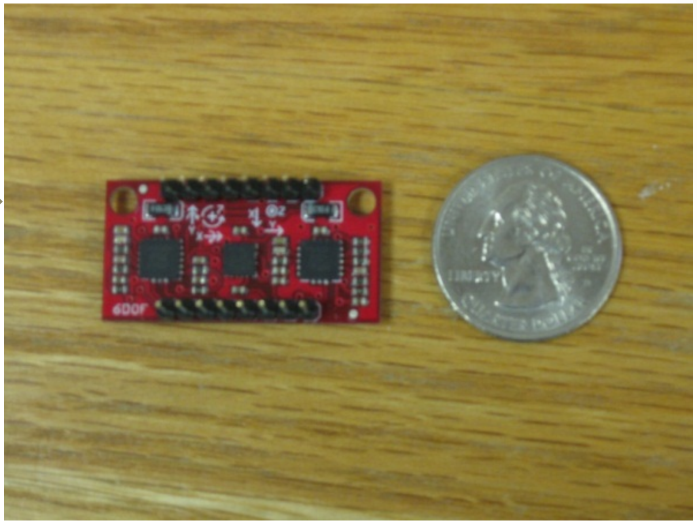
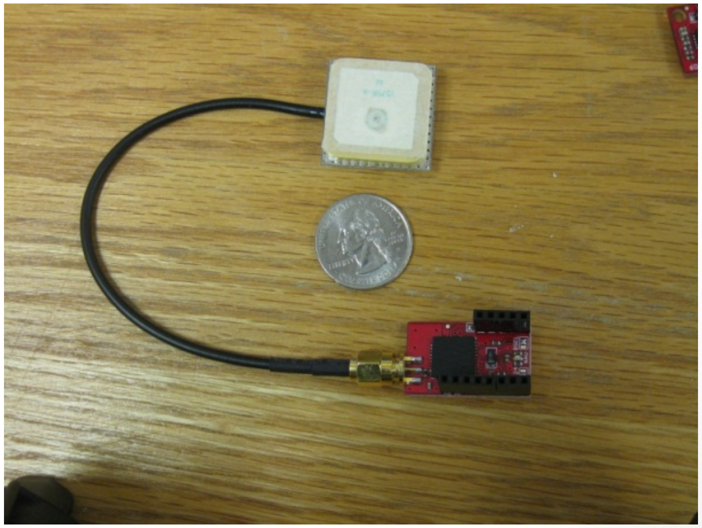
Sensing Package

- Razor 6DOF IMU
  - 3 Axis Accelerometer
    - Angle from horizon
  - 3 Axis Gyroscope
    - Angular velocity
- Venus GPS Receiver





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Test flight

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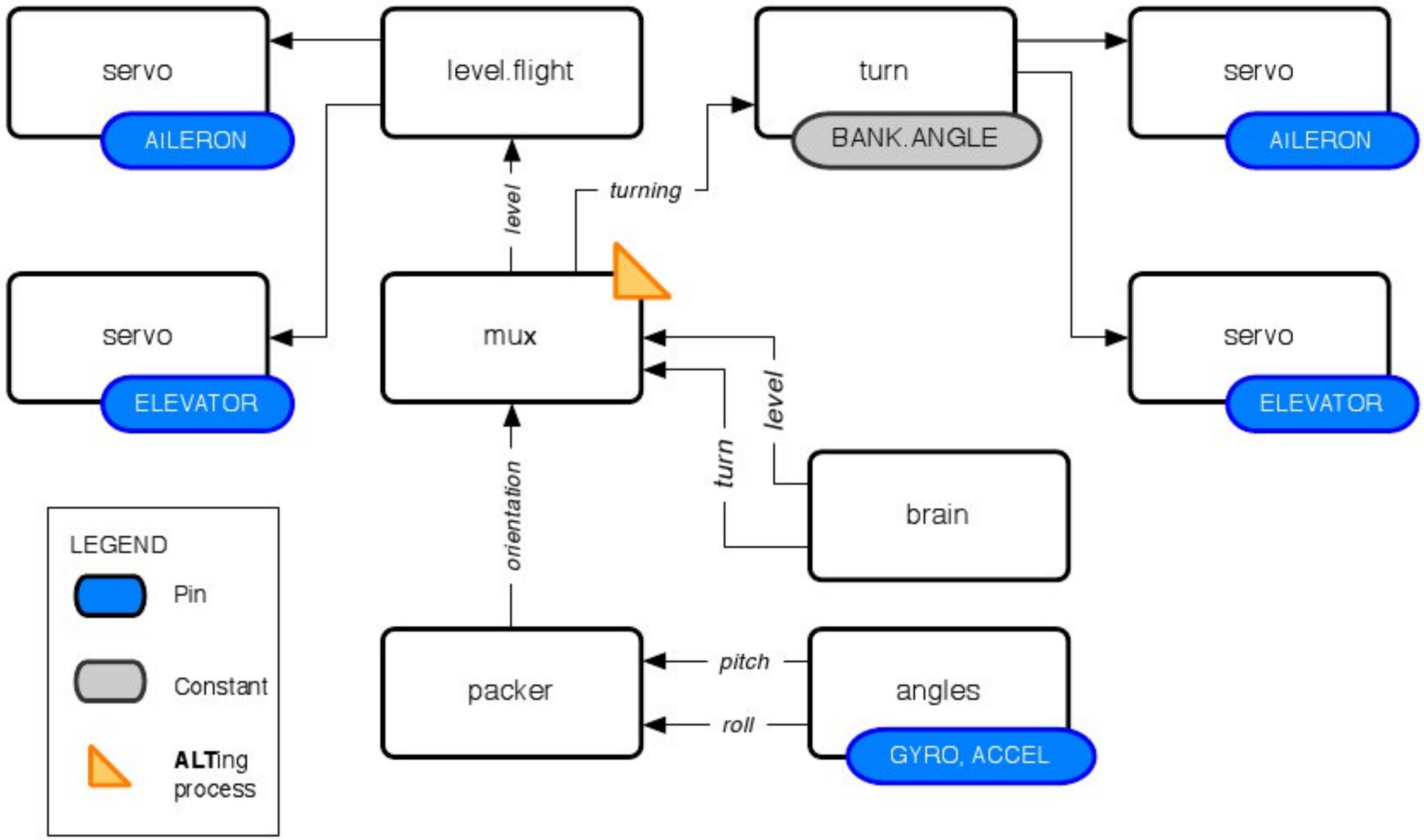
Process Network



Challenges

- Obtaining data from the accelerometer without trig functions
  - Solution: Direct ADC value to angle mapping (Lookup Table)
- Lack of Decimal Precision
  - Solution: Use of Integer math in creative ways
- Filtering Complexity
  - Solution: Simplified complementary filter
- How to best achieve Level Flight?
  - Solution: Reflex type leveling reaction
- Fine Tuning of Level Flight
  - Solution: Inflight Adjustment with data link?

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Obtaining Meaningful Data

- In reality sensors output noisy/unreliable data
  - Gyroscopes drift over time
  - Accelerometers lose accuracy in turns
- Aerial platforms experience rapid changes in environment
  - Wind Gusts
  - Temperature Variation
- Vibration
- Solution is Filtering
  - Kalman
  - Directional Cosine Matrices
  - Complementary

A Simpler Approach

- Due to the complexity involved in Kalman, Complementary filtering was pursued.

```
PROC comp.filter (CHAN INT gyro?, accelerometer?,theta!, VAL INT gain, dt)
  INT gyr, accel:
  INITIAL INT angle IS 0:
  WHILE TRUE
    SEQ
      gyro ? gyr
      accelerometer ? accel

      accel := accel * (-1)

      angle := (((gain * (angle + (gyr * dt))) + (( 100 - gain) * accel))/100)

      theta ! angle
:
```

An Involuntary Reflex

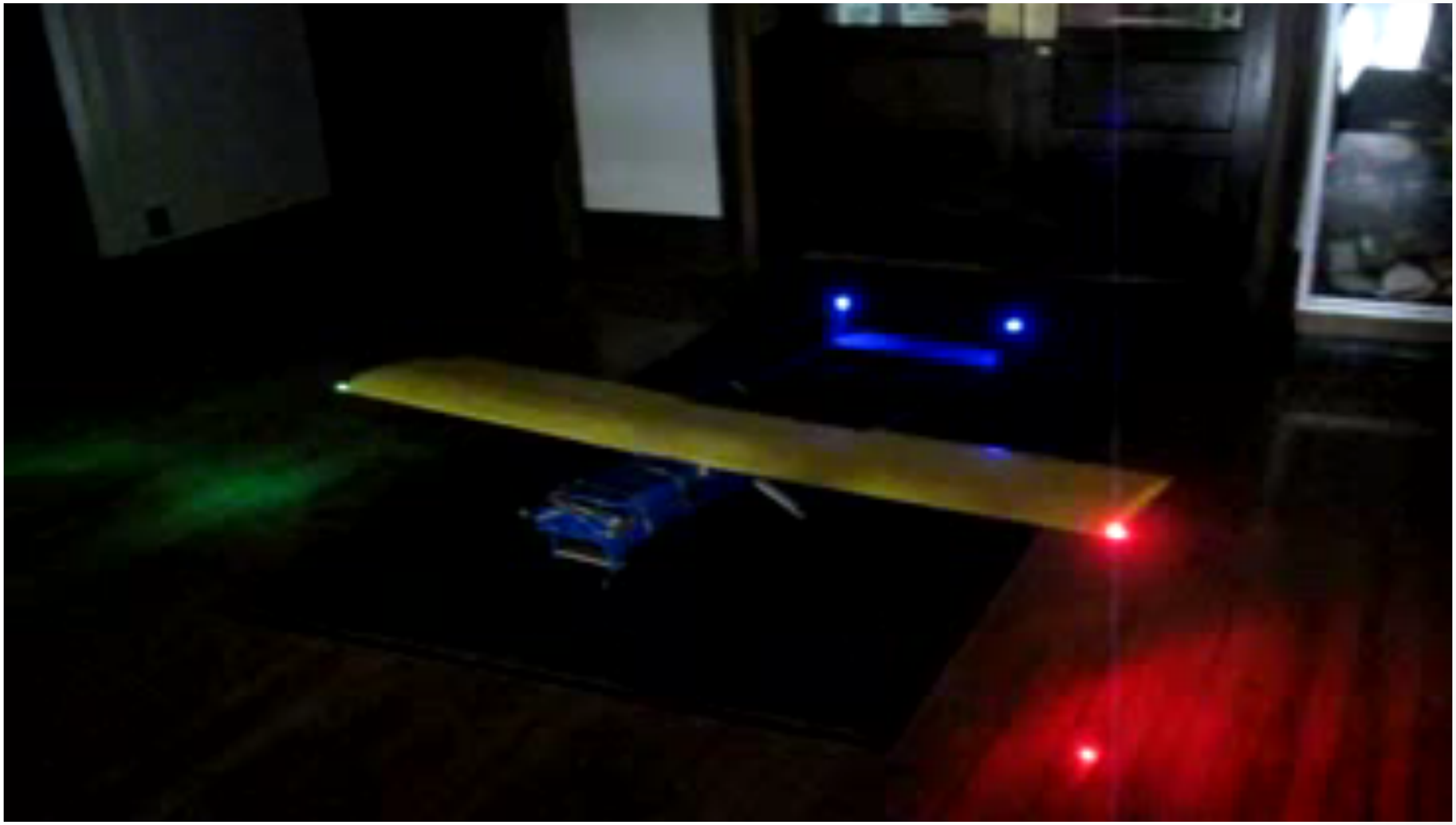
- Simple instinct level reaction is to bring the aircraft level with the horizon

```
PROC level.flight (CHAN IMU.DATA imu?, CHAN SERVO s, s2)
  INT  servo.pos.pitch, servo.pos.roll:
  IMU.DATA pos:
  SEQ
    WHILE TRUE
      SEQ
        imu ? pos

        servo.pos.pitch := (pos[pitch] * ((-1) * PITCH.SERVO.MULTIPLIER))+(90)
        s ! pos ; servo.pos.pitch

        servo.pos.roll := (pos[roll] * ((-1) * ROLL.SERVO.MULTIPLIER))+(90)
        s2 ! pos ; servo.pos.roll
:
```

Leveling Reflex



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Next Steps

- In Flight Telemetry
- GPS Navigation
- Integration of airspeed, heading, and altitude
- Holding Pattern implementation
- Subsumption Architecture
- Aerial Reconaissance

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Questions?

E-mail: armstri@allegheny.edu
Project Blog: http://rockalypse.org/blogs/flyinggator

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