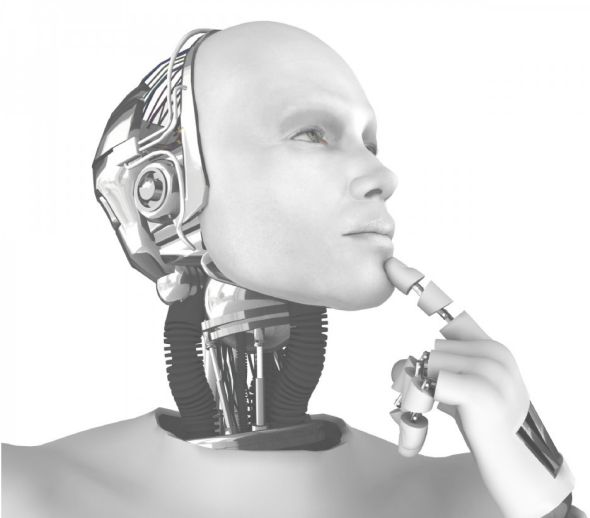

# AIOLI - AI Open Lab Initiative

## SciFi debunked - Slaughterbots

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December 10, 2017

# Agenda

Slaugherbots

Drone technology background

Navigation, Localization and Control

Autonomous drones

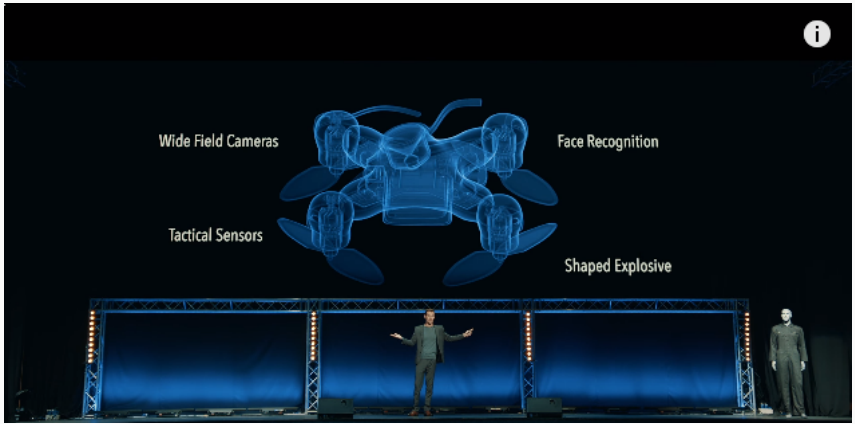
Finding and Identifying targets

Assessment

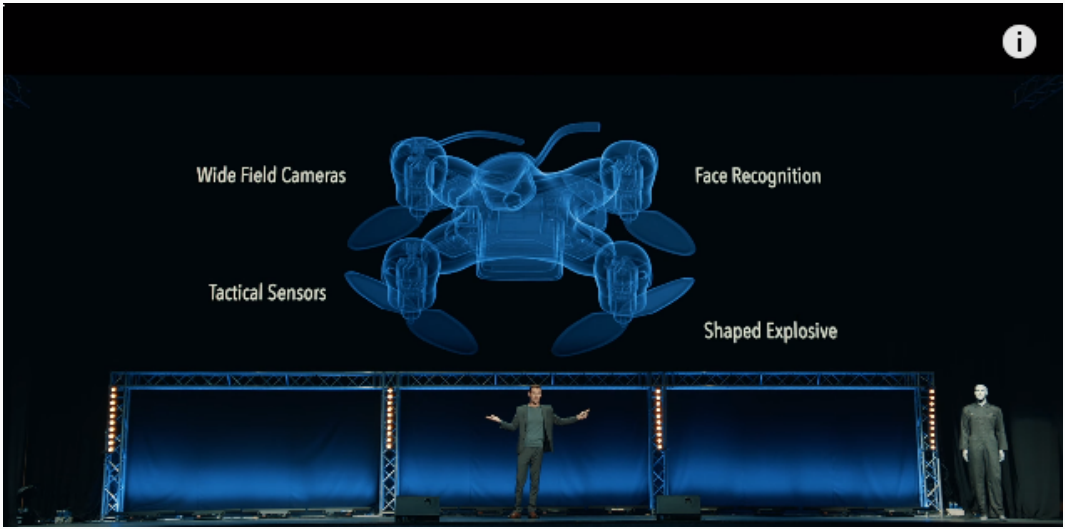
# Slaugherbots

# Video - Slaughterbots (7:47)

Video released by autonomousweapons.org, shall support the campaign(s) to pass laws against autonomous weapons (https://www.stopkillerrobots.org/) In the video: Prof. Stuart Russel (AI/CompSci, UC Berkeley)

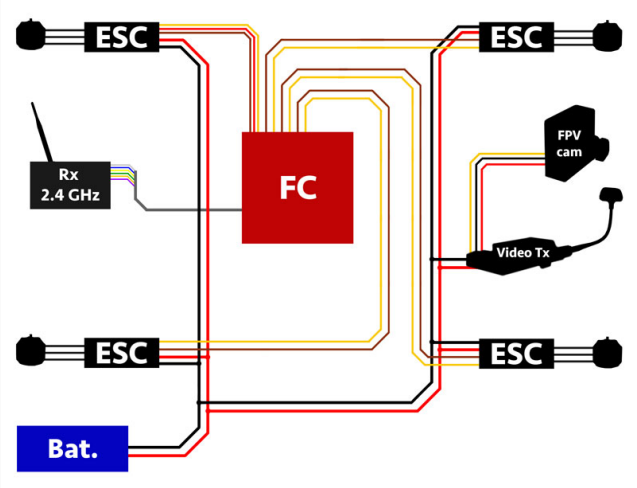


# Video - Slaughterbots (7:47)



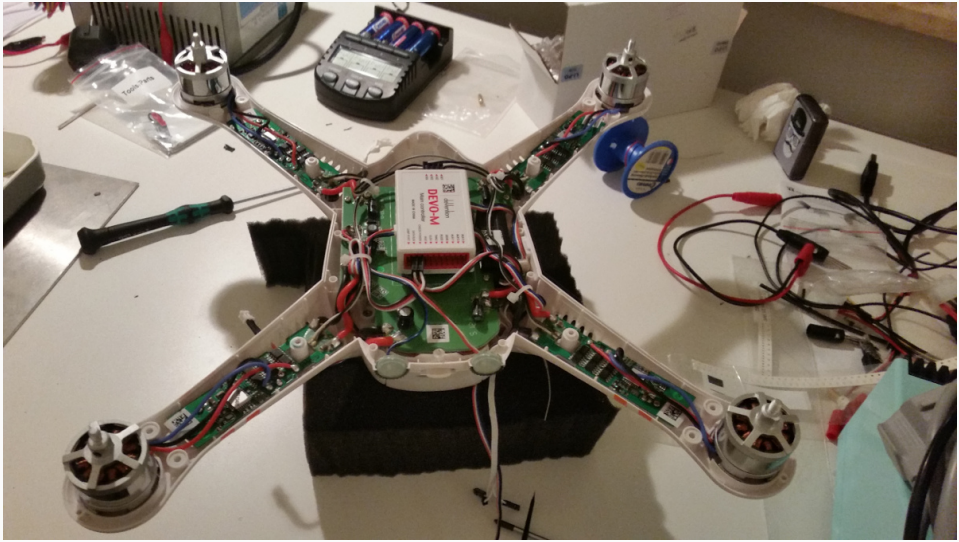
# Drone technology background

# Drone tech




http://fpvracing.ch/img/cms/infobereich/Bauanleitung/06-FPV-Overview_1.jpg

# Drone tech - Hardware



## Drone tech

Example: Walkera QR-X350 Pro

- Battery: 5Ah 30C Li-Po $\rightarrow$ 10-20 min. of flight w/ Cam + GPS
- Weight (incl. gimbal, camera, battery, transmitter): 1250g
- Topspeed: 71 km/h
- Cost: ca. 400 EUR

Remote-control

- Devo-7: 2.4Ghz, output: up to 20db (100mW) - up to 3km range

FPV - Camera stream transmission

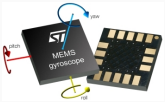
- 5.8 Ghz transmitter, 600mw - up to 2km range, most often below 600m

Telemetry - Serial data connection

- 433 Mhz - more than 1km range

# Drone tech - Sensors

To maintain stability and navigate, the Flight Controller is usually connected to a lot of onboard sensors:

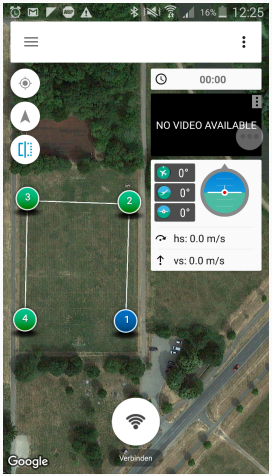



- Acceleration/Turnrate: Accelerometer + Gyroscope
- Height: Barometer
- Global orientation: Magnetometer (Compass)
- Global positioning: GPS
- Relative speed: Optical flow



Images from: http://www.dronetrest.com/t/beginners-guide-to-drone-autopilots-flight-controllers-and-how-they-work/1380

# Drone tech - GPS and positioning




Tower android app

- Mavlink-protocol to communicate with FlightController
- Get telemetry-data (current position, angles, height)
- Set targets, send control instructions

# Navigation, Localization and Control

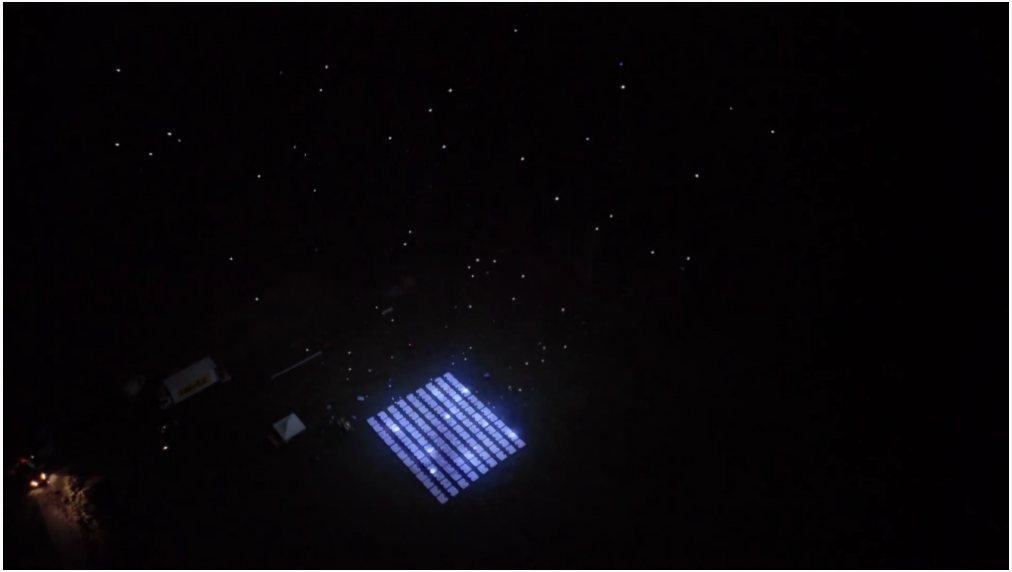
## this

- How are drones controlled atm?
- How can they navigate without crashing?
- What are the drawbacks?
- What are the current approaches to more autonomy?

# Drone- and weapon-related science and projects

- DoD: Perdix micro-drone-swarm
- The pentagon wants you to develop drone swarms: https://thenextweb.com/insider/2017/10/23/the-pentagon-wants-you-to-develop-drone-swarms-for-the-military/

# Intel drone swarm



# Intel drone swarm

Intel's name of the drones used: Shooting Star

| | |
|---|---|
| Type | Quadcopter with encased propellers |
| Size | 382 x 382 x 83mm |
| Rotor Diameter | 6'' (~15cm) |
| Max Take Off Weight | 330g |
| Flight Time | Up to 20 mins |
| Max Range | 1.5 km |
| Max Tolerable Wind Speed | 8 m/s |
| Max Light Show Speed | 3 m/s |

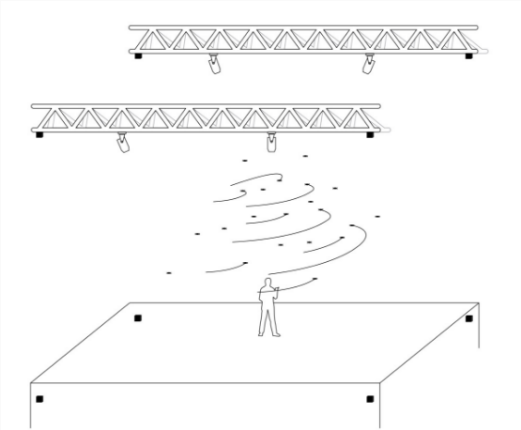
- Relies on GPS (plus the other sensors you have already seen)
- Central control software on offboard computer

https://newsroom.intel.com/wp-content/uploads/sites/11/2017/07/Intel-Shooting-Star-Tech-Fact-Sheet-073117-1.pdf

# D'Andrea, ETH + Verity studios

# D'Andrea, ETH + Verity studios

- ETH-spinoff Verity studios
- No details about indoor-localization to be found, but:



Lucie micro drones

- Weight: <50g (<2oz)
- Flight time: up to 4 minutes
- Charging time: approximately 1 hour
- Equipped with high–intensity, programmable RGB lights

Stage Flyer drones

- Weight (without costume): 1kg (2.2lbs)
- Flight time: up to 5 minutes
- Charging time: approximately 1 hour
- Equipped with multiple high–intensity lights

https://veritystudios.com/products/#synthetic-swarm

# Weaponized drones - Some guy (Austin Haghwout)

# Weaponized drones - IAI

IAI - Israel Aerospace Industries

- 4.5 kg,day/night cameras for piloting and reconnaissance
- multiple acoustic transducers (obstacle avoidance, flight through buildings)
- 30 minutes flight time with 0.45kg of explosive payload
- Warhead: two blast-fragmentation grenades
- packed folded, transported in canister or backpack
- piloted with tablet

http://defense-update.com/20160216_rotem.html

# Weaponized drones - Duke Robotics

https://dukeroboticsys.com/invest/

# Weaponized drones - Countermeasures

- Jam signals by overpowering them with noise
- "Take out" GPS-positioning (1575.42 MHz or 1227.60 MHz) and radio remote-control (2.4Ghz)


- Logical next step? Autonomy without GPS and remote operator.

http://www.dailymail.co.uk/sciencetech/article-3978762/The-death-ray-knock-drones-mile-away-Rifle-uses-radio-waves-kill-UAVs.html

# Autonomous drones

# Autonomy

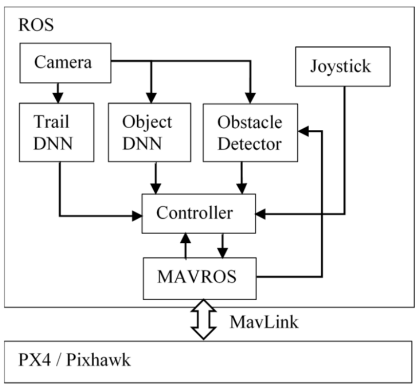
Entering AI/ML: How can an artificial system perceive, act, localize and navigate in an unknown open world without a human operator?

- **Learn** from examples - Build knowledge - Abstract and apply
- For the weaponization scenario: Without sensors that might be jammed

# NVIDIA - Autonomous Drone video (3:10)

# NVIDIA - Autonomous Drone video (3:10)

- NVIDIA Jetson TX1 onboard processing, trained on videos of eight miles of trails
- Resnet-18 architecture computes view orientation and lateral offset output
- YOLO DNN for object detection, Visual odometry




https://arxiv.org/pdf/1705.02550.pdf

# NASA JPL autonomous drone race

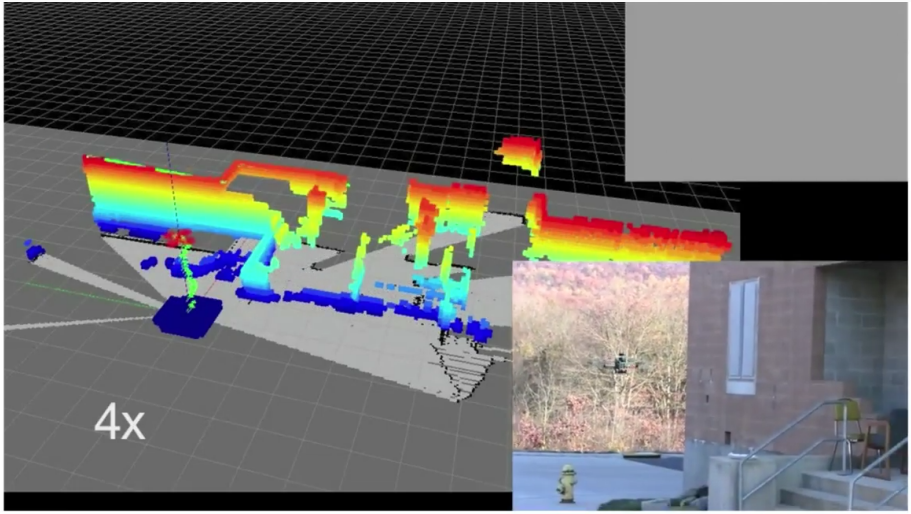
# NASA JPL autonomous drone race

*[...] processing is all done onboard. The team holds the drone and walks it through the course slowly ahead of the race to teach it the layout.[...]*
*(Andrew Good, JPL, 06.12.17)*

- Localize by comparing current sensor-input to pre-built map
- Google Tango technology for VR - 3D mapping
- Qualcomm Snapdragon Flight board is used for real-time flight control
- 2 wide-field-of-view-cameras: forward + downward
- Depth-map from motion stereo

https://www.nasa.gov/feature/jpl/drone-race-human-versus-artificial-intelligence

# UPENN - Vijay Kumar Lab - RAPID




[Shen, Michael and Kumar, 2011]

# UPENN - Vijay Kumar Lab - RAPID

- 1.9 kg MAV platform
- IMU, laser scanner, stereo cameras, pressure altimeter, magnetometer, GPS
- computation is performed onboard on an Intel NUC computer with 3rd generation i3 processor.

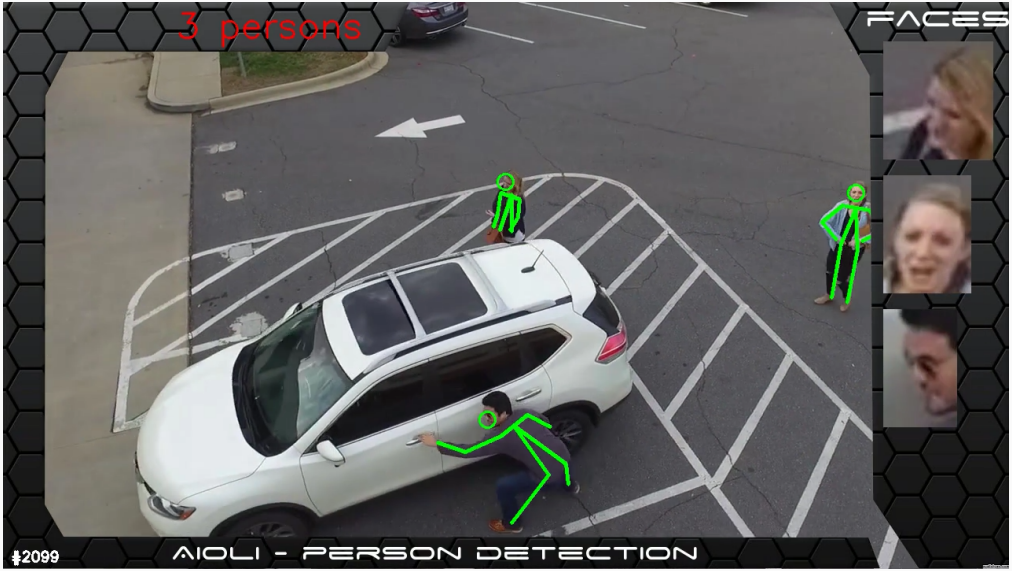
https://www.kumarrobotics.org/videos/rapid/

# Finding and Identifying targets

# And now?

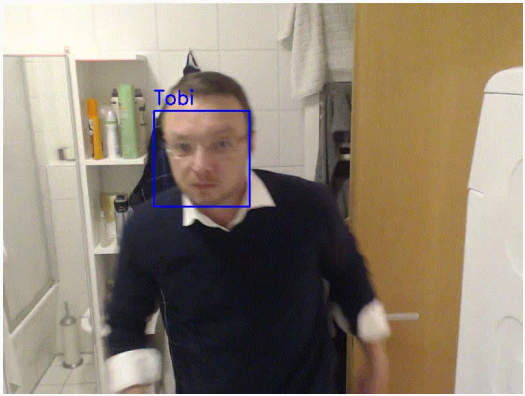
- Drones are now able to fly without operator and without crashing
- How should they find their targets in the Slaughterbot scenario?
- State-of-the-art in ML allows to find human bodies in camera images (when sufficiently bright)
- The drone can attempt facial identification once a body is found

# Demo



# Detection

- Identification requires some (most times: a lot) images of the target



# Assessment

# Assessment

# Drone tech - Computer vision

Off-Drone-Processing

- Re-use compute-hardware
- Latency
- Limited range

On-Drone-Processing

- No latency
- Requires additional hardware,
  - more weight
  - more power-usage
  - hardware evt. destroyed

Suitable hardware not existent *yet*