

AIOLI - AI Open Lab Initiative

SciFi debunked - Slaughterbots

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Agenda

Slaughterbots

Drone technology background

Navigation, Localization and Control

Autonomous drones

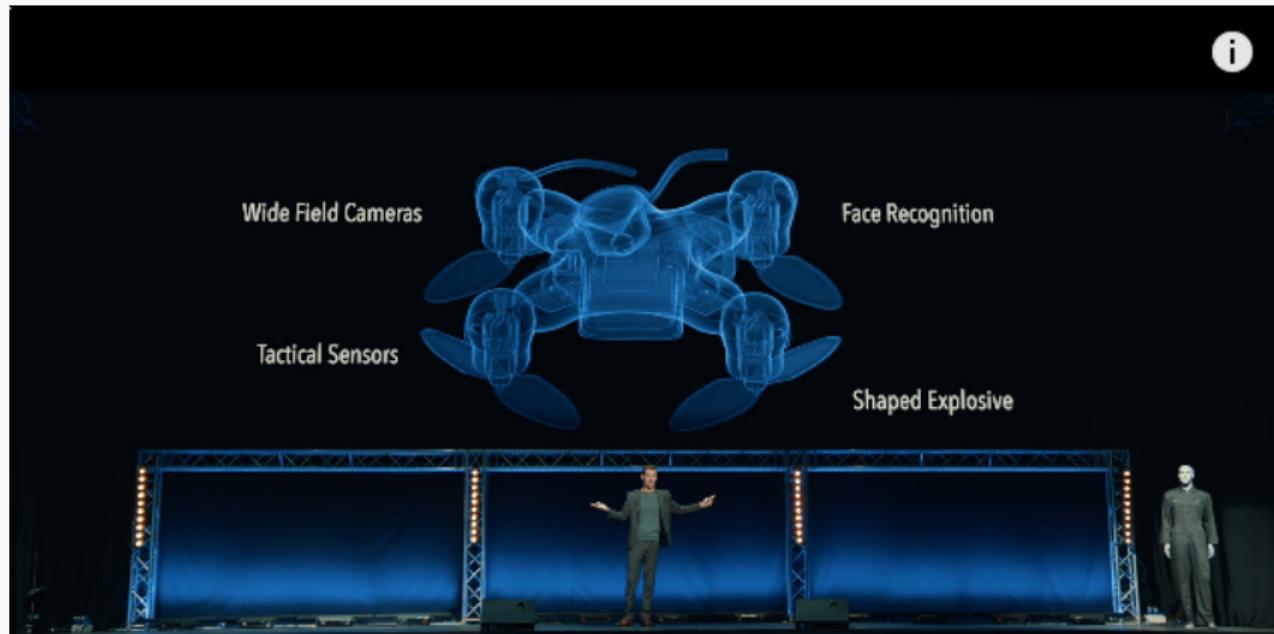
Finding and Identifying targets

Assessment

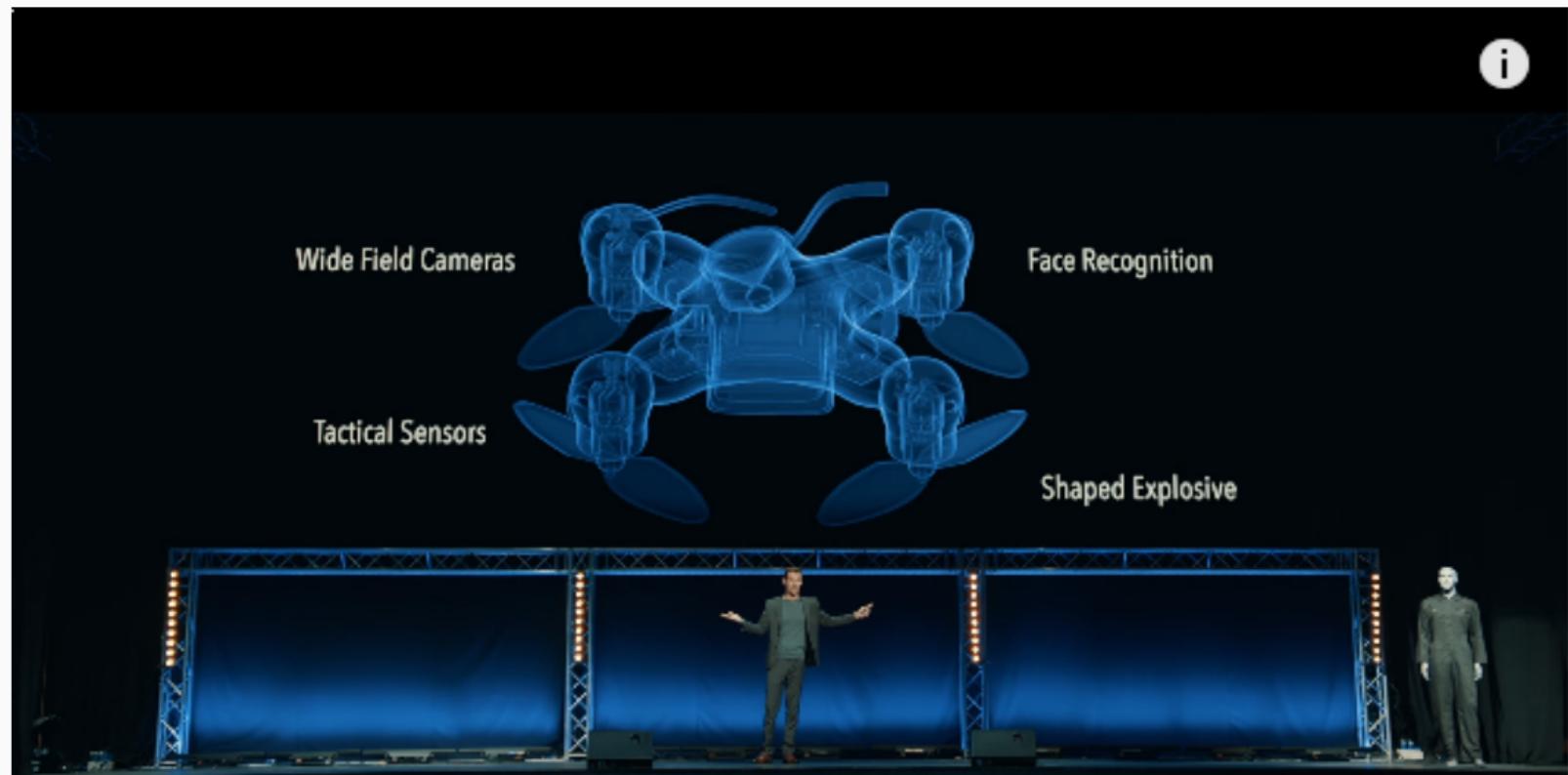
Slaughterbots

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)

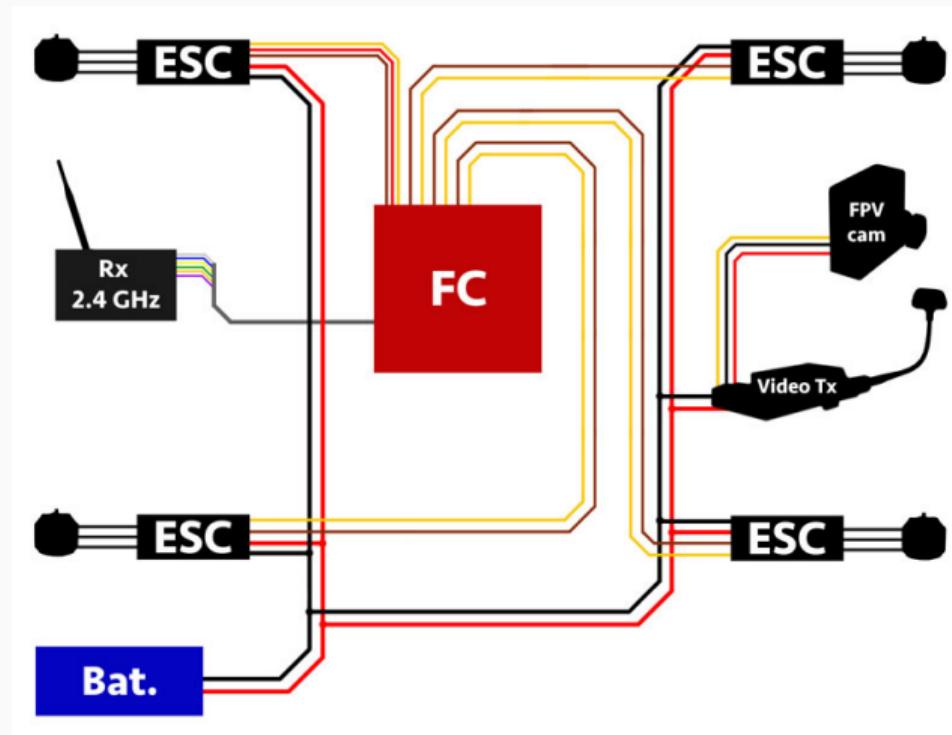


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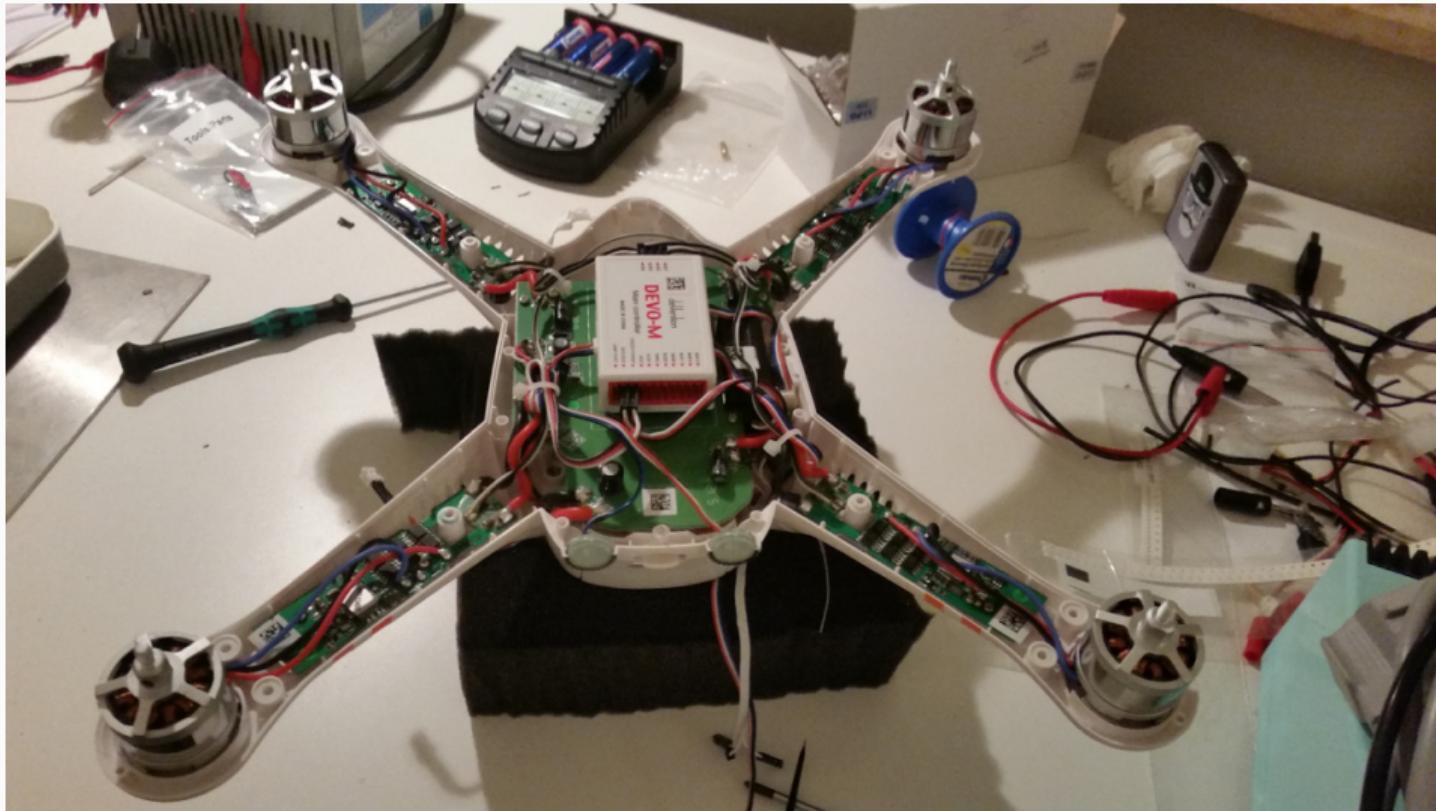


Drone technology background

Drone tech



Drone tech - Hardware



Drone tech

Example: Walkera QR-X350 Pro

- Battery: 5Ah 30C Li-Po → 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

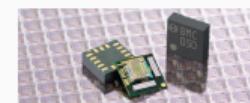
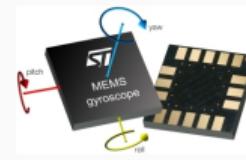
Telemetry - Serial data connection

- 433 Mhz - more than 1km range

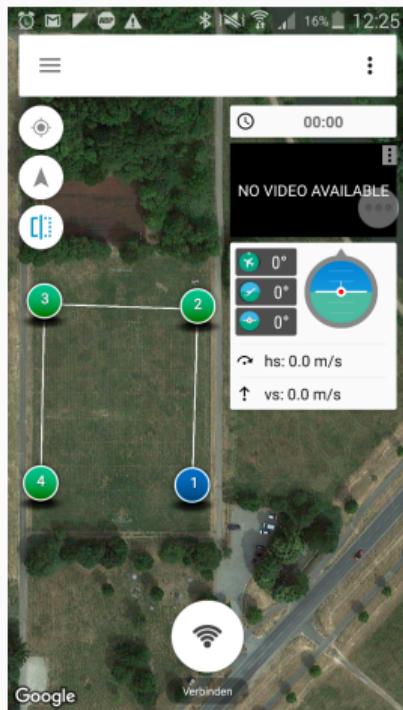
Drone tech - Sensors

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



Drone tech - GPS and positioning



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

Tower android app

Navigation, Localization and Control

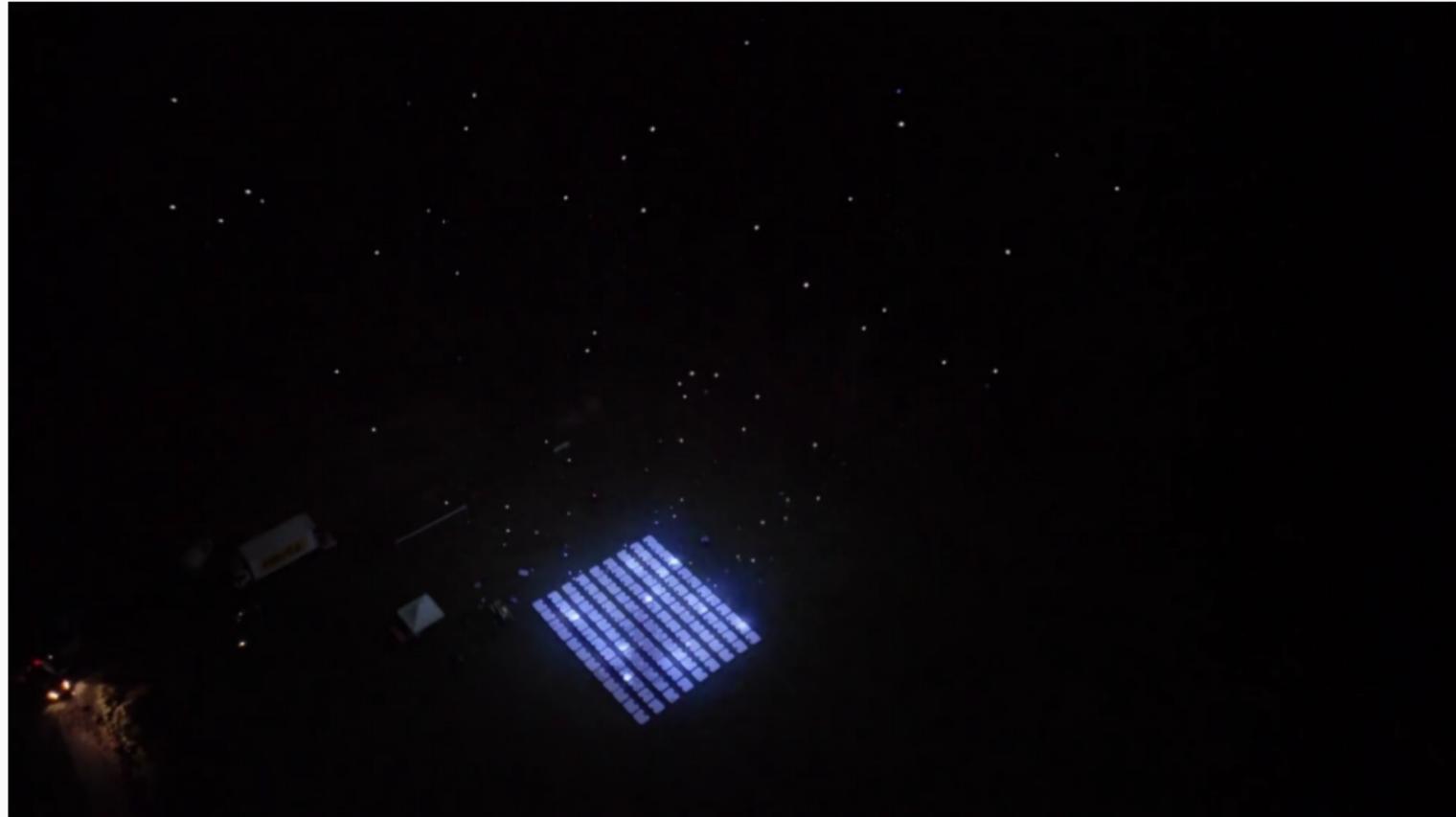
Navigation, localization and control

- How are drones controlled at the moment?
- 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

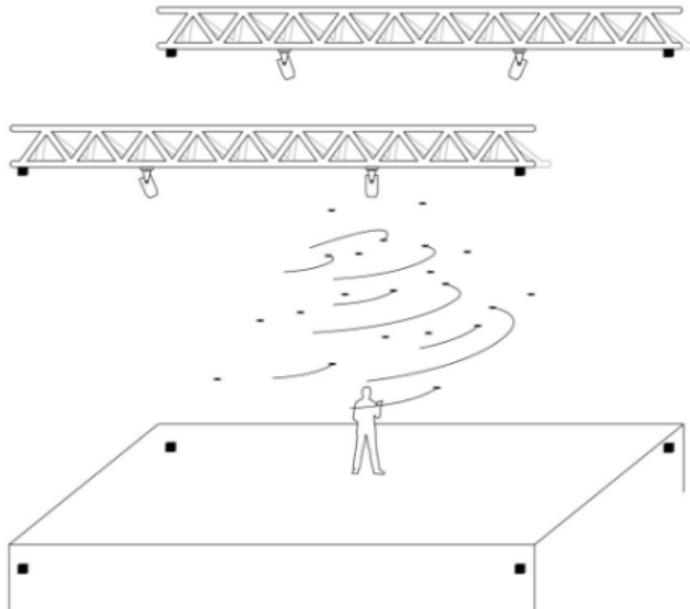
<https://newsroom.intel.com/wp-content/uploads/sites/11/2017/07/Intel-Shooting-Star-Tech-Fact-Sheet-073117-1.pdf>

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

Weaponized drones - Some guy (Austin Haghout)



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



How to defend?

Already, a lot of different ideas are tested to defend against drone attacks

Weaponized drones - Countermeasures

SCI & TECH

DUTCH POLICE TRAIN EAGLES
TO TAKE DRONES OUT OF SKY

TO
MO

Weaponized drones - Countermeasures



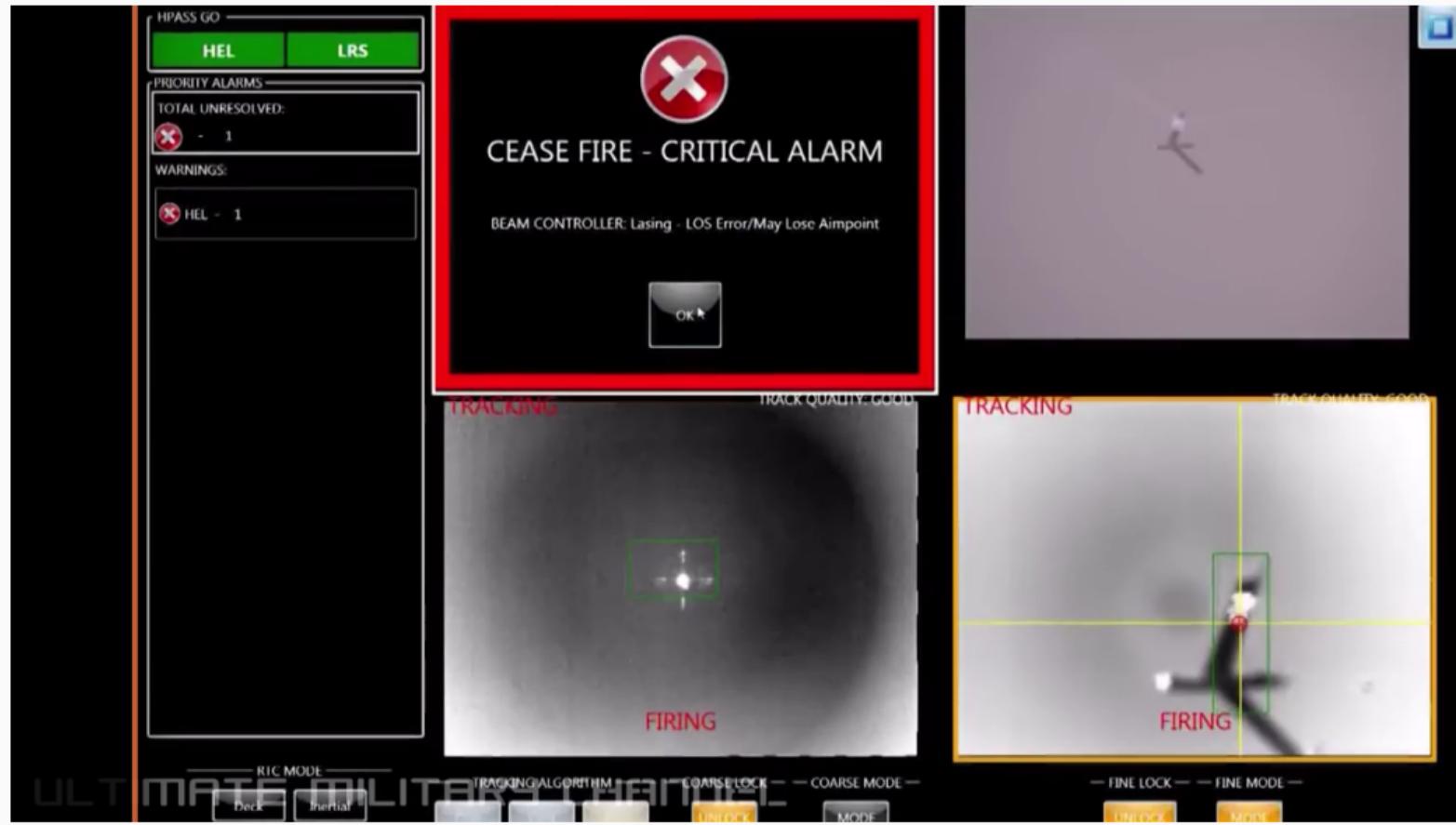
BRITISH ENGINEERS AT OPENWORKS ENGINEERING HAS CAME UP WITH AN ALTERNATIVE SURFACE-TO-AIR **ANTI-DRONE** SOLUTION

Weaponized drones - Countermeasures

Michigan Tech HIROLab



Weaponized drones - Countermeasures



Weaponized drones - Countermeasures

Most of these approaches are expensive or not really feasible. The currently most often used approach is therefore:

- 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.

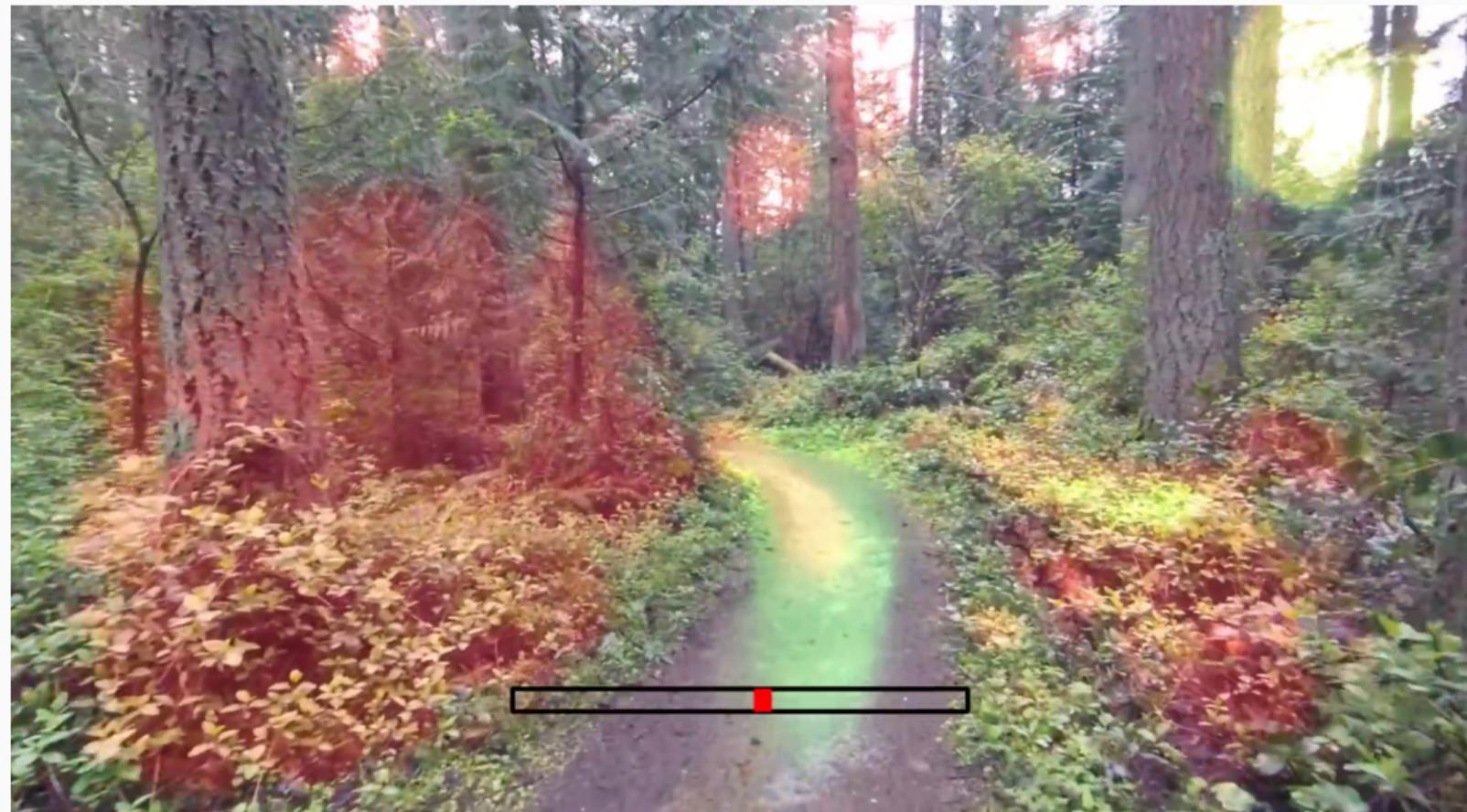
Autonomous drones

Autonomy

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

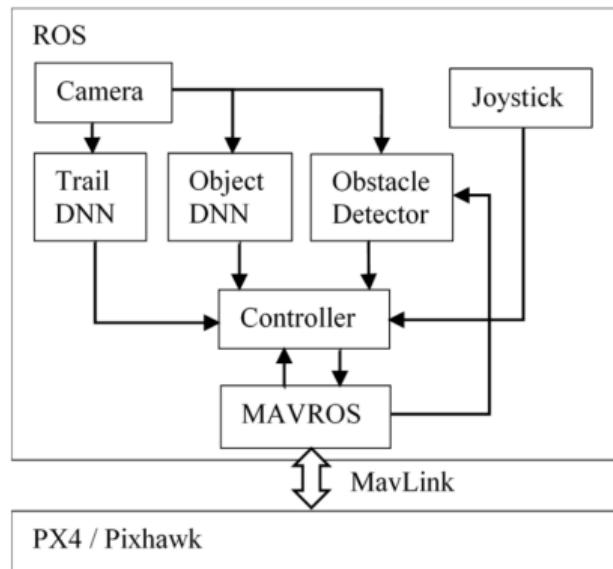
- **Learn** from examples - Build knowledge - Abstract and apply
- For the weaponization scenario: Without sensors that might be jammed

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



NASA JPL autonomous drone race



then matches it with a pre-loaded map.

NASA JPL autonomous drone race

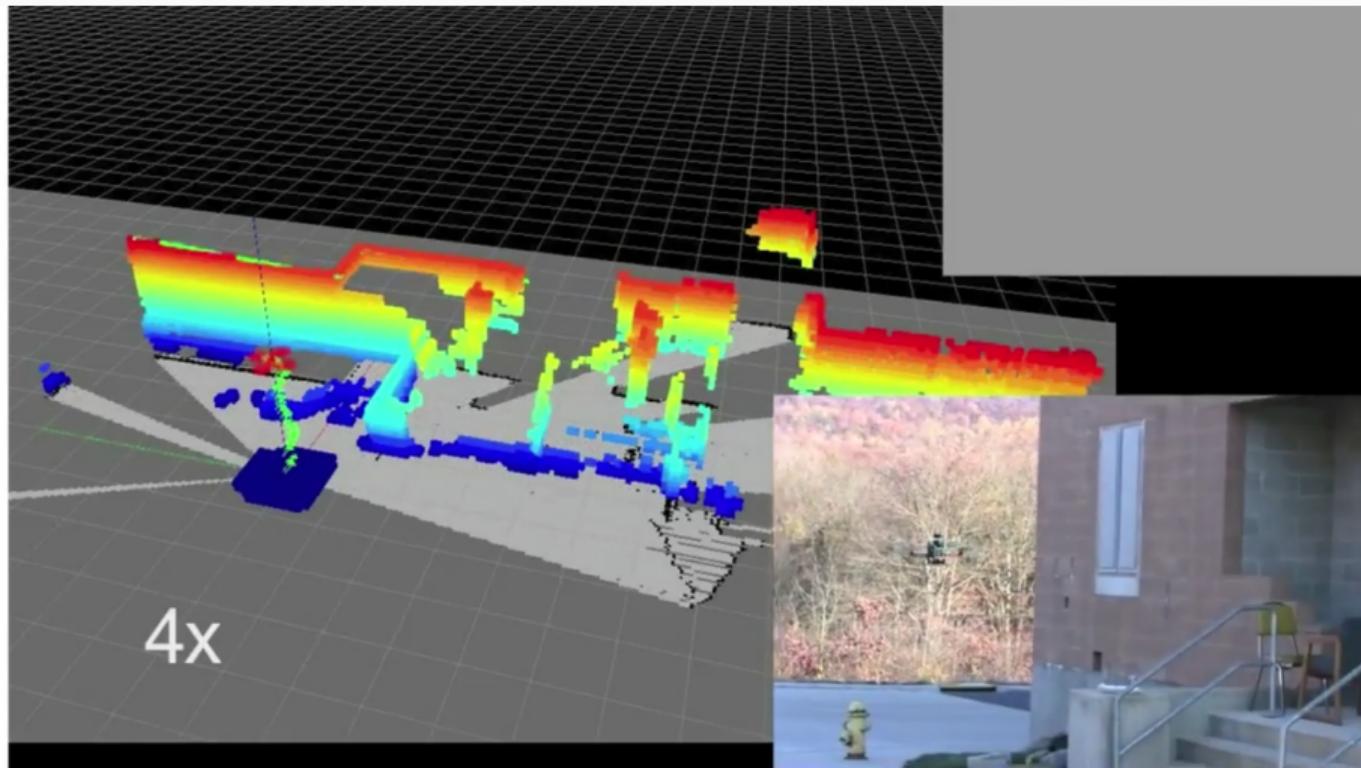
[...] processing is all done onboard. The team holds the drone and walks it through the course slowly ahead of the race to teach it the layout.[...]

(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

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/>

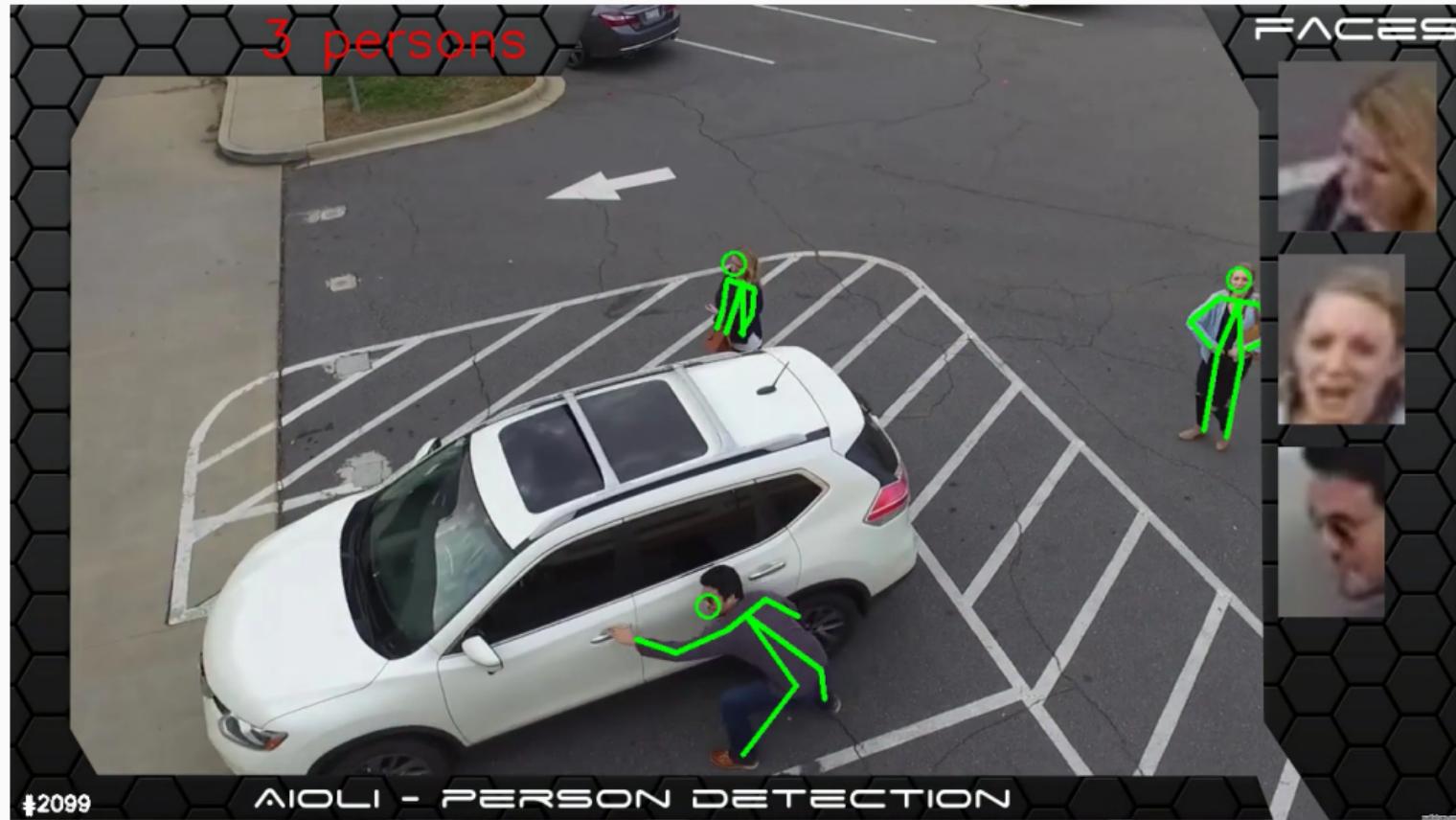
Finding and Identifying targets

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

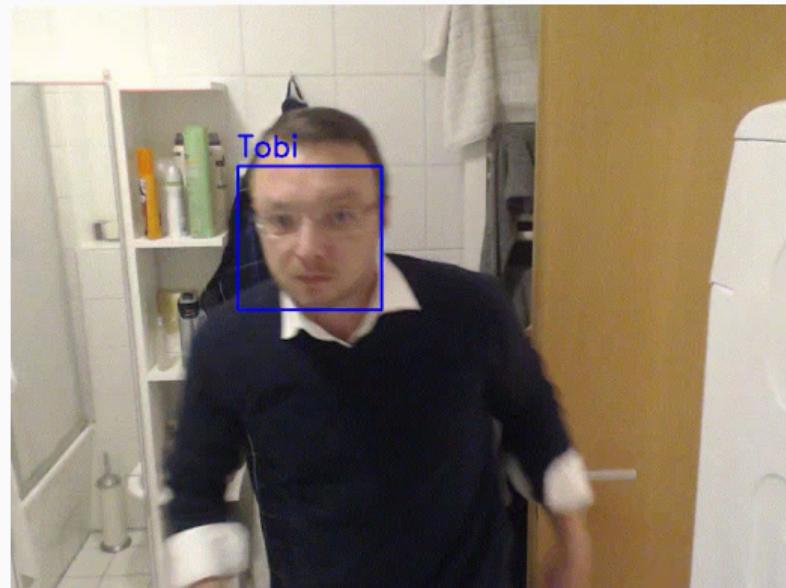


Demo



Detection

- Identification requires some (most times: a lot) images of the target
- Famous persons: easy
- Others: facebook, social media, government database



Hardware used for this demo

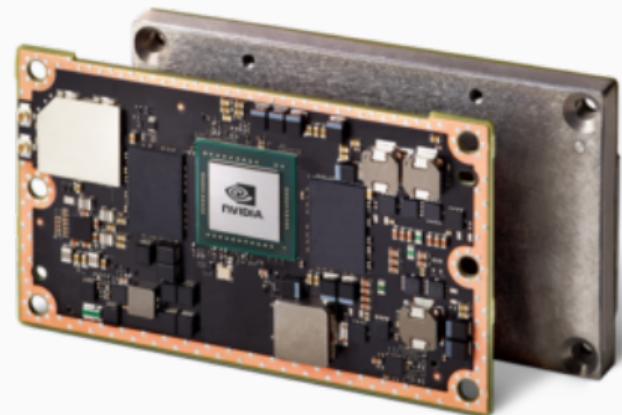
Processed offline:

- Hardware used: NVIDIA GTX 1080 Ti, i7-7700K @ 4.2Ghz
- Framerate achieved: 20fps
- Energy spent? (GPU: 250W, @12V - i ca. 20A)

Embedded GPUs

NVIDIA Jetson TX2

- System-on-module
- 256-core NVIDIA Pascal GPU
- hex-core ARMv8 64-bit CPU
- 8GB of LPDDR4 memory with a 128-bit interface
- weight: 85g, size: 50x87mm
- up to 12W power consumption (@12V → 1A)
- Reported fps for pose-detection: 8fps



<https://devblogs.nvidia.com/parallelforall/jetson-tx2-delivers-twice-intelligence-edge/>
<https://github.com/CMU-Perceptual-Computing-Lab/openpose/pull/245>

Lifting capabilities of some consumer drones

Model	Payload	Size	Airtime	Price	Image
Cheerson CX10	4-6g	40x40mm, 15g	5-8min	15 EUR	
Syma x8c	200g	50x50cm, 500g	12min	70 EUR	
3DR X8+	1kg	35x50cm, 2.5 kg	15min	1150 EUR	
DJI S900	3kg	90cm diam, 3.3kg	18min	1200 EUR	
Tarot T18	8kg	127cm diam, 8kg	30min	2000 EUR	

Assessment

Assessment

- Today not feasible
- Limited flight time - if specific targets, need a GPS-fix or something beforehand
- Drone cannot "loiter" to wait for a target to get out of a building
- Far too expensive for "everyday" use

Try it yourself

Want to get your hands dirty?

- Microsoft airsim Unreal simulator, c++ and python programmable:
<https://github.com/Microsoft/AirSim>
- Cheap indoor, python-programmable computer vision Wifi drone: Parrot AR 2.0
(used for 50EUR on ebay)
- Self-built drone-plattforms with necessary parts (radio-control, camera, batteries, charger, etc.): starting from 400EUR

Discussion - End

Thanks a lot for your attention!