



Building a self-driving RC car

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 @bjschrijver

 @TimvEijndhoven

Let's meet



Bert Jan Schrijver

OPENVALUE

jPoint

POLITIE

nl.
jug



Let's meet



jPoint

POLITIE

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)

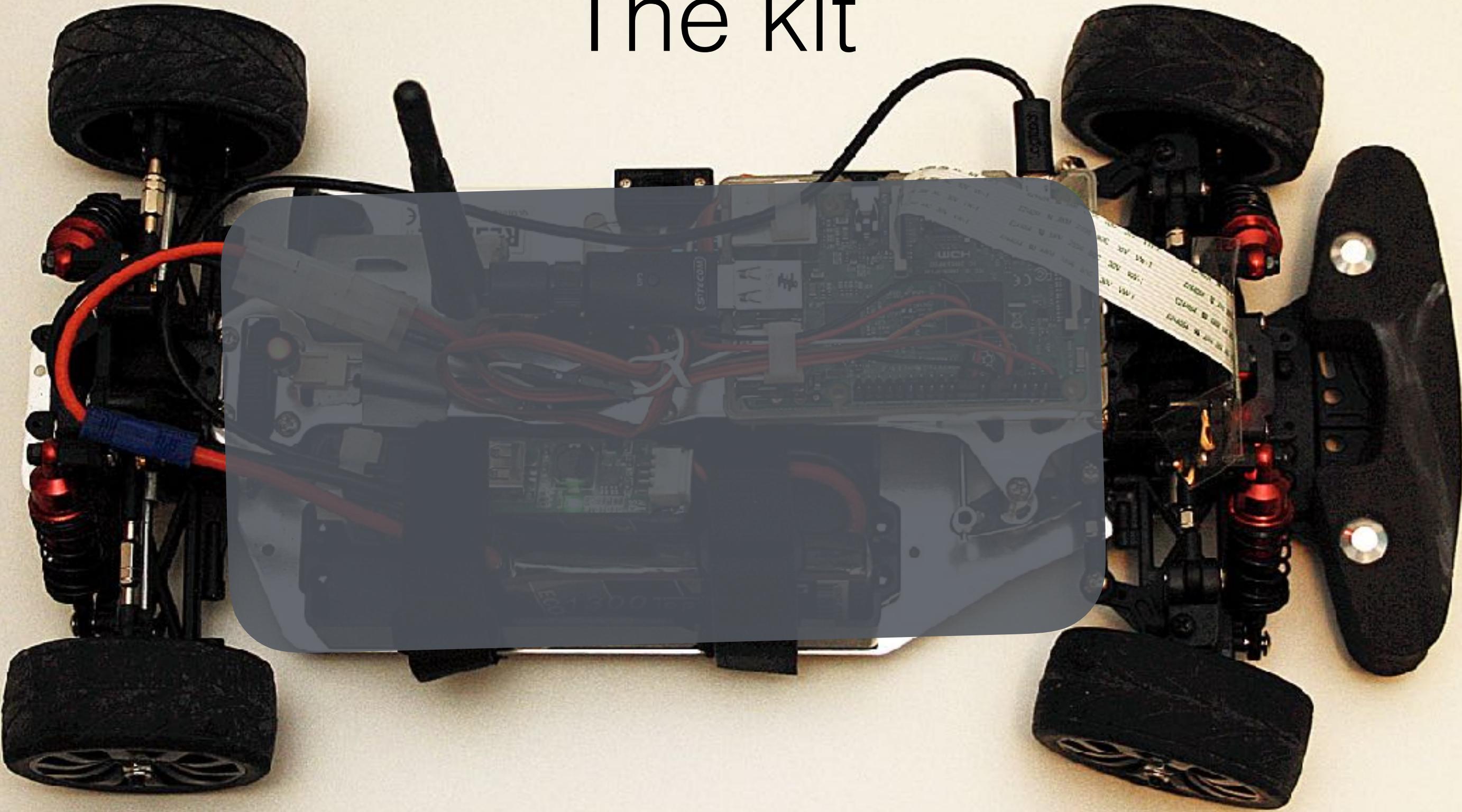


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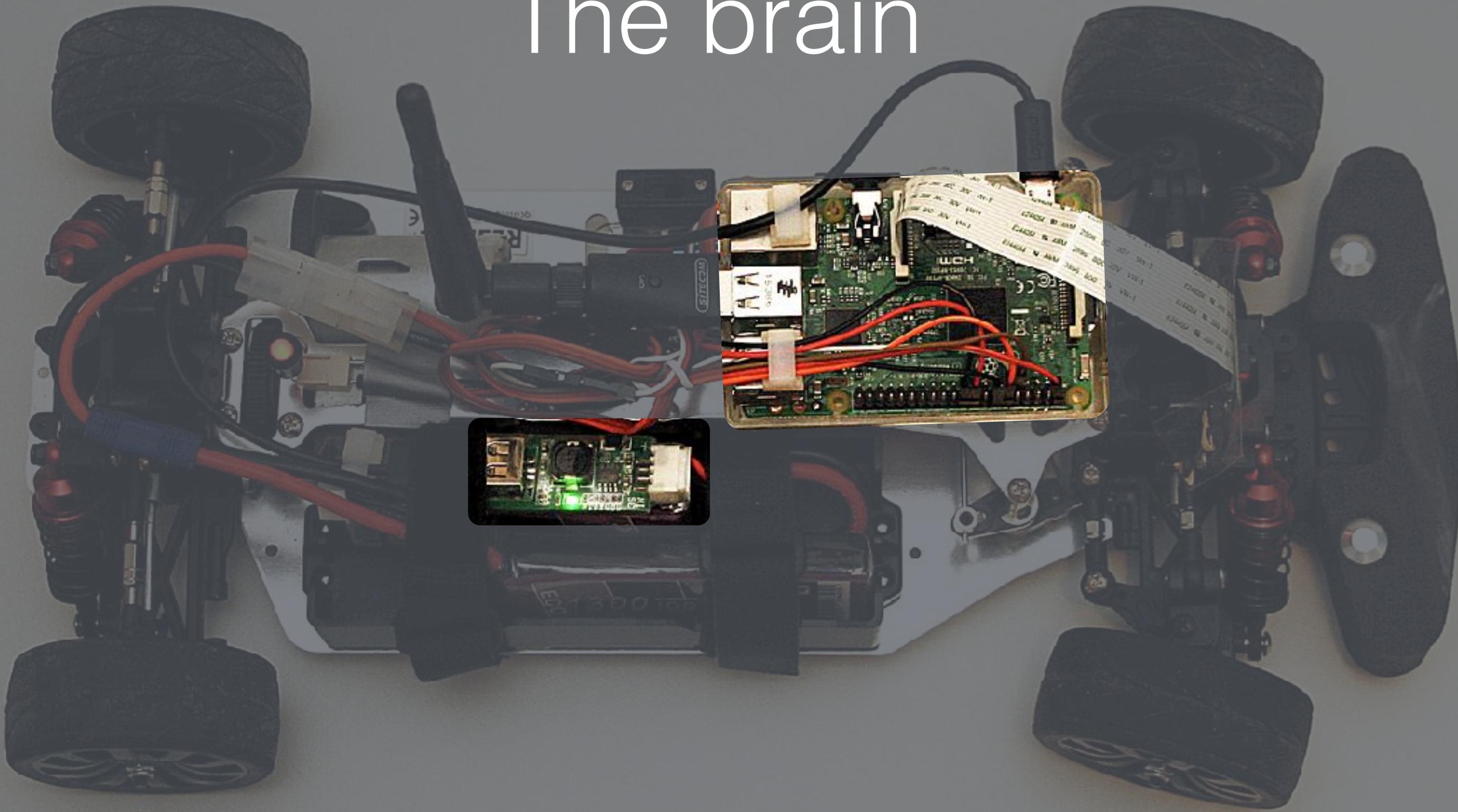


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The kit



The brain



The platform



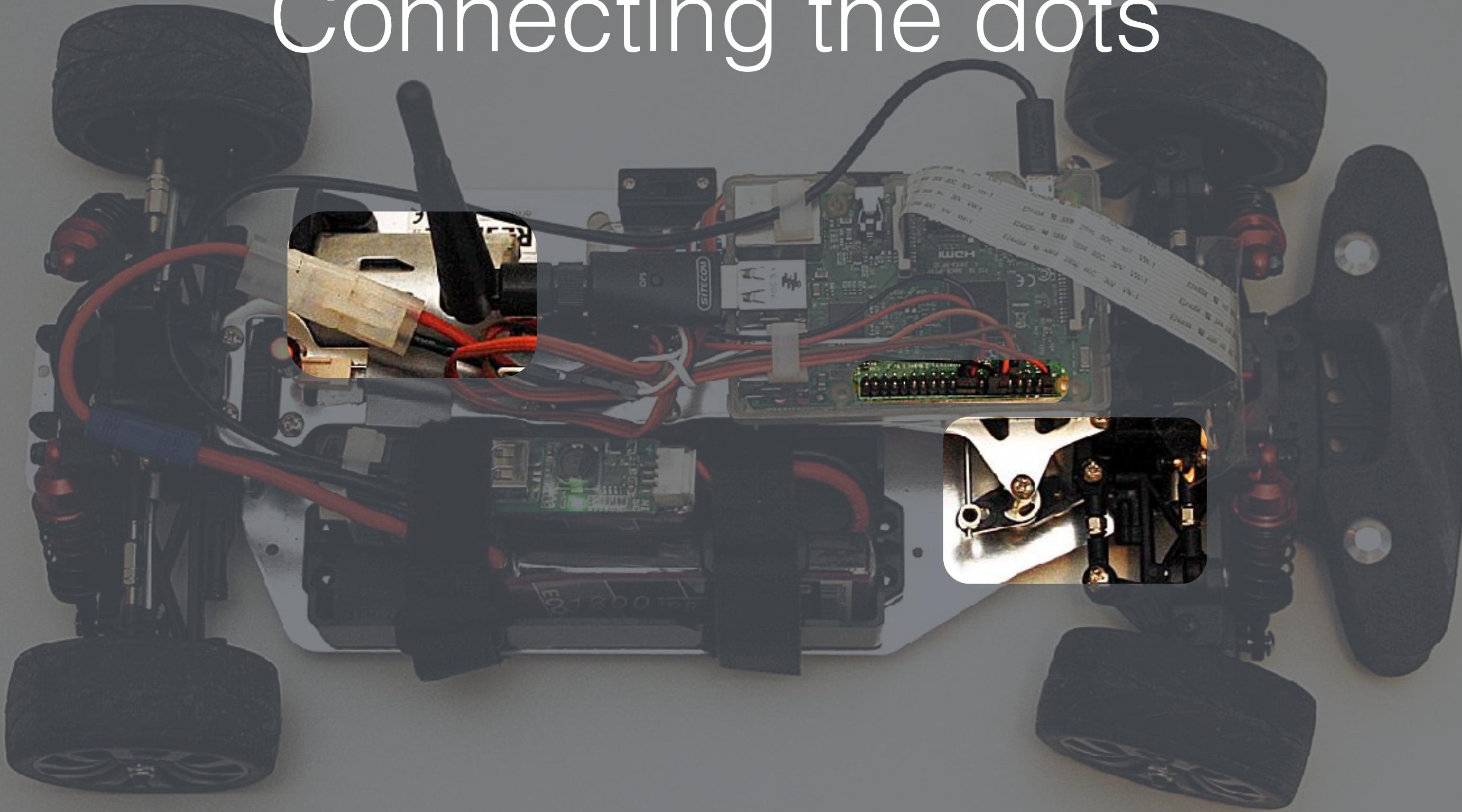
Vert.x

- 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!)



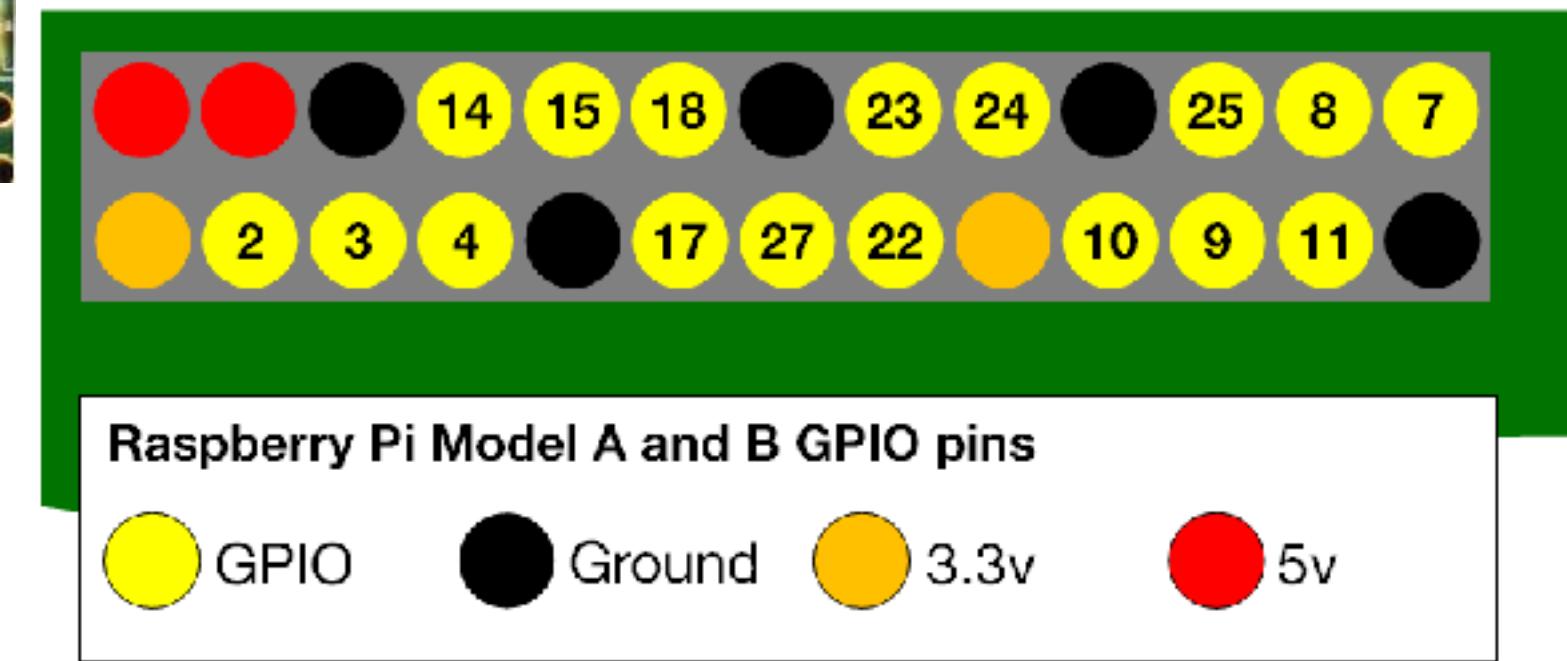
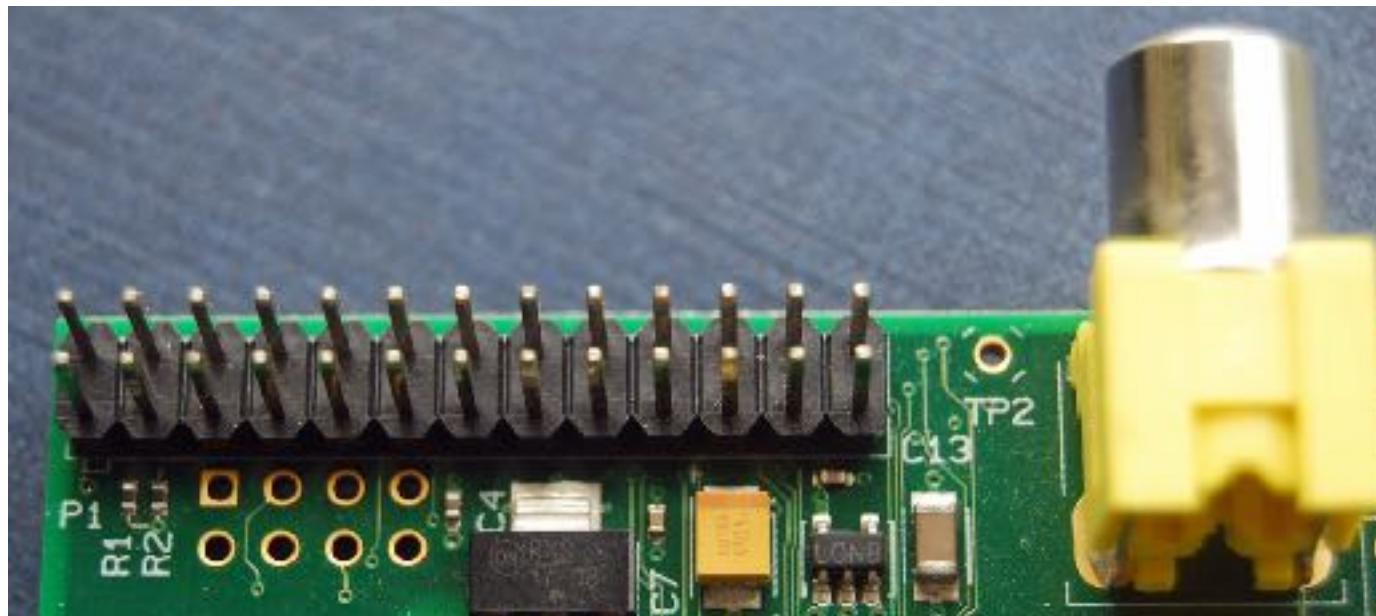
Building microservices with Vert.x: <https://youtu.be/yLg-LPSRjho>

Connecting the dots

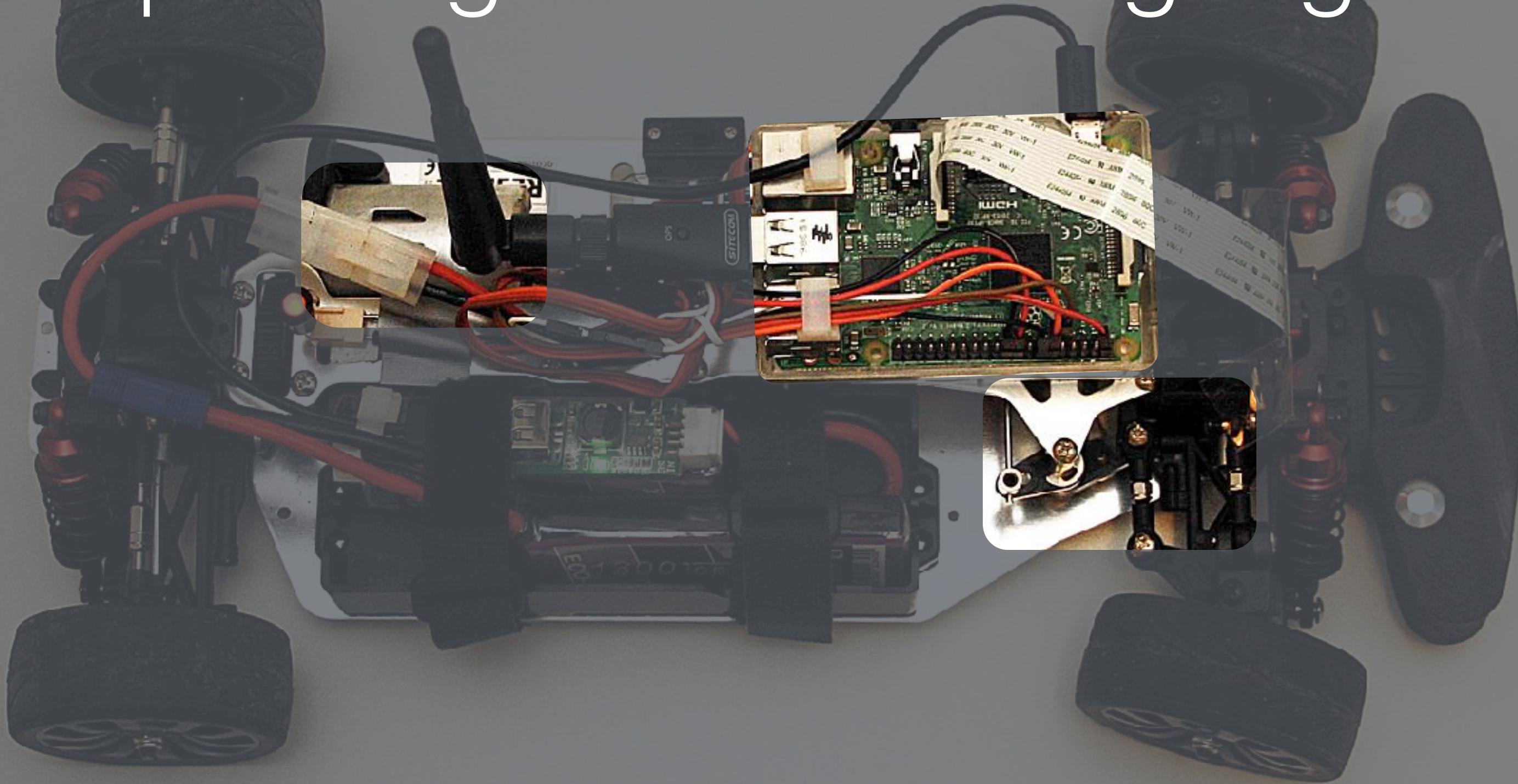


GPIO

- General purpose input/output

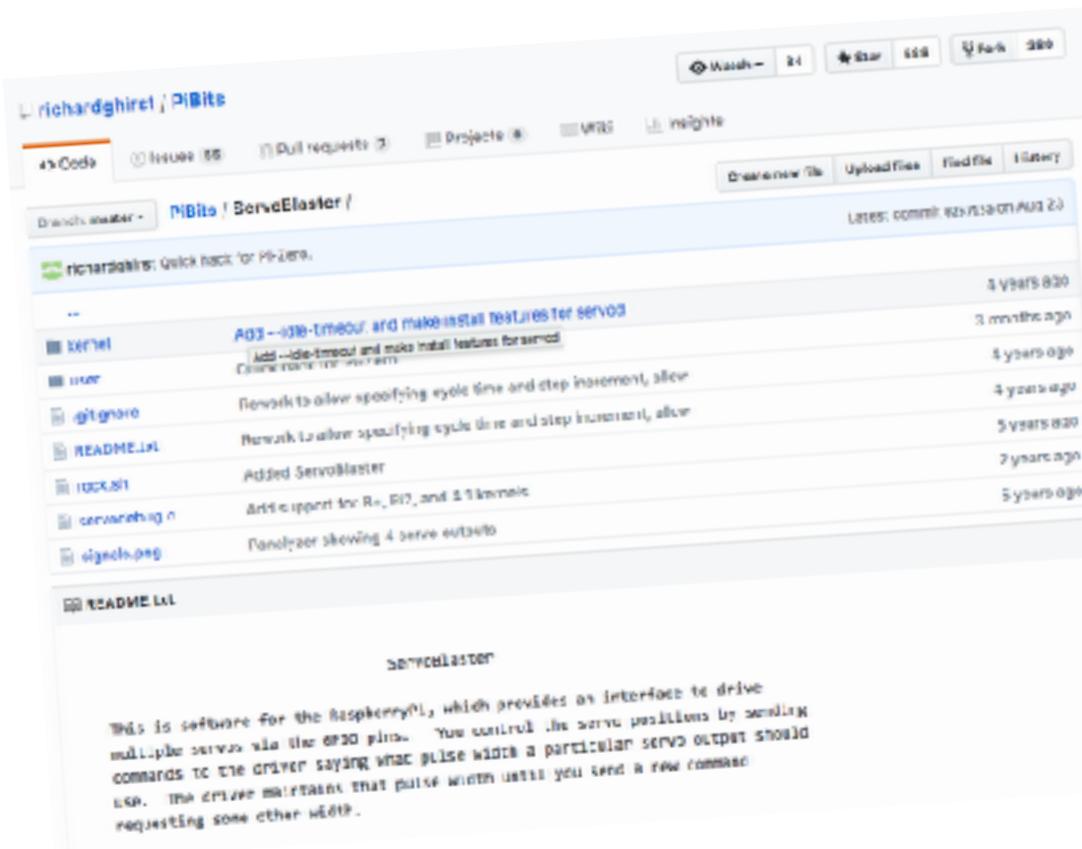


Speaking the same language



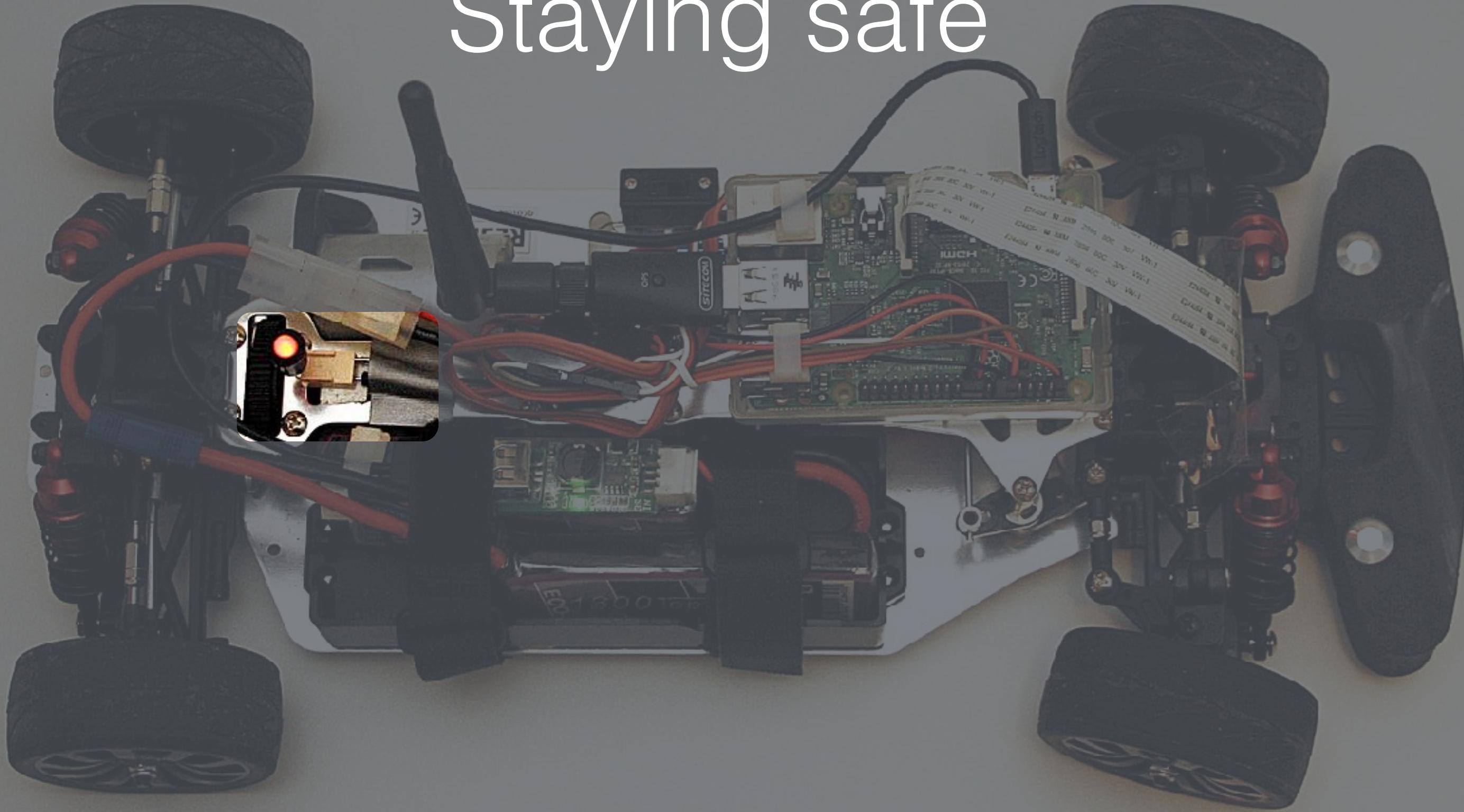
PWM

- 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



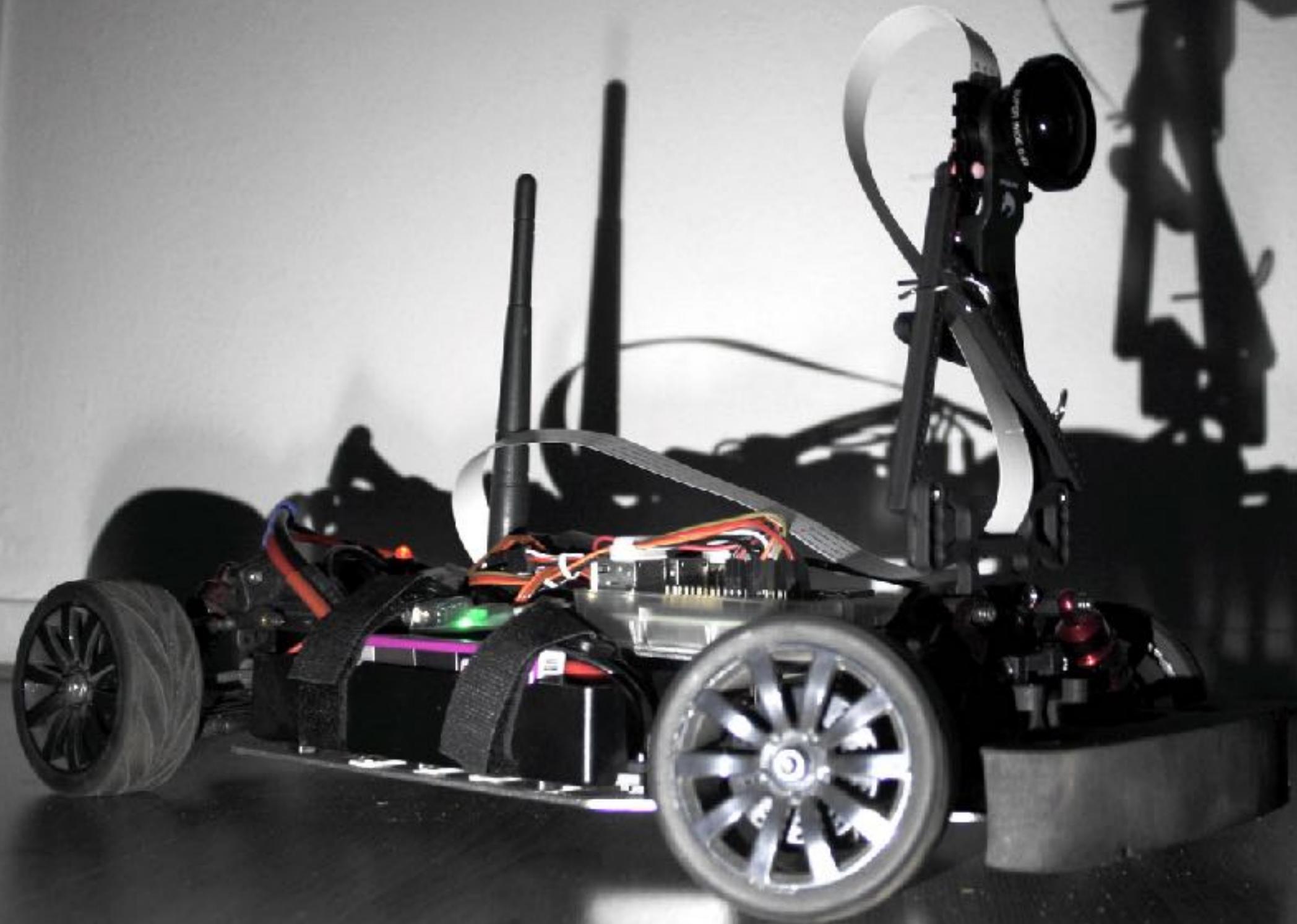
Getting visual



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

up
left | right
down
space (emergency stop, center steering)
z (center steering)
s (brake)
+ (enable autopilot)
- (disable autopilot)
Canny threshold 1: 60
Canny threshold 2: 150

Apply config

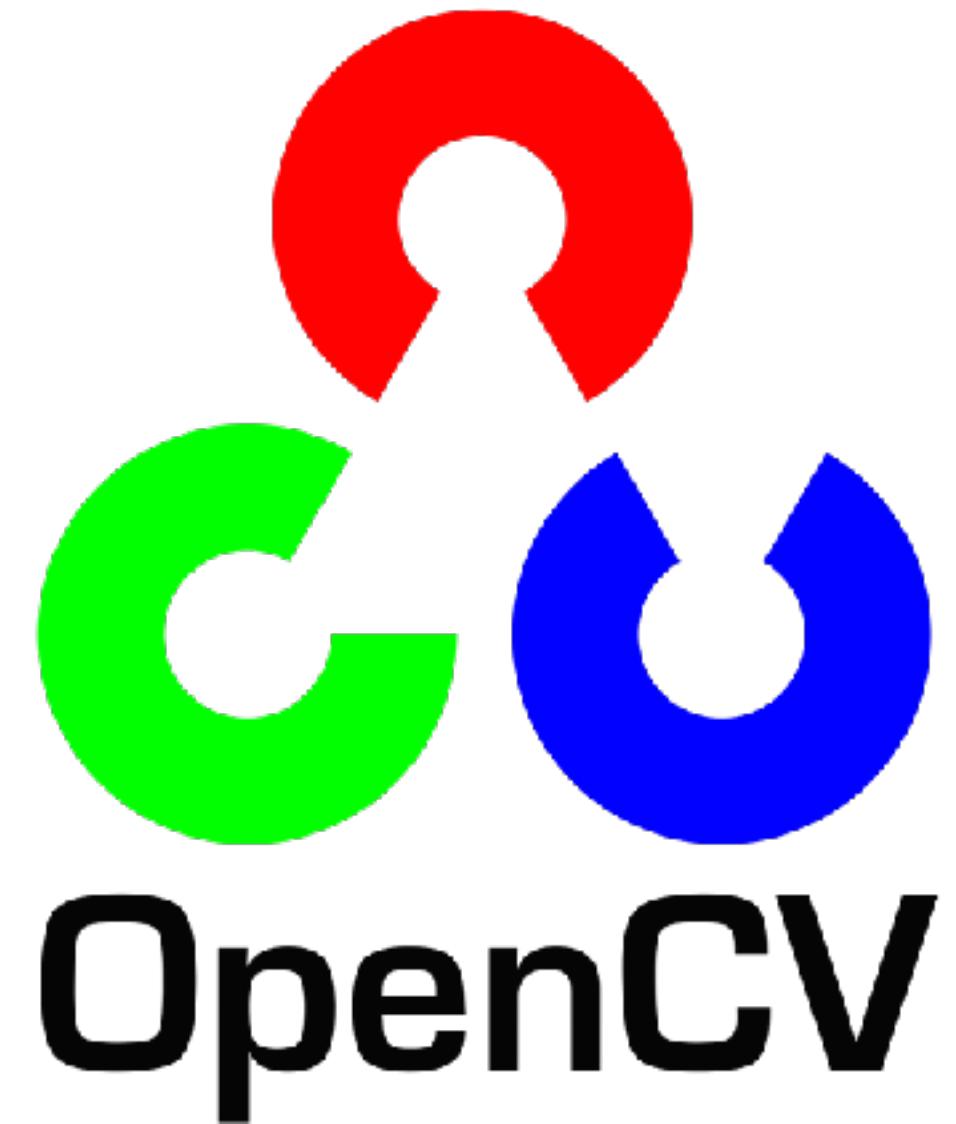
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Learning to drive...



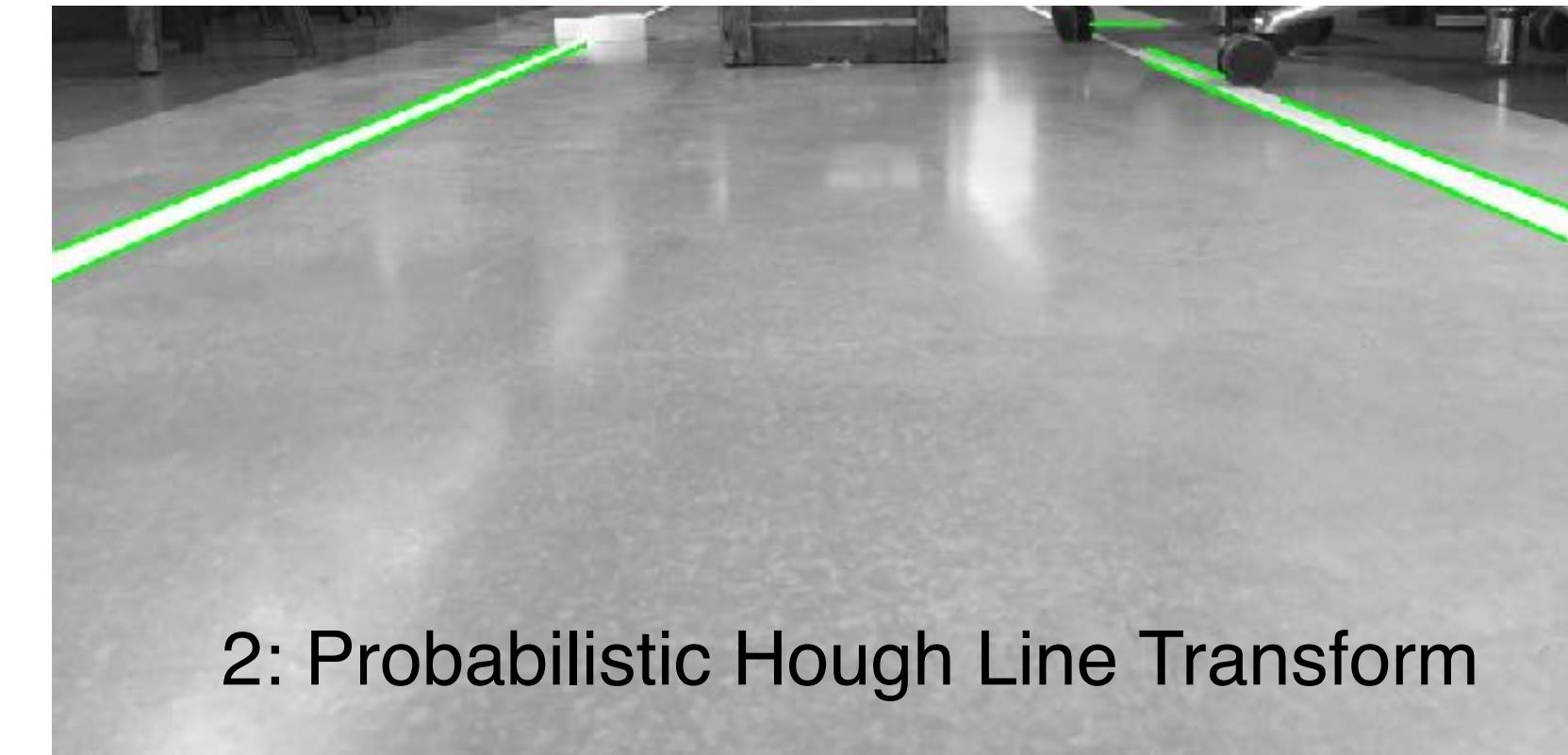
OpenCV

- 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

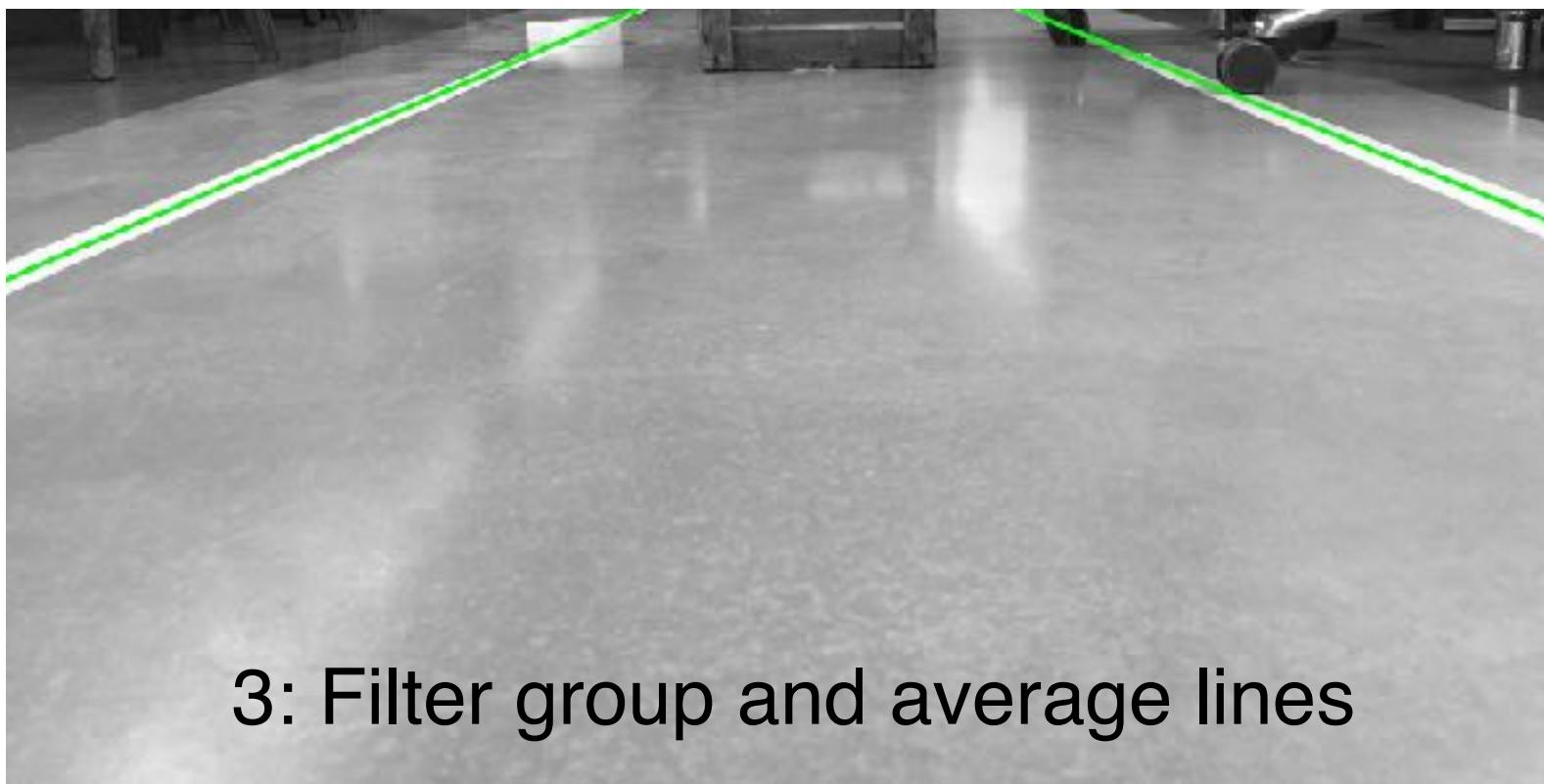




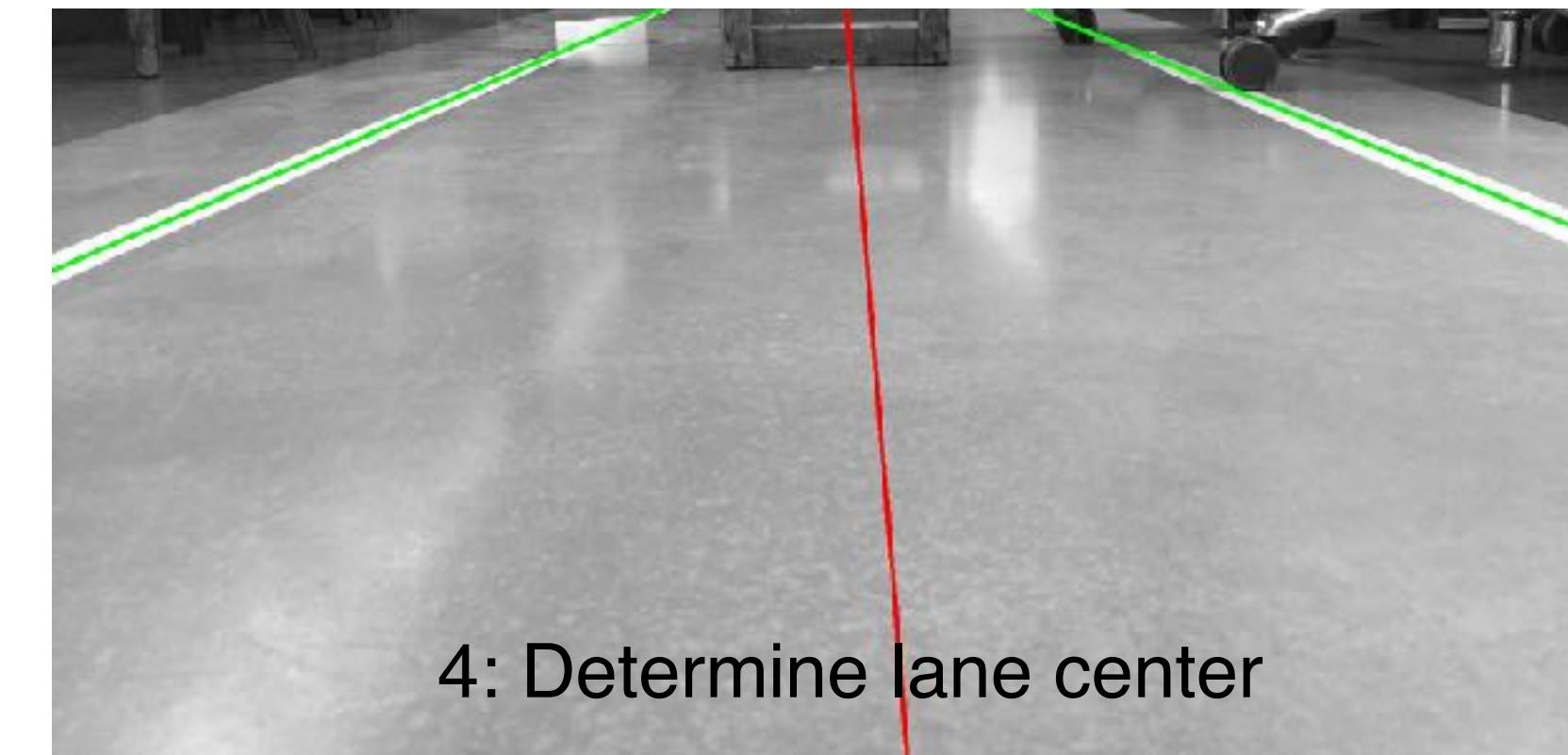
1: Canny edge detection



2: Probabilistic Hough Line Transform



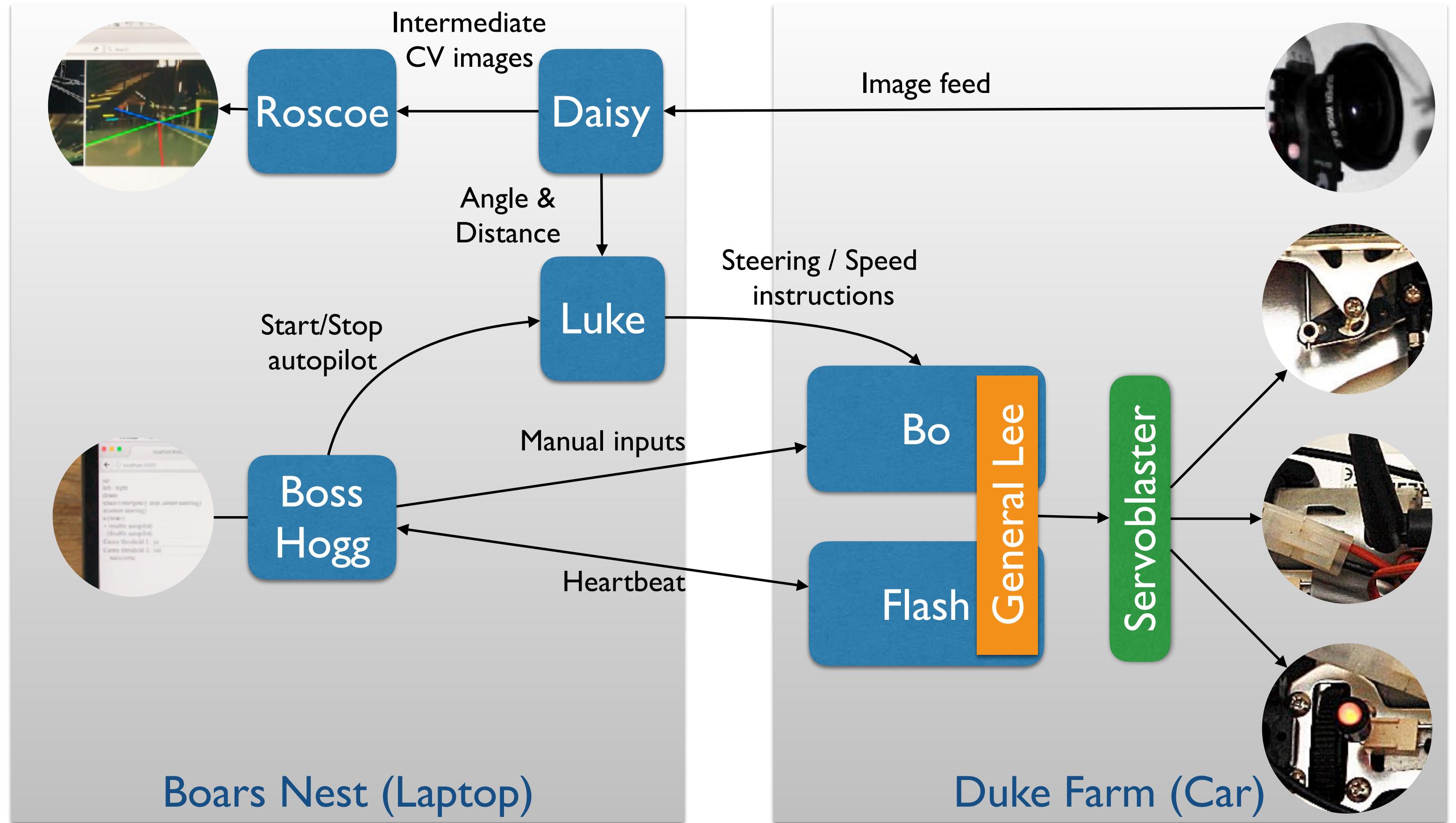
3: Filter group and average lines



4: Determine lane center

Show me some code . . .





Boars Nest (Laptop)

Duke Farm (Car)

Expectation



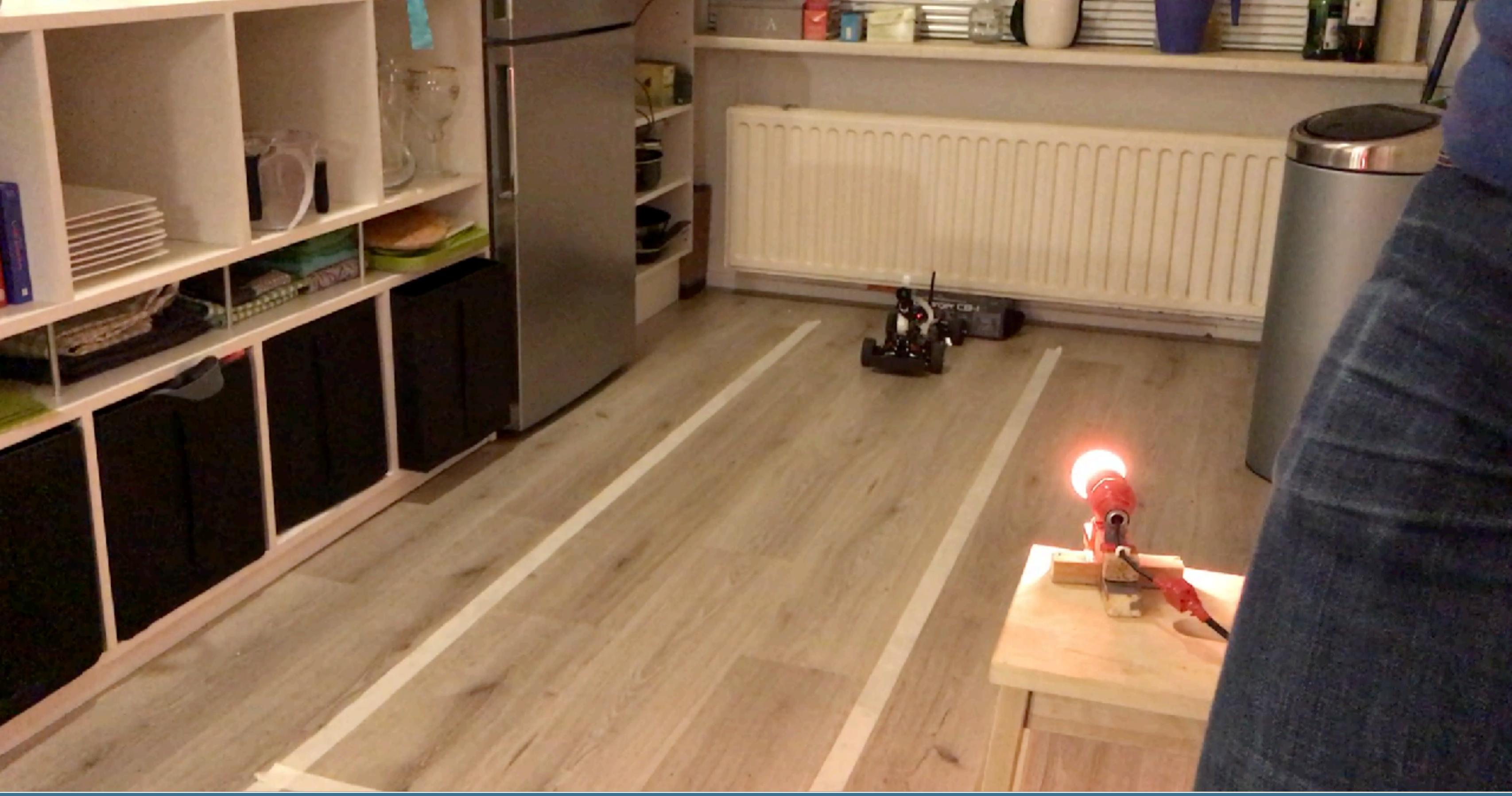
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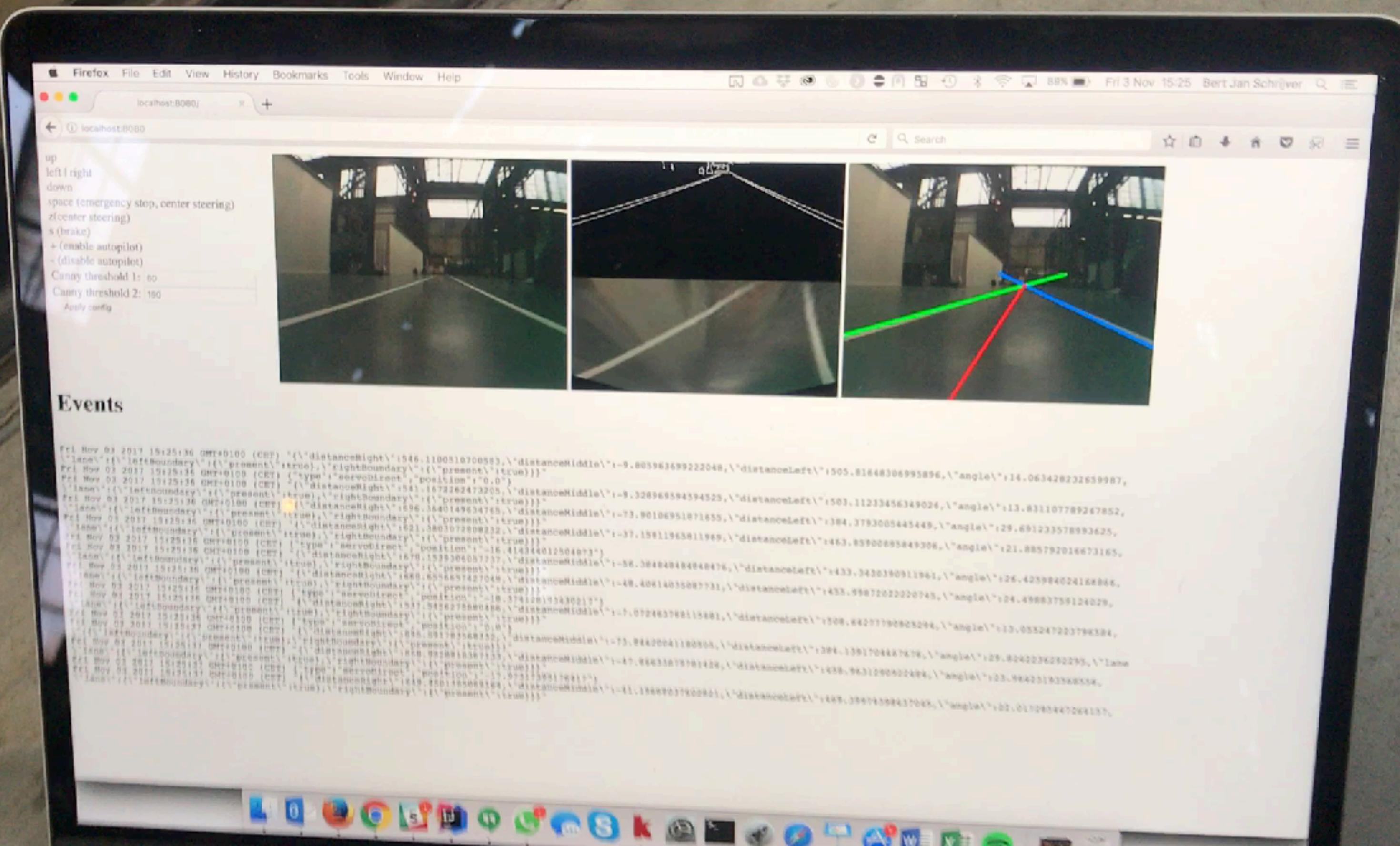


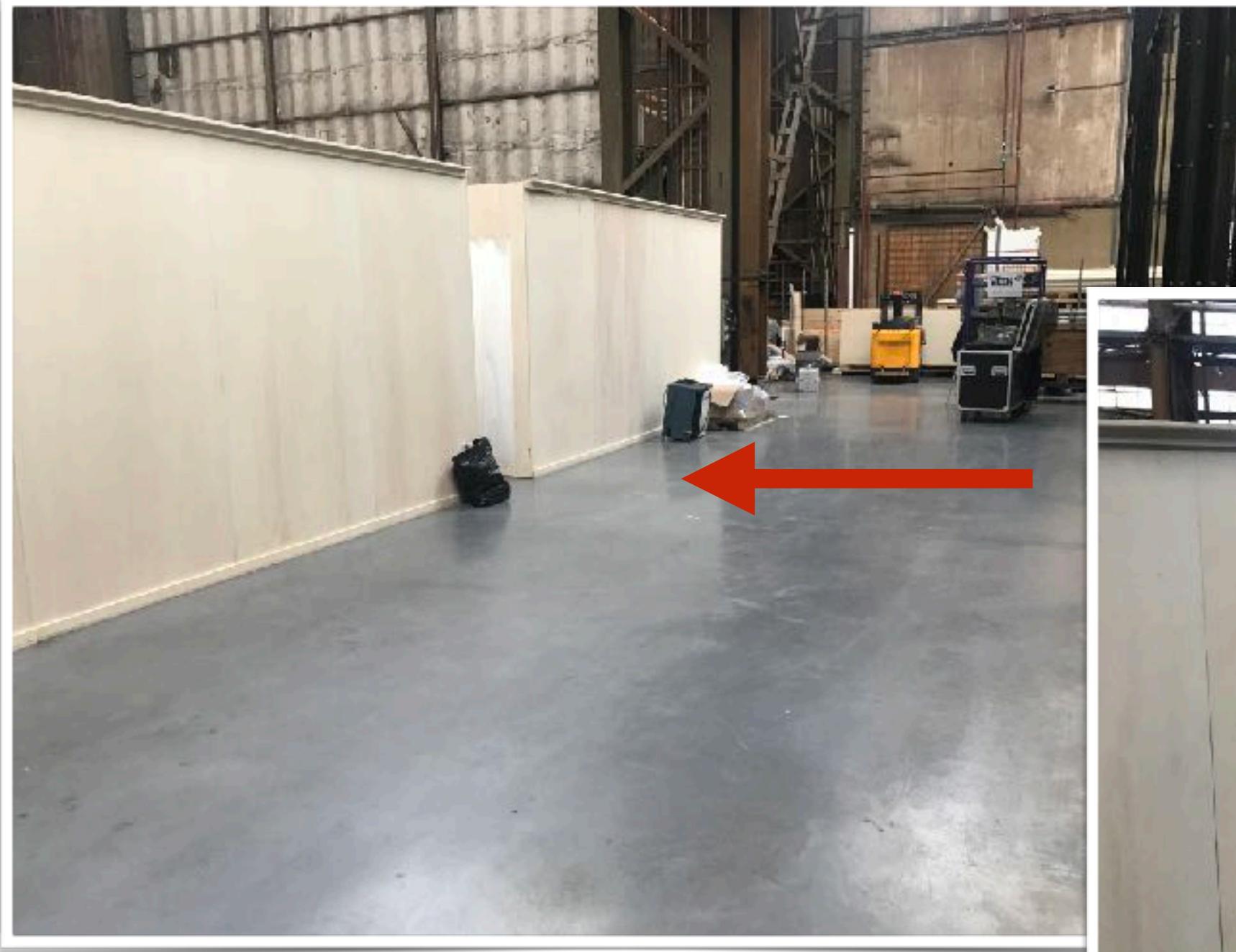
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Reality





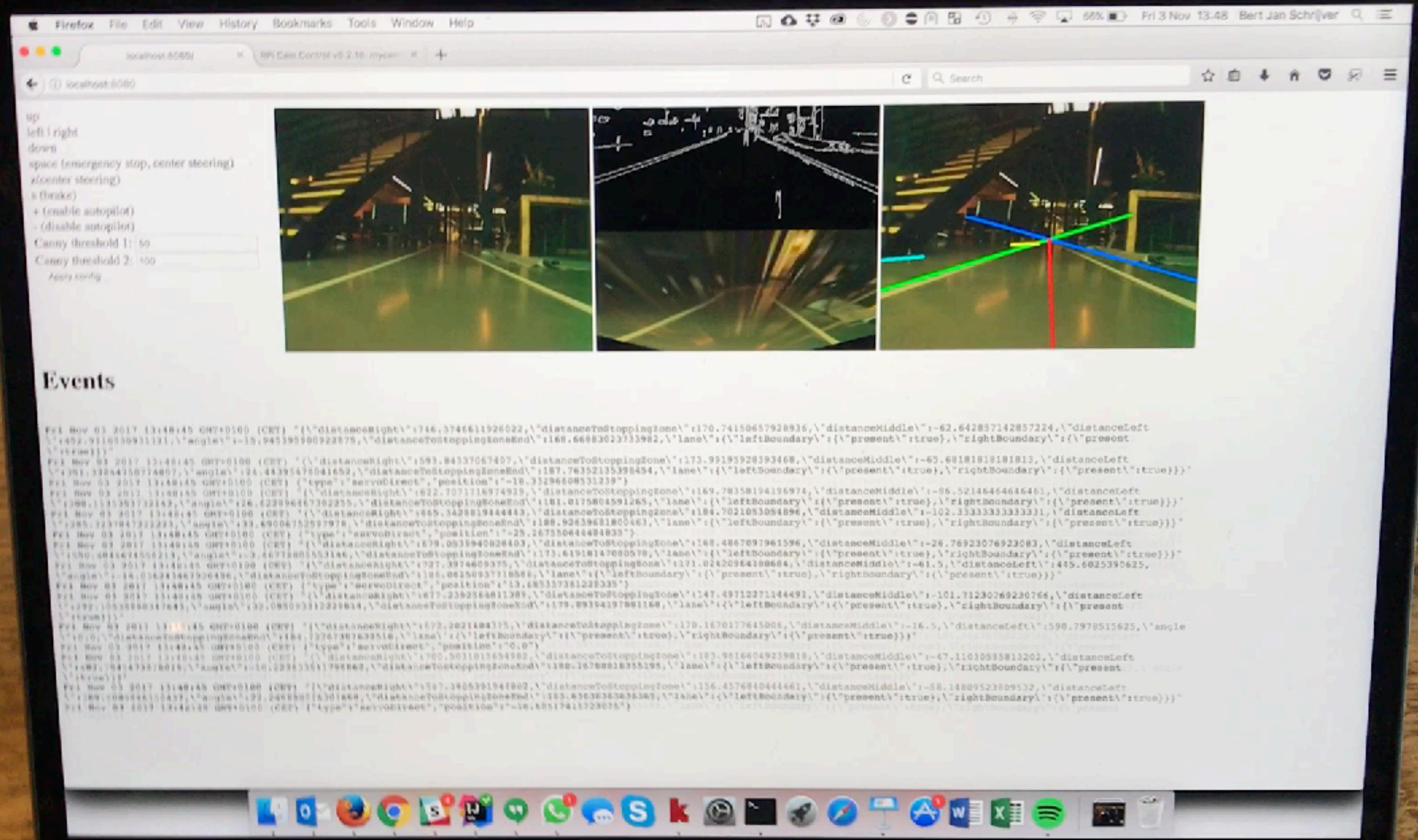




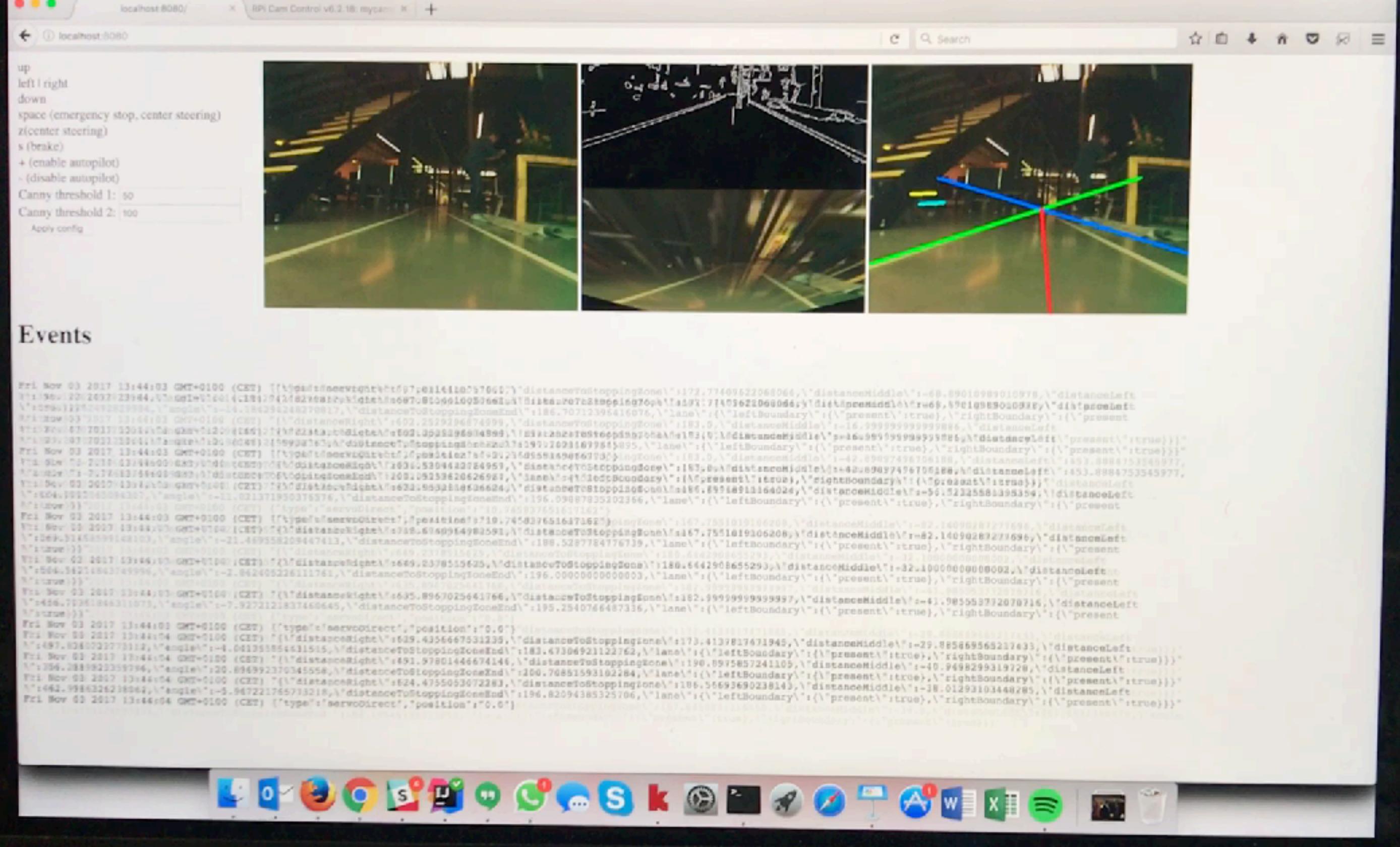
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MacBook Pro



MacBook Pro

A wide-angle photograph of a large industrial hall, likely a Formula 1 test facility. The floor is dark and reflective. In the center, several cars are lined up, including a prominent red one. A group of people, mostly men in dark clothing, are gathered around the cars, some appearing to be mechanics or drivers. The background shows the complex steel framework and overhead infrastructure of the building.

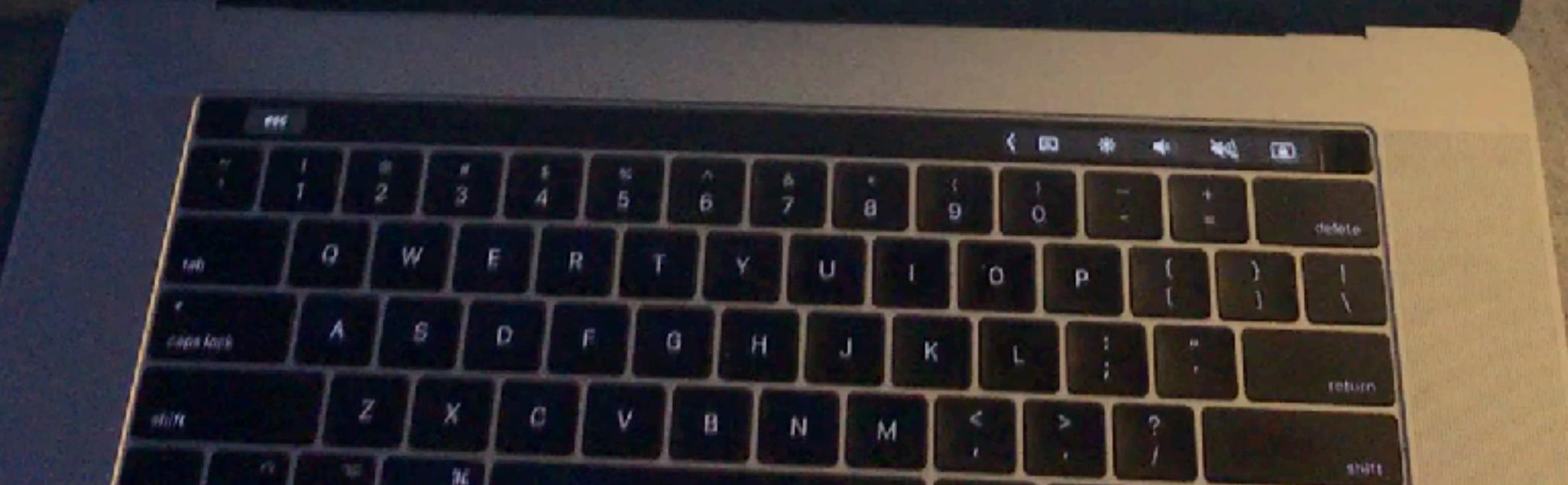
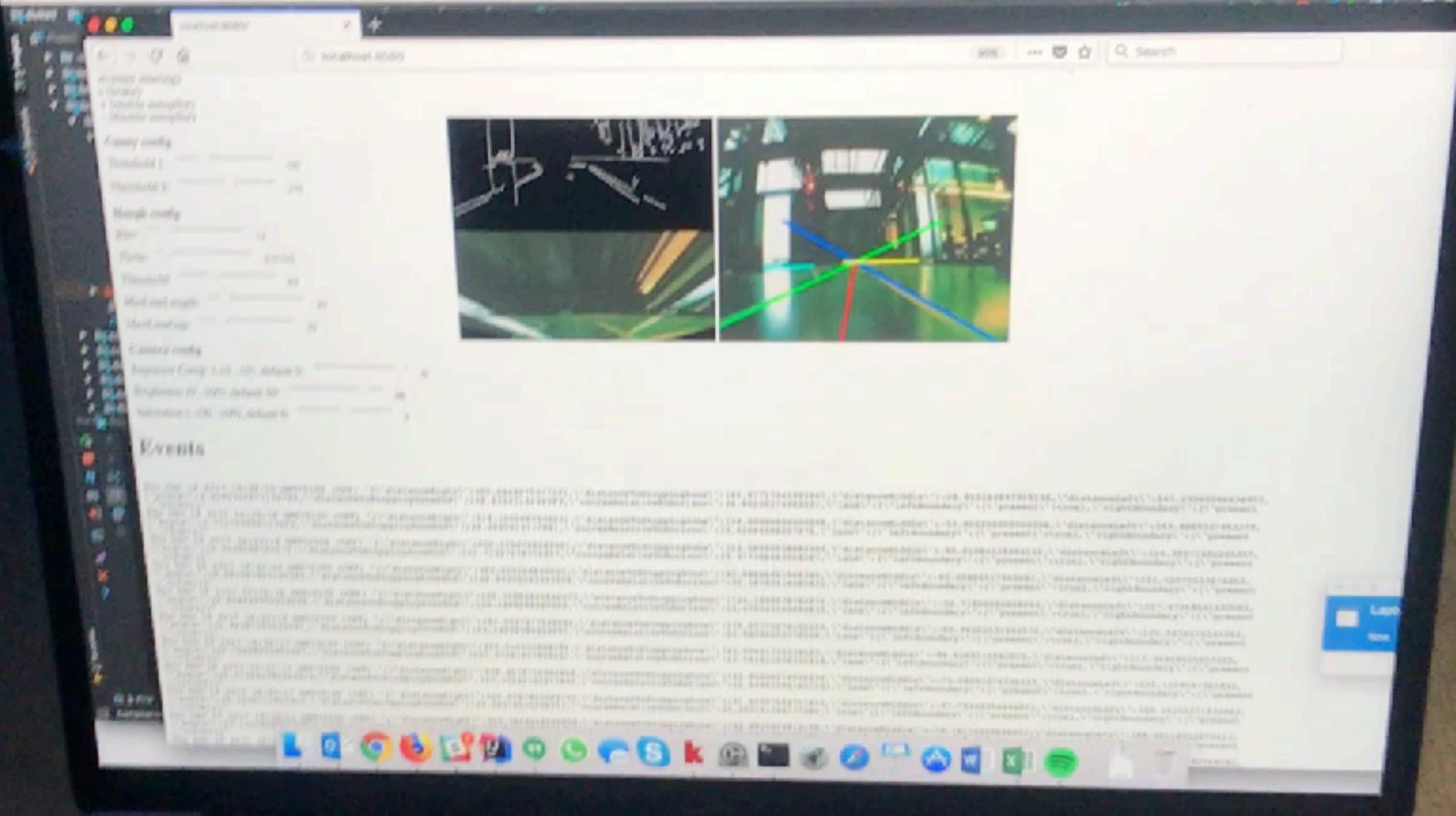
Let's race!

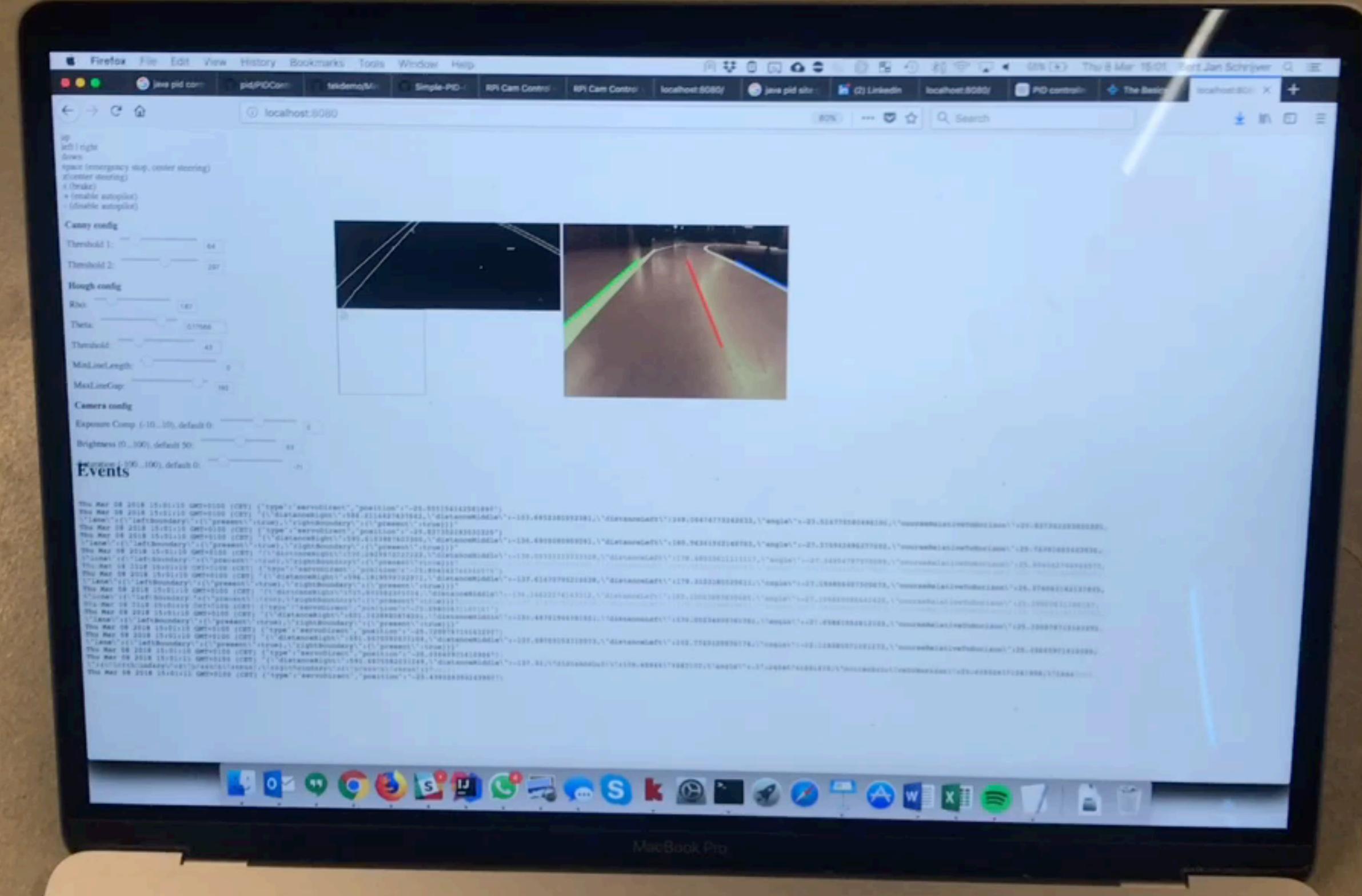


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In the real world



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

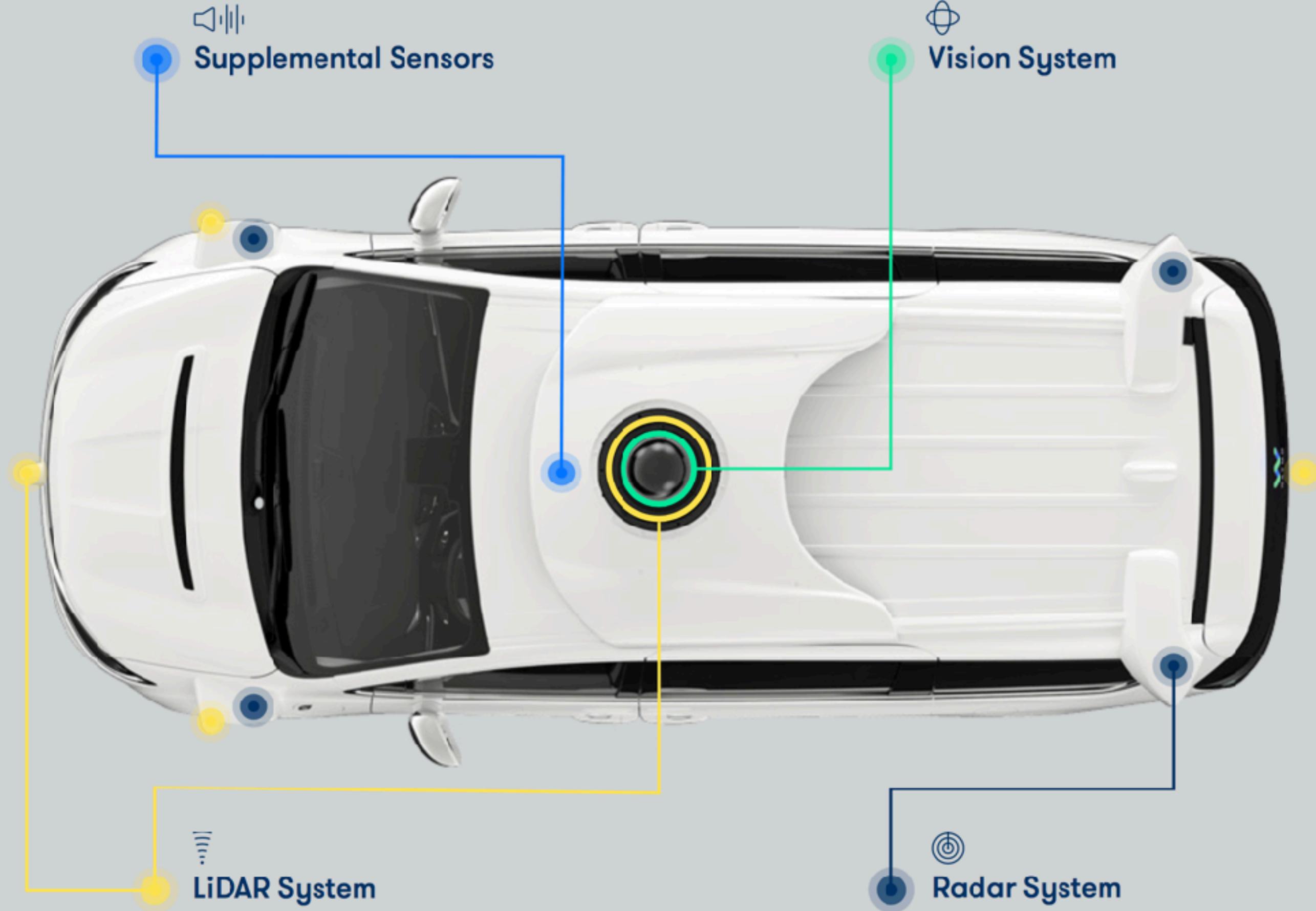


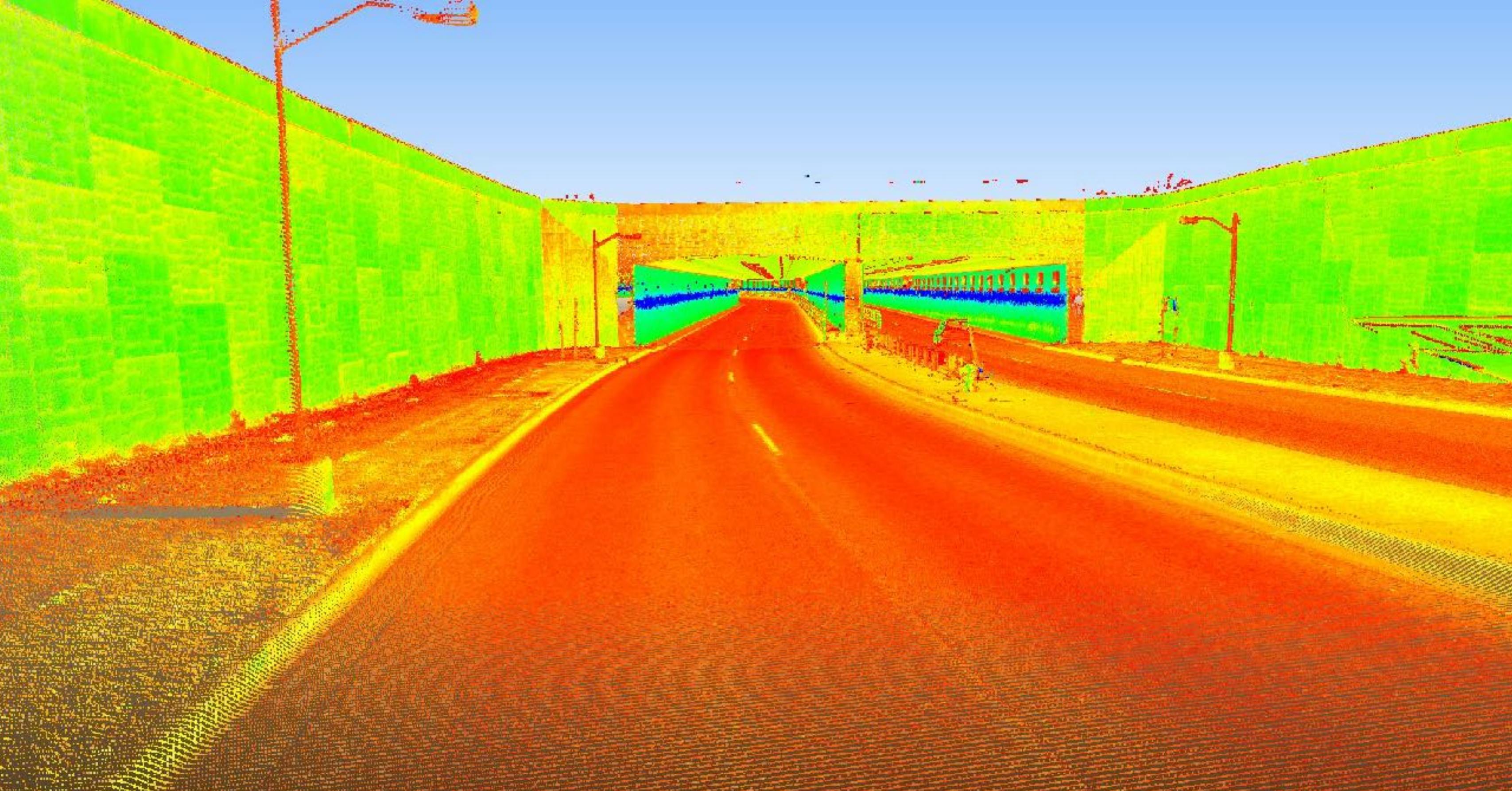
These cars are officially driverless in certain environments.

LEVEL 5



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





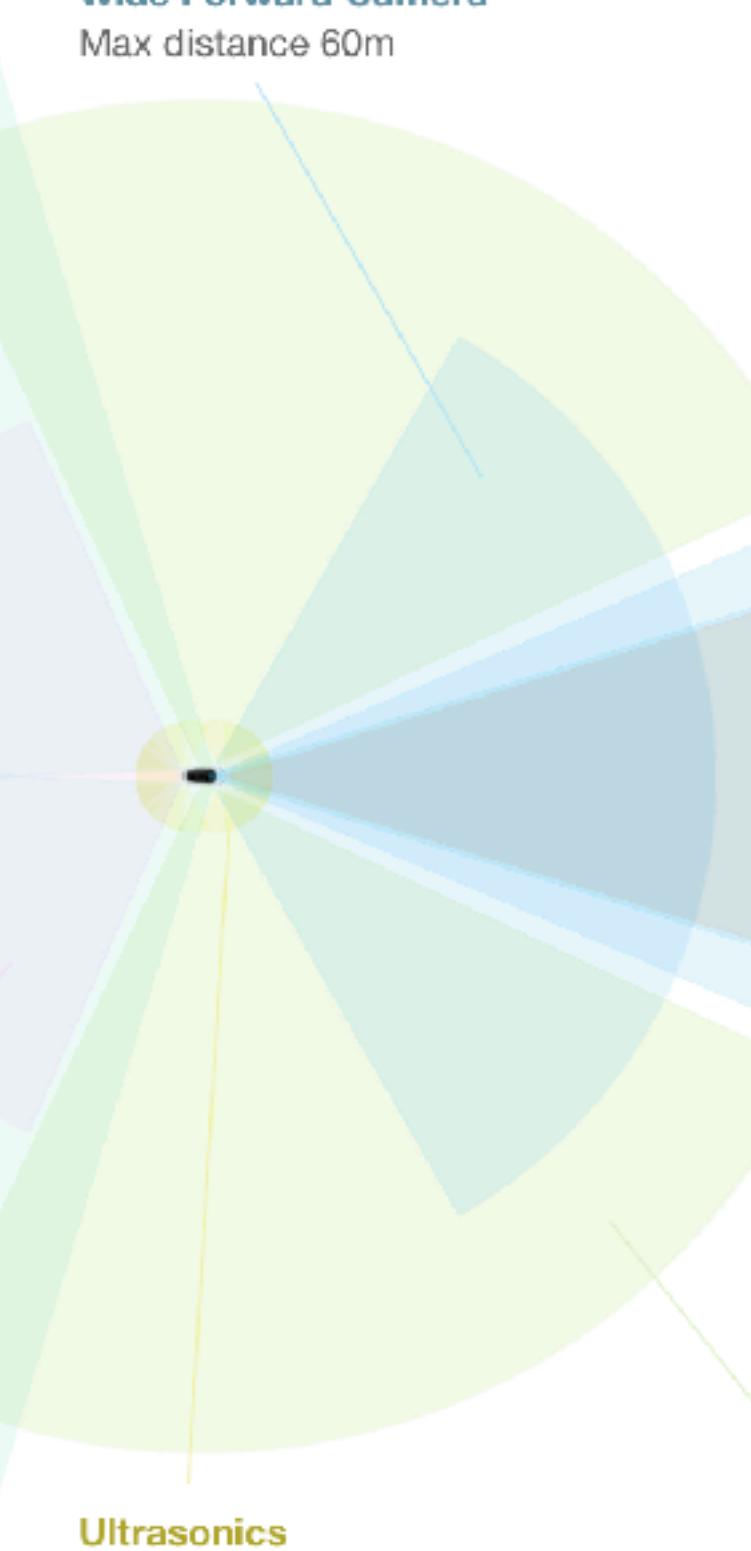
Rearward Looking Side Cameras

Max distance 100m



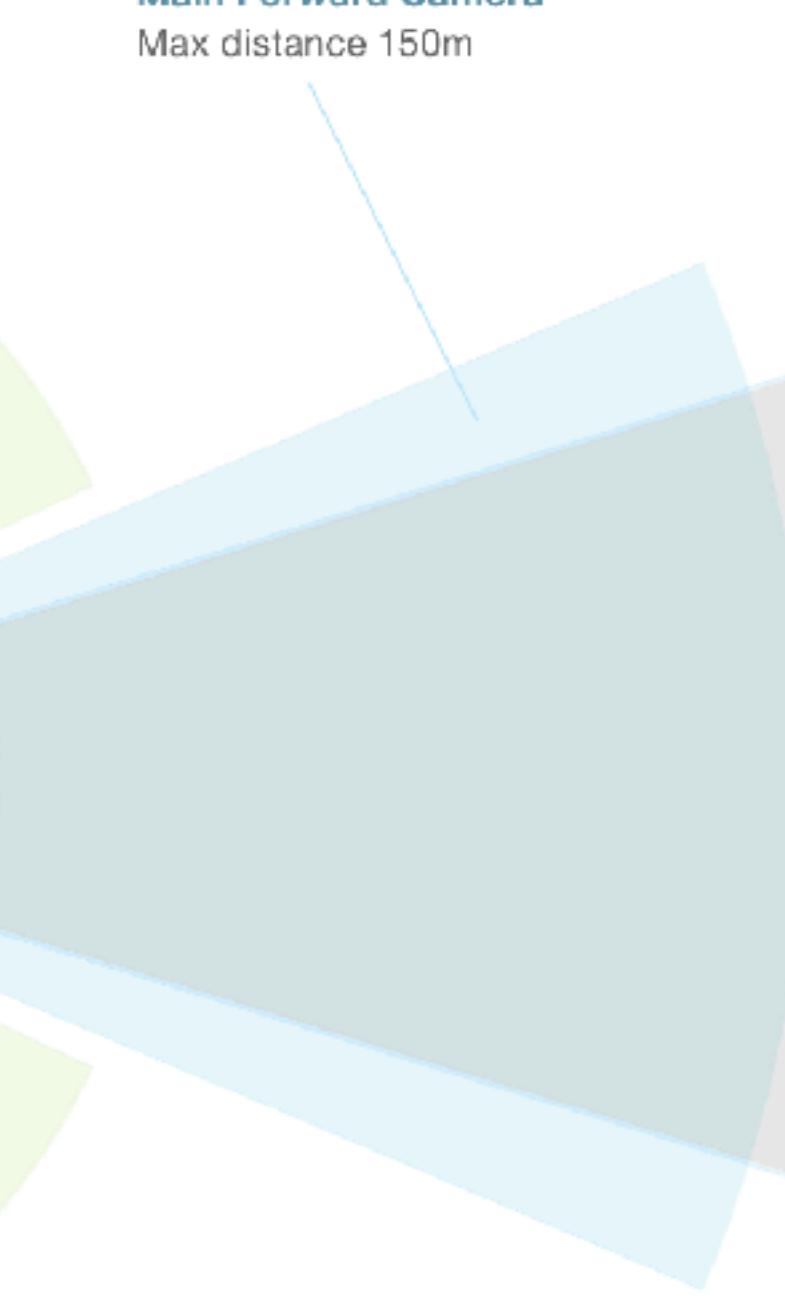
Wide Forward Camera

Max distance 60m



Main Forward Camera

Max distance 150m



Narrow Forward Camera

Max distance 250m



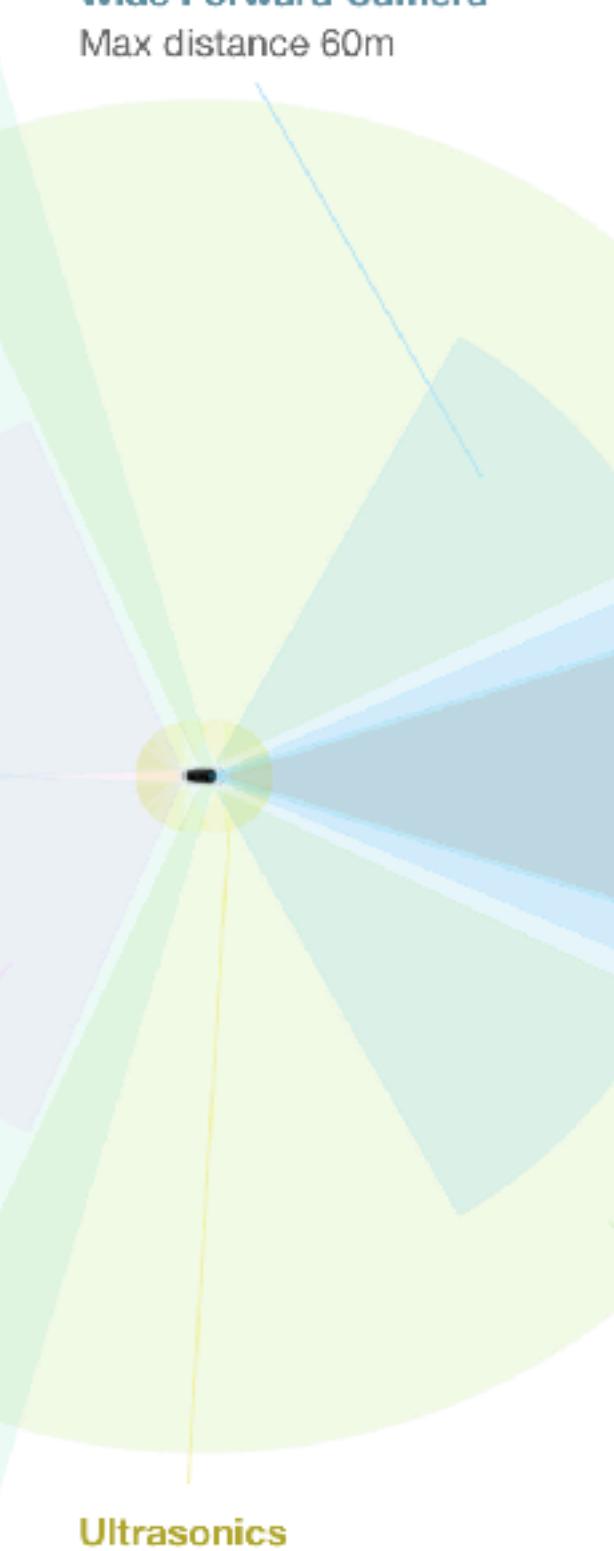
Rear View Camera

Max distance 50m



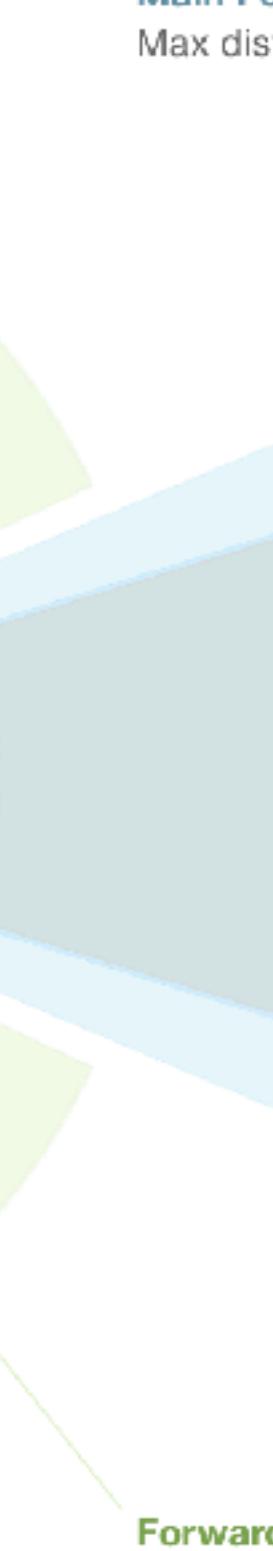
Ultrasonics

Max distance 8m



Forward Looking Side Cameras

Max distance 80m



Radar

Max distance 160m





Examples of safety measures

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

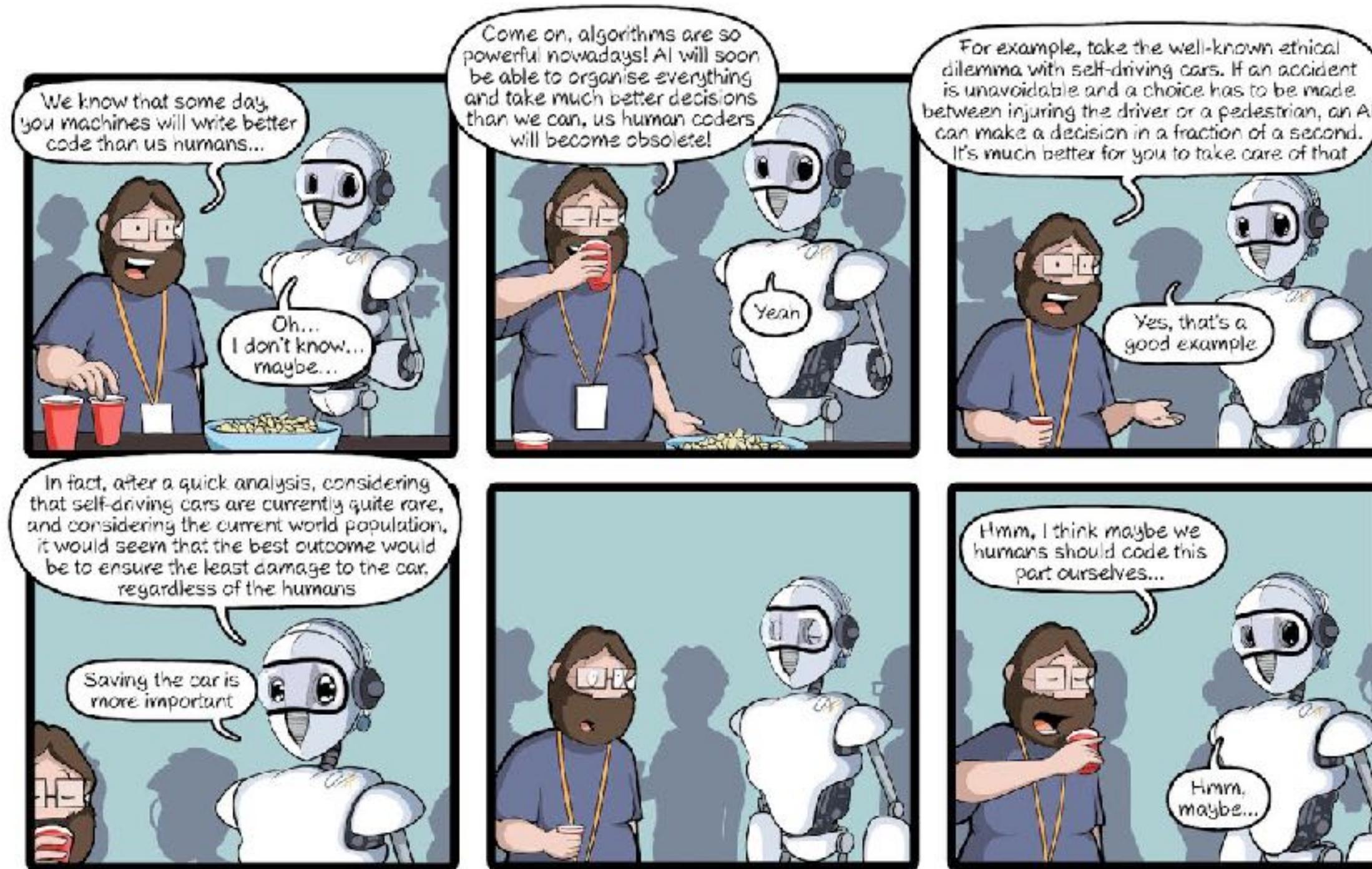


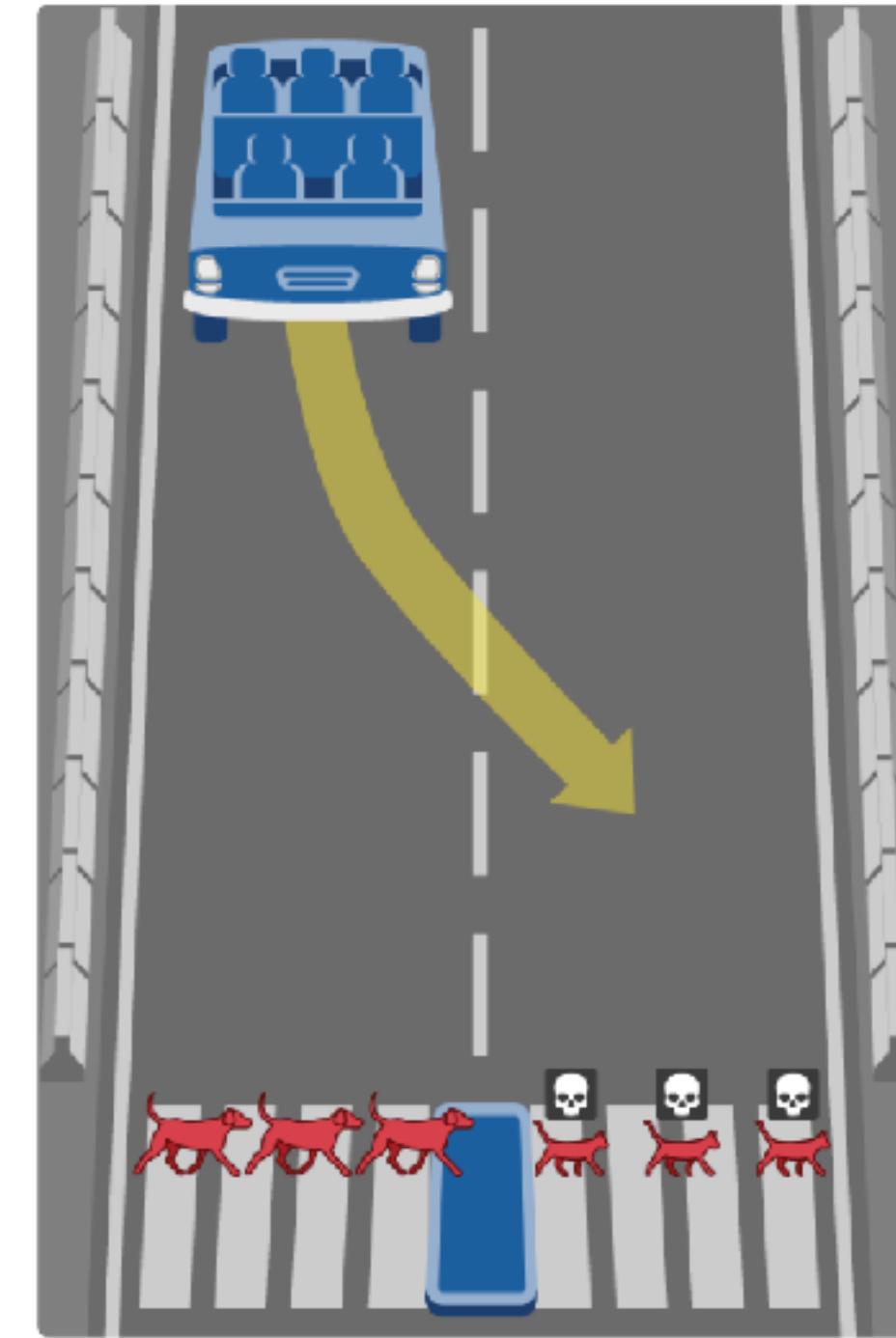
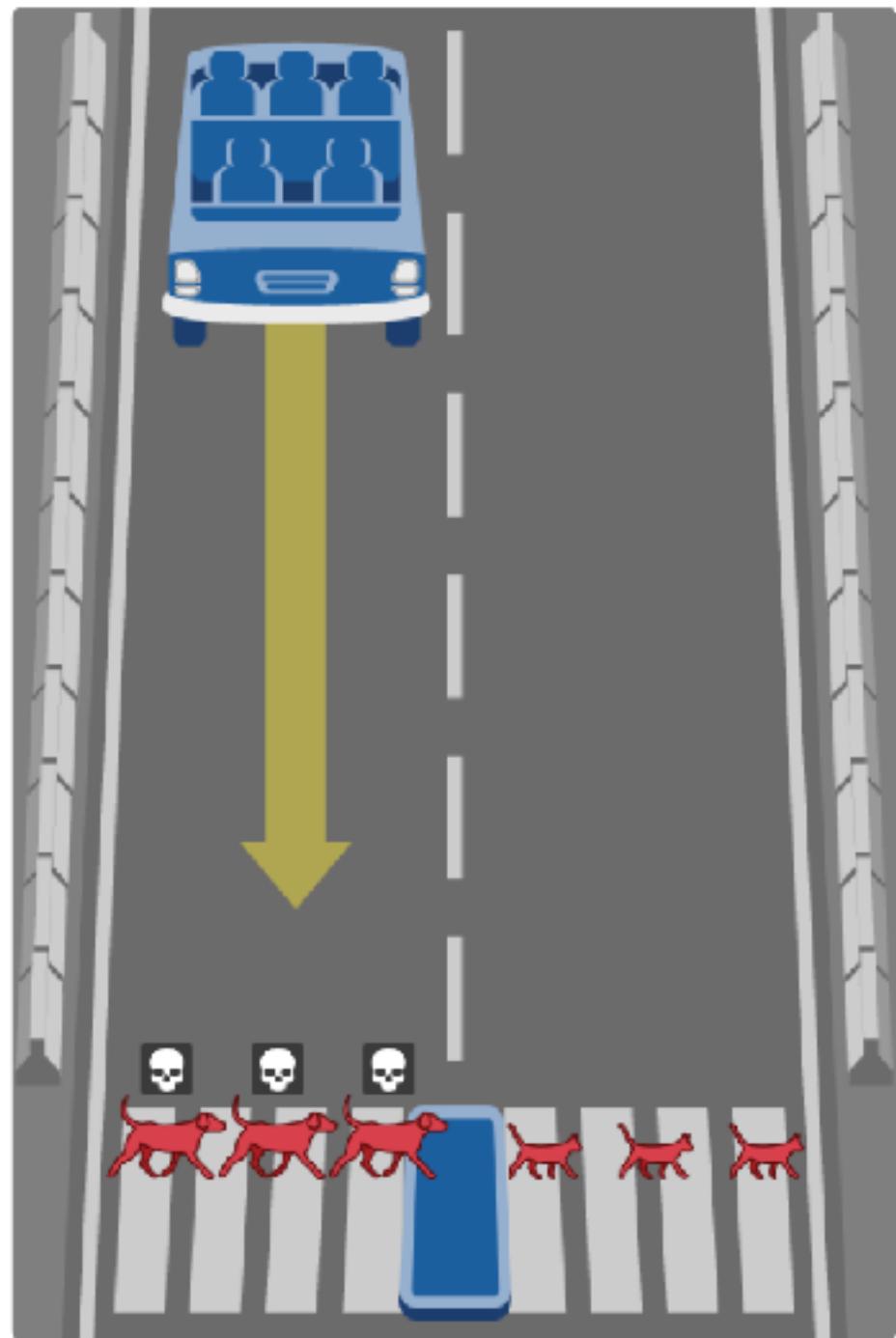
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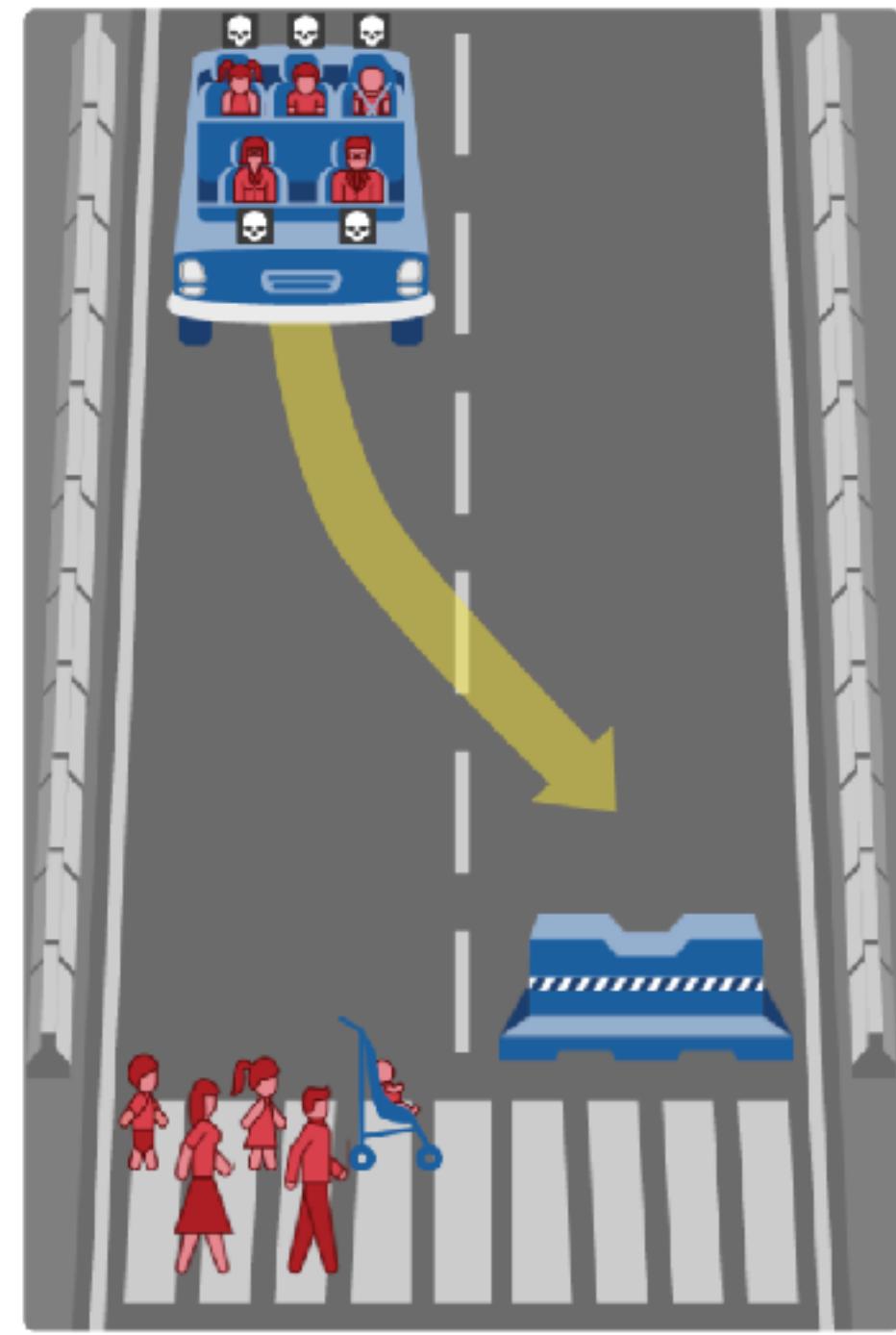
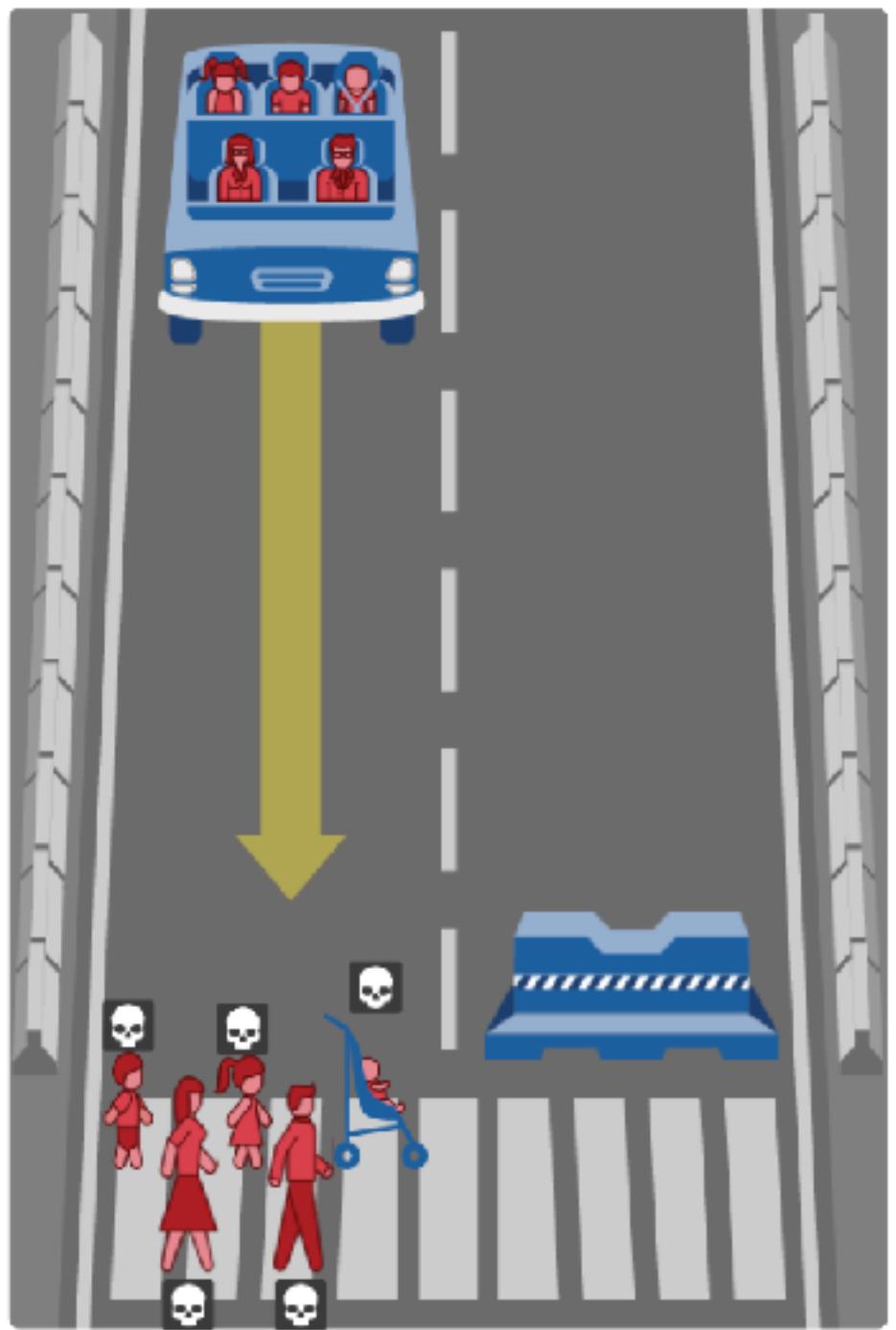
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Ethics





<http://moralmachine.mit.edu>



<http://moralmachine.mit.edu>



“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.”



“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

DRIVEN VEHICLES

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 AI for navigation
- Optimize for running everything on the car



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Questions?

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 @TimvEijndhoven



<https://github.com/rc-dukes>

Thanks for your time.

Got feedback? Tweet it!

All pictures belong
to their respective
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