Creating Our Robot Overlords

Autonomous Drone Development with Java and IoT

#JfokusDrone

James Weaver / Mark Heckler
Java Ambassador / Software Engineer
Oracle

Sean Phillips
Software Engineer
Ai Solutions

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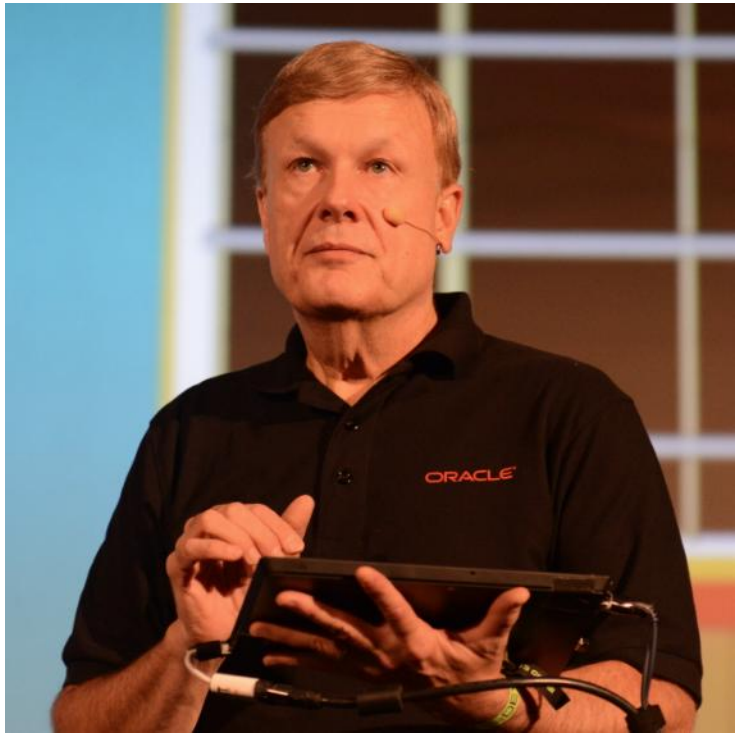
About the presenter



#JfokusDrone

James Weaver

Java Technology Ambassador
Oracle Corporation
Twitter: @JavaFXpert
Email: ***james***.weaver@oracle.com

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Program Agenda

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1. Achieving autonomous flight
2. Raspberry Pi for brains
3. Anatomy of a quadcopter
4. Leveraging IoT concepts and tools
5. 3D flight simulation
6. Next step: Self-aware drone (implementing a control loop)

Java™ ORACLE

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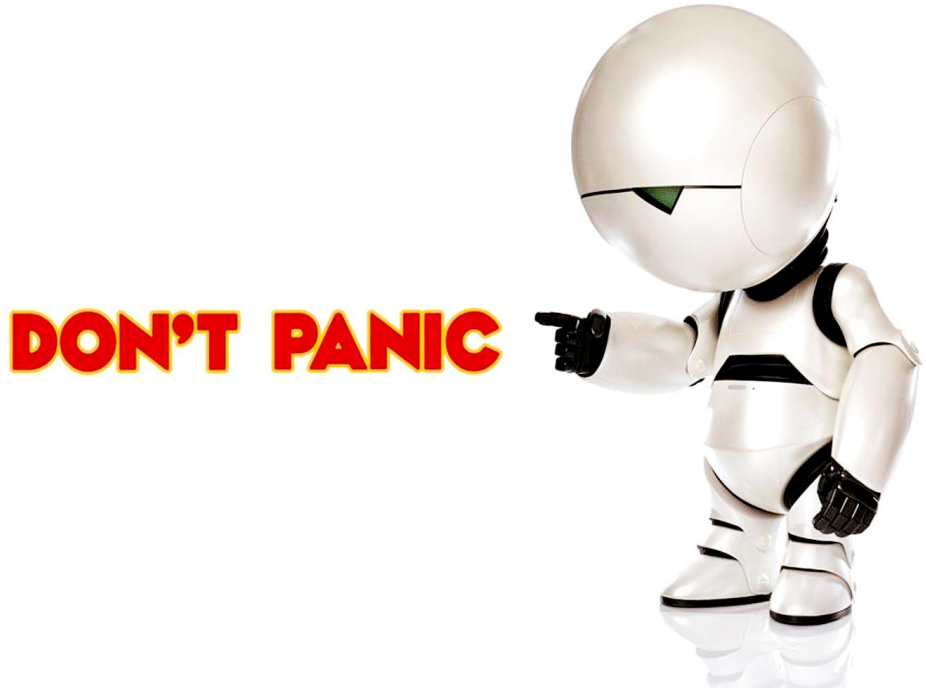
Achieving Autonomous Flight!

- First things first
  - Choosing a drone
  - Finding or writing a foundational library
  - Determining level of autonomous ops
- Equipment list
  - Drone
  - Brain
  - Power
- Making it work
  - And **this** is where the story gets really interesting



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Achieving Autonomous Flight!
Making the Tough Choices

- Which drone?
  - Published API
  - Community
  - Price of equipment
  - **Parrot AR.Drone 2.0 (Parrot.com)**
- Which library?
  - Capability
  - Reliability
  - Responsibility
  - **Parrots On Java/Parroteer (ParrotsOnJava.com)**

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Message from co-presenter Mark Heckler @MkHeck

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Achieving Autonomous Flight! Assembling the Pieces

- Equipment list
  - Parrot AR.Drone 2.0
  - Brain
    - Raspberry Pi Model B with case
    - Two (2) Edimax EW-7811un wifi adapters
    - 16G Class 10 SD card
  - Power
    - dodocool 2600 mAh mini power bank/charger
    - Cablejive microStubz extra short USB to micro USB cable
  - Anything else?
    - Duct/gaffer's tape! (Just kidding, we used Velcro)

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Achieving Autonomous Flight!
Configuring the Positronic Brain

- Central piece of the puzzle
- Configure one wifi adapter to connect as a client to the drone
- Configure other with Pi running
  - Wireless Access Point
  - DHCP server
- More details in a bit…

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Achieving Autonomous Flight!
Powering the Positronic Brain

- No straightforward means of powering other devices from drone
- How to fix?
- Add a power source!

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Raspberry Pi for Brains
Bill of Materials

- One (1) Raspberry Pi Model B
- One (1) Raspberry Pi case (smaller/lighter is better)
- One (1) SD card, Class 10, minimum 8G
- Two (2) Edimax EW-7811un wifi adapters
- One (1) Raspberry Pi power adapter (for initial configuration steps)
- One (1) portable USB mobile phone charger
- One (1) ethernet cable (for initial configuration steps)
- Parts list with links in appendix

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Raspberry Pi for Brains
Configuring the Software Stack

- Raspbian, typical configuration
- Configure as Wireless Access Point (hostapd, DHCP server) – 1st adapter
- Configure to connect to drone, get IP address (DHCP client) – 2nd adapter
- Tweak ifplugd to maintain two concurrent connections
- Startup script, timing (initiating network connections, DHCP server a bit fiddly initially)
- Full documentation available at:

https://bitbucket.org/autonomous4j/autonomous4jga/wiki/PiConfiguration

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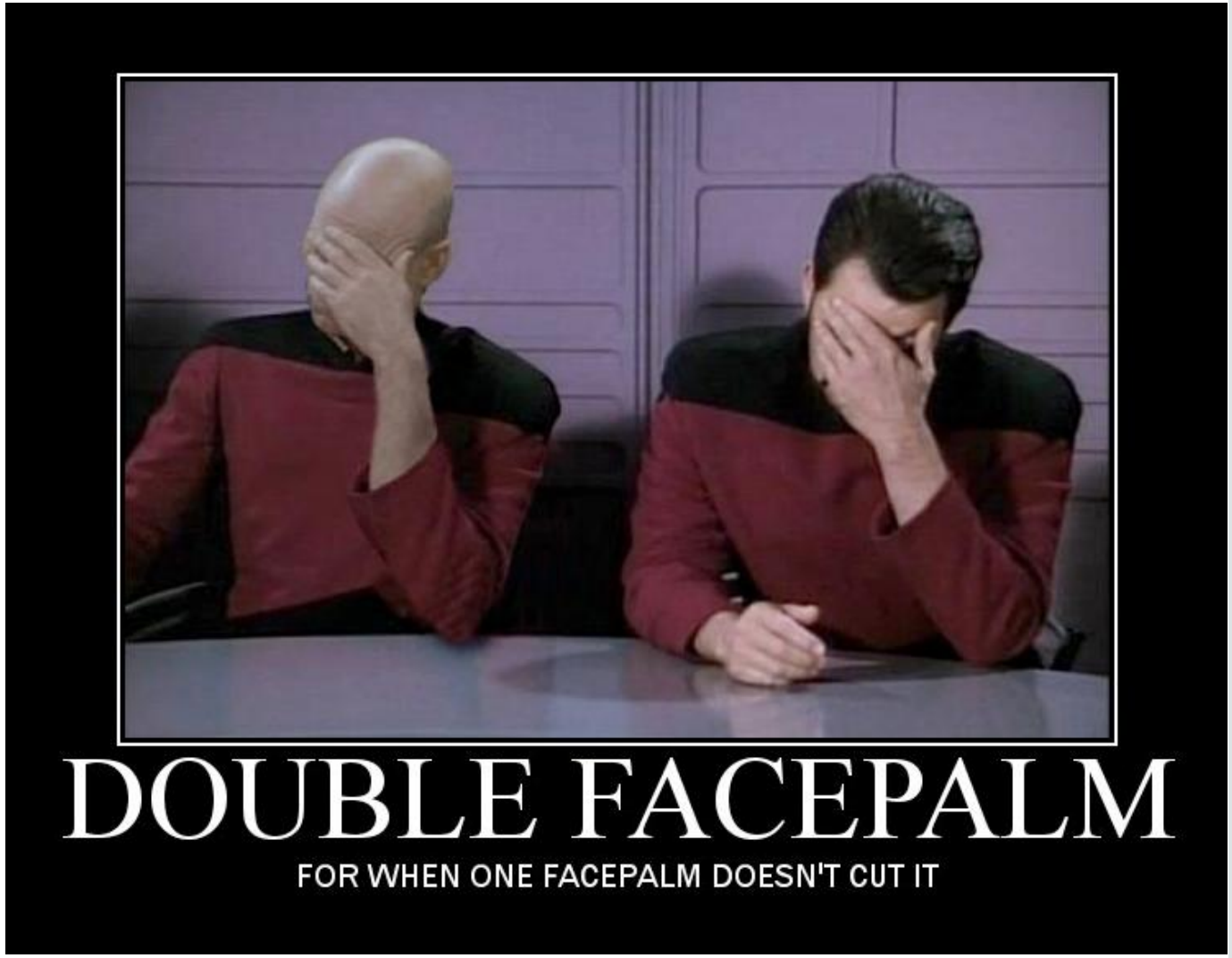
Achieving Autonomous Flight! Making it Work

- Didn’t anticipate many issues
- In hindsight, that was just silly
- Firmware challenges
- API challenges
- Equipment challenges
- Sensing a pattern?



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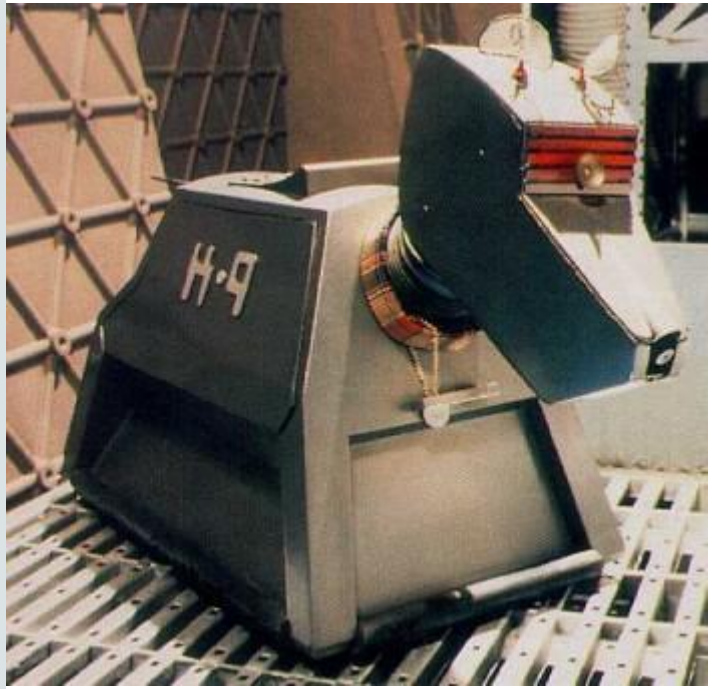
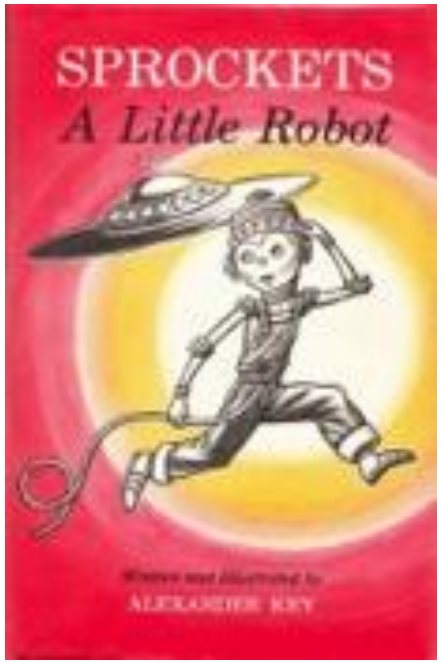
Achieving Autonomous Flight! (Unrealistic) Expectations





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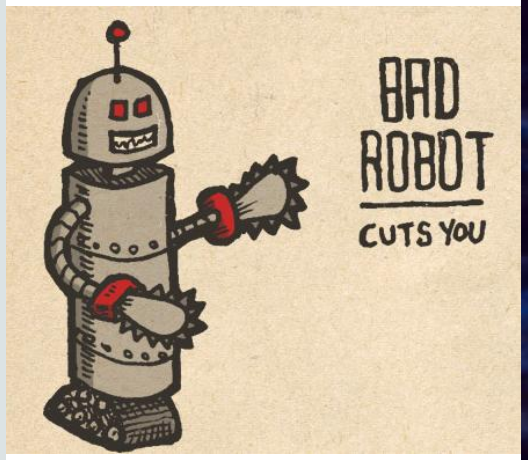
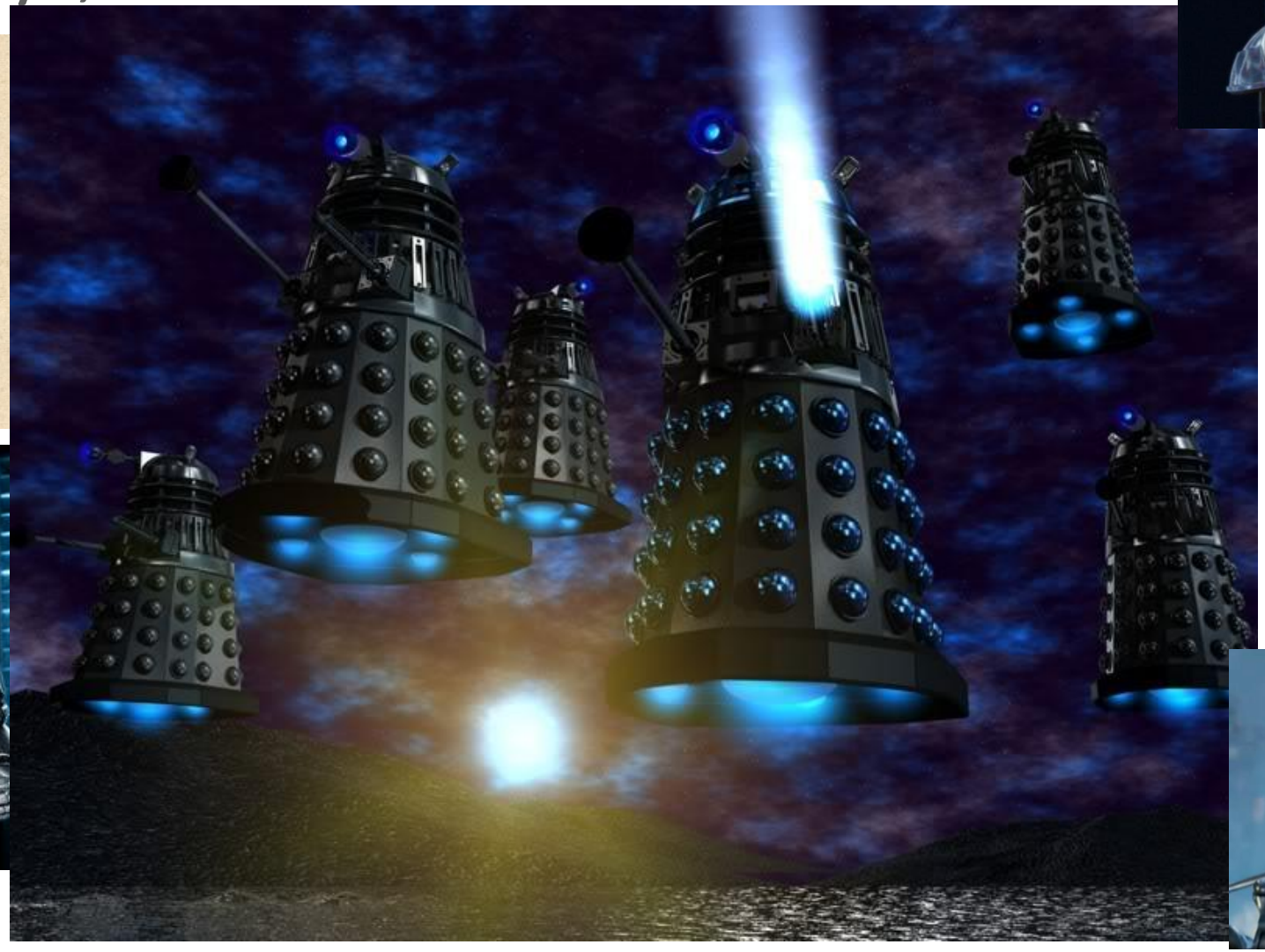
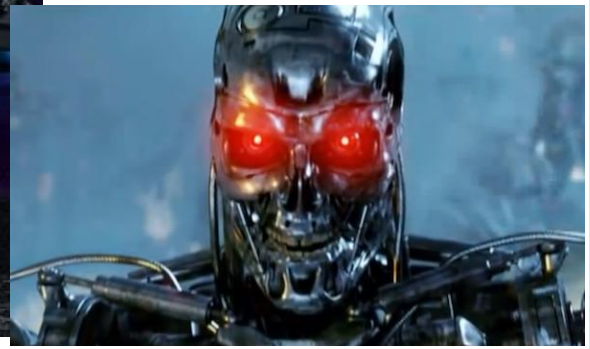
Achieving Autonomous Flight!
In some ways, it's more like…







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Achieving Autonomous Flight!
With a bit of this thrown in for good measure…

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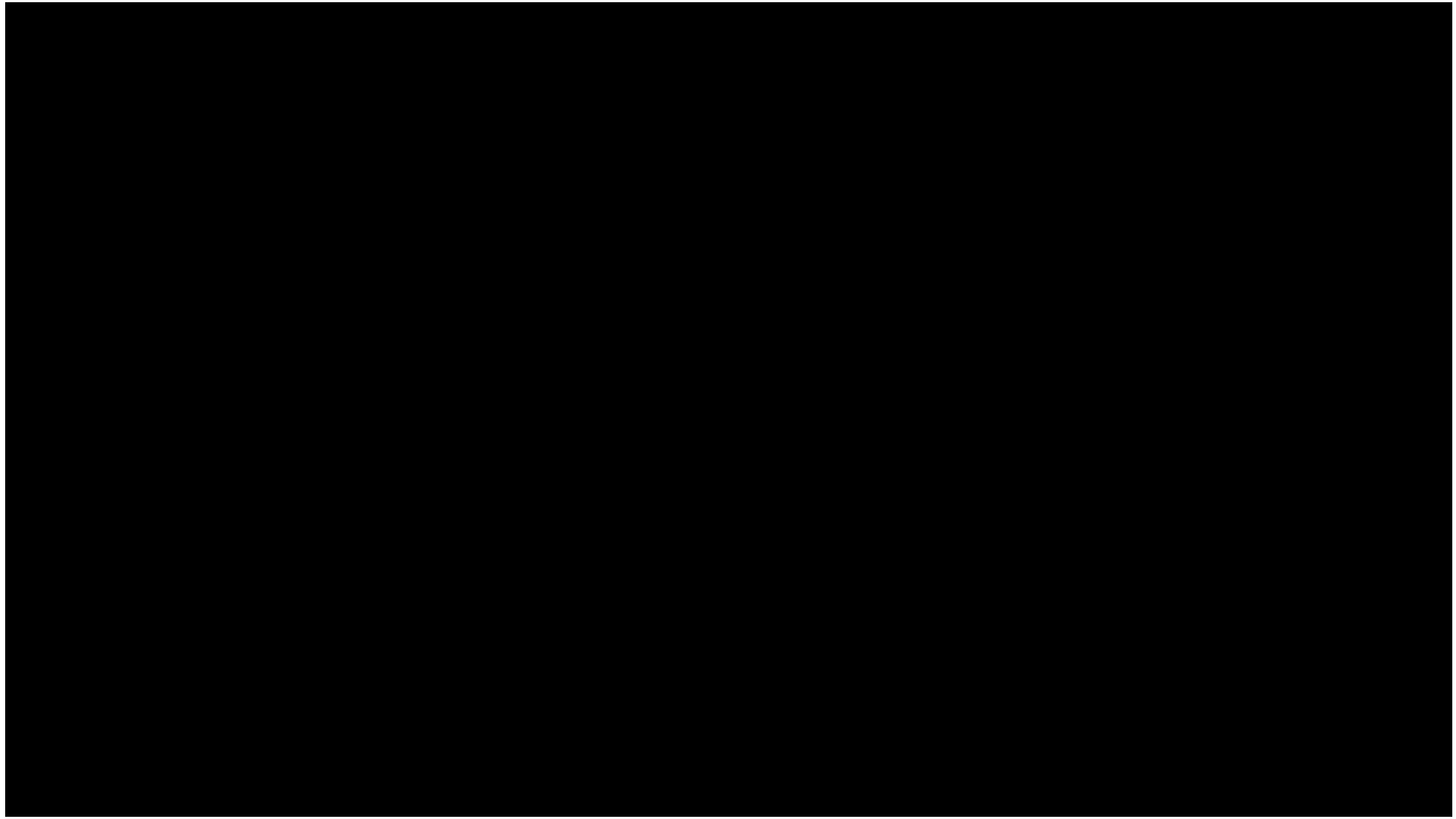
The AR Drone flies better without the extra weight ...



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Anatomy of a Quadcopter (AR Drone 2.0)

- Four spinning blades of doom (!)
  - brushless motors
  - motor controllers
- Lithium polymer battery, 1000mAh
- Onboard wireless access point
- Indoor shell / outdoor shell

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Anatomy of a Quadcopter (AR Drone 2.0 sensors)

- Inertial Measurement Unit:
  - gyroscope (3 degrees of freedom)
  - accelerometer (3 degrees of freedom)
  - magnetometer (3 degrees of freedom)
- Ultrasound height sensor
- Pressure sensor (measures high flight)
- Front camera (720p, 30fps)
- Downward camera (360p, 30fps visual odometry sensor)

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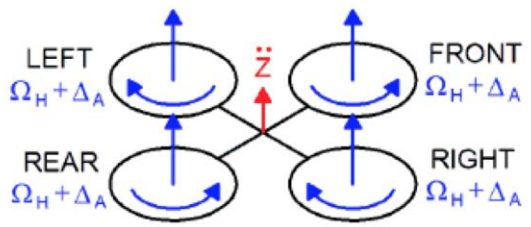
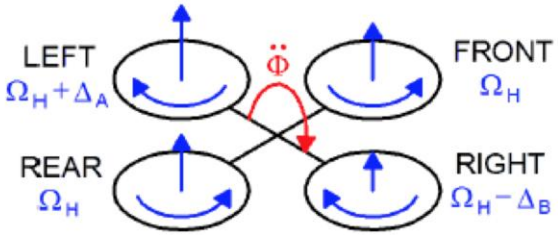
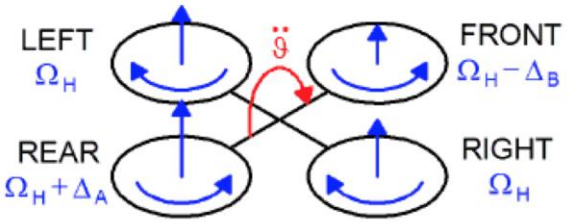
Anatomy of a Quadcopter (Flying Principle)



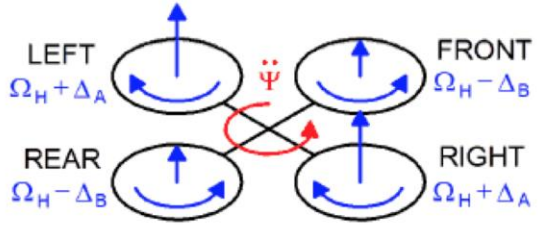
(a) Throttle



(b) Roll



(c) Pitch



(d) Yaw

From https://projects.ardrone.org ARDrone_Developer_Guide.pdf

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Demo: Fly drone with this code for a box pattern...

```
private static void doDemoFlightBox(A4jBrain brain) {
  brain.takeoff().hold(5000);

  brain.goRight(20).doFor(1000); // % speed, ms duration
  brain.hover().hold(4000);
  brain.backward(20).doFor(800);
  brain.hover().hold(4000);
  brain.goLeft(20).doFor(1500);
  brain.hover().hold(4000);
  brain.forward(20).doFor(1200);
  brain.hover().hold(4000);

  brain.land();
}
```


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Example code for goHome() functionality

```
private static void doDemoFlightHome (A4jBrain brain) {
  brain.takeoff().hold(6000);

  brain.forward(20).doFor(400);
  brain.hover().hold(2000);
  brain.goRight(20).doFor(400);
  brain.hover().hold(2000);
  brain.forward(20).doFor(400);
  ...

  brain.goHome();
  brain.hover().hold(2000);

  brain.land();
}
```


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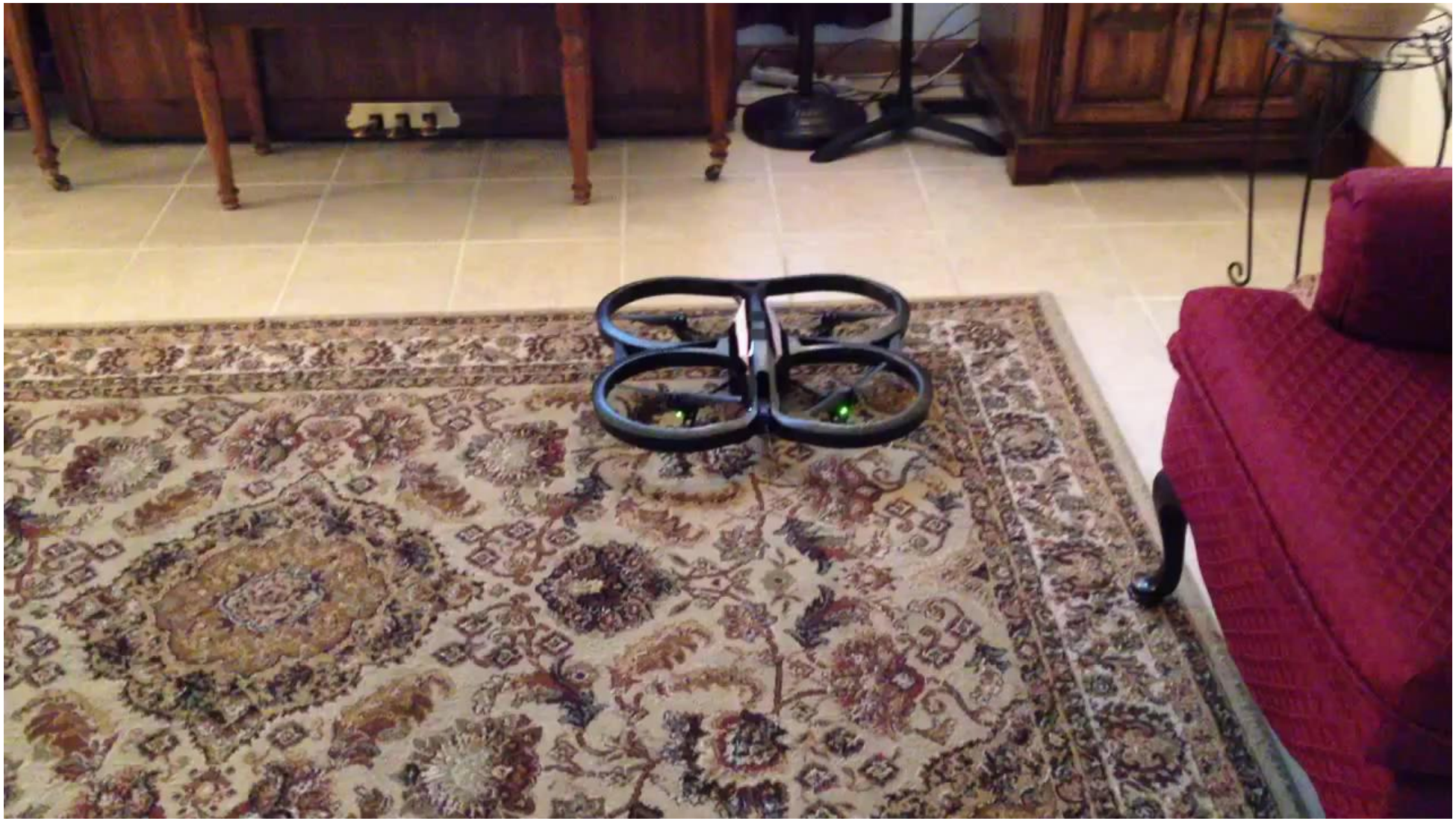
Video: Fly drone and goHome()



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Example code for controlling LEDs

```
private static void doDemoFlightLeds(A4jBrain brain) {
  brain.takeoff().hold(6000);

  brain.playLedAnimation(LedAnimation.BLINK_GREEN,
                                      10, 3);
  brain.hover().hold(2000);

  brain.playLedAnimation(LedAnimation.BLINK_GREEN,
                                      10, 3);
  brain.hover().hold(2000);

  brain.land();
}
```


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Video: Fly drone and control LEDs

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Leveraging IoT Concepts and Tools

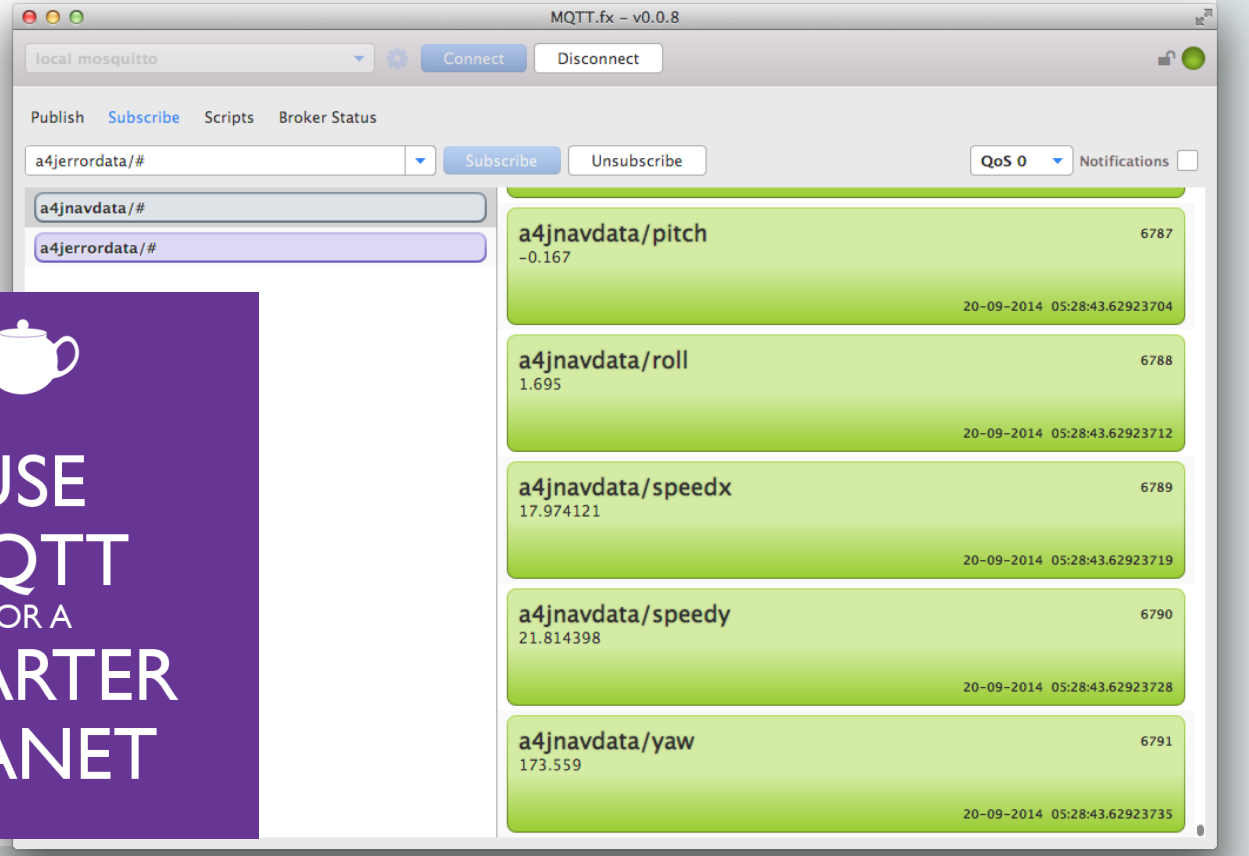
NetBeans

Java

Mosquitto

An Open Source MQTT v3.1/v3.1.1 Broker

USE MQTT FOR A SMARTER PLANET



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Leveraging IoT Concepts and Tools

Thanks to Jens Deters @Jerady for MQTT.fx http://mqttfx.org

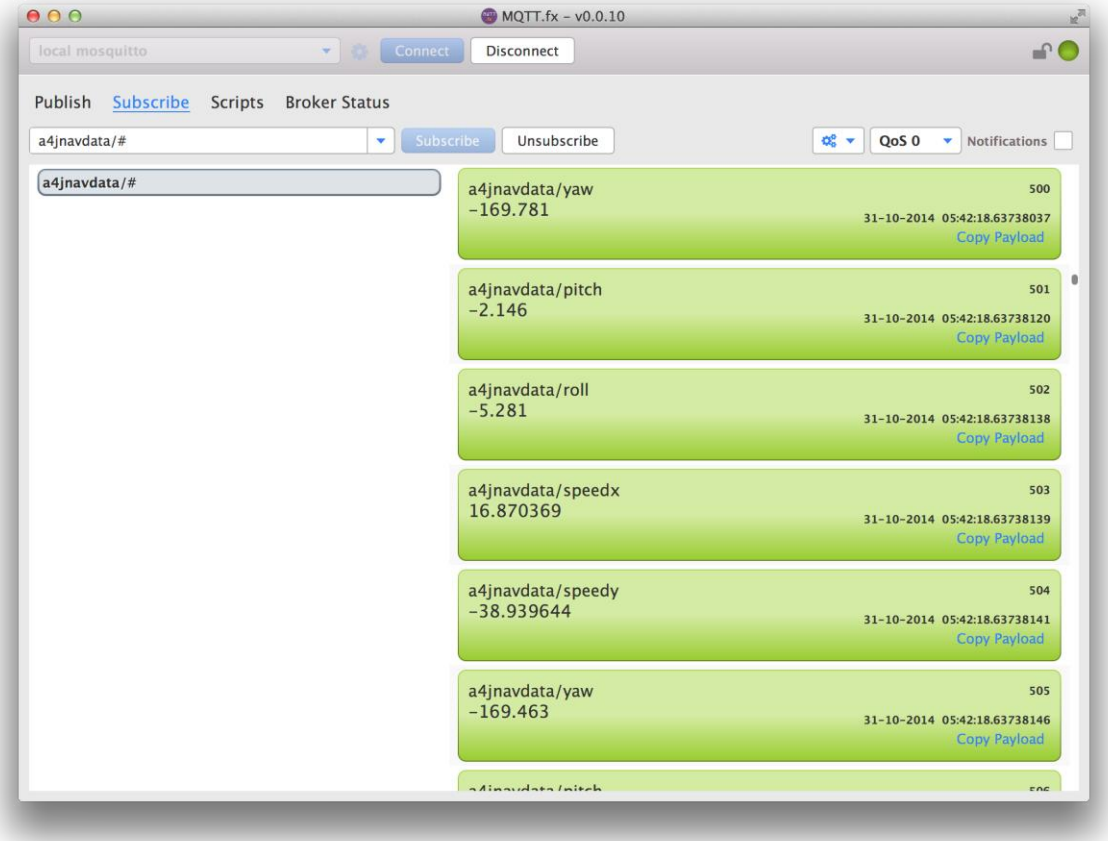
Publish flight data

Java

Mosquitto

An Open Source MQTT v3.1/v3.1.1 Broker

Subscribe to flight data



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Demo: Monitoring drone flight with MQTT.fx
Let's have a look!

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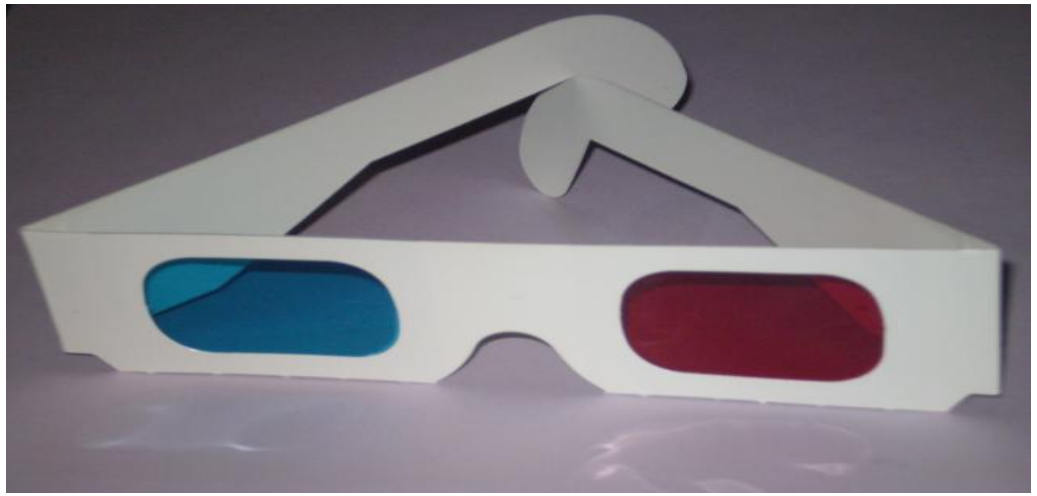
Welcoming our Robot Overlords…

IN 3D!!! *



** Skull Faced Alien Space Helmeted Gorilla Suit not included.*

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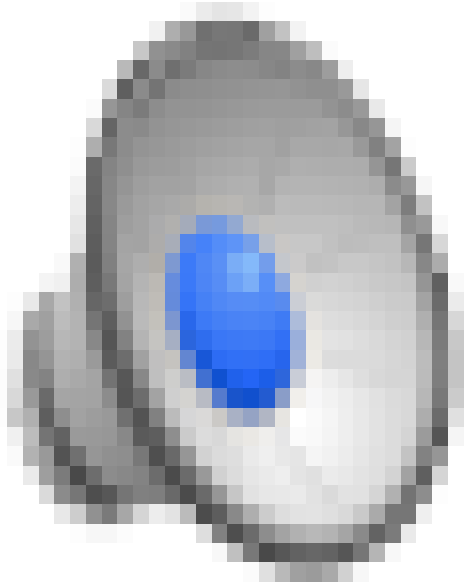
Message from co-presenter Sean Phillips @SeanMiPhillips



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Know your Overlord!!

Loading a Robot Overlord 3D Model

- Overlord class is a Group
  - Load model assests (.obj) within constructor
  - Leverages Interactive
    - http://www.interactivemesh.org/models/jfx3dimporter.html
  - Importer adds object MeshViews as children
- All transforms made on the entire group
- Overlord has no control smarts only API

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