Building a self-driving RC car

Bert Jan Schrijver
bertjan@openvalue.de
@bjschrijver

Building a self-driving RC car

Bert Jan Schrijver
bertjan@openvalue.de
@bjschrijver

#Devoxx #RoboRace @bjschrijver @TimvEijndhoven

Let’s meet

Bert Jan Schrijver

OPENVALUE

.nl. jug

Let’s meet

Tim van Eijndhoven

How it all started…

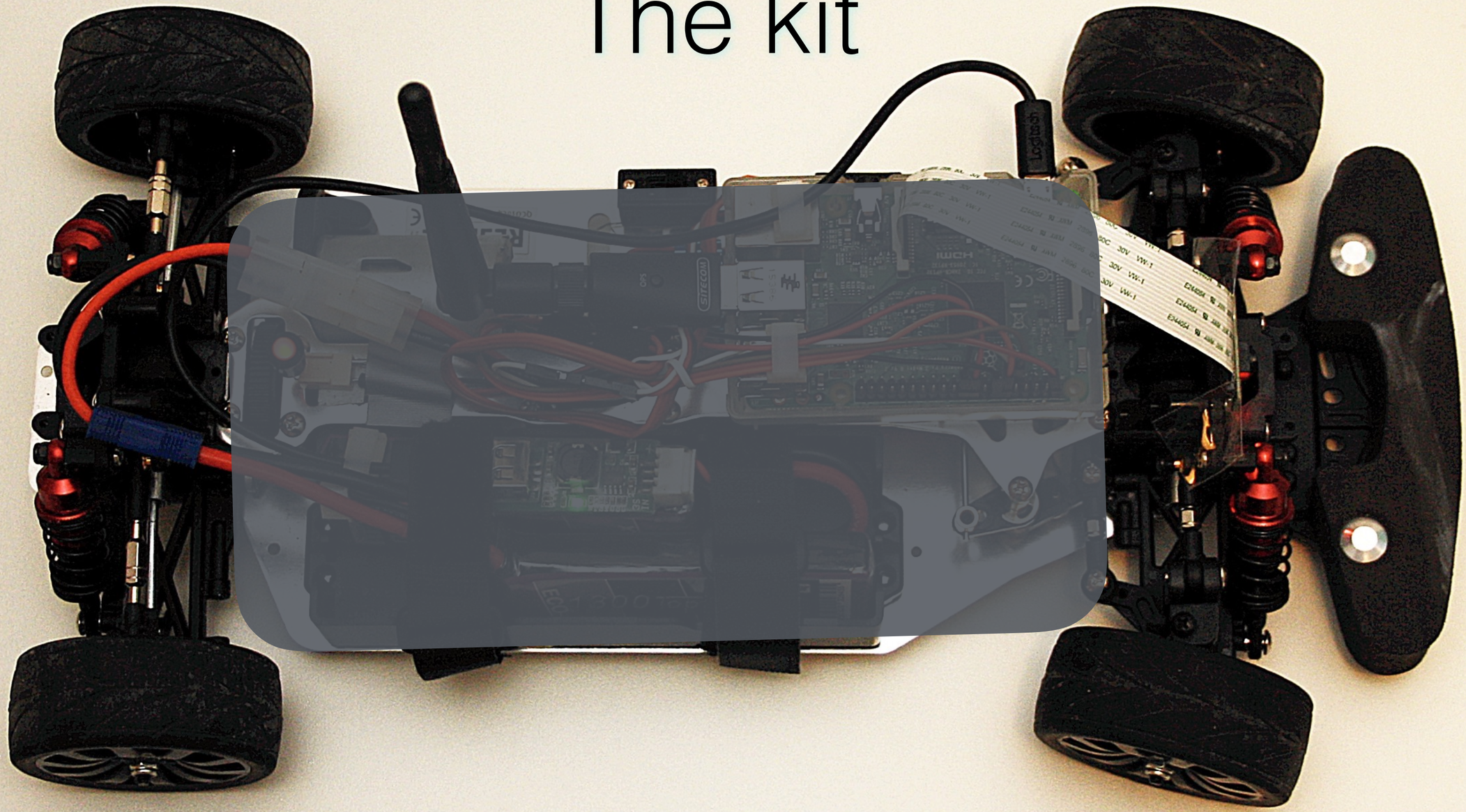
RoboRace challenge

The rules

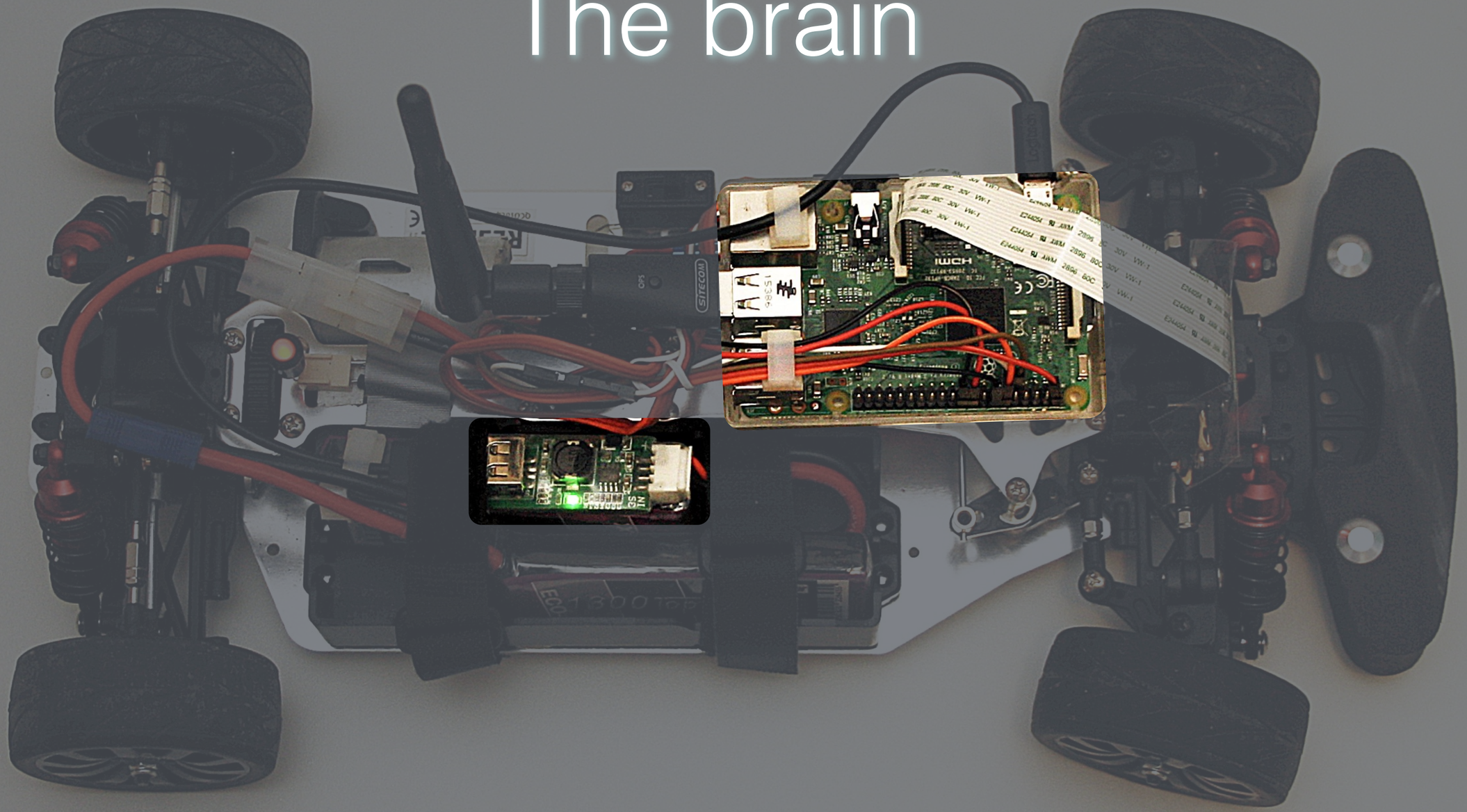
- 4 teams
- Each team gets:
  - RC car kit
  - Fixed budget (150 euro)
- Three races:

1. drag race (start, drive, stop)
2. race track (race 1 + corners)
3. destruction derby ;-)
   (race 2 with multiple cars on same track)

The kit



The brain



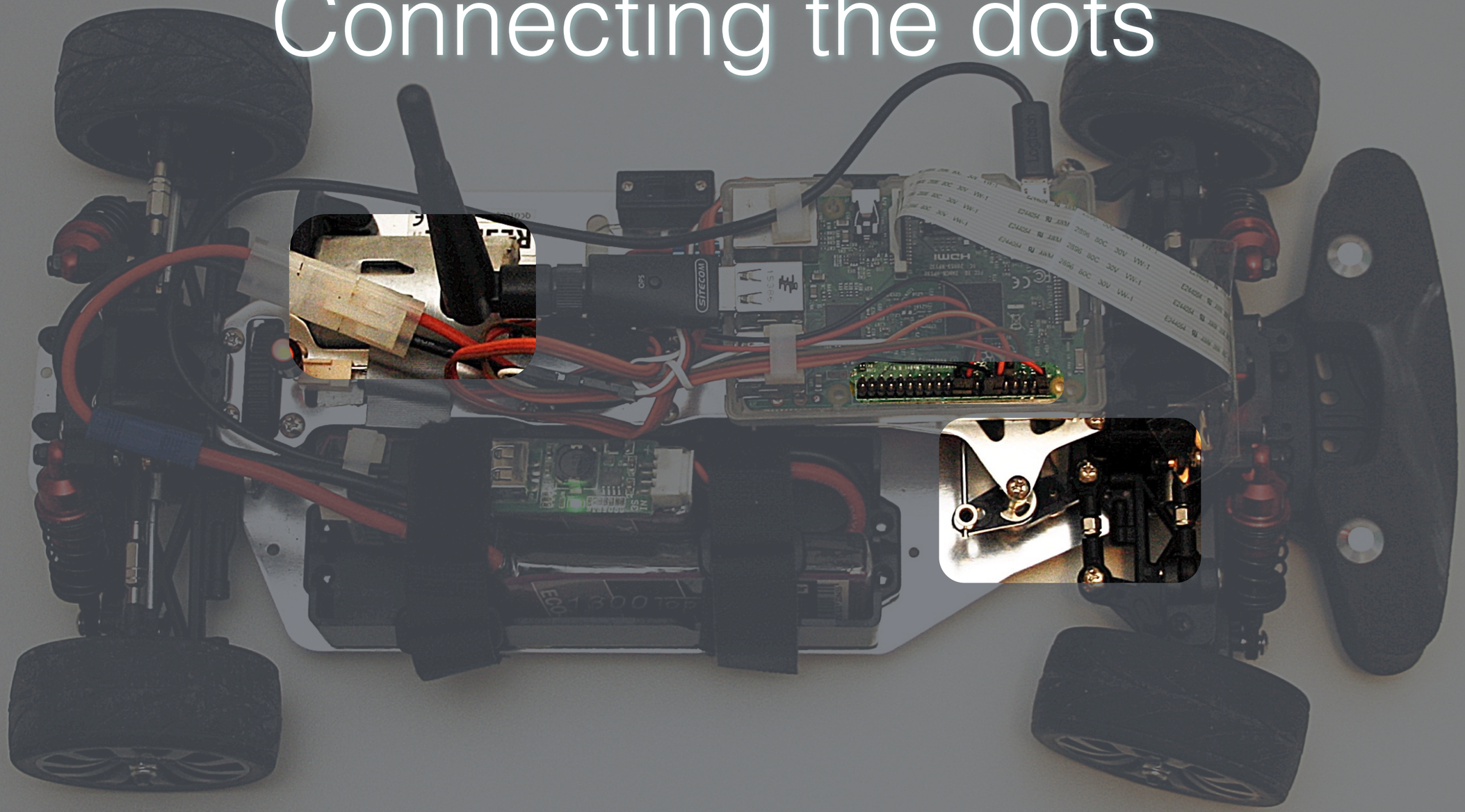
The platform

Vert.x

- Toolkit for building reactive applications on the JVM
- Event-driven, non-blocking
- General purpose application framework
- Why Vert.x for our project?
  - Lightweight, fast
  - Polyglot
  - Distributed eventbus (browser included!)

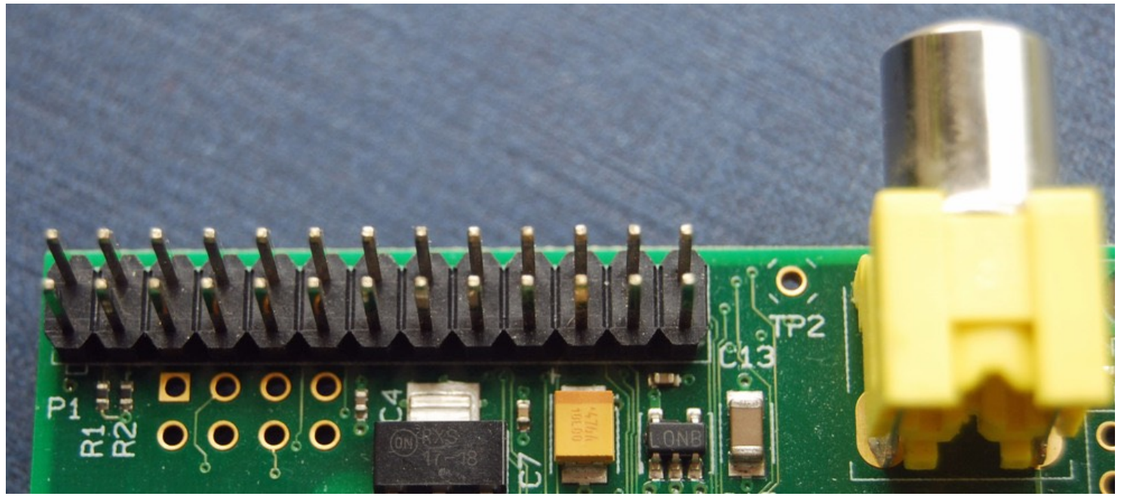
Building microservices with Vert.x: https://youtu.be/yLg-LPSRjho

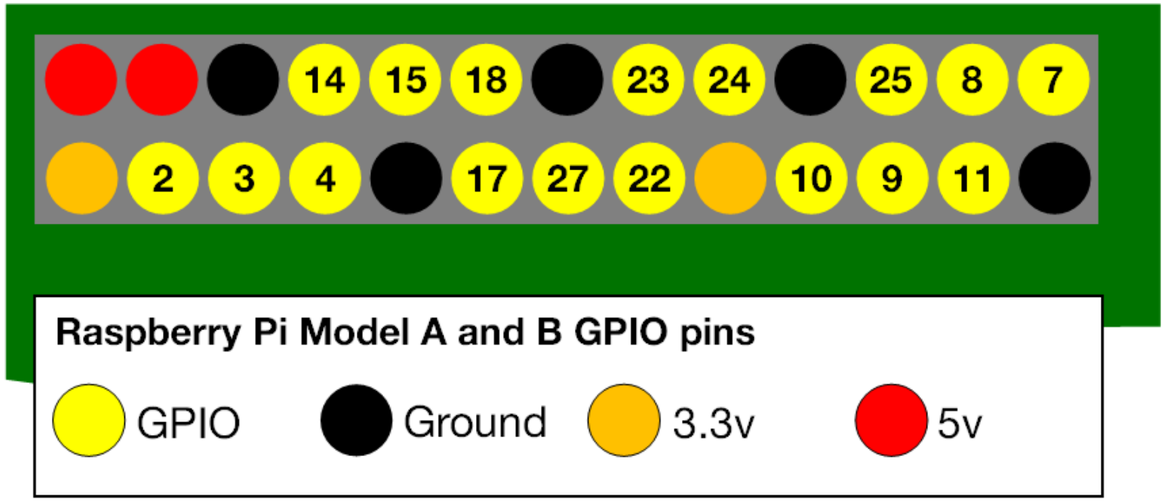
Connecting the dots



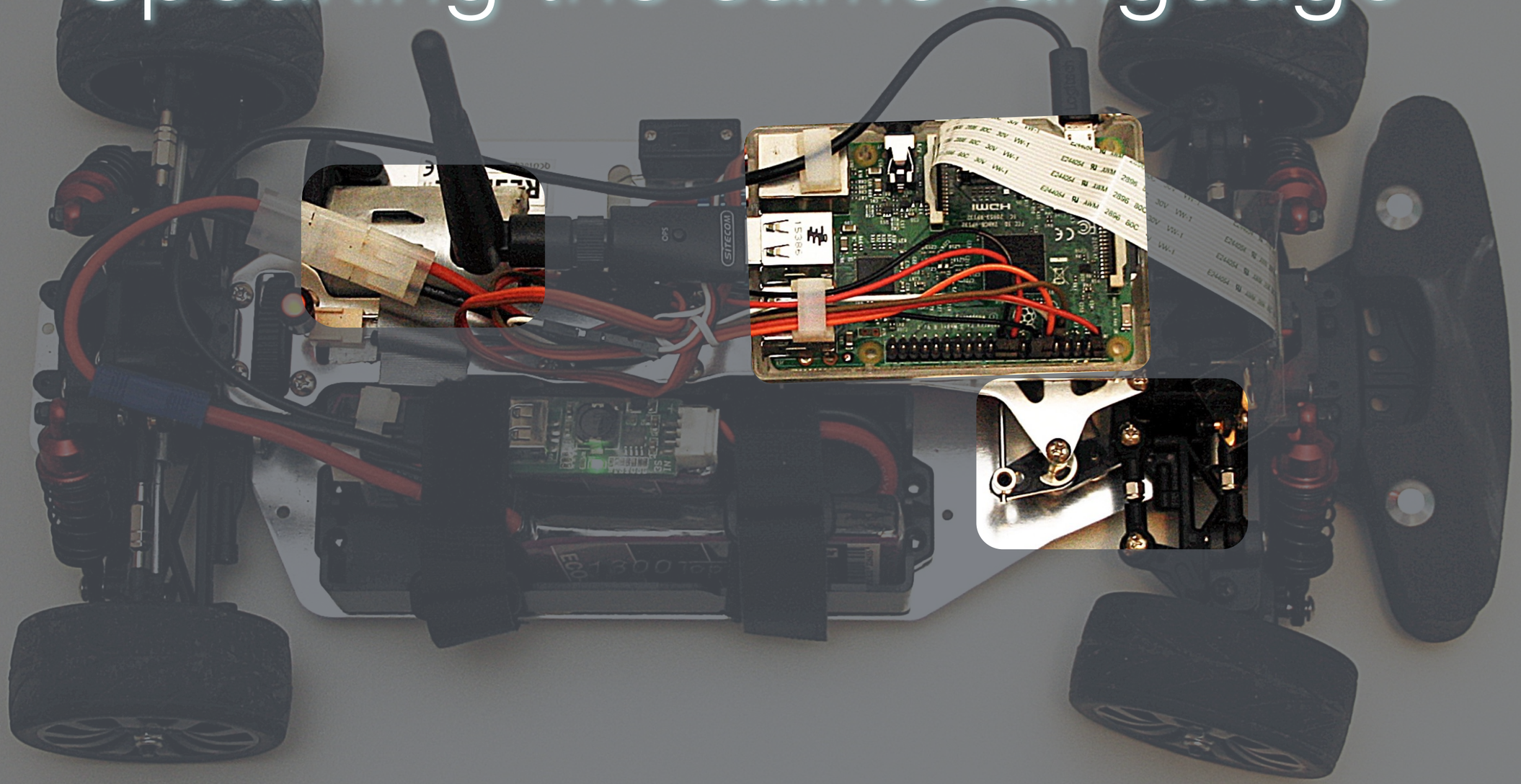
GPIO

- General purpose input/output



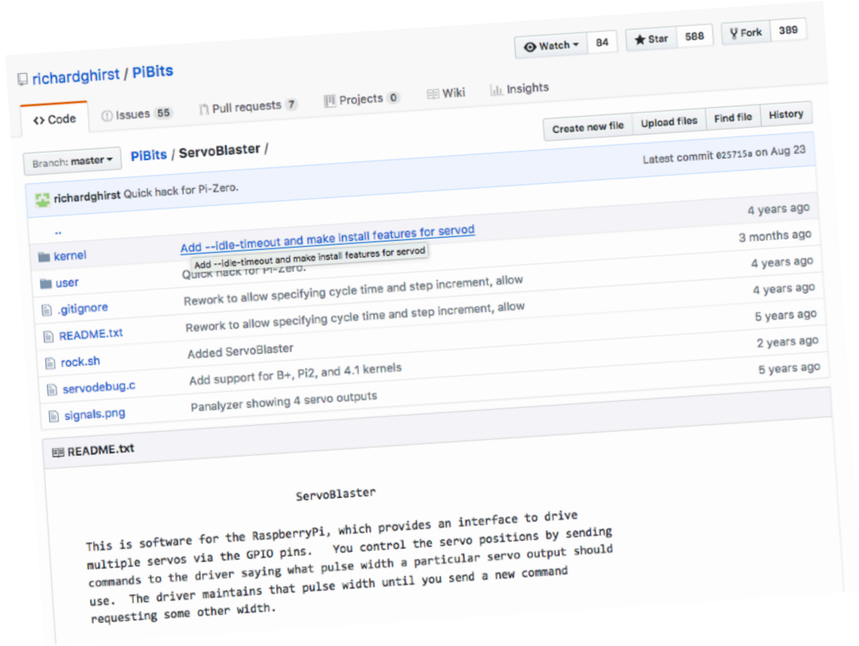


Speaking the same language



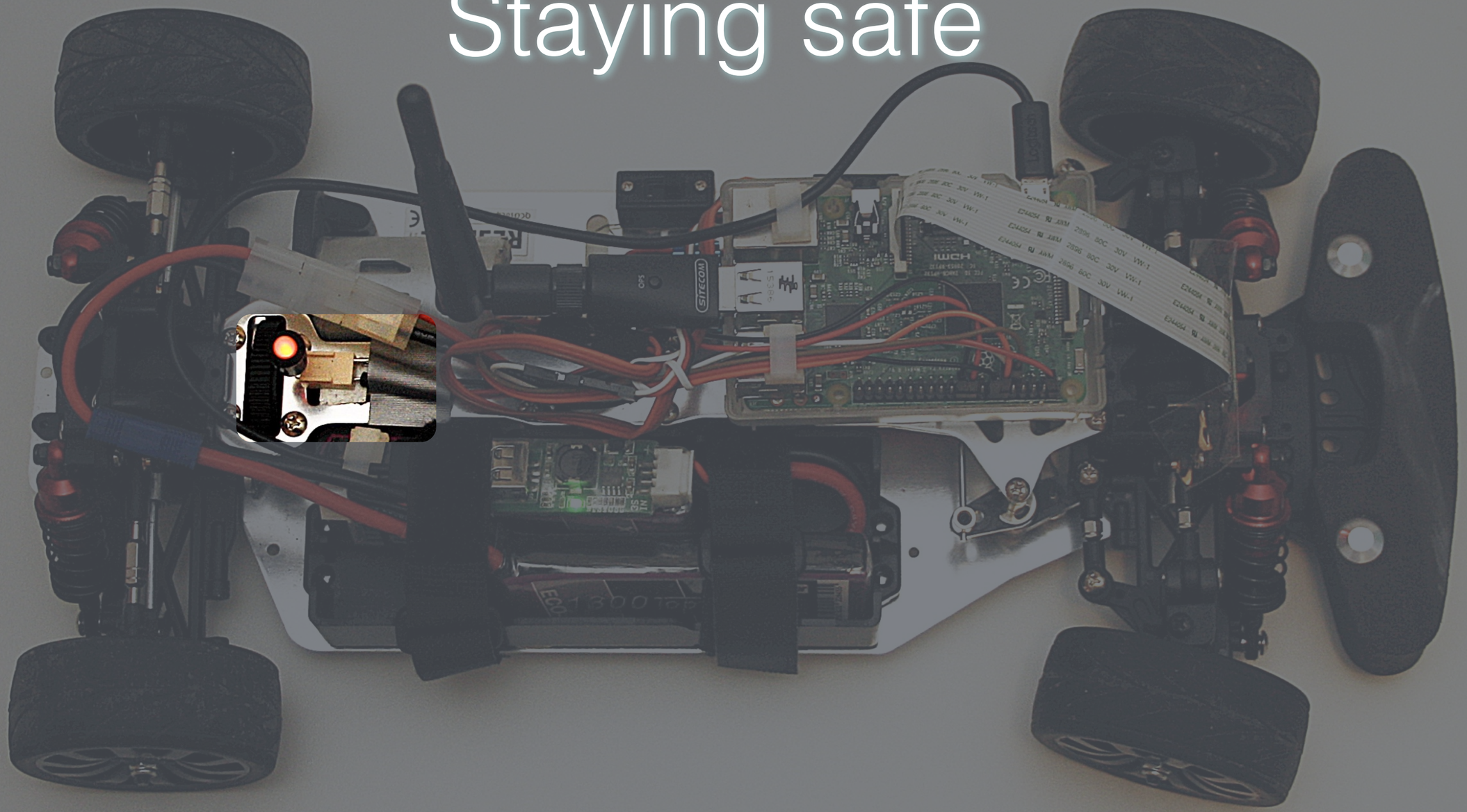
PWM

- Pulse-width modulation, repeating pulses of variable width
- ServoBlaster: https://github.com/richardghirst/PiBits/tree/master/ServoBlaster

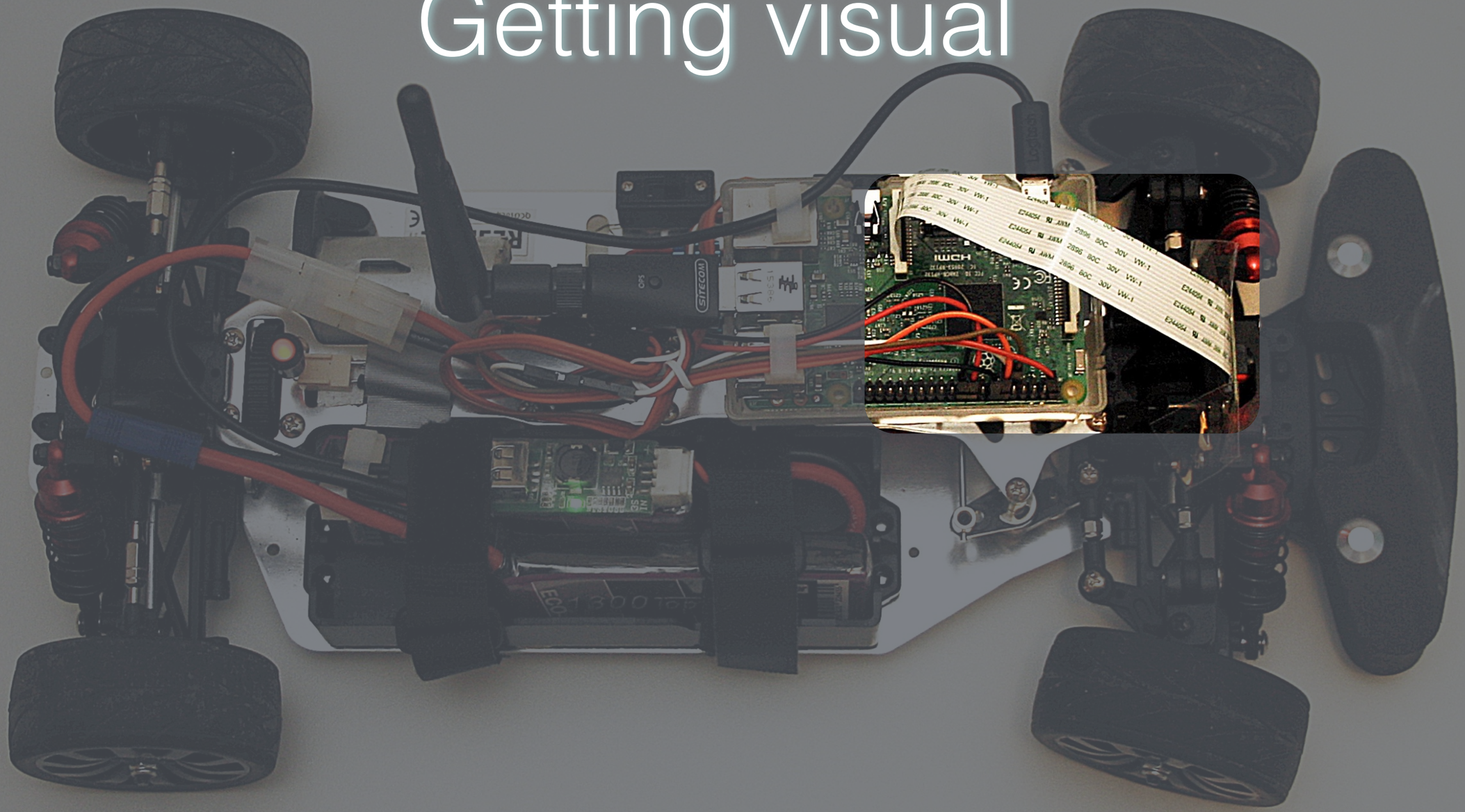


Servo number	GPIO number	Pin in P1 header
0	4	P1-7
1	17	P1-11
2	18	P1-12
3	21/27	P1-13
4	22	P1-15
5	23	P1-16
6	24	P1-18
7	25	P1-22

Staying safe



Getting visual



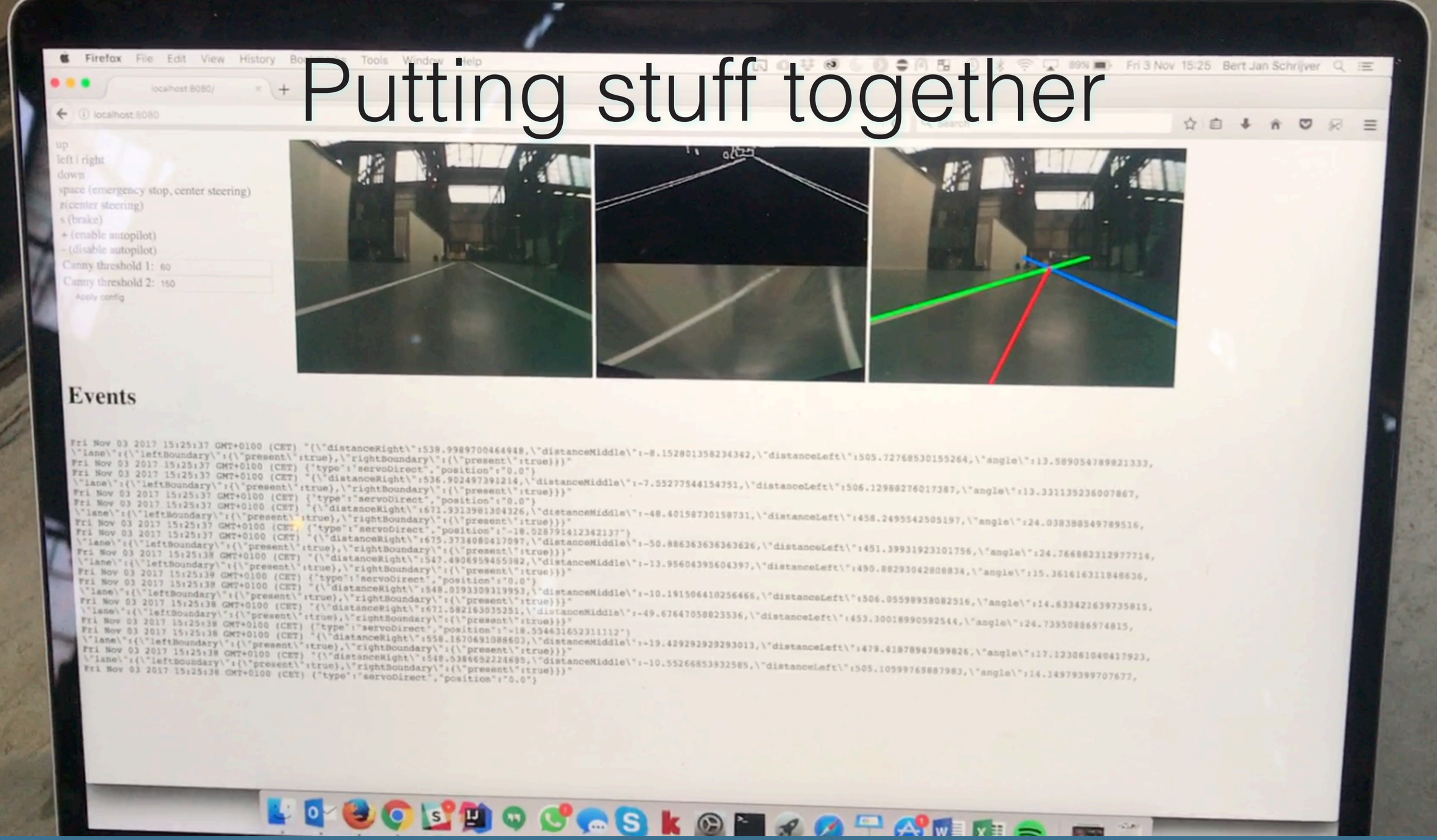
RPi Cam Web Interface

- Web interface for the Raspberry Pi Camera module
- Video streaming
- Web interface to configure video settings

https://github.com/silvanmelchior/RPi_Cam_Web_Interface

Ready for the road

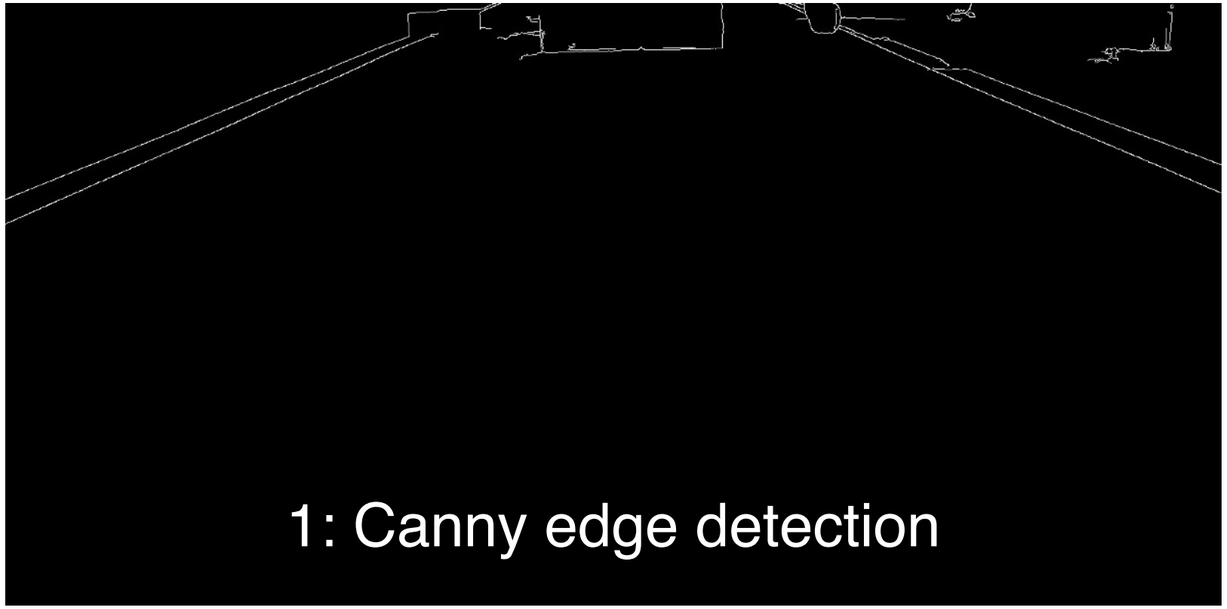
Putting stuff together

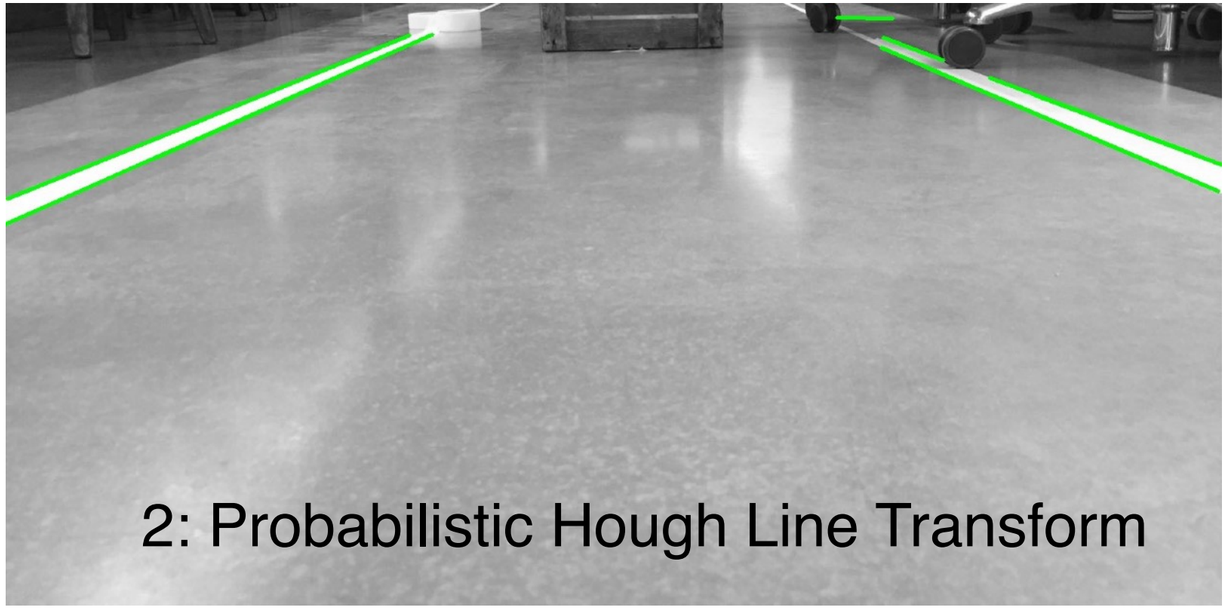


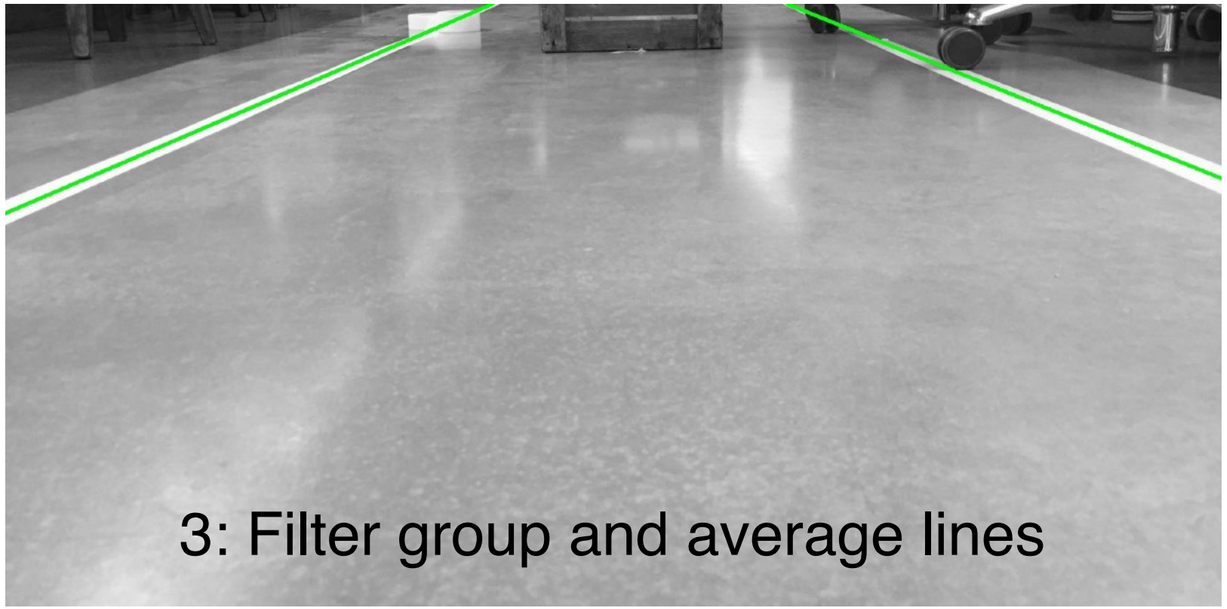
Learning to drive…

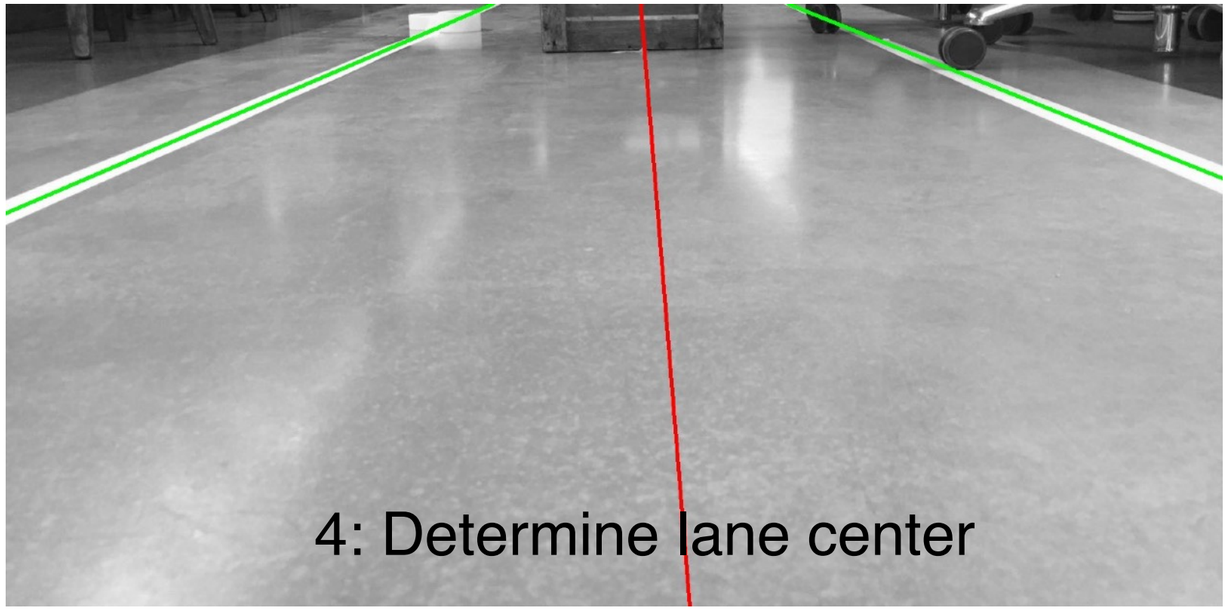
OpenCV

- Open source computer vision and machine learning library written in C++ with Java interfaces
- Optimised algorithms for computer vision
- Most widely used computer vision library
- Many resources available

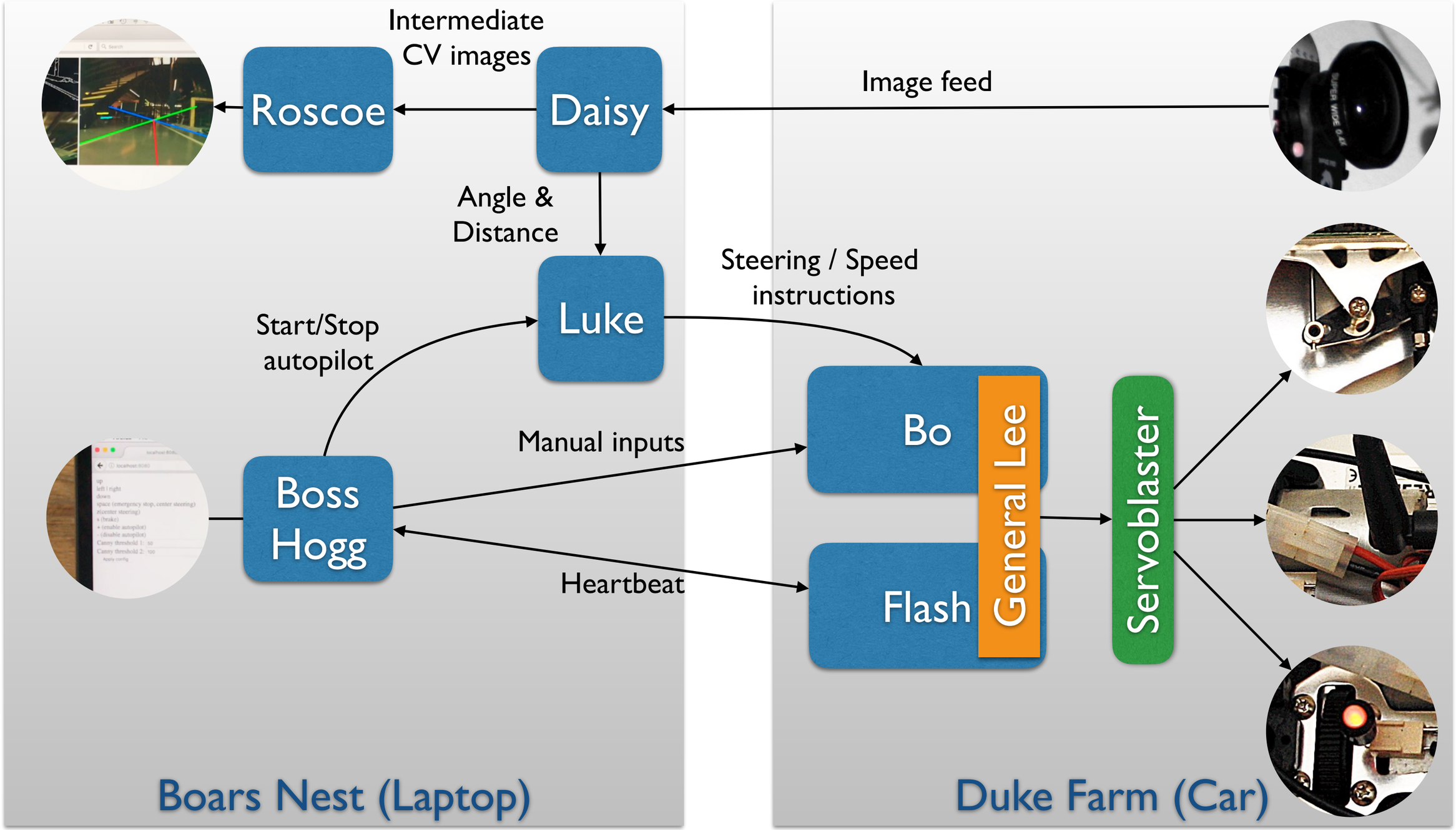

1: Canny edge detection


2: Probabilistic Hough Line Transform


3: Filter group and average lines

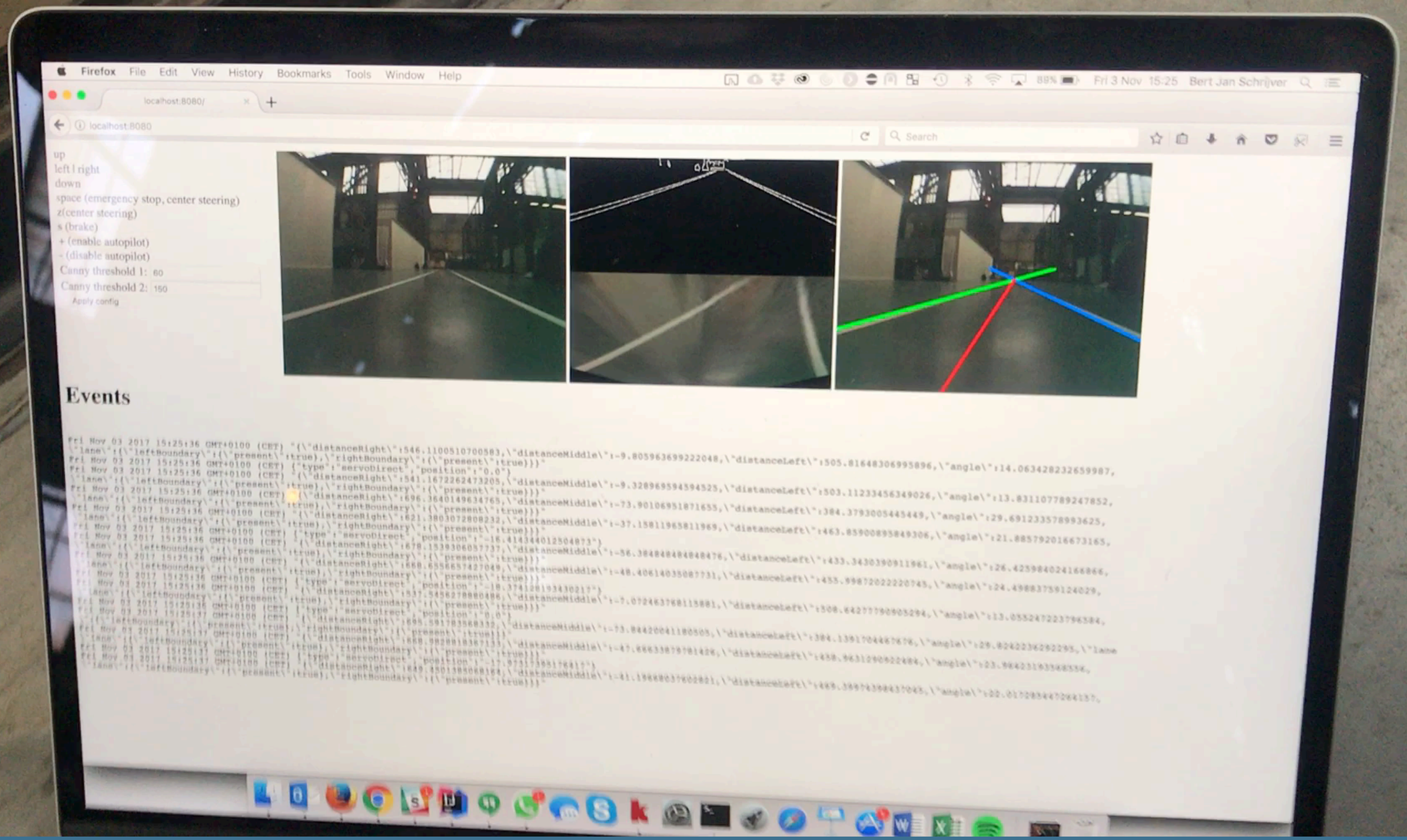

4: Determine lane center

Show me some code…


Intermediate
CV images
Roscoe
Daisy
Image feed
Angle &
Distance
Luke
Steering / Speed
instructions
Start/Stop
autopilot
Bo
General Lee
Servoblaster
Manual inputs
Boss
Hogg
Heartbeat
Flash
Boars Nest (Laptop)
Duke Farm (Car)

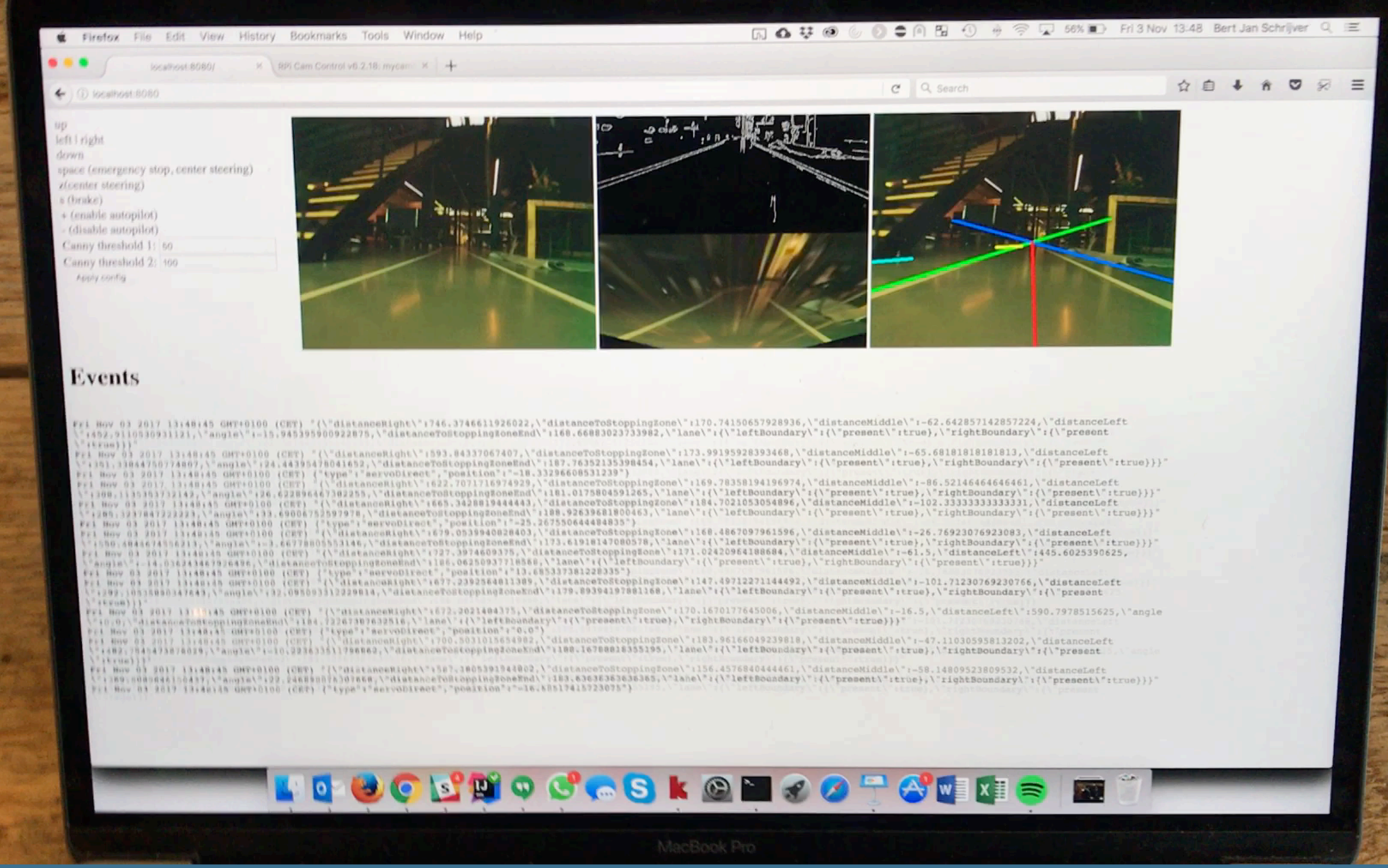
Expectation

Reality

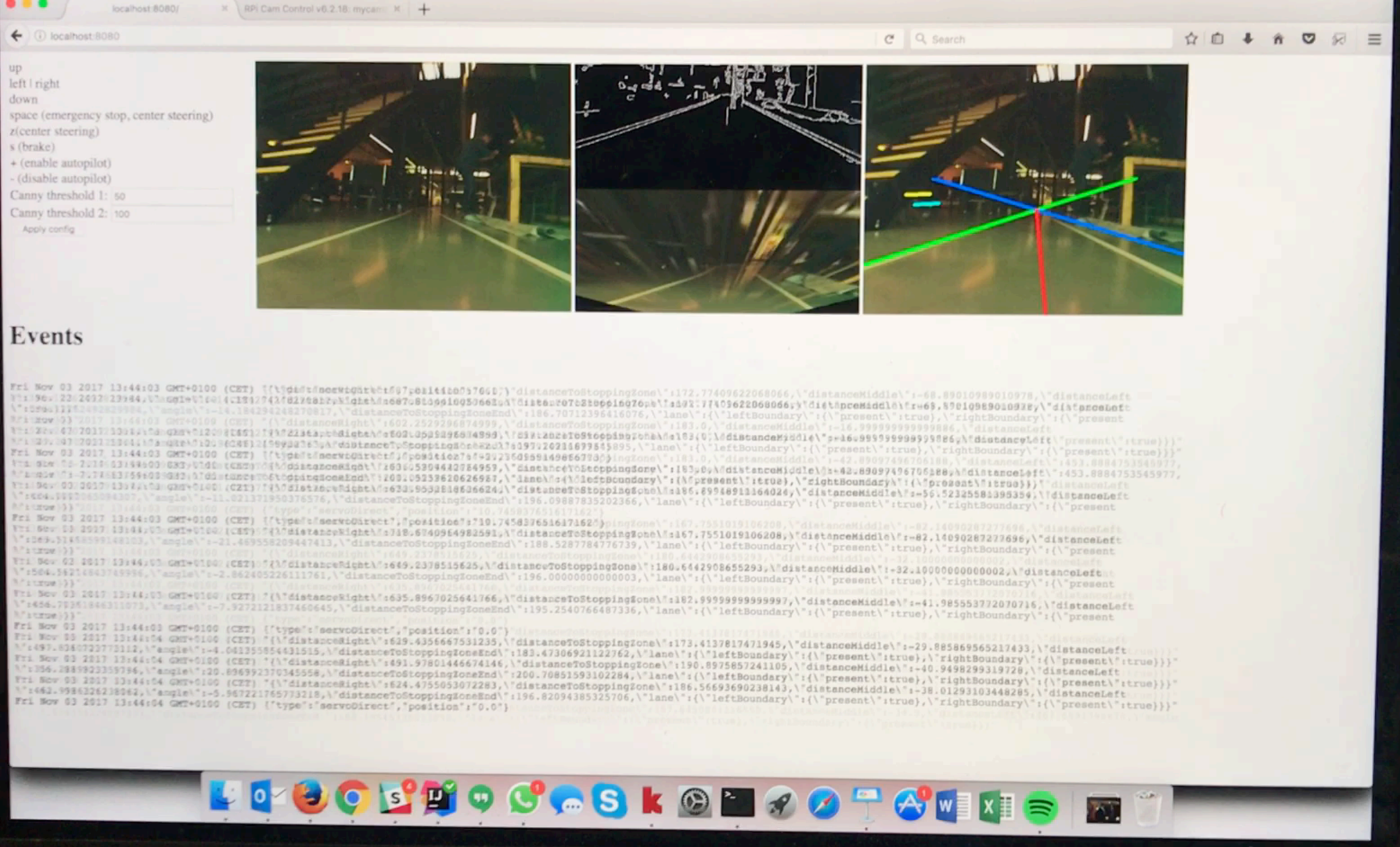


@bjschrijver

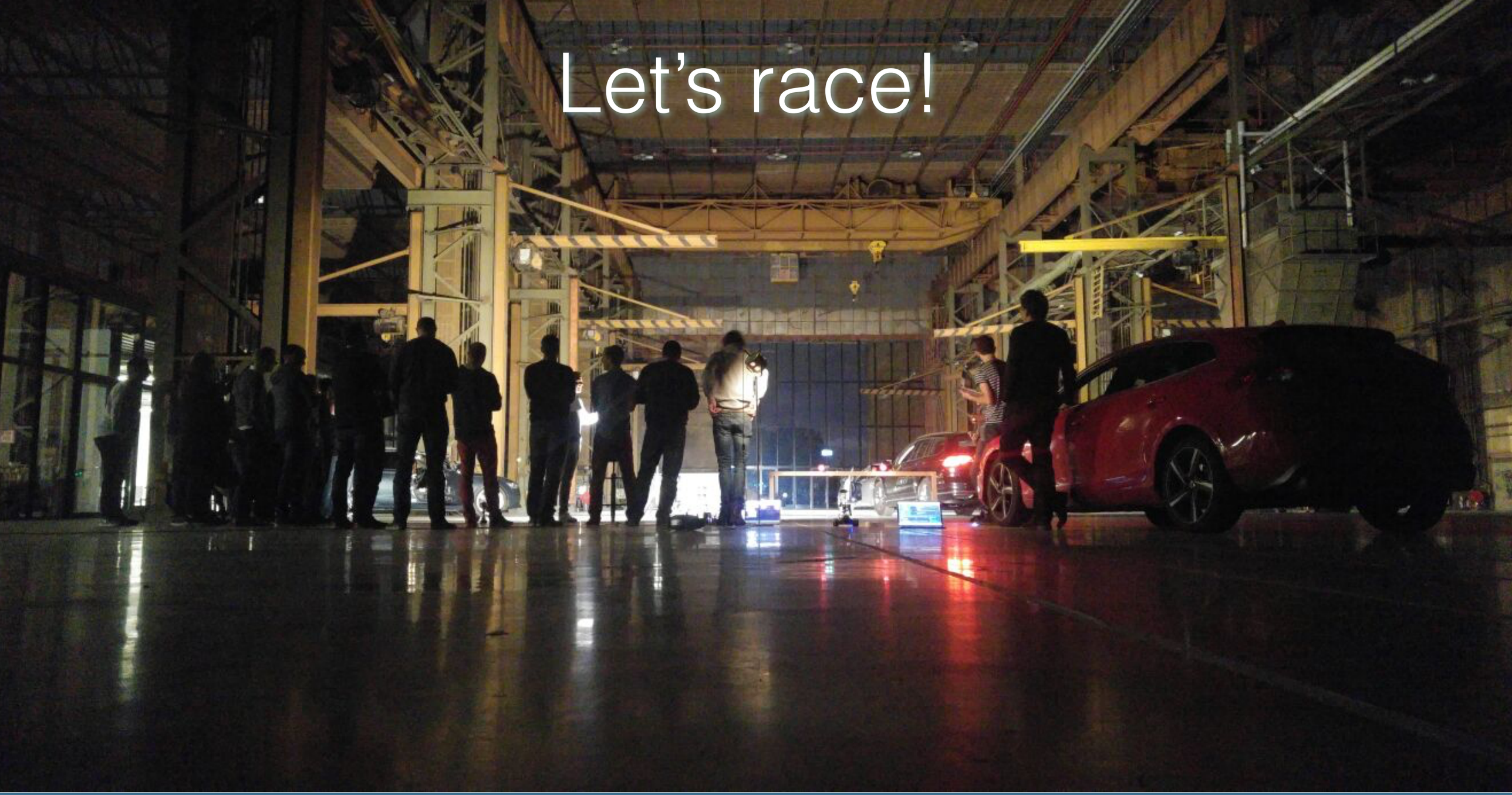

VEEN

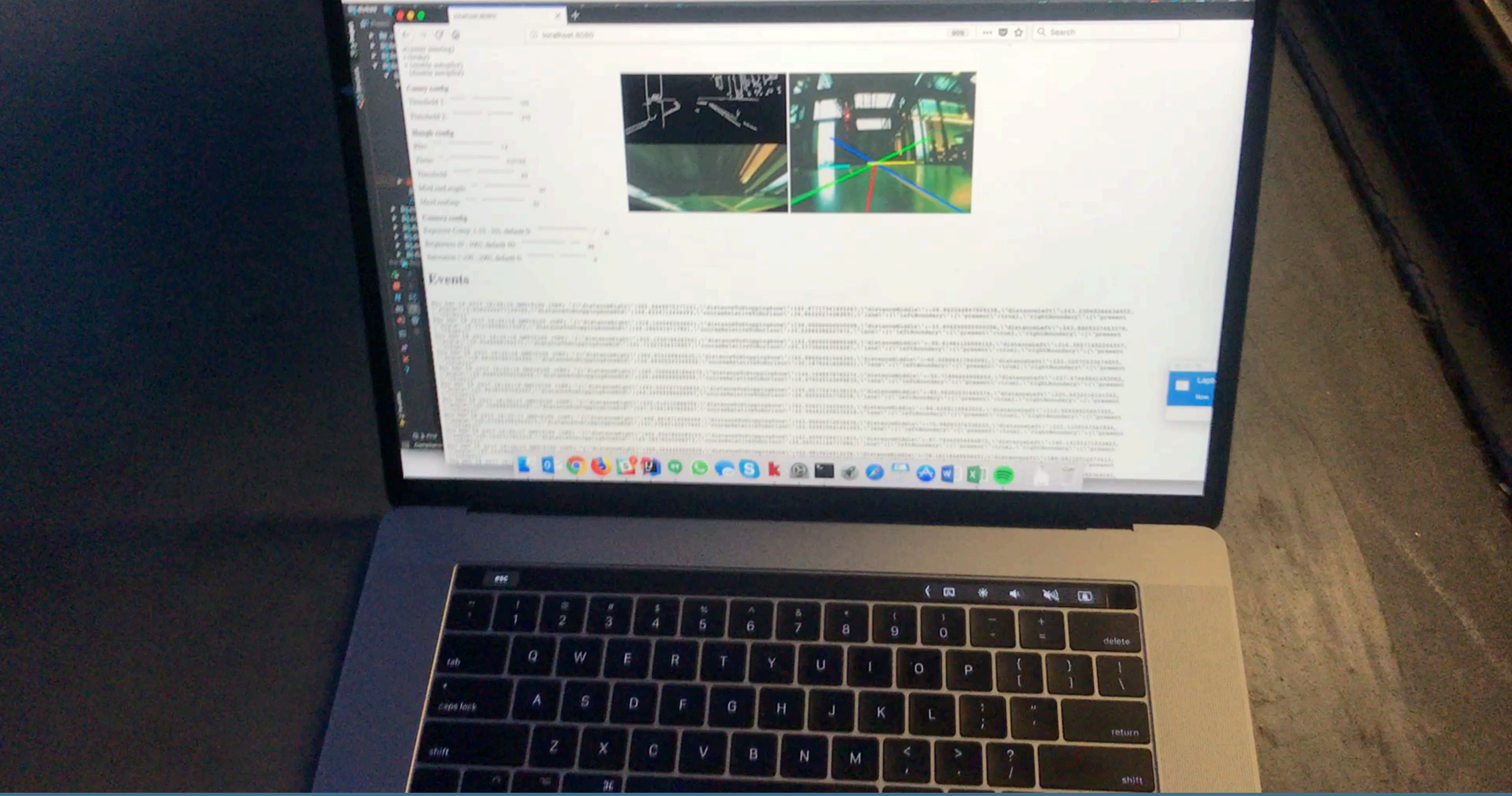


@bjschrijver

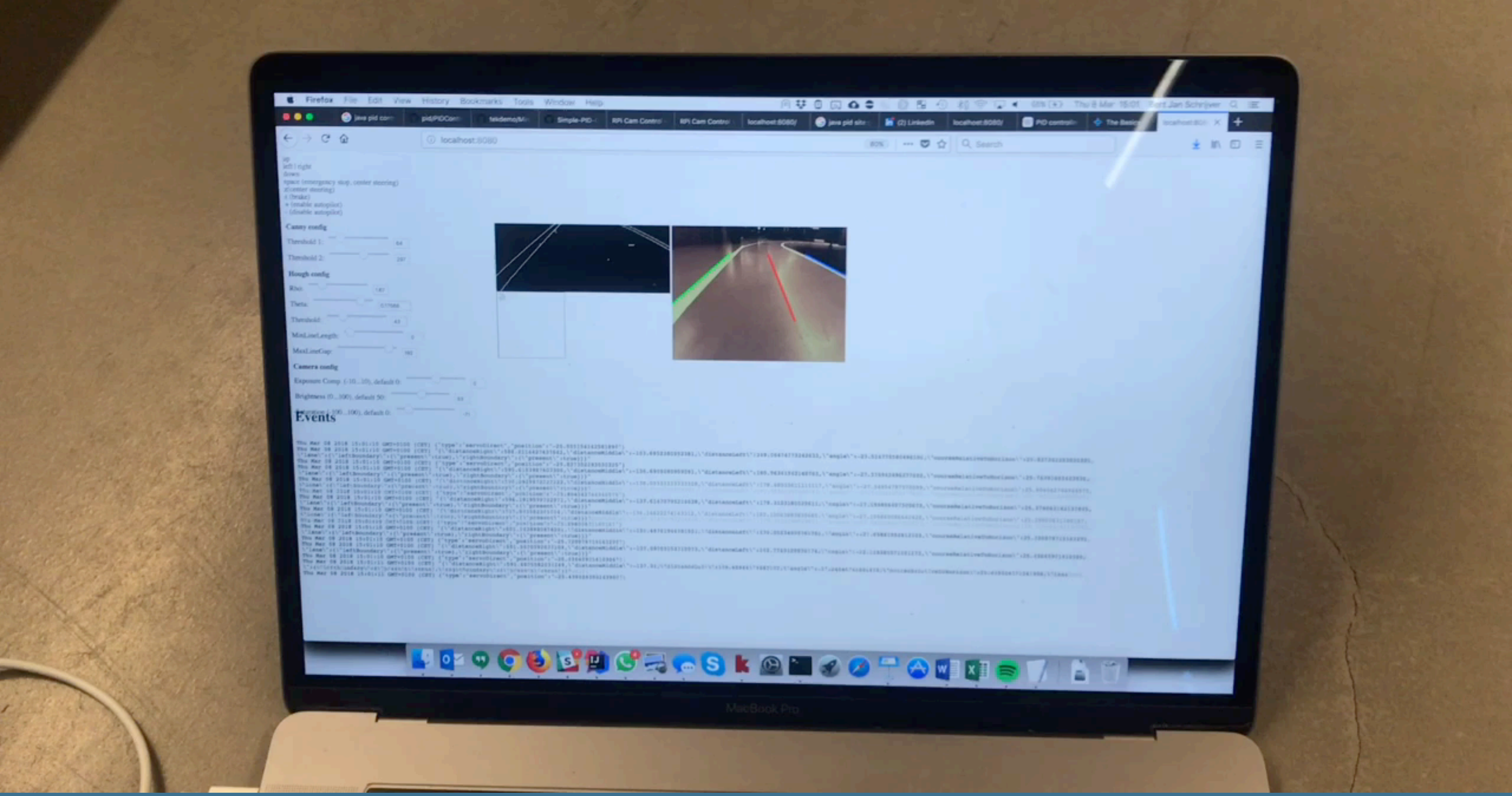

localhost:8080/
RPi Cam Control v6.2.18: mycam
localhost:8080
Search
up
left | right
down
space (emergency stop, center steering)
z(center steering)
s (brake)
+ (enable autopilot)
- (disable autopilot)
Canny threshold 1: 50
Canny threshold 2: 100
Apply config
Events
MacBook Pro

Let’s race!





@bjschrijver



@bjschrijver

In the real world

LEVEL 0

There are no autonomous features.

LEVEL 1

These cars can handle one task at a time, like automatic braking.

LEVEL 2

These cars would have at least two automated functions.

LEVEL 3

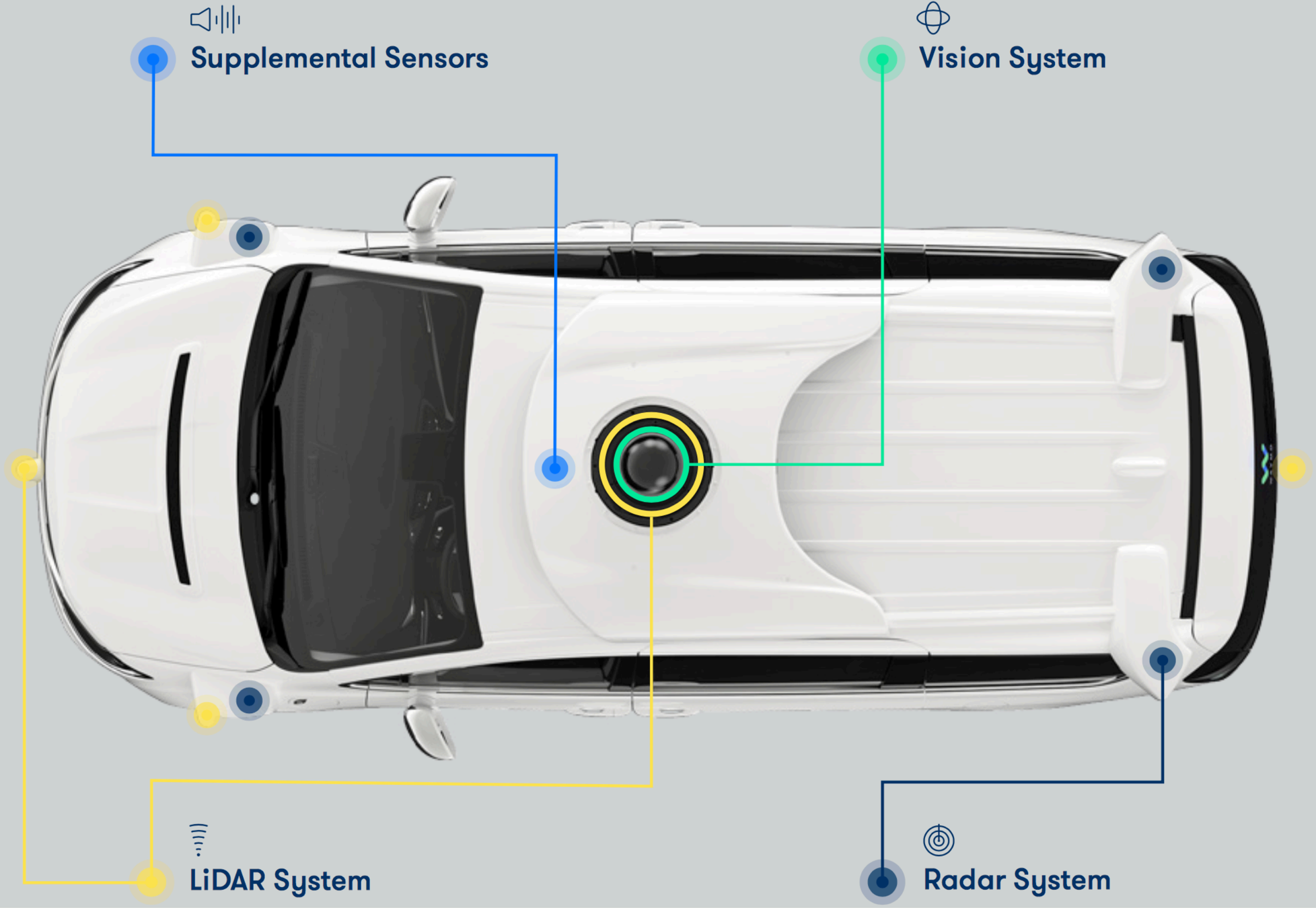
These cars handle “dynamic driving tasks” but might still need intervention.

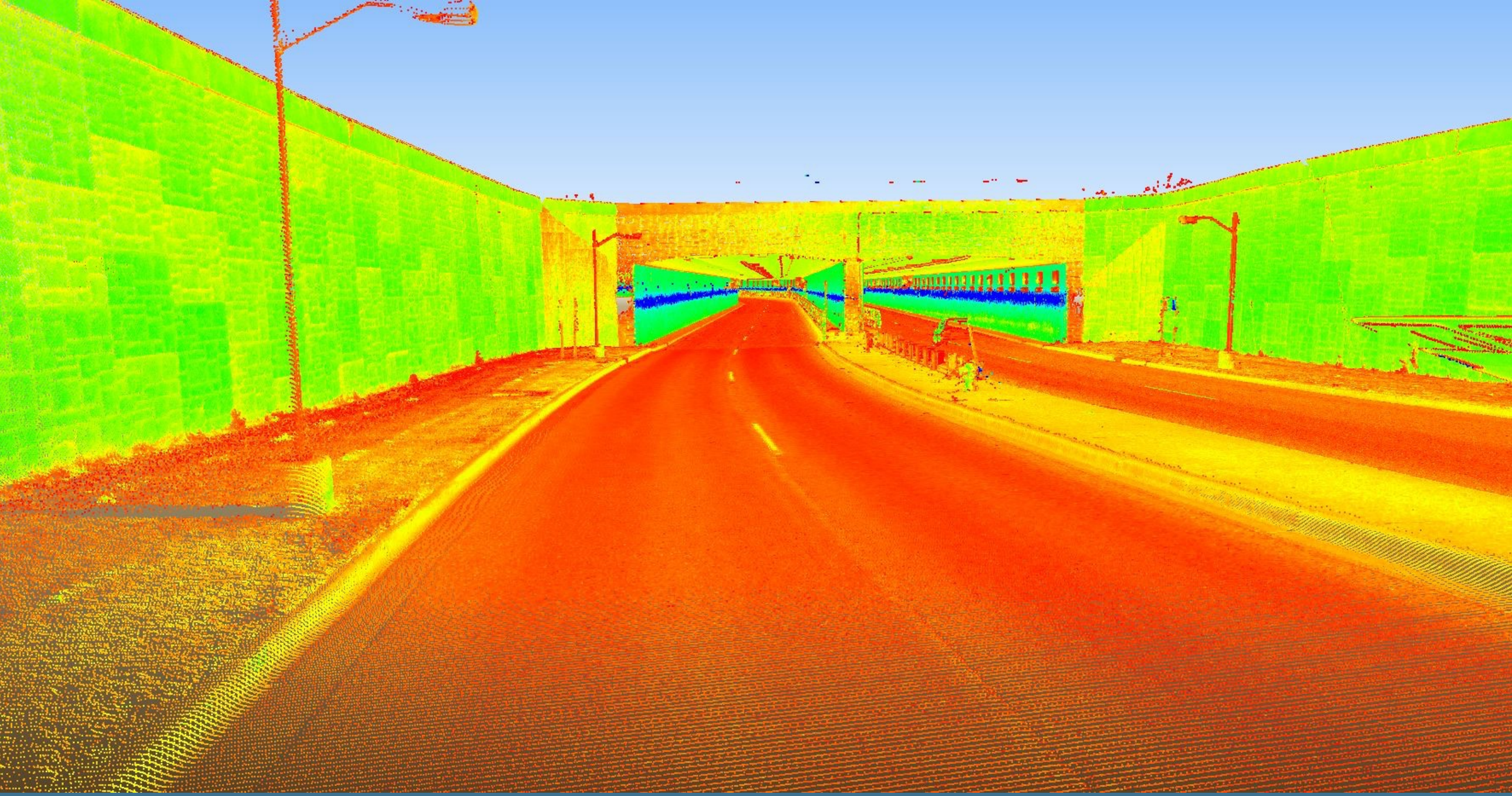
LEVEL 4

These cars are officially driverless in certain environments.

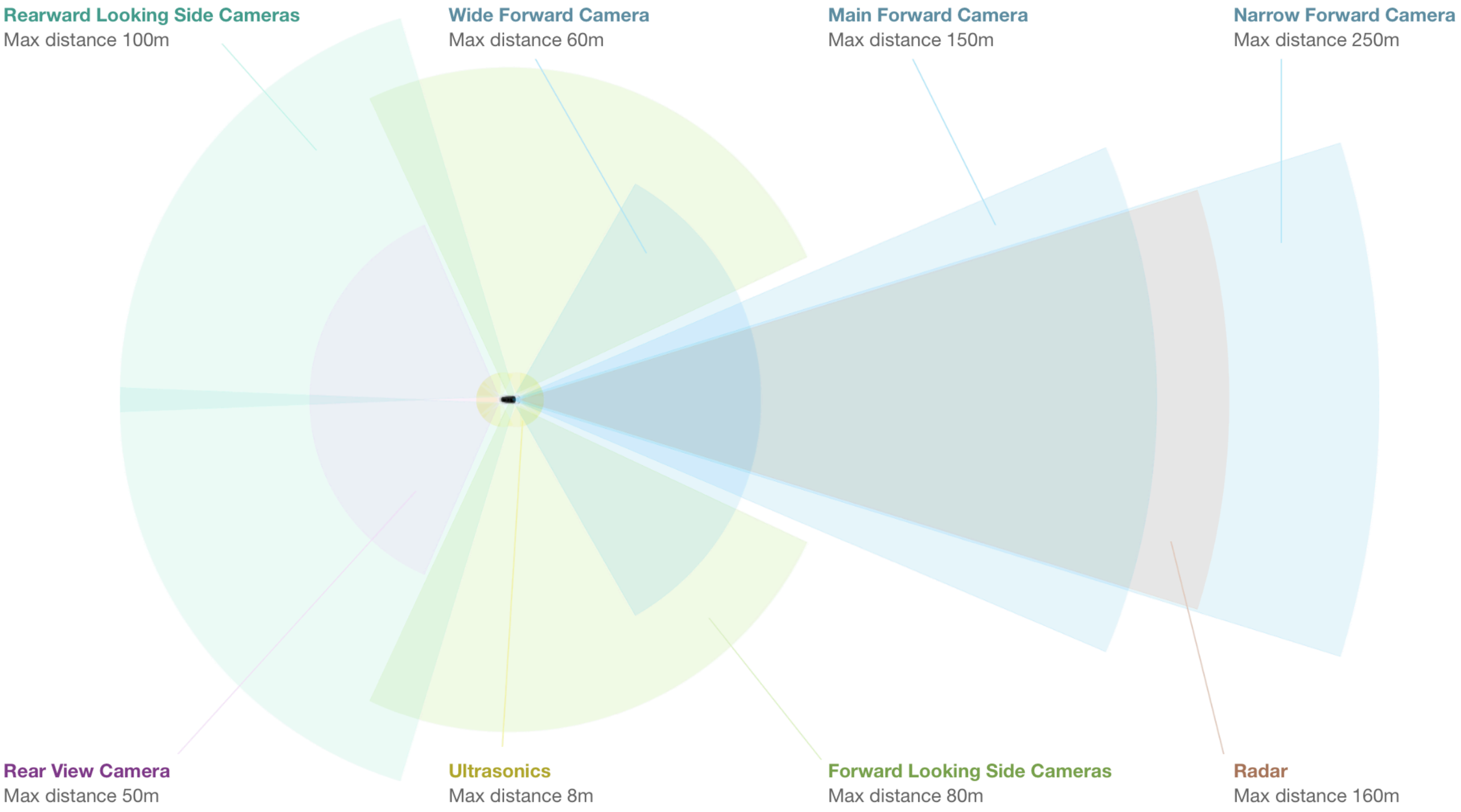
LEVEL 5

These cars can operate entirely on their own without any driver presence.


Supplemental Sensors
Vision System
LiDAR System
Radar System



@bjschrijver


Rearward Looking Side Cameras
Max distance 100m
Wide Forward Camera
Max distance 60m
Main Forward Camera
Max distance 150m
Narrow Forward Camera
Max distance 250m
Rear View Camera
Max distance 50m
Ultrasonics
Max distance 8m
Forward Looking Side Cameras
Max distance 80m
Radar
Max distance 160m

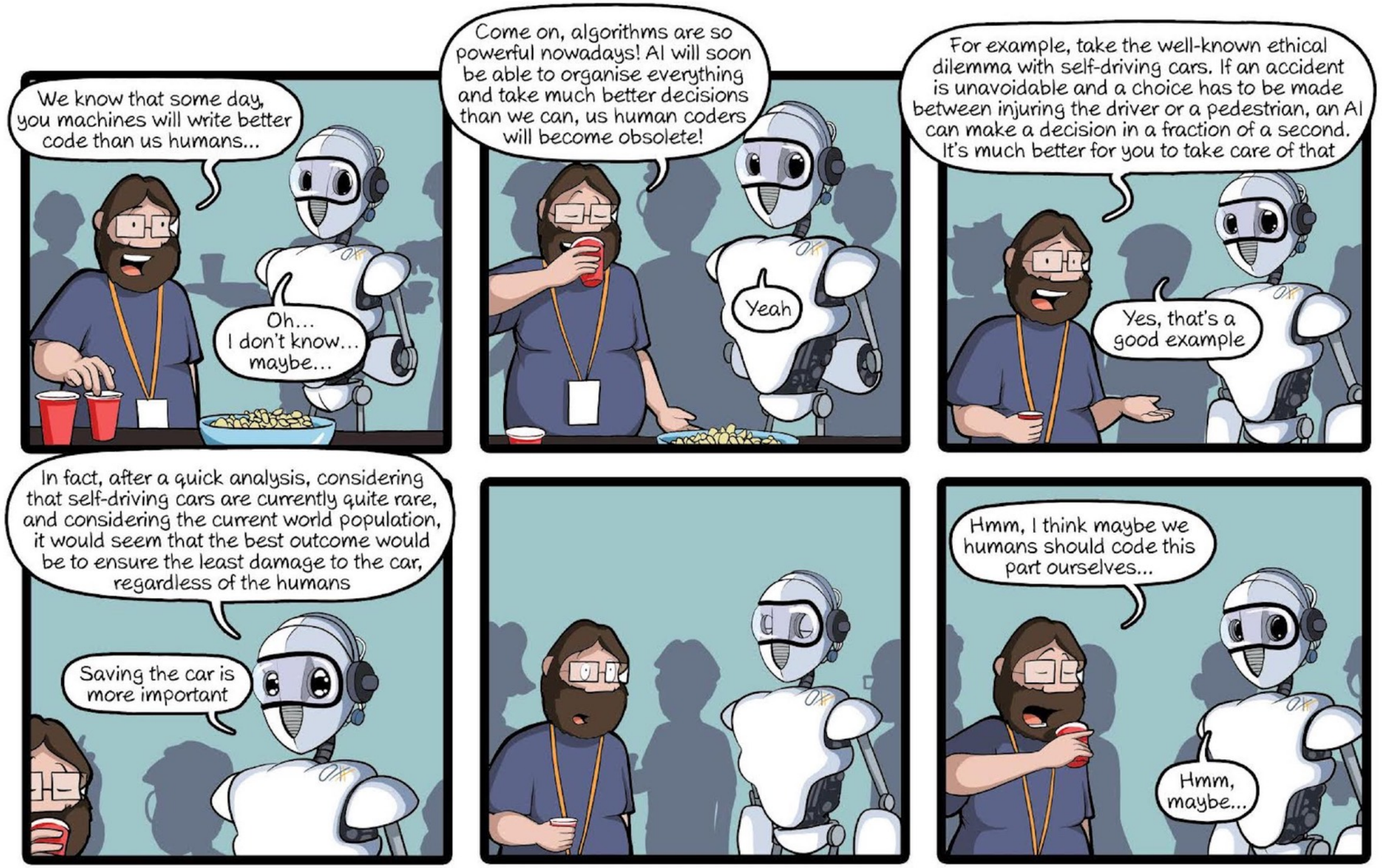
@bjschrijver

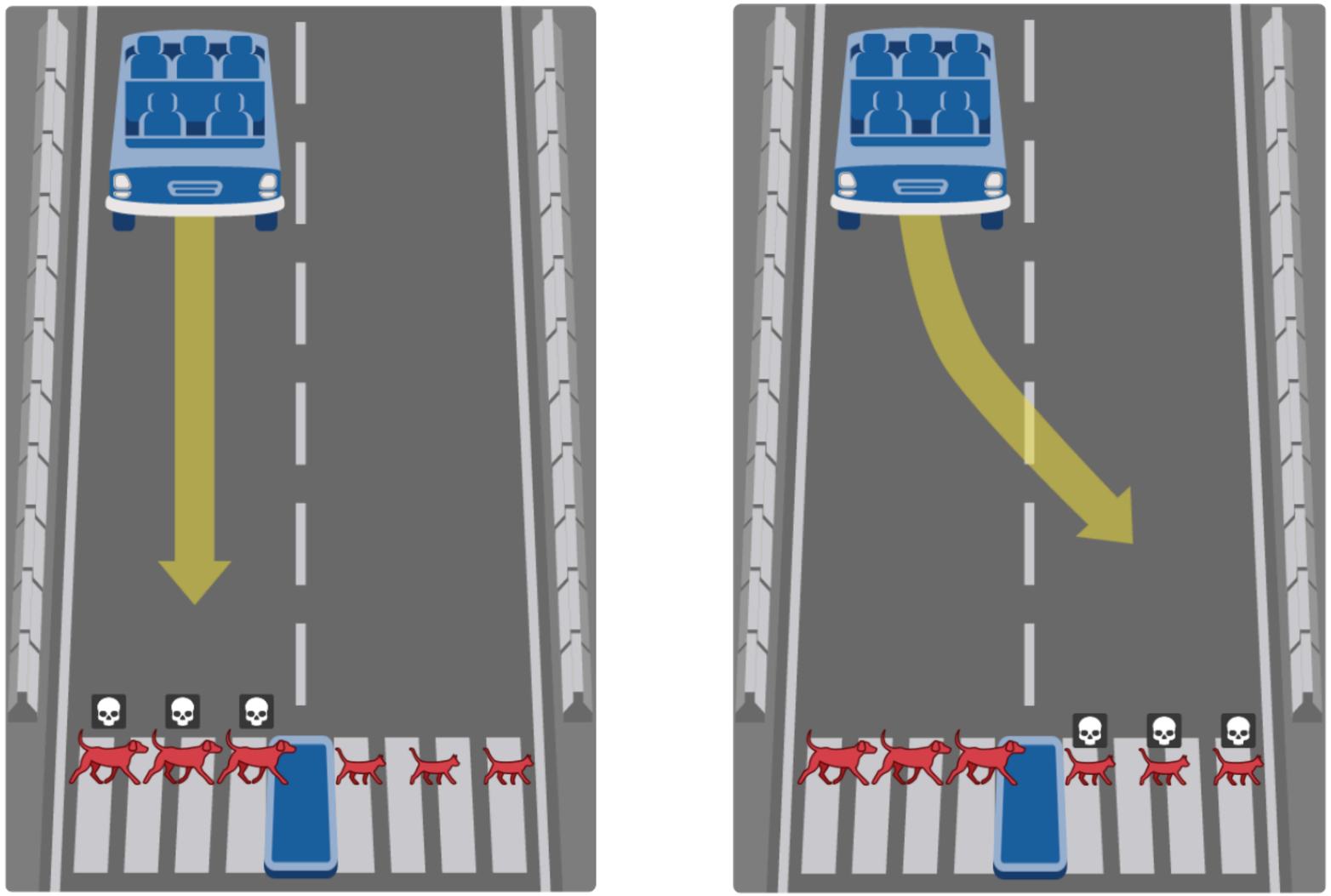
Examples of safety measures

- Geographic area limitation
- Strictly defined conditions
- Redundancy
- Multiple sensors
- Isolating control systems
- Human intervention fallback

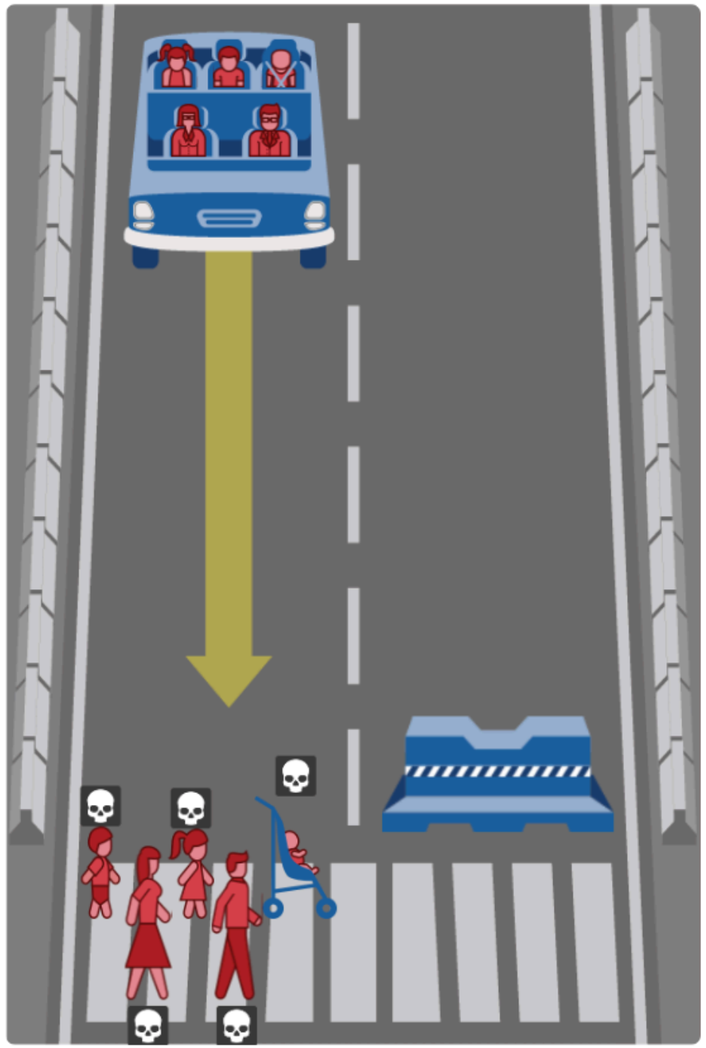
Weakness of AI for computer vision

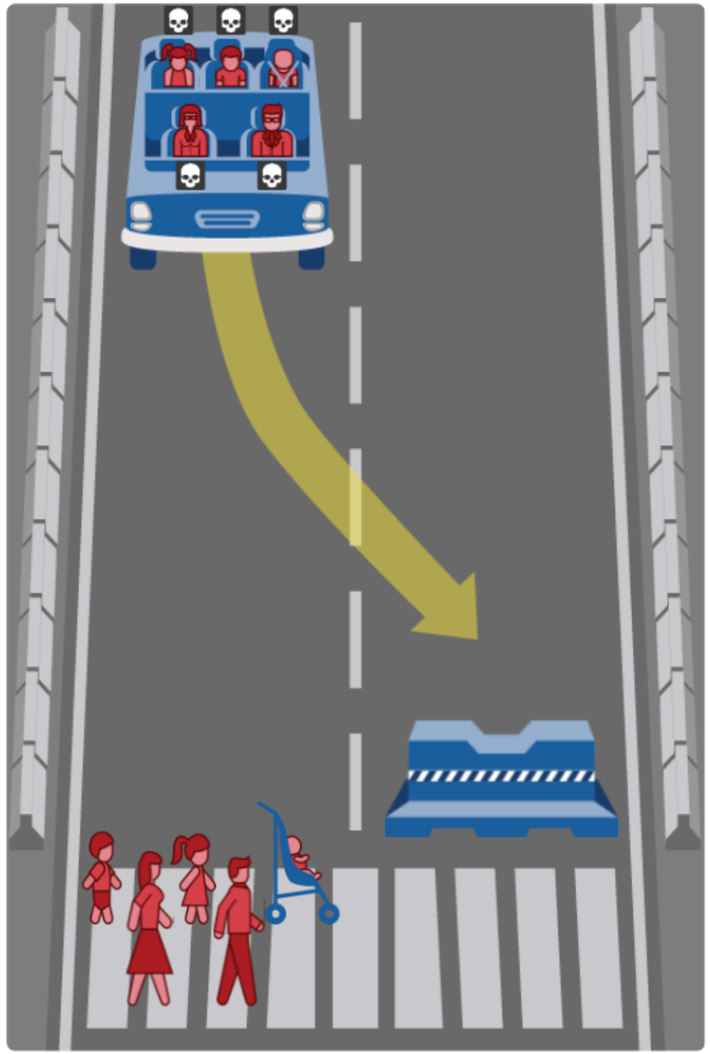
Ethics


We know that some day, you machines will write better code than us humans...
Oh... I don't know... maybe...
Come on, algorithms are so powerful nowadays! AI will soon be able to organise everything and take much better decisions than we can, us human coders will become obsolete!
Yeah
For example, take the well-known ethical dilemma with self-driving cars. If an accident is unavoidable and a choice has to be made between injuring the driver or a pedestrian, an AI can make a decision in a fraction of a second. It's much better for you to take care of that
Yes, that's a good example
In fact, after a quick analysis, considering that self-driving cars are currently quite rare, and considering the current world population, it would seem that the best outcome would be to ensure the least damage to the car, regardless of the humans
Saving the car is more important
Hmm, I think maybe we humans should code this part ourselves...
Hmm, maybe...



http://moralmachine.mit.edu





http://moralmachine.mit.edu

Federal Ministry
of Transport and
Digital Infrastructure

“In hazardous situations that prove to be unavoidable, despite all technological precautions being taken, the protection of human life enjoys top priority in a balancing of legally protected interests.”

ETHICS COMMISSION
AUTOMATED AND
CONNECTED DRIVING

Federal Ministry
of Transport and
Digital Infrastructure

"In the event of unavoidable accident situations, any distinction based on personal features (age, gender, physical or mental constitution) is strictly prohibited."

ETHICS COMMISSION
AUTOMATED AND

Future improvements

- Improve detection and navigation of curved lanes
- Optimize line detection algorithm using sliding window
- Automatic (re)calibration of:
  - Video parameters
  - OpenCV parameters
- Add Flight recorder to enable replay and debug
- Control servos directly from Java
- Use a neural network for navigation
- Optimize for running everything on the car

Questions?

@bjschrijver

https://github.com/rc-dukes

Thanks for your time.

Got feedback? Tweet it!

@bjschrijver