

# Creating Our Robot Overlords

Autonomous Drone Development with Java and IoT



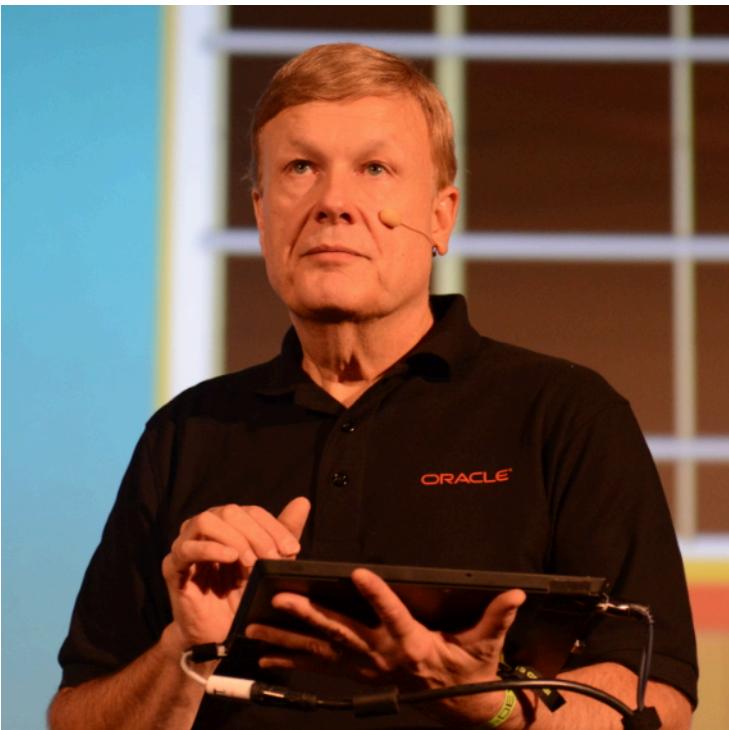
#DevNexusDrone

James Weaver / Mark Heckler  
Java Ambassador / Software Engineer  
Oracle

Sean Phillips  
Software Engineer  
Ai Solutions



# About the presenter



#DevNexusDrone

## James Weaver

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

# 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)

# 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



**DON'T PANIC**



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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)**



# 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)



# 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...



# Achieving Autonomous Flight! Powering the Positronic Brain

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



# 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



# Raspberry Pi for Brains

## Configuring the Software Stack

- Raspbian, typical configuration
- Configure as Wireless Access Point (hostapd, DHCP server) – 1<sup>st</sup> adapter
- Configure to connect to drone, get IP address (DHCP client) – 2<sup>nd</sup> 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>

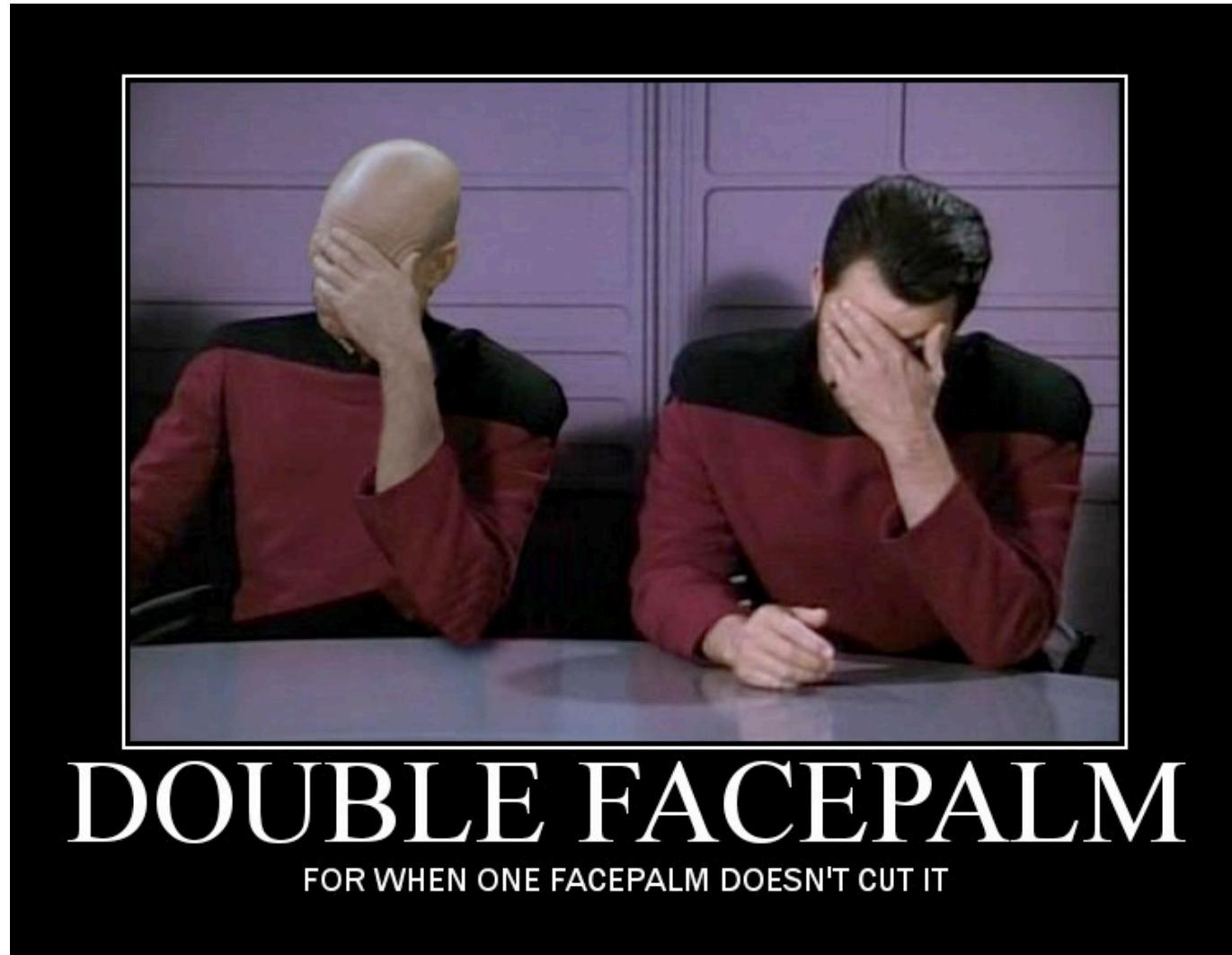


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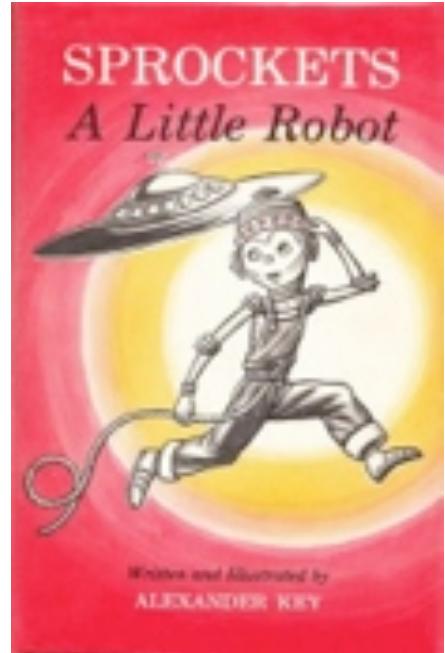
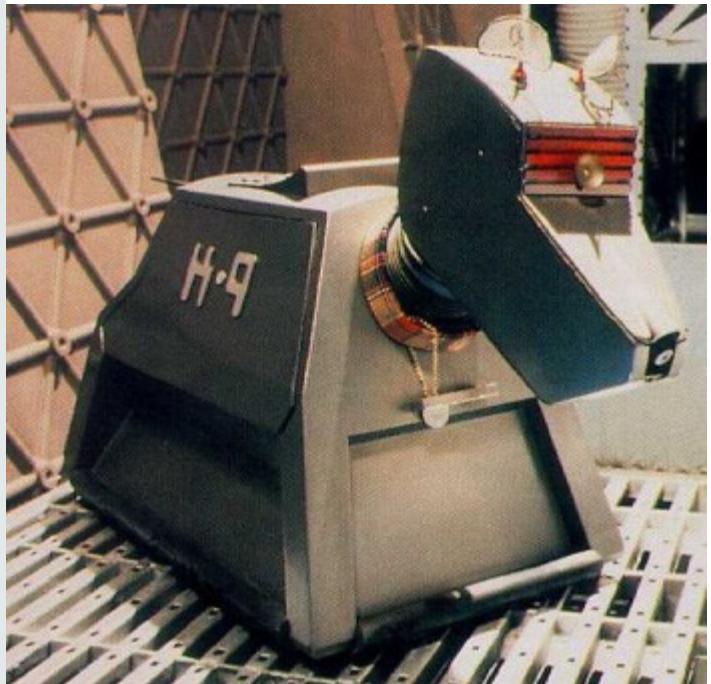
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# Achieving Autonomous Flight! Making it Work

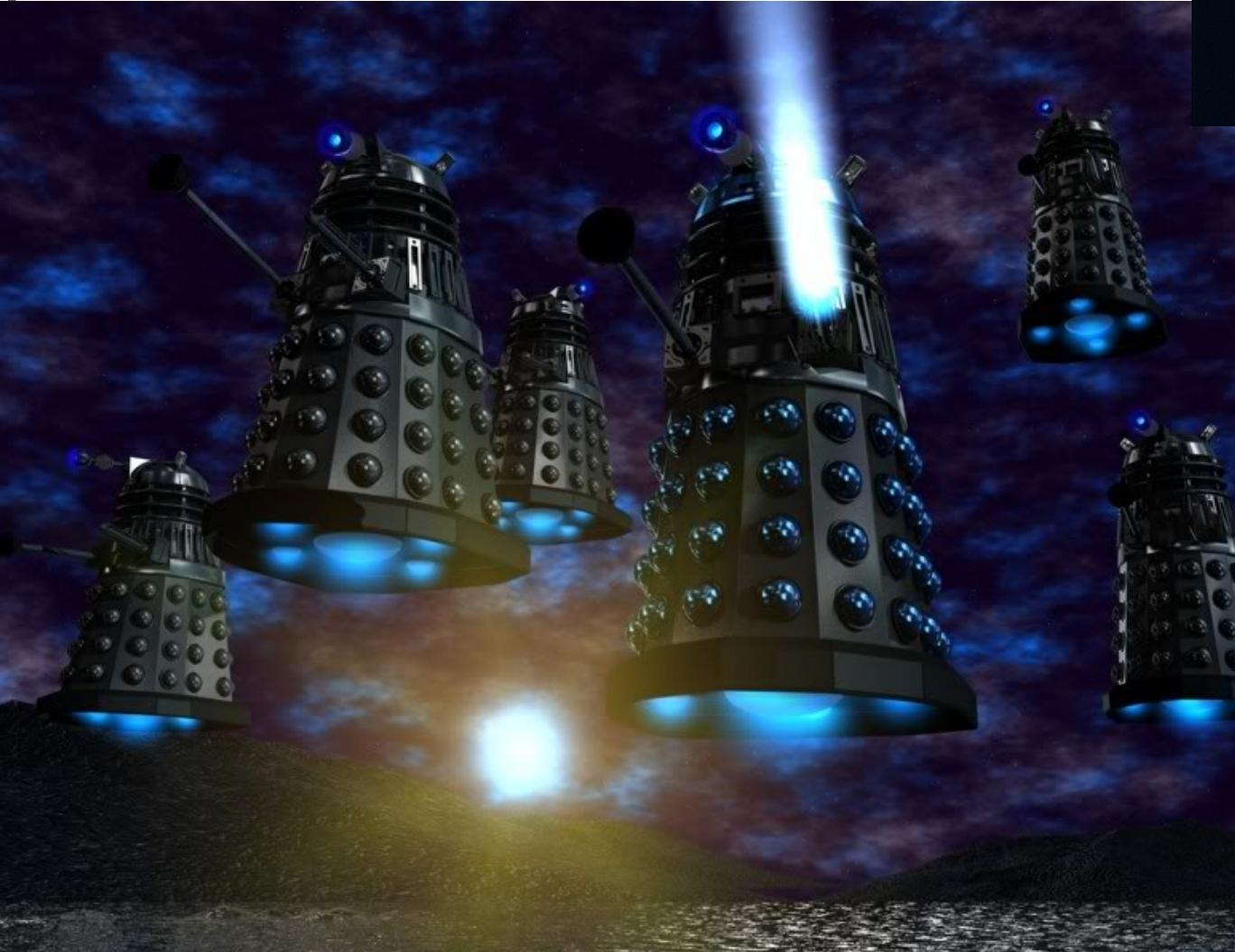
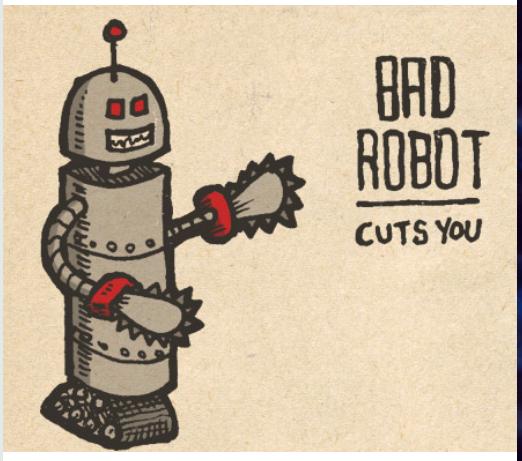
- Didn't anticipate many issues
- In hindsight, that was just silly
- Firmware challenges
- API challenges
- Equipment challenges
- Sensing a pattern?



# Achieving Autonomous Flight! (Unrealistic) Expectations



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



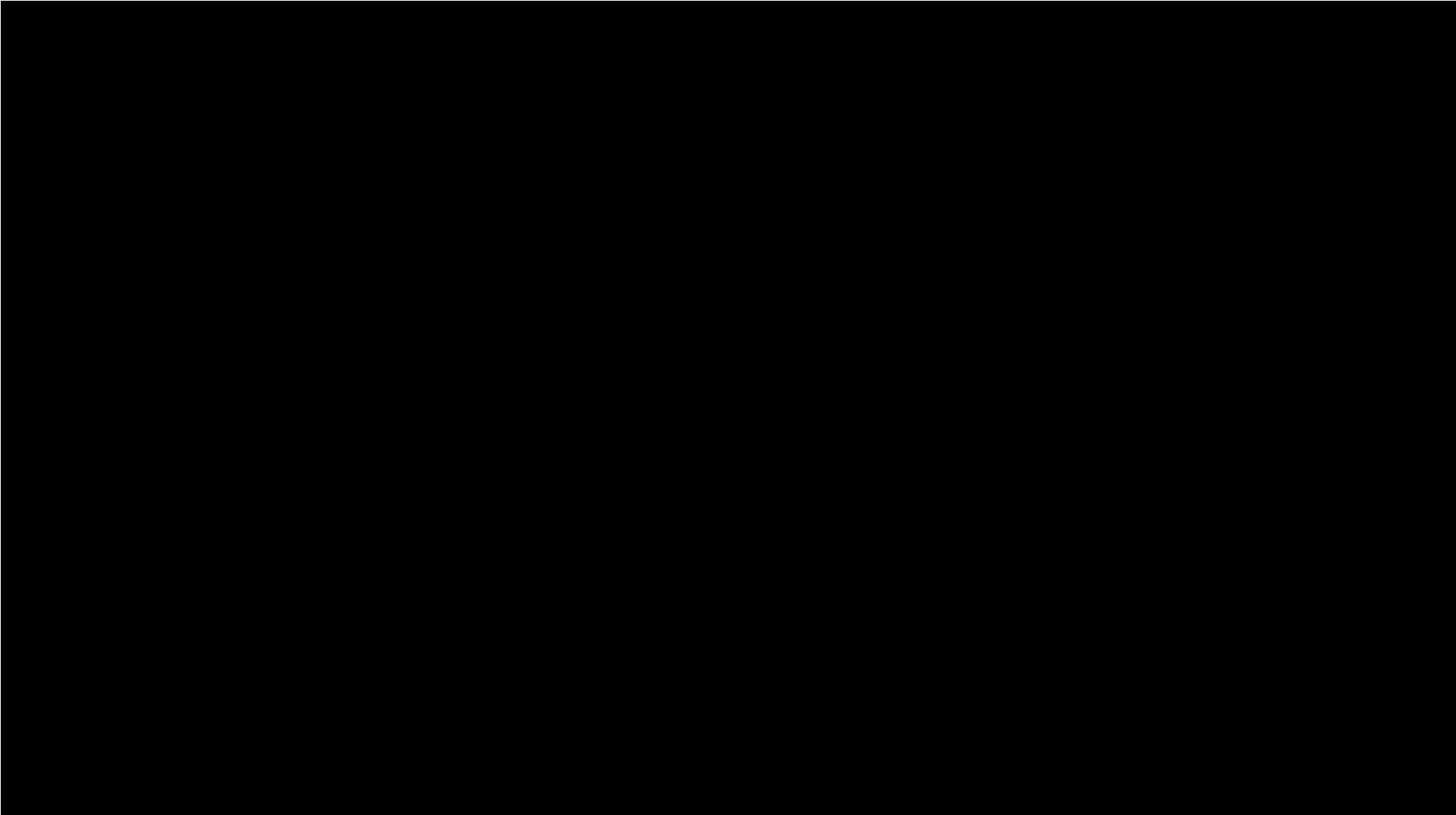
# Achieving Autonomous Flight! With a bit of this thrown in for good measure...



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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

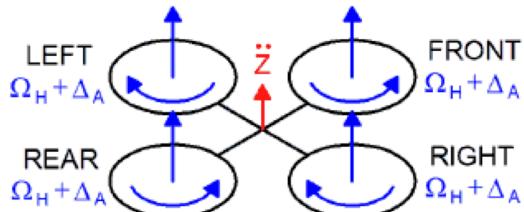


# Anatomy of a Quadcopter (AR Drone 2.0 sensors)

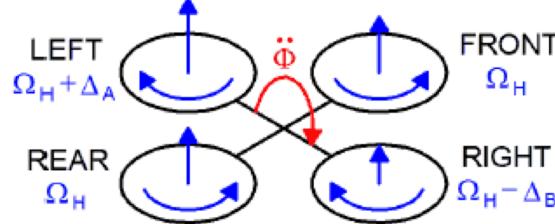
- Inertial Measurement Unit:
  - gyroscope (3 degrees of freedom)
  - accelerometer (3 degrees of freedom)
  - magnetometer (3 degrees of freedom)
- Ultrasound height sensor
- Pressure sensor (measures high flight)
- Front camera (720p, 30fps)
- Downward camera (360p, 30fps visual odometry sensor)



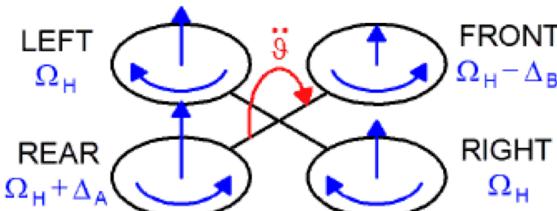
# Anatomy of a Quadcopter (Flying Principle)



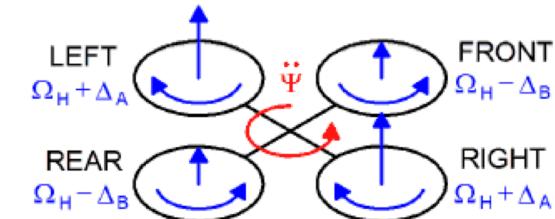
(a) Throttle



(b) Roll



(c) Pitch



(d) Yaw



From <https://projects.ardrone.org> ARDrone\_Developer\_Guide.pdf

# 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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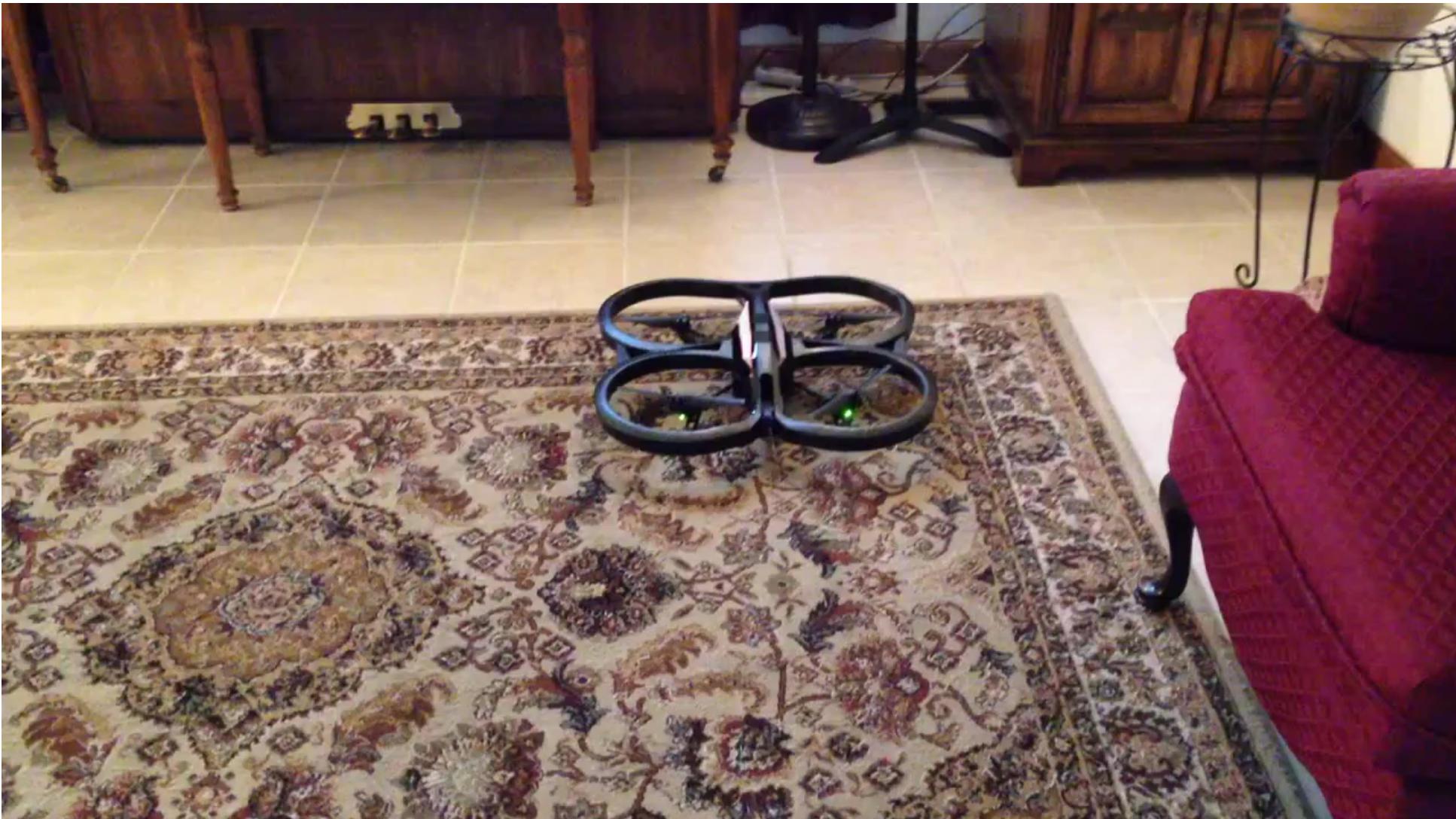
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# Example code for goHome( ) functionality

```
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();  
}
```



# Video: Fly drone and goHome( )



# 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();  
}
```



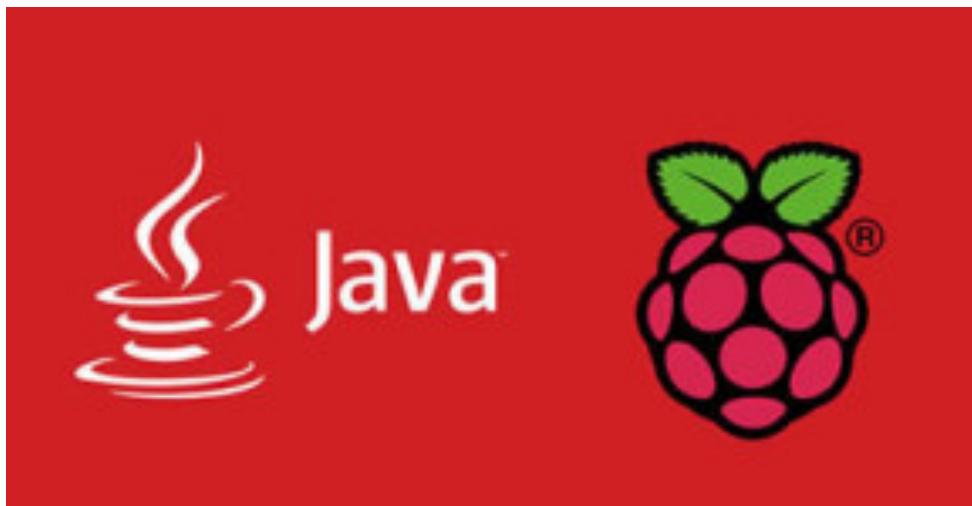
# Video: Fly drone and control LEDs



# Leveraging IoT Concepts and Tools



# NetBeans



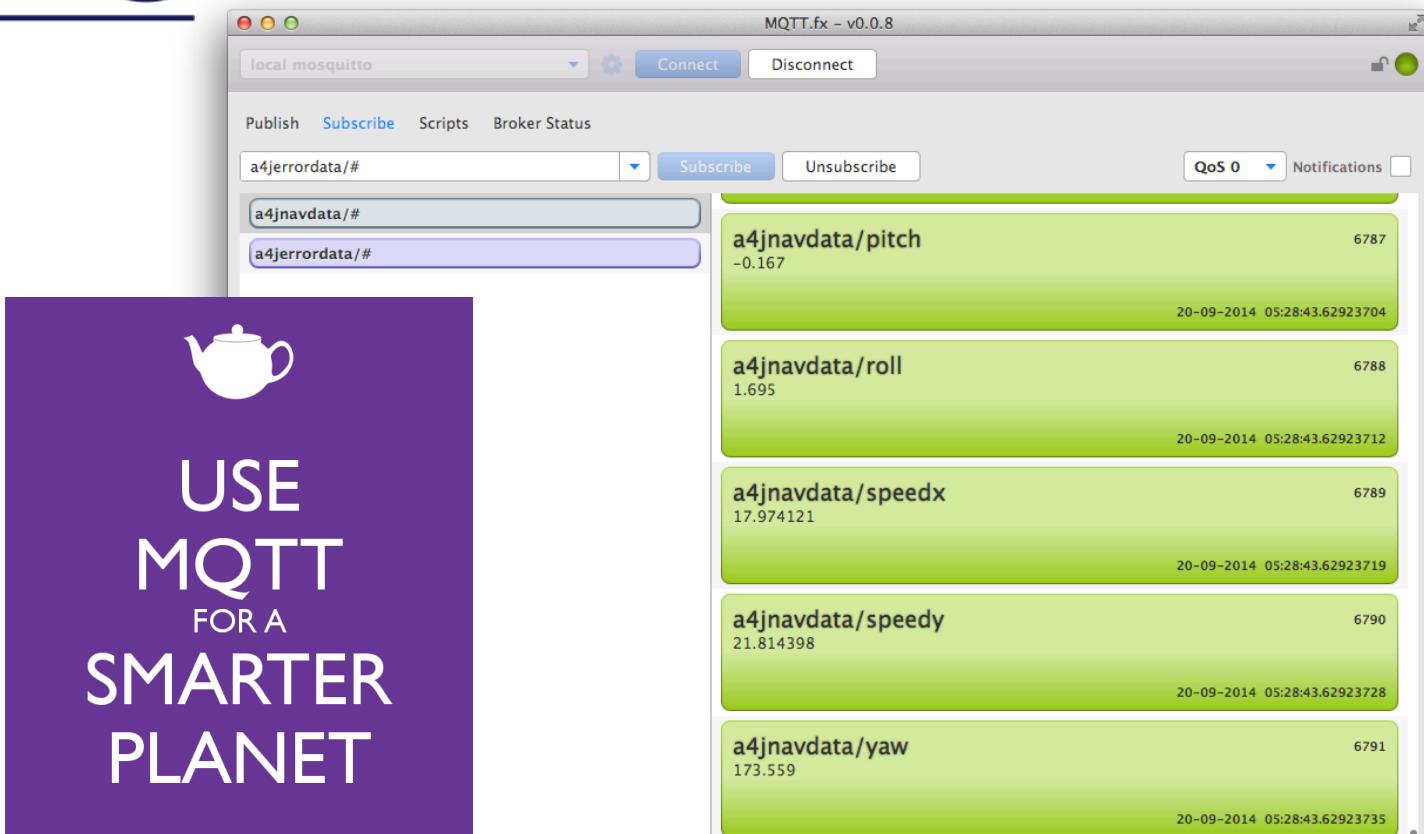
An Open Source MQTT v3.1/v3.1.1 Broker

TEA  
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>

Subscribe to flight data

Publish flight data



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

MQTT.fx - v0.0.10

local mosquitto Connect Disconnect

Publish Subscribe Scripts Broker Status

a4jnavdata/# Subscribe Unsubscribe QoS 0 Notifications

a4jnavdata/#

Topic	Message	QoS	Timestamp	Action
a4jnavdata/yaw	-169.781	500	31-10-2014 05:42:18.63738037	<a href="#">Copy Payload</a>
a4jnavdata/pitch	-2.146	501	31-10-2014 05:42:18.63738120	<a href="#">Copy Payload</a>
a4jnavdata/roll	-5.281	502	31-10-2014 05:42:18.63738138	<a href="#">Copy Payload</a>
a4jnavdata/speedx	16.870369	503	31-10-2014 05:42:18.63738139	<a href="#">Copy Payload</a>
a4jnavdata/speedy	-38.939644	504	31-10-2014 05:42:18.63738141	<a href="#">Copy Payload</a>
a4jnavdata/yaw	-169.463	505	31-10-2014 05:42:18.63738146	<a href="#">Copy Payload</a>
a4jnavdata/pitch		506		

# Demo: Monitoring drone flight with MQTT.fx

Let's have a look!



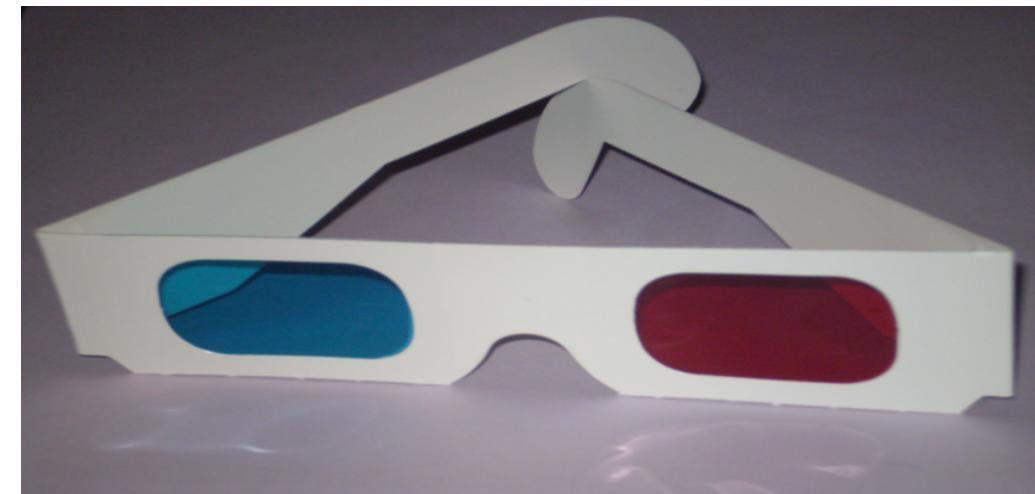
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Welcoming our Robot Overlords...

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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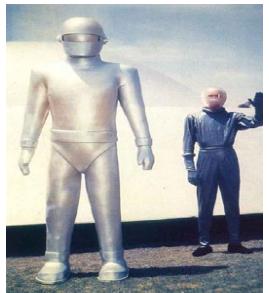
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# Know your Overlord!!

## Loading a Robot Overlord 3D Model



- Overlord class is a Group
  - Load model assets (.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

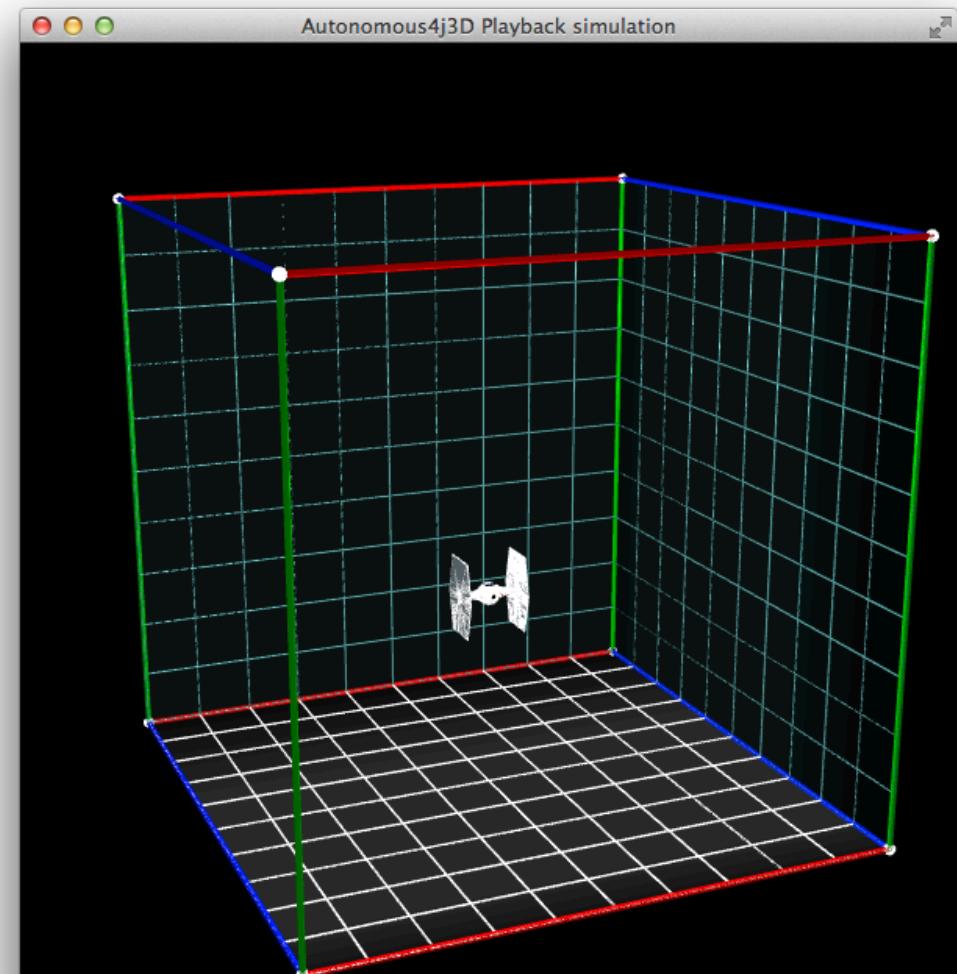


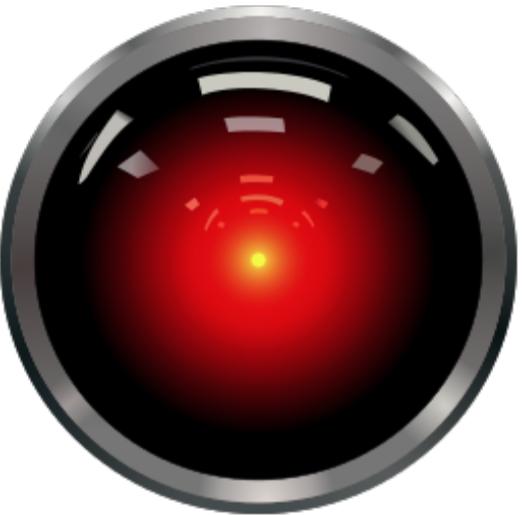
# Klaatu barada nikto

## Acquiring and Processing Commands

- Drag and Drop your .afr Flight Command Log onto the 3D scene.
- Function to parse into FlightCommand Object
- Add your Overlord like any other object

```
Task <Void> task = new Task<Void>() {  
    @Override  
    protected Void call() throws Exception {  
        try {  
            //Read in the playback file:  
            List<FlightCommand> playback = Files.lines(file.toPath())  
                .filter(line -> !line.isEmpty())  
                .map(mapToFlightCommand)  
                .collect(toList());  
  
            Platform.runLater(() -> {  
                sceneRoot.getChildren().add(overlord);  
            });  
        } catch (Exception e) {  
            e.printStackTrace();  
        }  
    }  
}
```





Demo. Pay attention.

# Next Step: Self-aware Drone

## Implementing a Control Loop

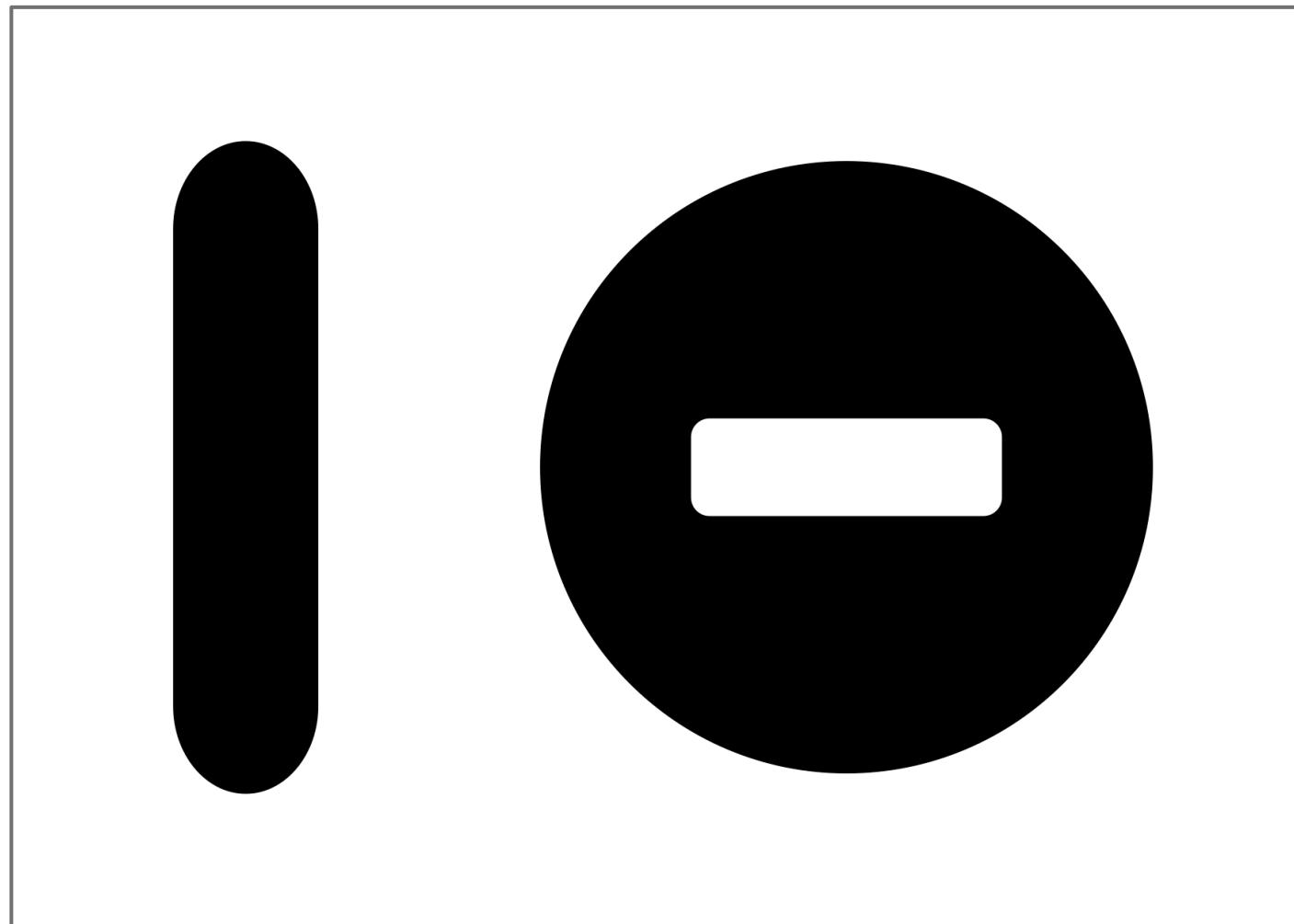
- “General Autonomy” vs. “Advanced Autonomy”
- Creating an external control loop
- Self-adjustment to achieve/maintain goal
- Higher-level goals vs. commands
- May require change of platform



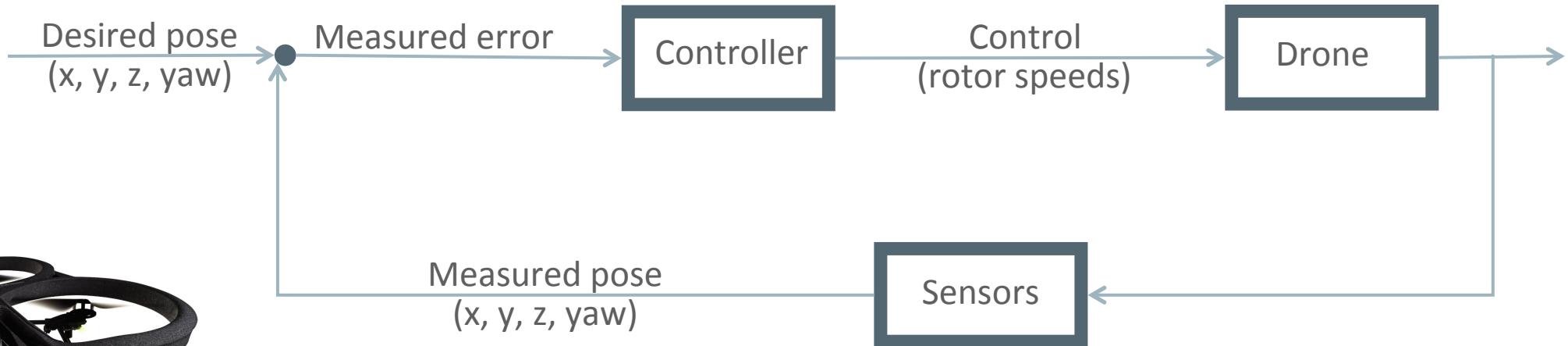
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# Enabling state estimation with an oriented roundel



# State estimation and position control



```
brain.goRight(20).doFor(1000); // % speed, ms duration
```

**VS.**

```
Pose des = new Pose(3500, 4800, 300, 45); // x, y, z, yaw  
brain.moveTo(des);
```

# In Conclusion...

- Thank you for attending
- Keep the information flowing
  - James Weaver (@JavaFXpert)
  - Mark Heckler (@MkHeck)
  - Sean Phillips (@SeanMiPhillips)
- Any questions?



# Appendix A

## Parts list: Positronic Brain

- Raspberry Pi Model B
- Pi case (ex: <http://www.amazon.com/gp/product/B008TD1FSQ/>)
- SD card (ex: <http://www.amazon.com/gp/product/B00DX5D9I4/>)
- Edimax wifi adapters (  
<http://www.amazon.com/Edimax-EW-7811Un-Adapter-Raspberry-Supports/dp/B003MTTJOY/>)
- Power adapter (ex: <http://www.amazon.com/gp/product/B00GWDLJGS/>)
- USB charger (ex: <http://www.amazon.com/gp/product/B00H7TR9WY/>)
- Ethernet cable

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