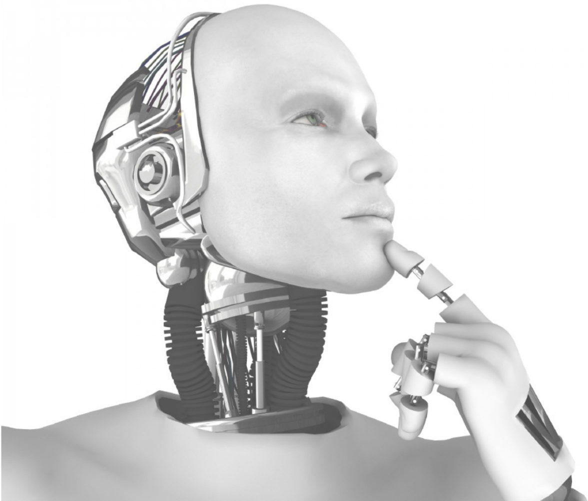

AIOLI - AI Open Lab Initiative

SciFi debunked - Slaughterbots

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December 13, 2017

Agenda

Slaugherbots

Drone technology background

Navigation, Localization and Control

Autonomous drones

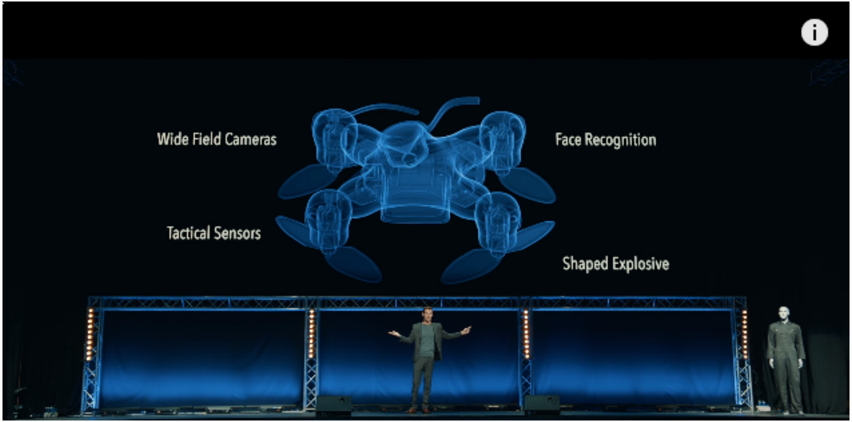
Finding and Identifying targets

Assessment

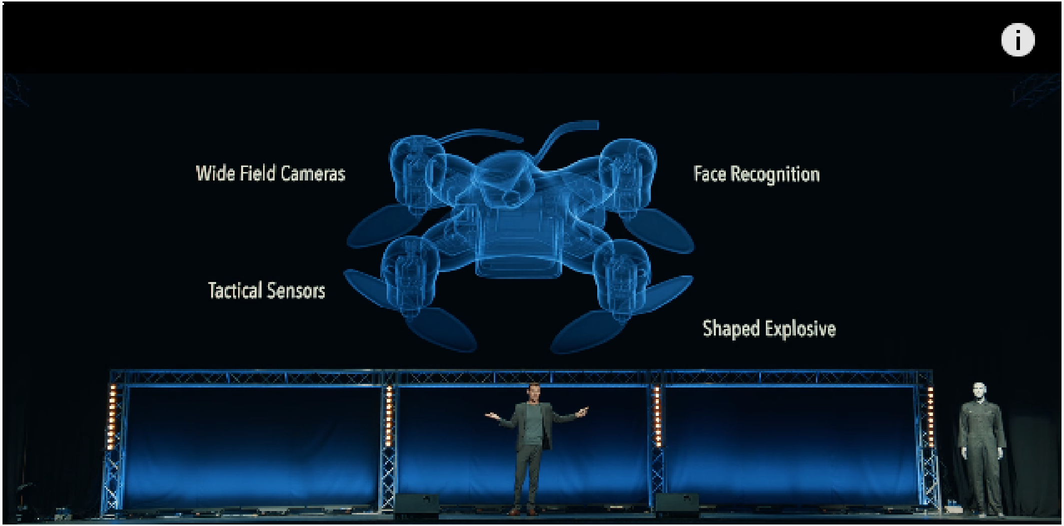
Slaugherbots

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)

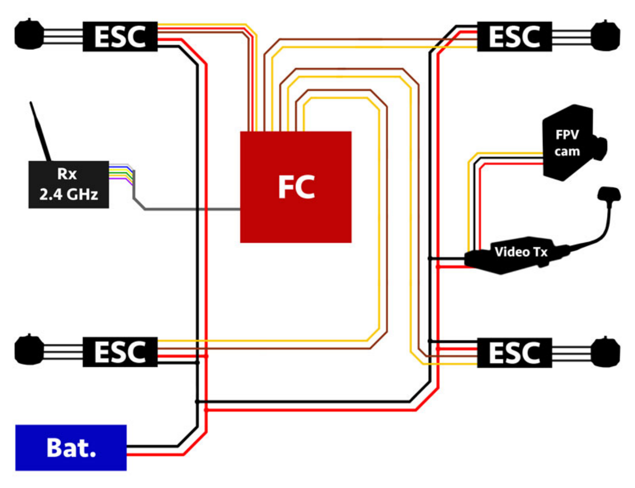


Video - Slaughterbots (7:47)



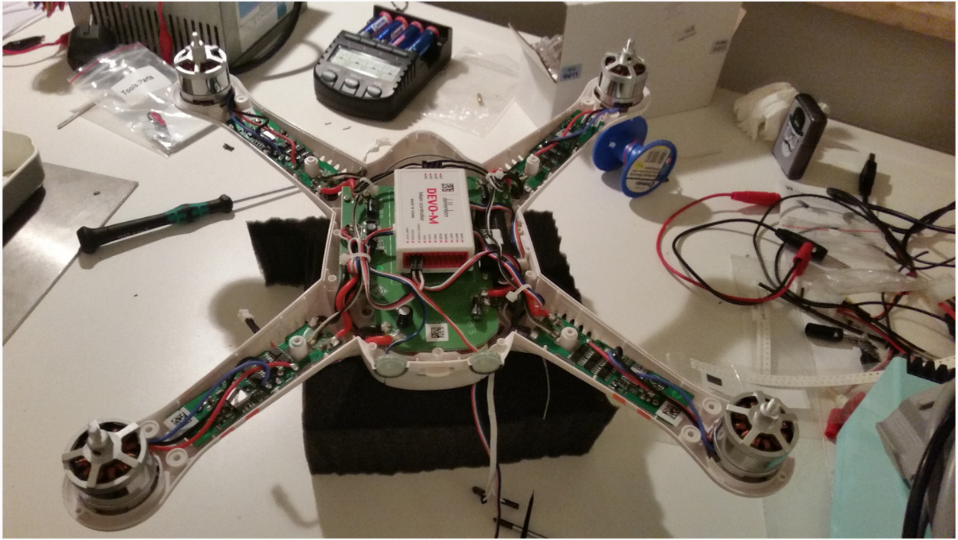
Drone technology background

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

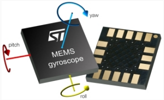
- 5.8 Ghz transmitter, 600mw - up to 2km range, most often below 600m

Telemetry - Serial data connection

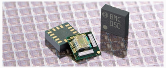
- 433 Mhz - more than 1km range

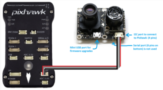
Drone tech - Sensors

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



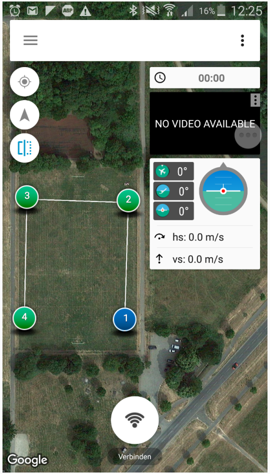
- Acceleration/Turnrate: Accelerometer + Gyroscope
- Height: Barometer
- Global orientation: Magnetometer (Compass)
- Global positioning: GPS
- Relative speed: Optical flow





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

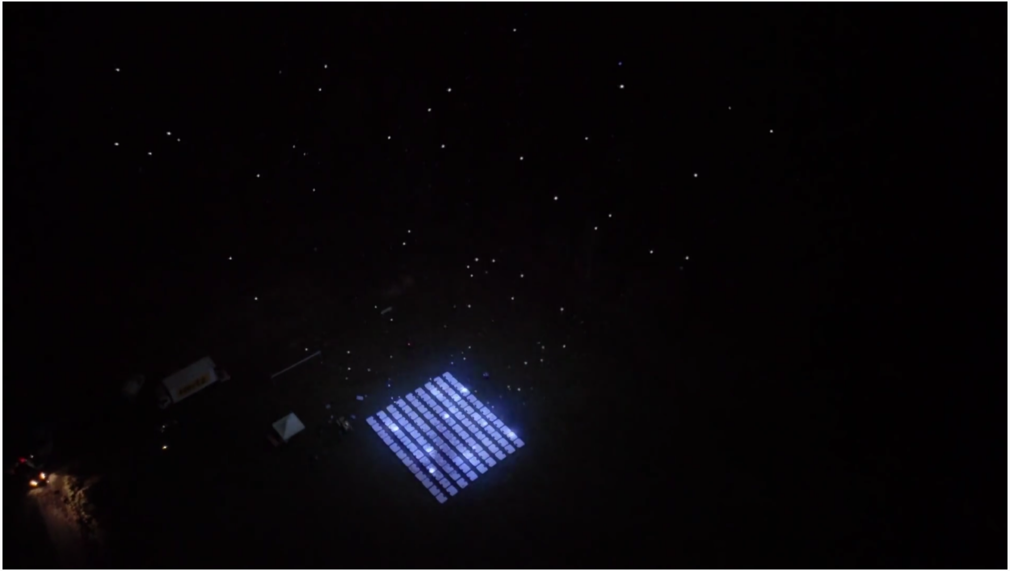
Navigation, localization and control

- 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

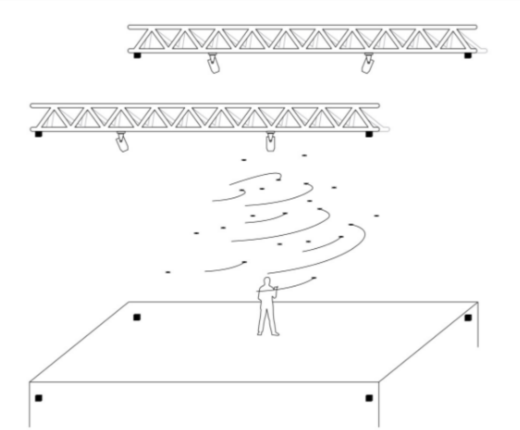
- Relies on GPS (plus the other sensors you have already seen)
- Central control software on offboard computer

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

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/

How to defend?

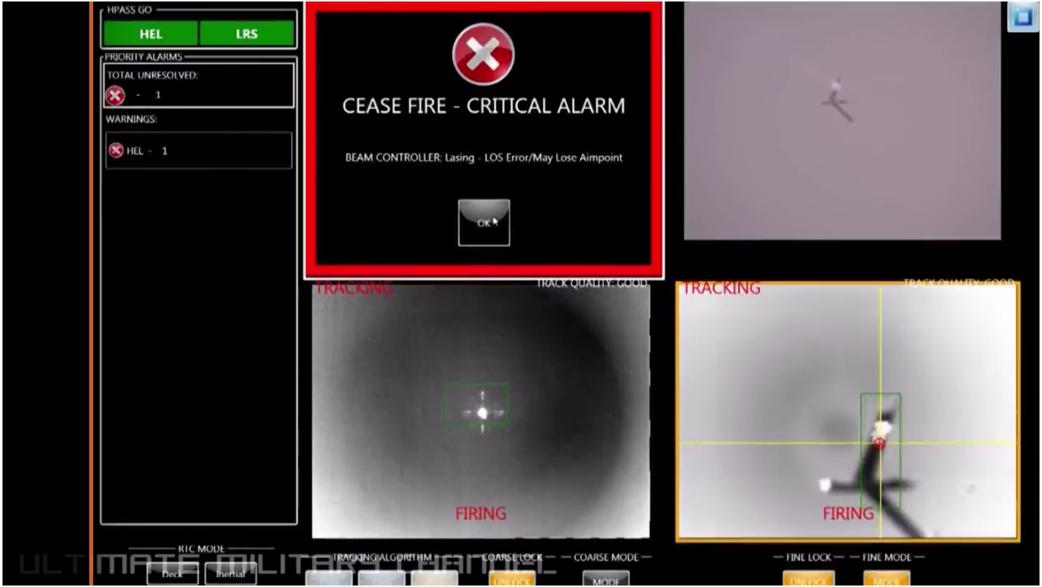
Already, a lot of different ideas are tested to defend against drone attacks

Weaponized drones - Countermeasures

Weaponized drones - Countermeasures

Weaponized drones - Countermeasures

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.

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

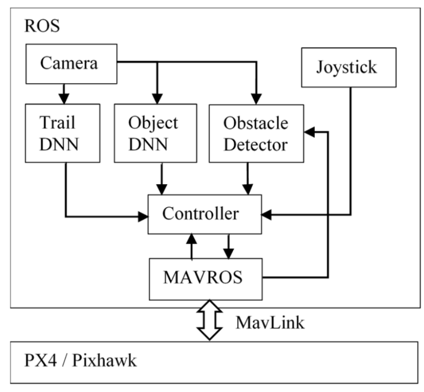
Entering AI/ML: How can an artificial system perceive, act, localize and navigate in an unknown open world without a human operator?

- **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

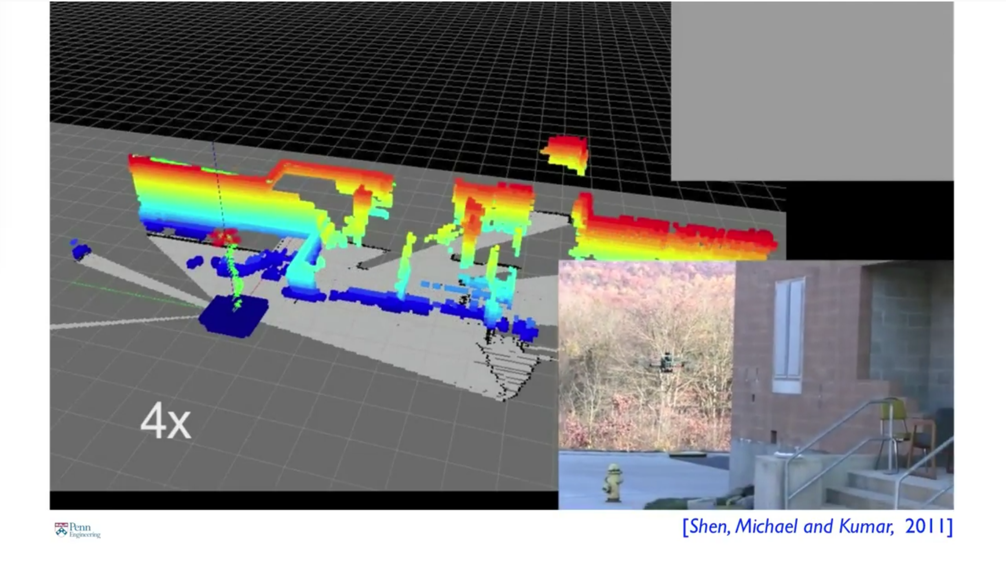
NASA JPL autonomous drone race

[...] 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



UPENN - Vijay Kumar Lab - RAPID

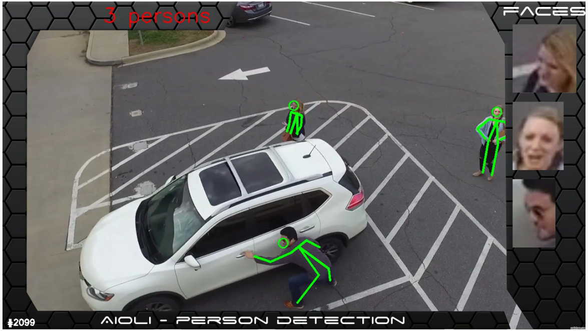
- 1.9 kg MAV platform
- IMU, laser scanner, stereo cameras, pressure altimeter, magnetometer, GPS
- computation is performed onboard on an Intel NUC computer with 3rd generation i3 processor.

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

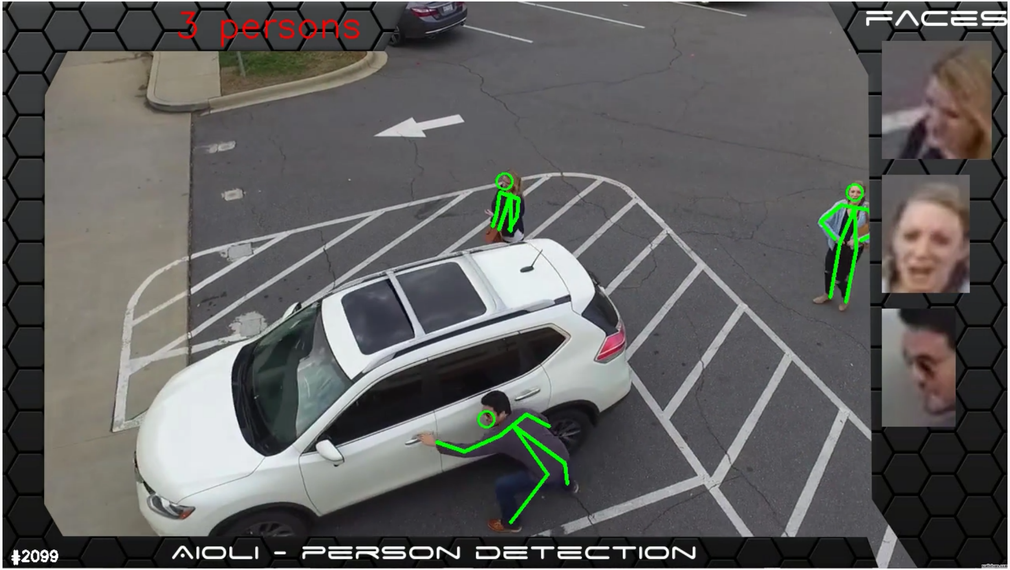
Finding and Identifying targets

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

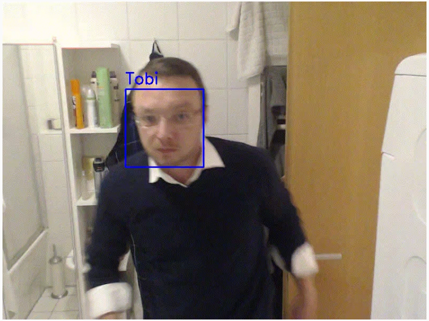


Demo



Detection

- Identification requires some (most times: a lot) images of the target
- Famous persons: easy
- Others: facebook, social media, government database
- Current best: 83.29% among 1Million faces on MegaFace (5 million photos, 600k persons, mean: 7pics/person)



Hardware used for this demo

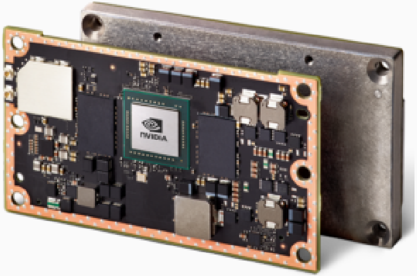
Processed offline:

- Hardware used: NVIDIA GTX 1080 Ti, i7-7700K @ 4.2Ghz
- Framerate achieved: 20fps
- Energy spent? (GPU: 250W, @12V -¿ 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 $\rightarrow$ 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 capabilites 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 and basis for discussions

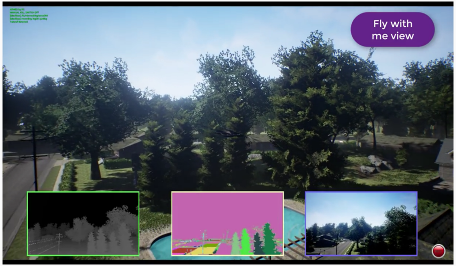
Today not feasible (at least not in the complete package)

- Tradeoff between necessary compute-power, take-off-weight, flight-time, size and speed
- $\rightarrow$ Today not feasible in the shown size
- Limited flight time and range - if specific persons should be targeted, need a GPS-fix or initial position beforehand
- Far too expensive to be widely deployed (today: several hundred dollars)

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!