



# Building a self-driving RC car

Bert Jan Schrijver  
bertjan@openvalue.de







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Bert Jan Schrijver  
Tim van Eijndhoven

JPoint



#Devoxx #RoboRace

@bjschrijver @TimvEijndhoven



# Let's meet



Bert Jan Schrijver

OPENVALUE

nl.  
jug





# Let's meet



Tim van Eijndhoven

Jpoint

POLITIE



# How it all started...





# RoboRace challenge



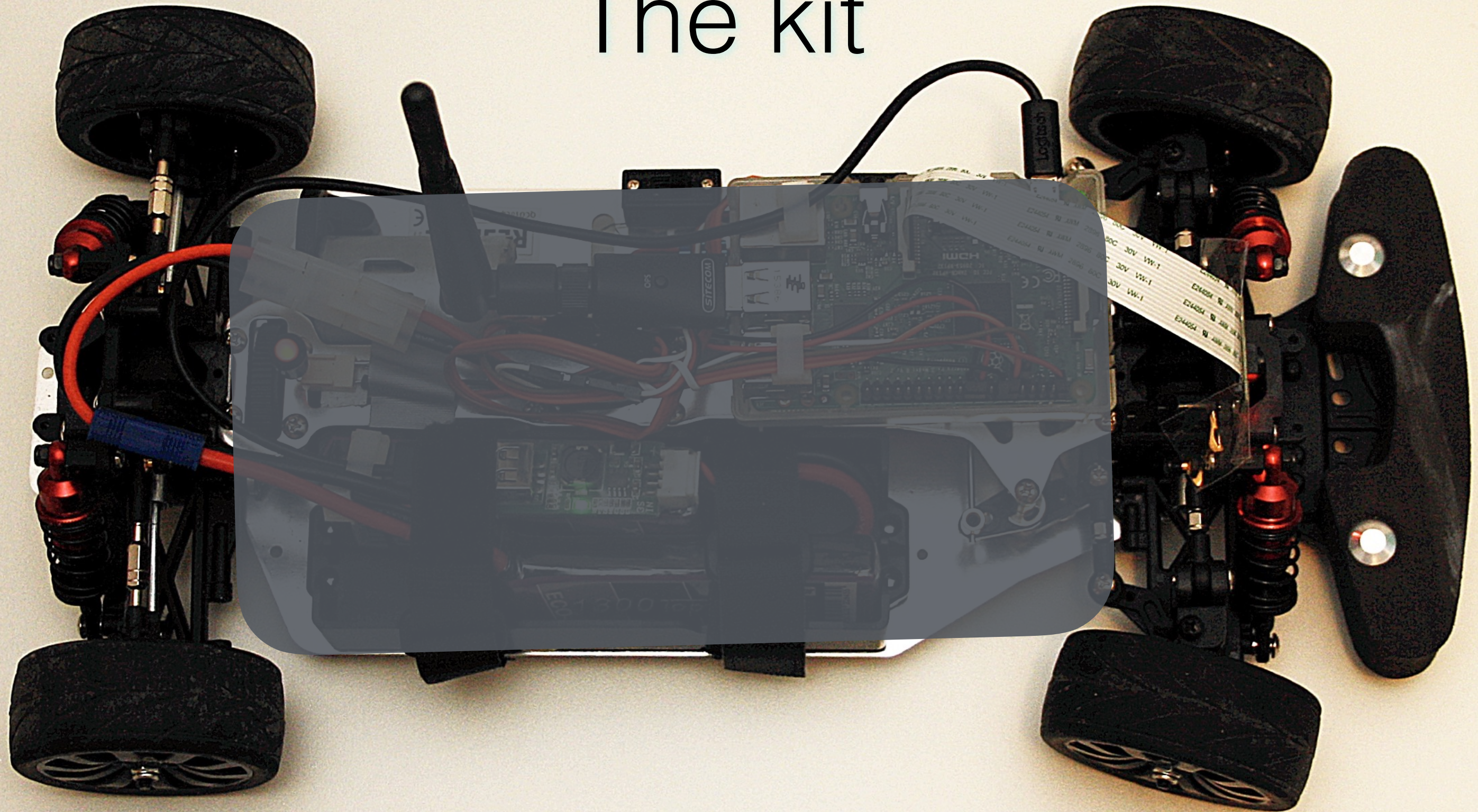


# The rules

- 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)

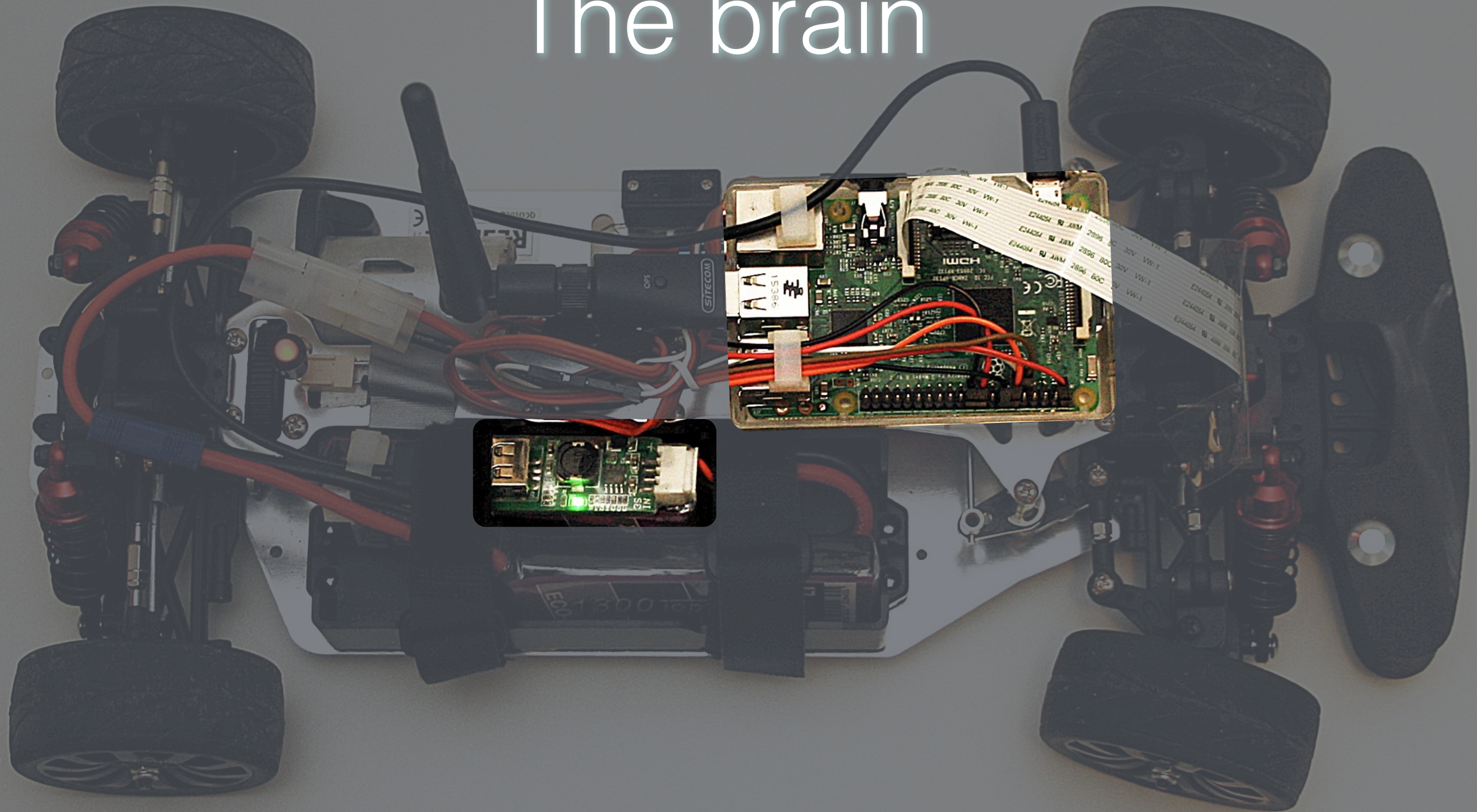


# The kit





# The brain





# The platform





# Vert.x

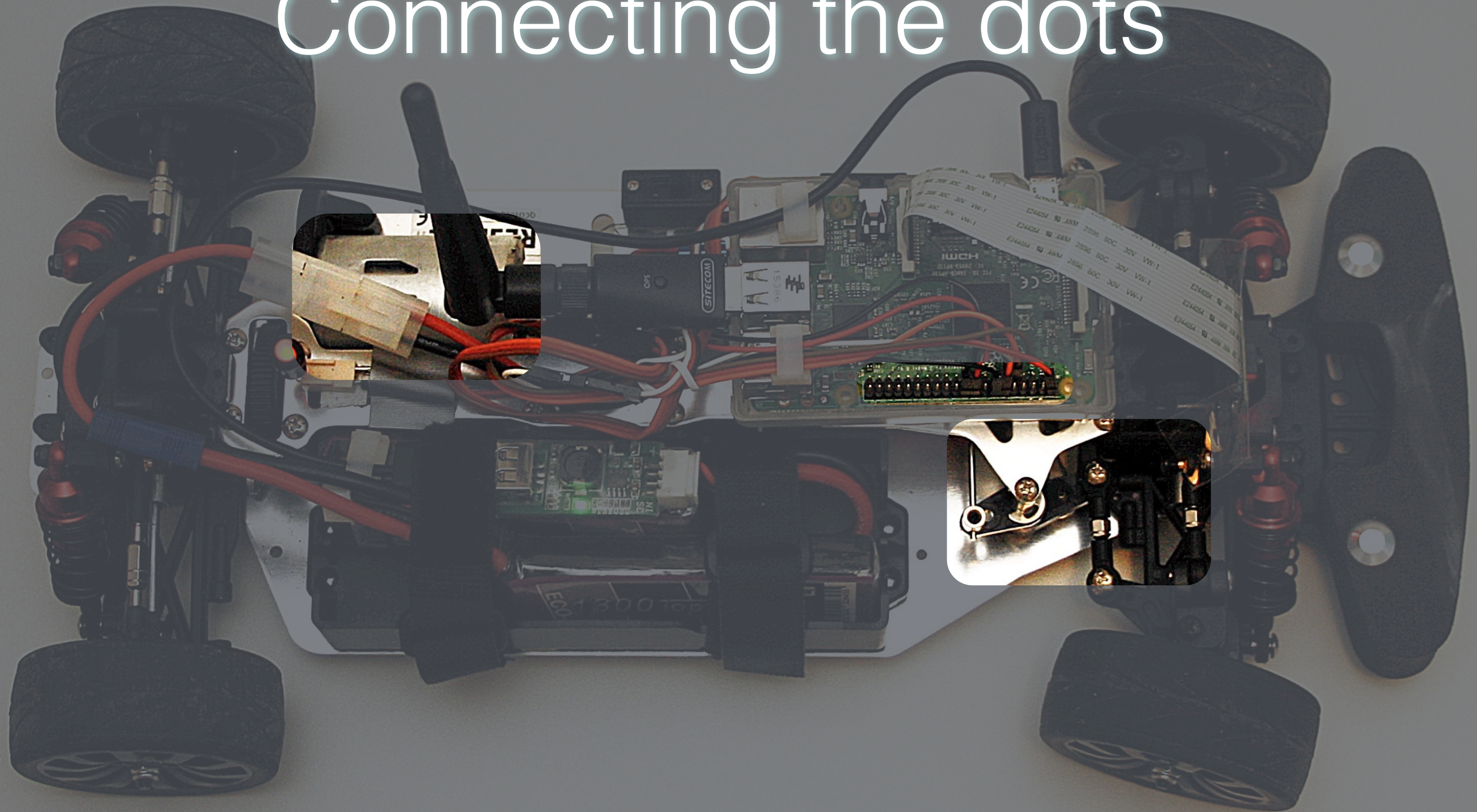
- Toolkit for building reactive applications on the JVM
- Event-driven, non-blocking
- General purpose application framework
- Why Vert.x for our project?
  - Lightweight, fast
  - Polyglot
  - Distributed eventbus (browser included!)



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



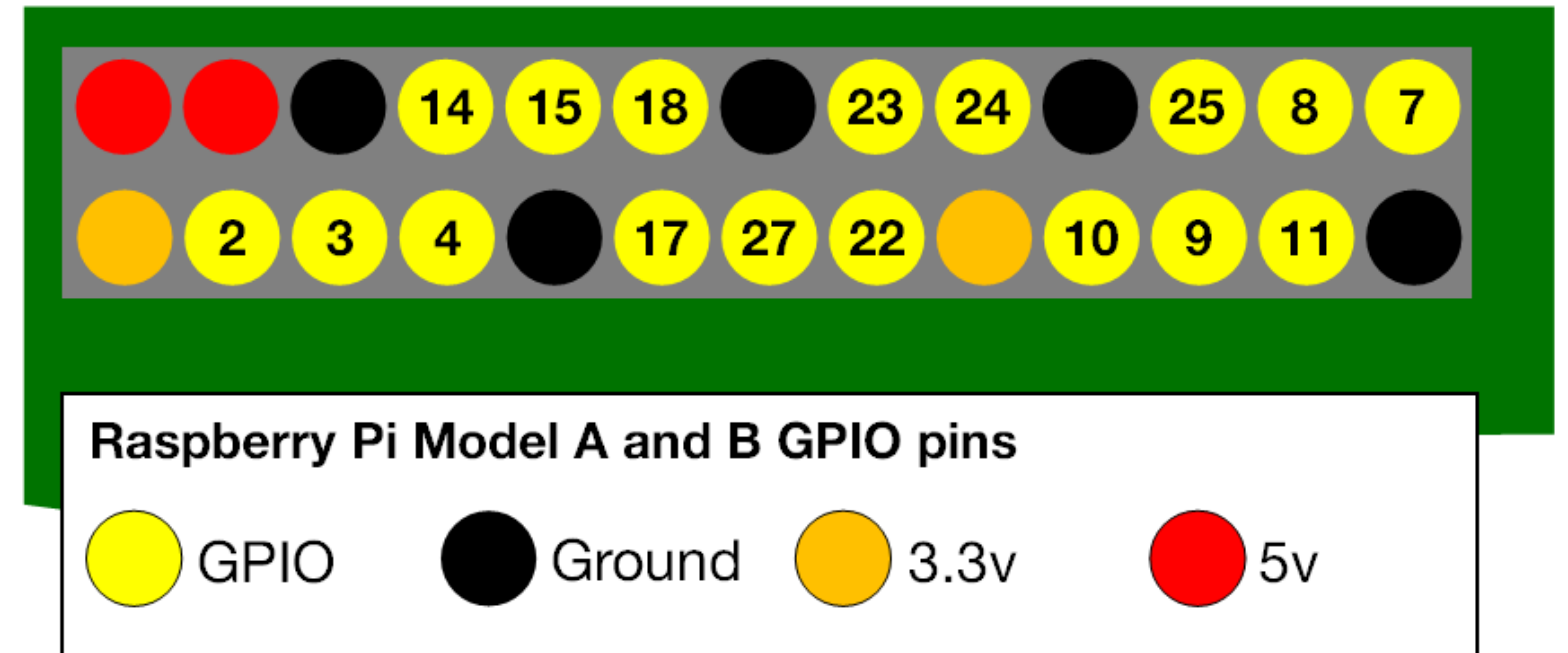
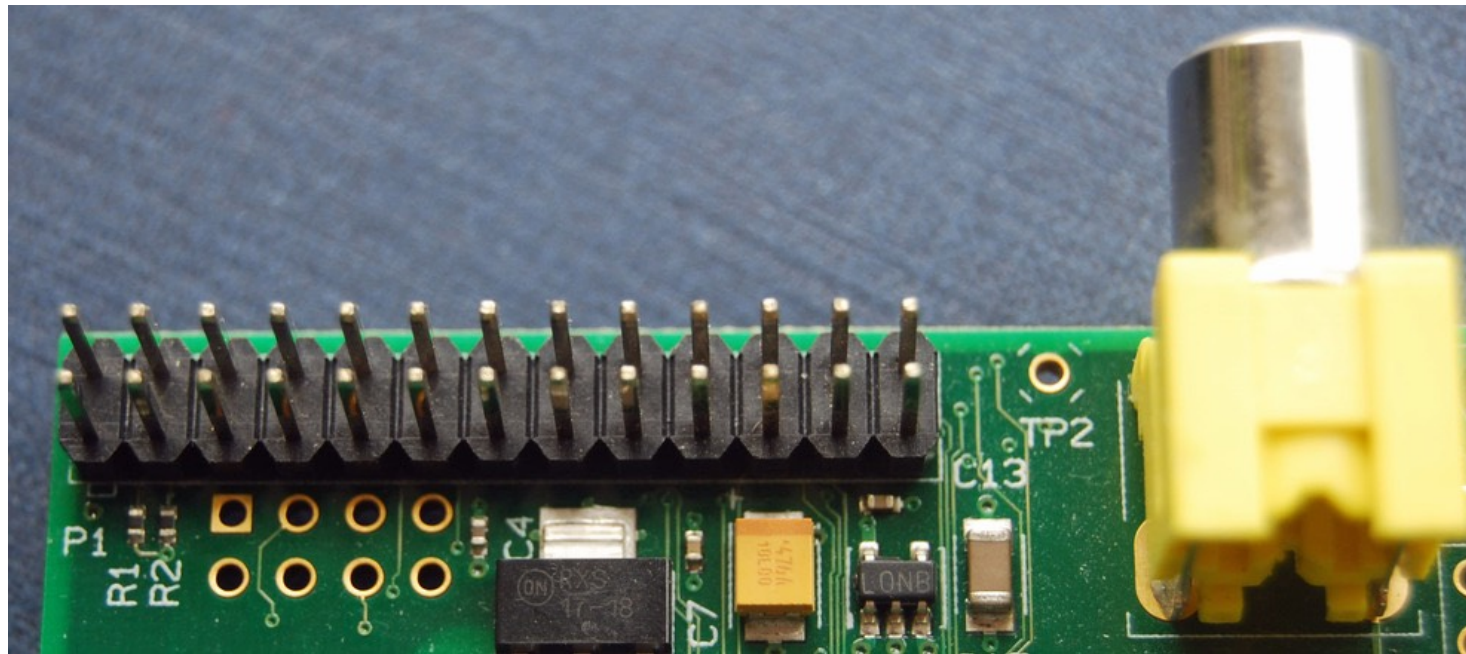
# Connecting the dots





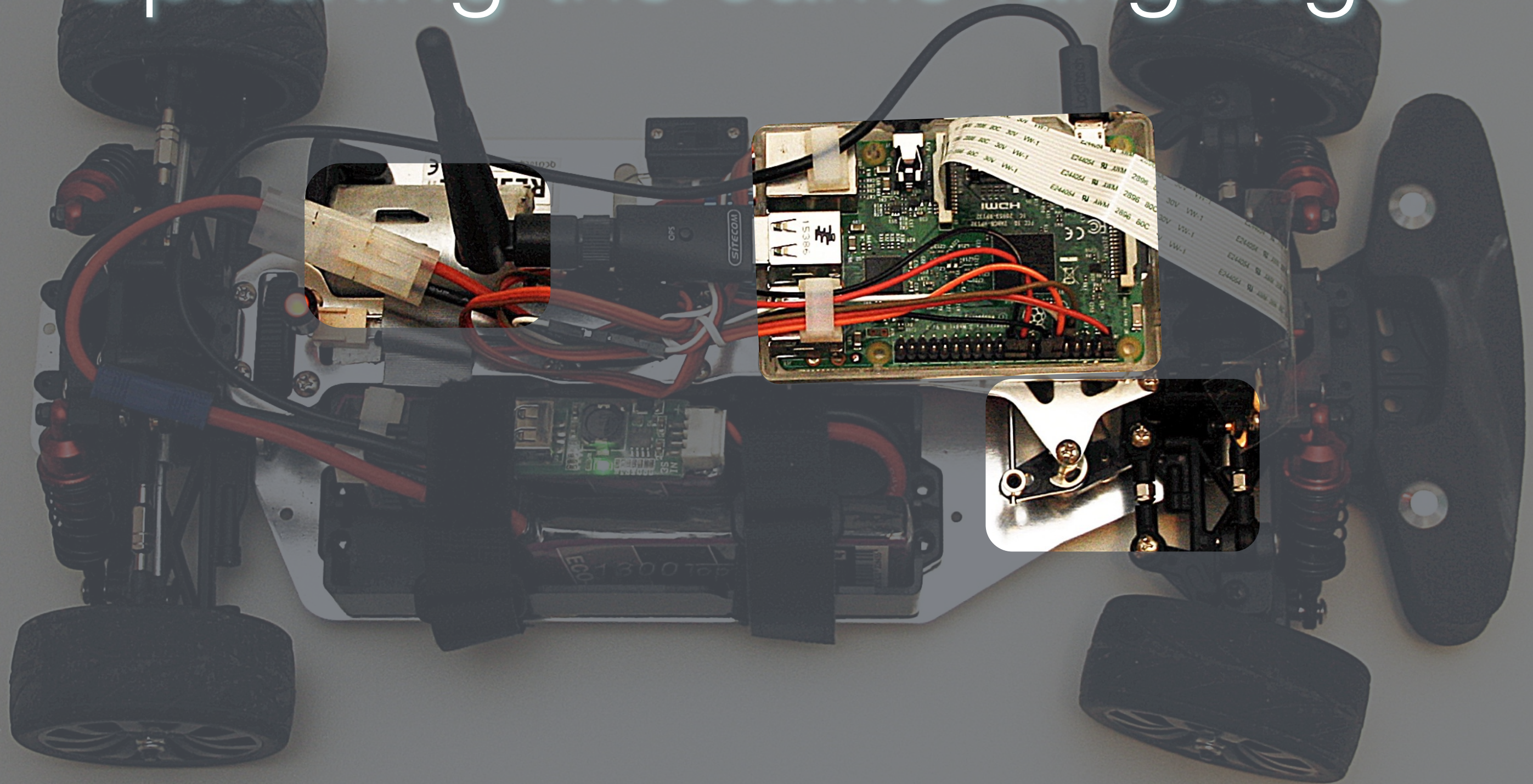
# GPIO

- General purpose input/output





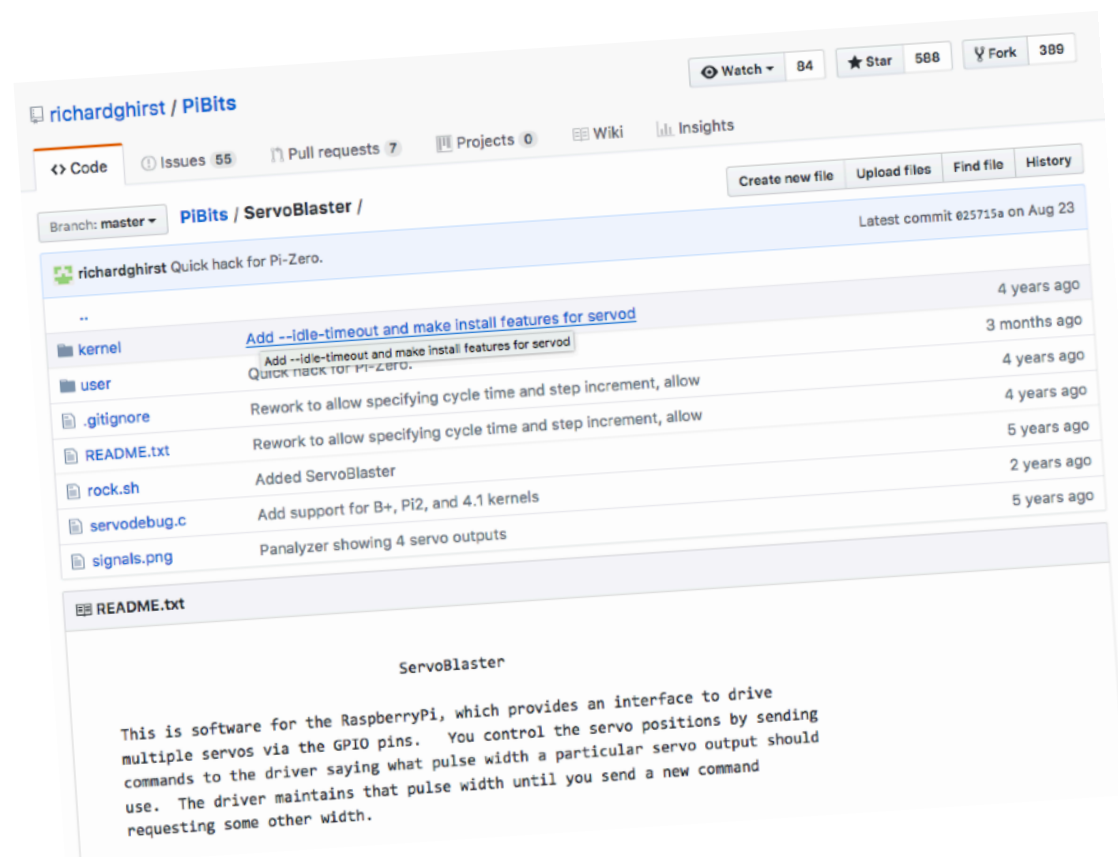
# Speaking the same language





# PWM

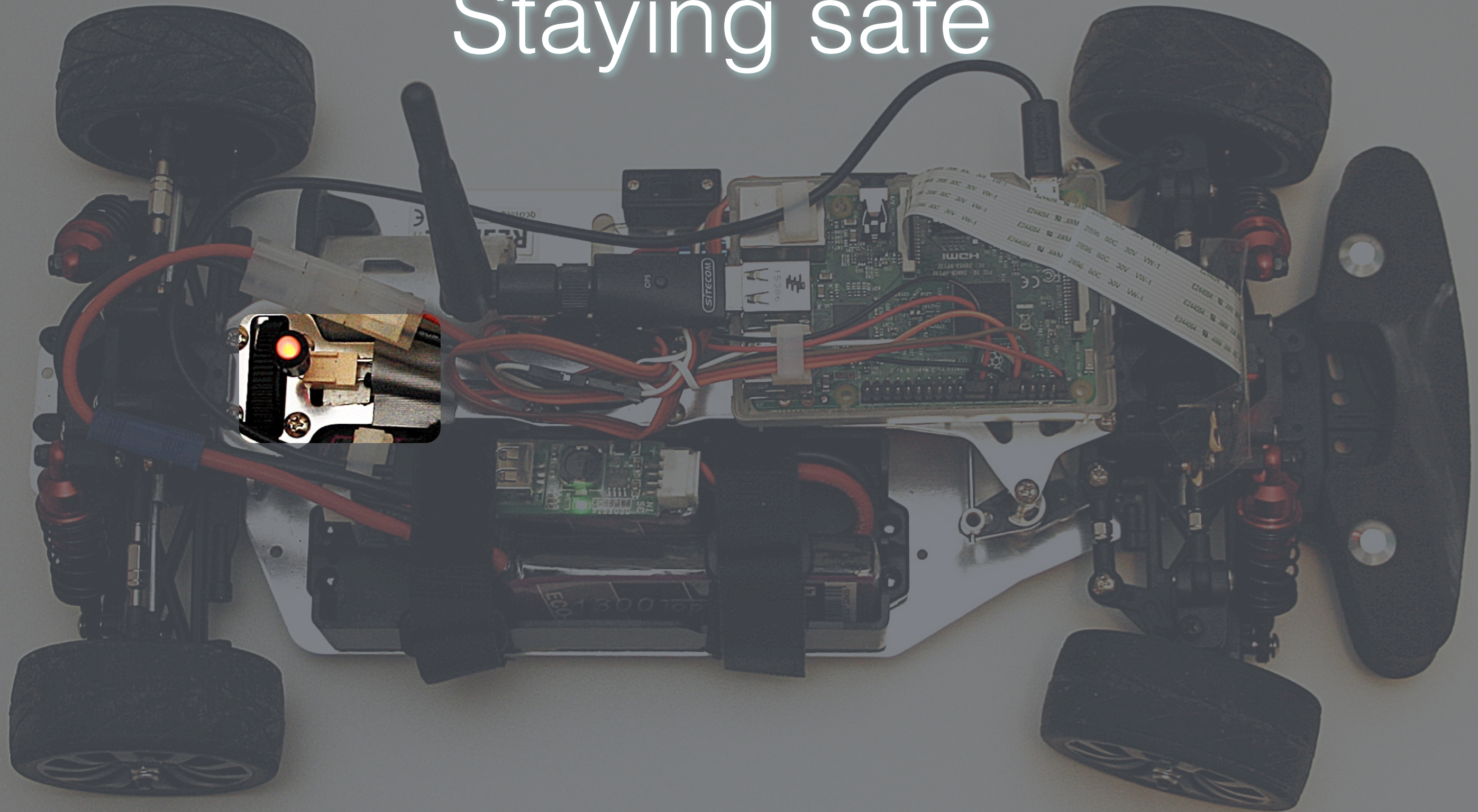
- Pulse-width modulation, repeating pulses of variable width
- ServoBlaster: <https://github.com/richardghirst/PiBits/tree/master/ServoBlaster>



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

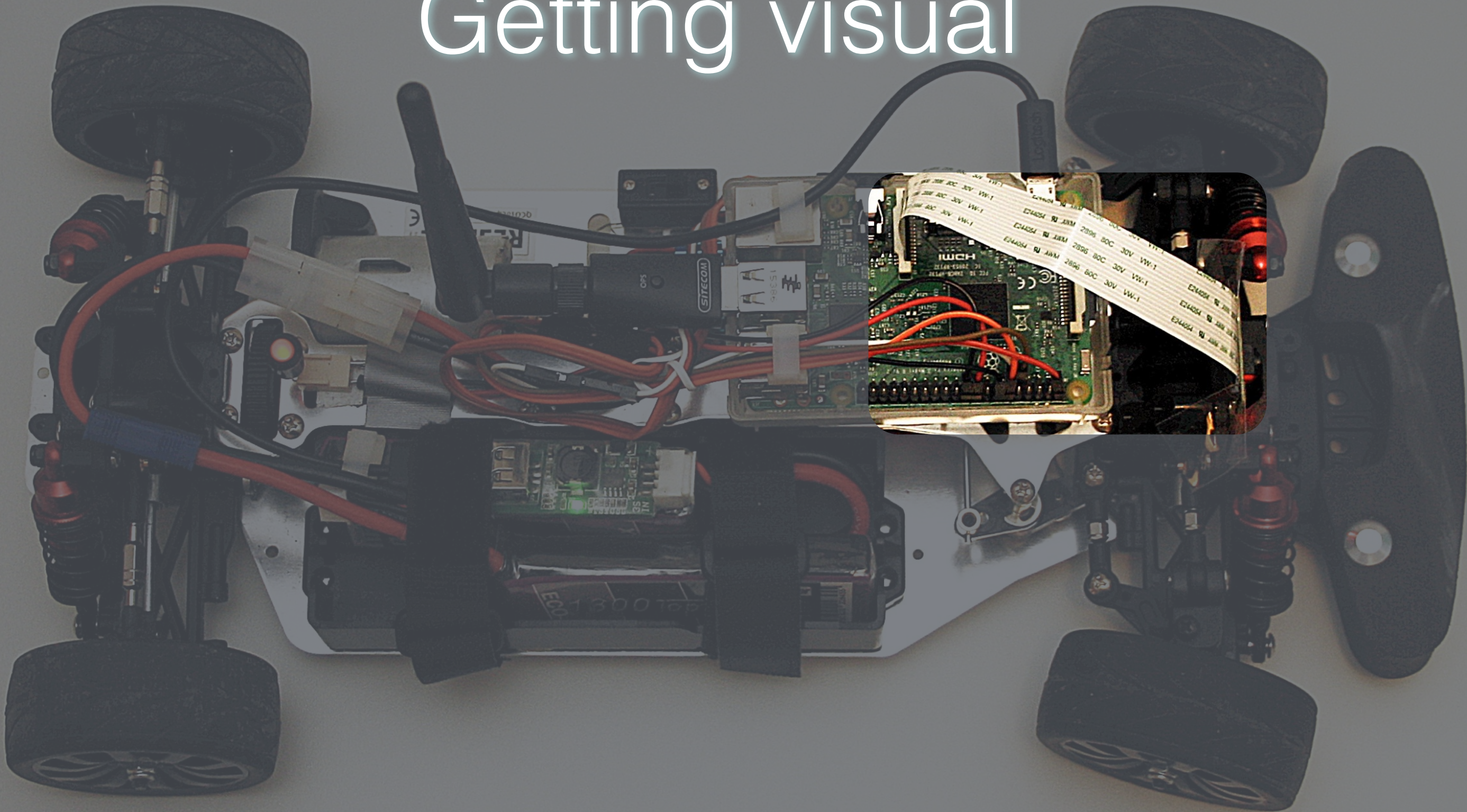


# Staying safe





# Getting visual



The image shows a custom-built robotic car chassis. The chassis is white and features a central green circuit board with various components, including a microcontroller, memory modules, and connectors. A black battery pack is visible on the left side. The car has four black wheels and a black frame. A red light is visible on the right side. An inset image shows a close-up of the circuit board, highlighting a ribbon cable connection.



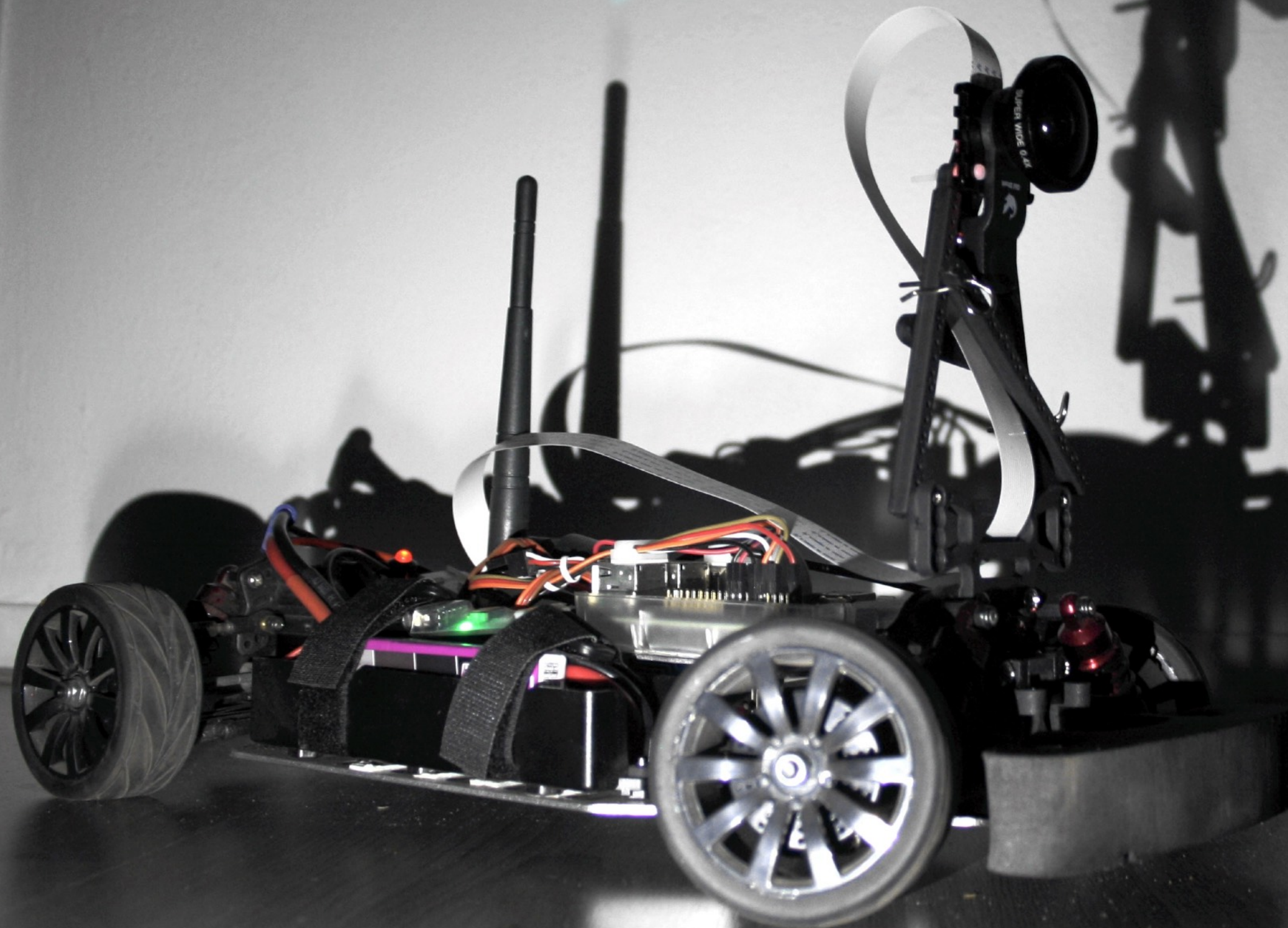
# RPi Cam Web Interface

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

 [https://github.com/silvanmelchior/RPi\\_Cam\\_Web\\_Interface](https://github.com/silvanmelchior/RPi_Cam_Web_Interface)



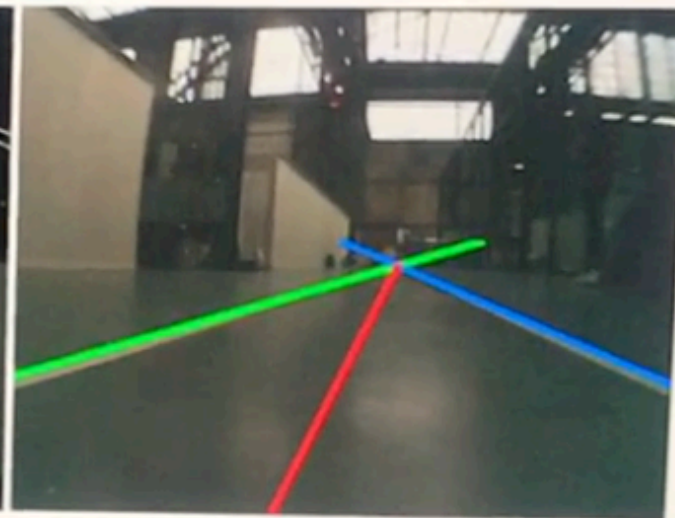
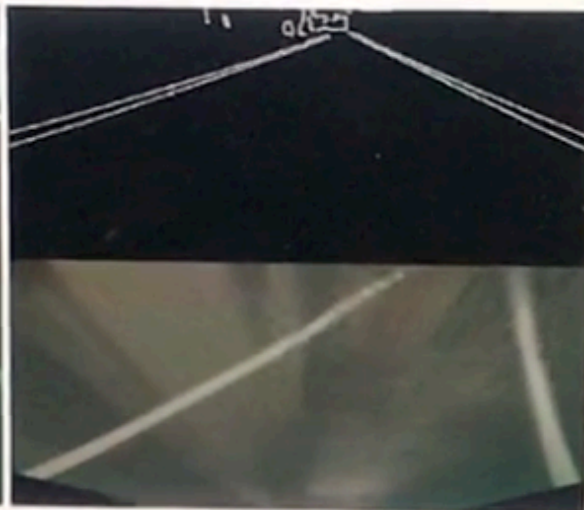
# Ready for the road





# 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



## Events

```
Fri Nov 03 2017 15:25:37 GMT+0100 (CET) {"\\distanceRight\\":539.9989700464948,\\distanceMiddle\\":-8.152801358234362,\\distanceLeft\\":505.72768530155264,\\angle\\":13.589054789821333,\\lane\\":{\\leftBoundary\\":{\\present\\":true},\\rightBoundary\\":{\\present\\":true}}}  
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```



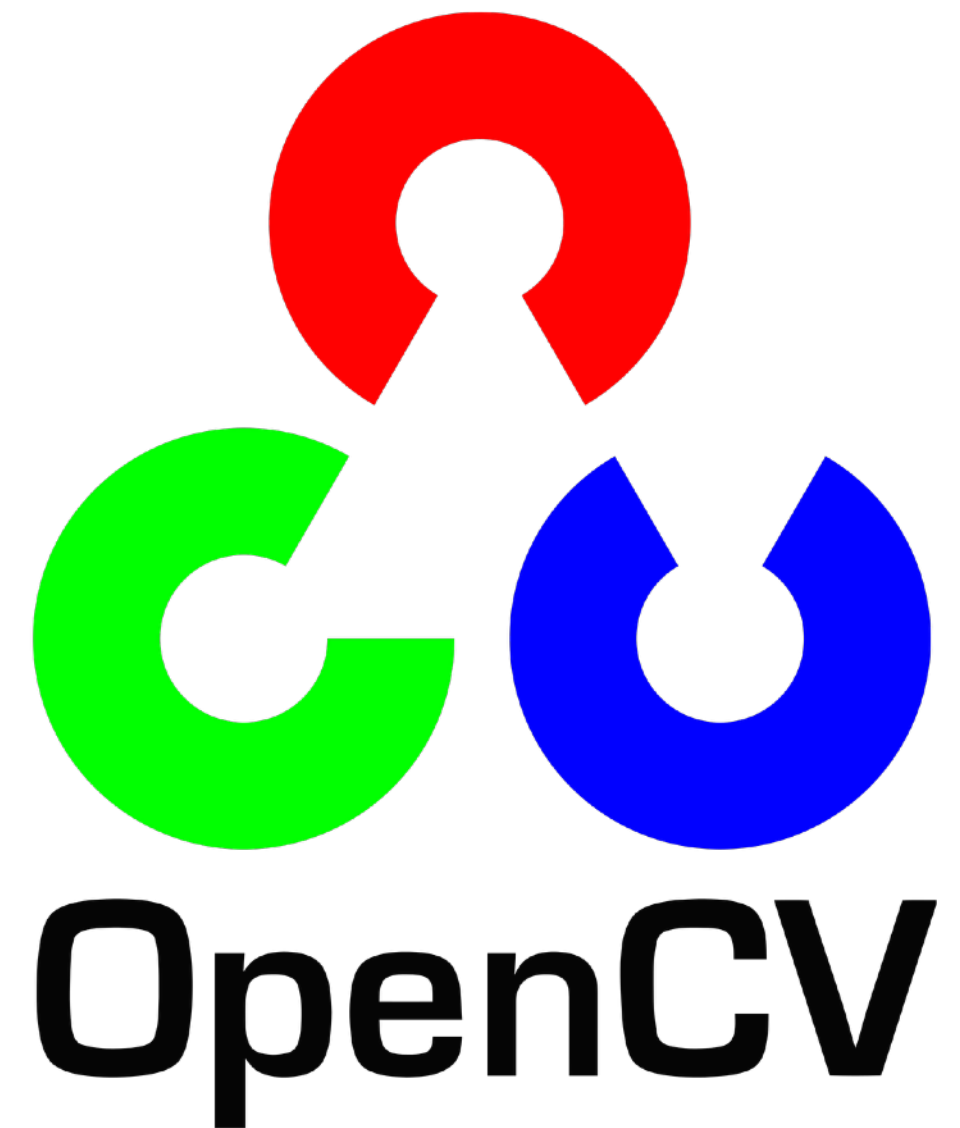
# Learning to drive...



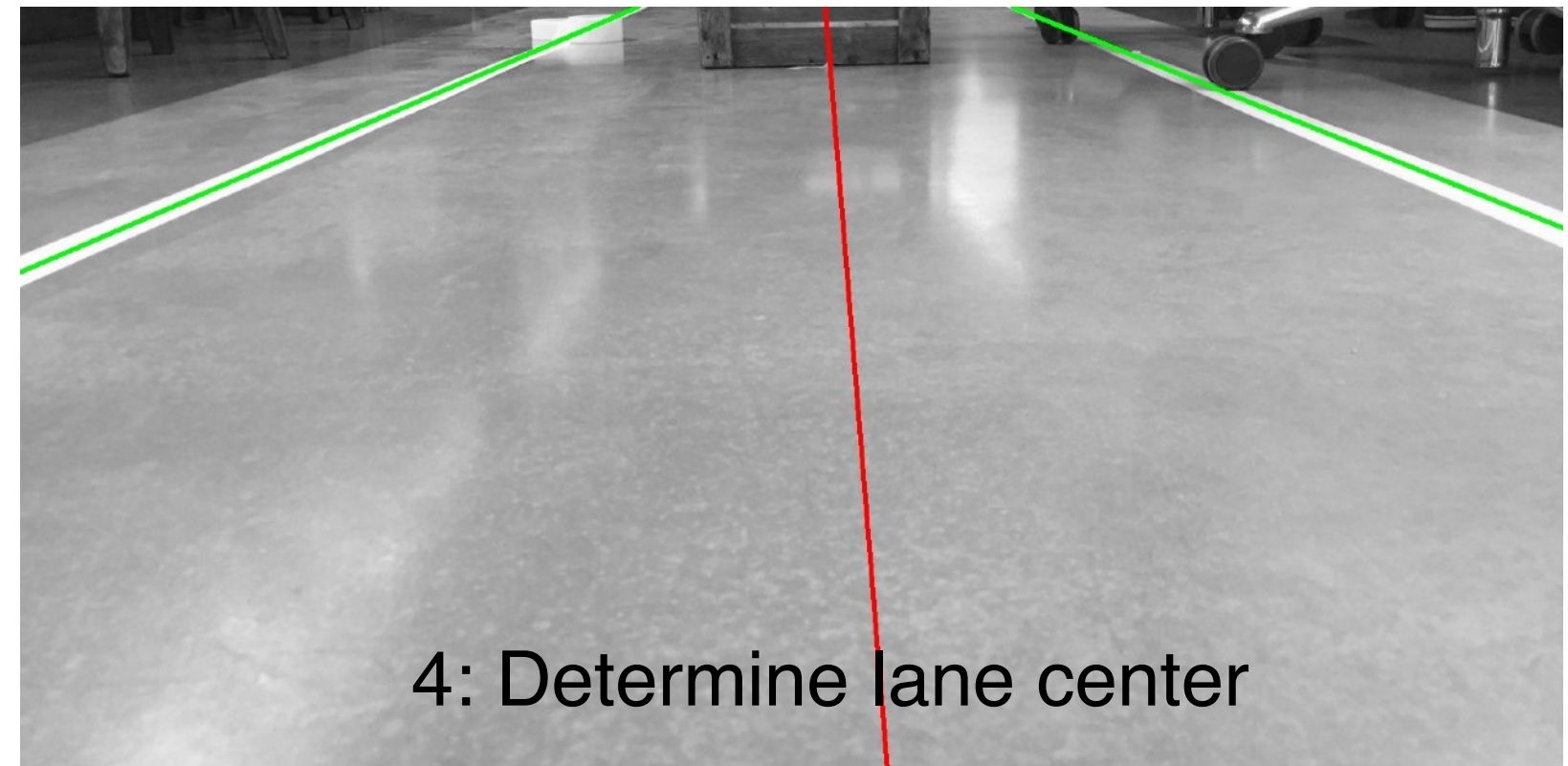
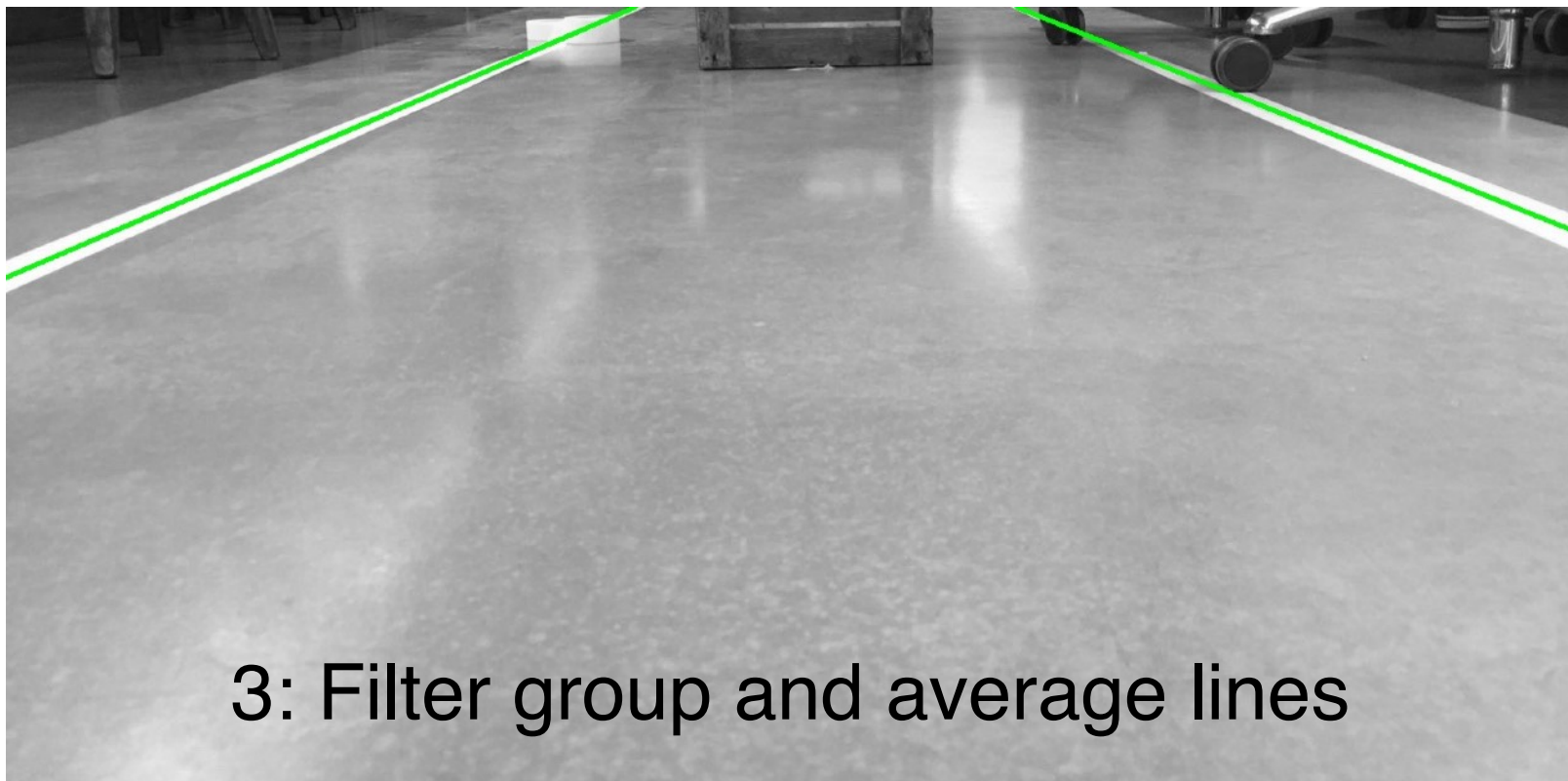
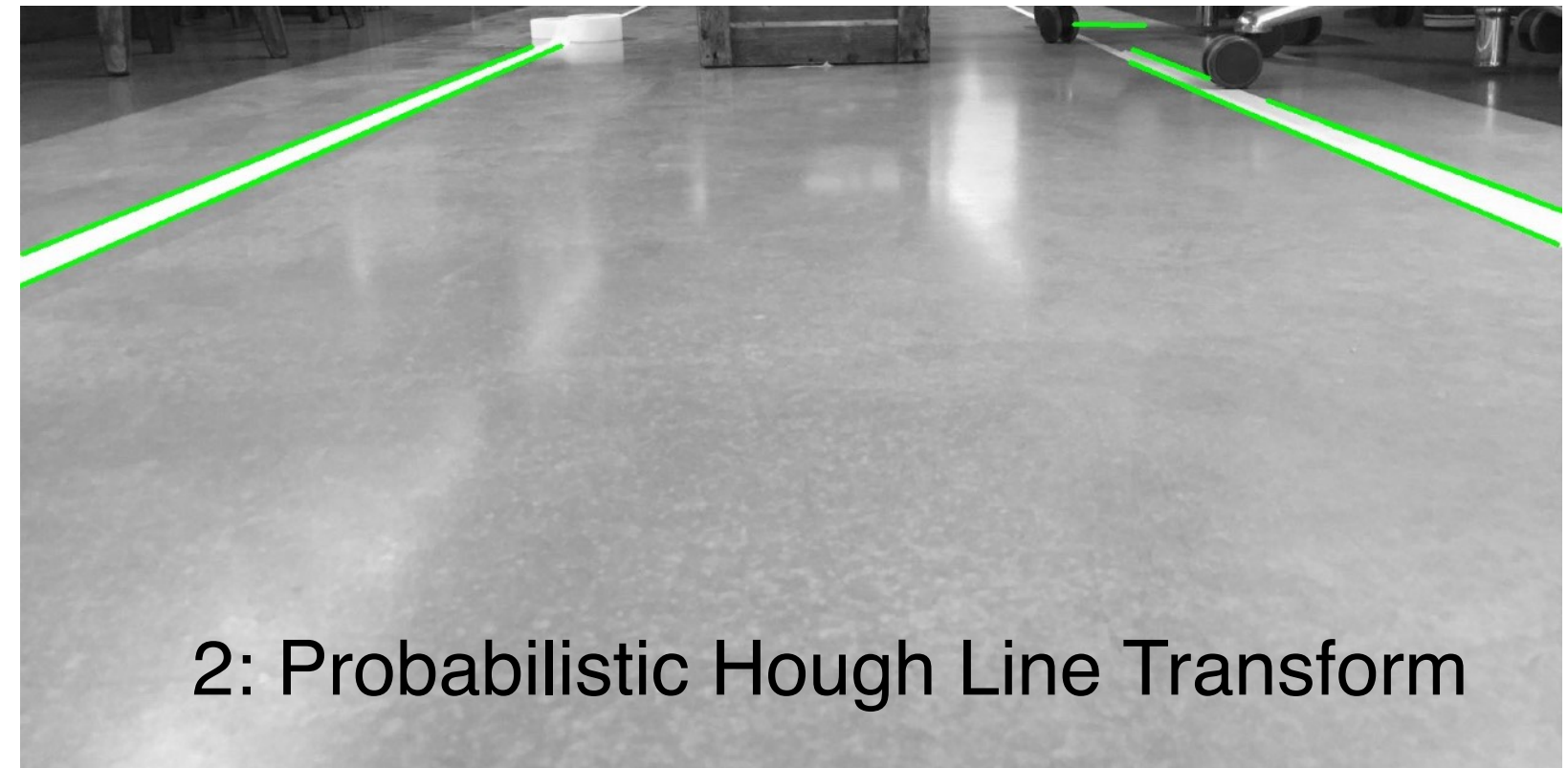


# OpenCV

- 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





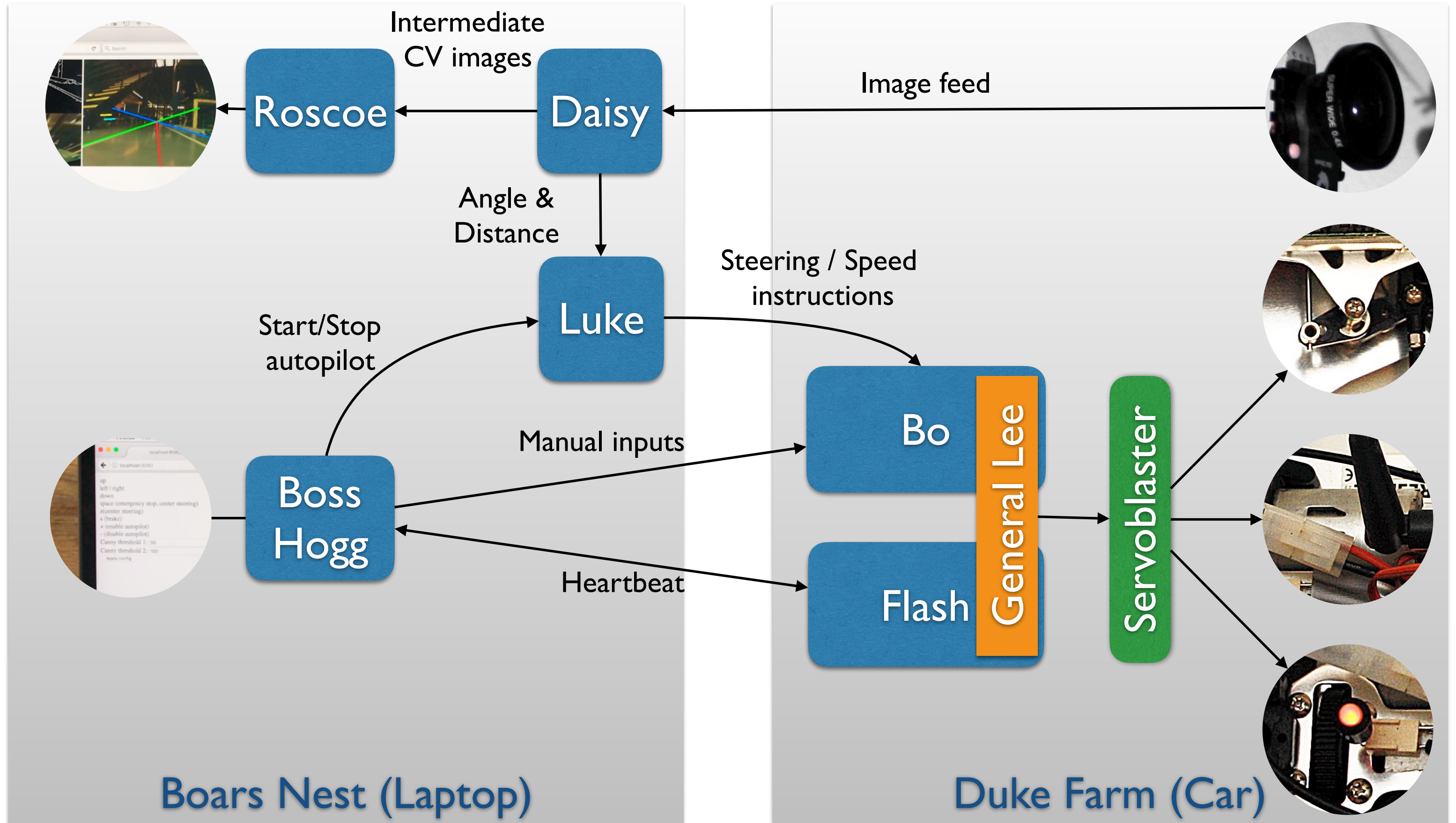




# Show me some code....









# Expectation

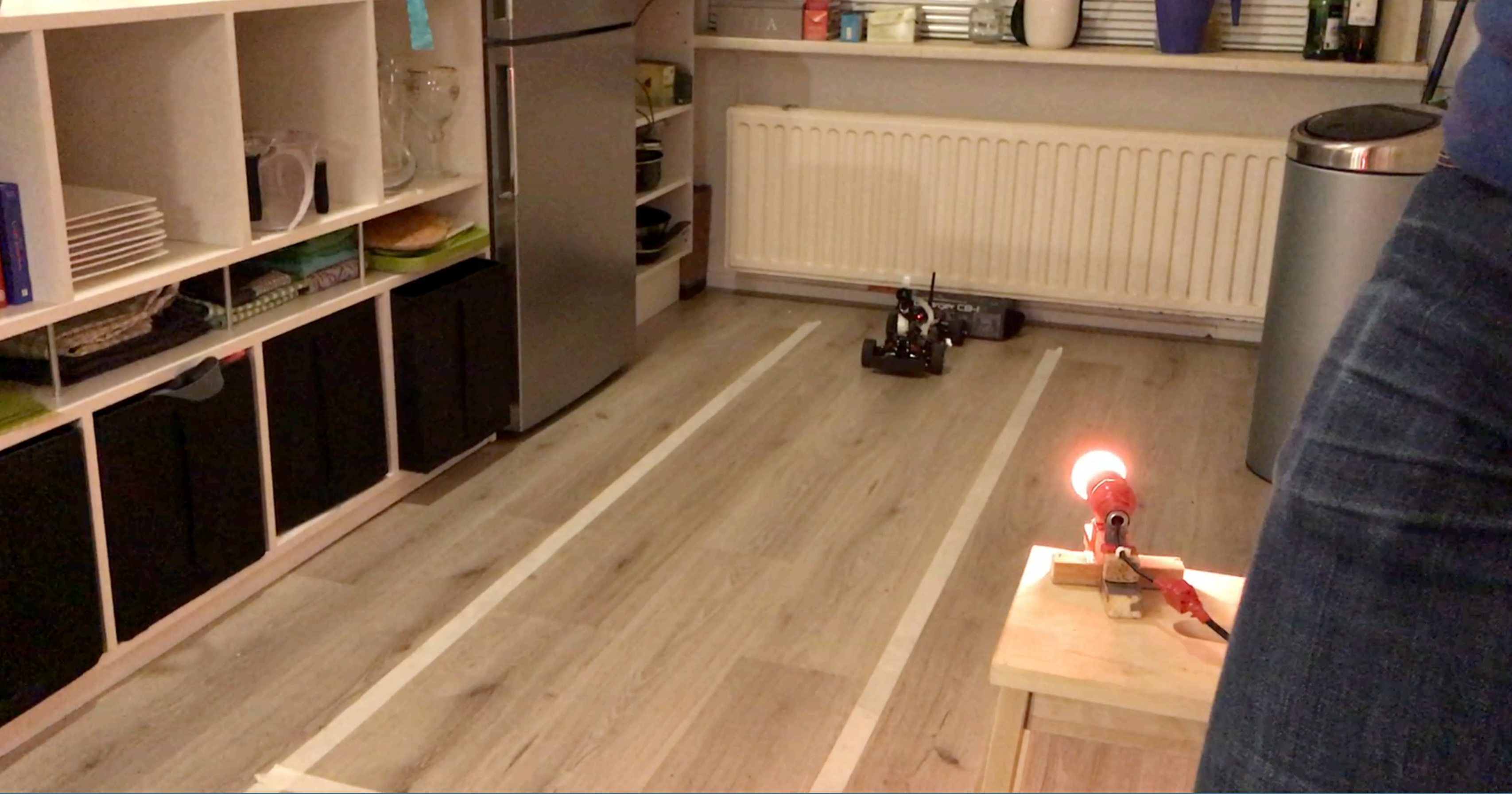




# Reality







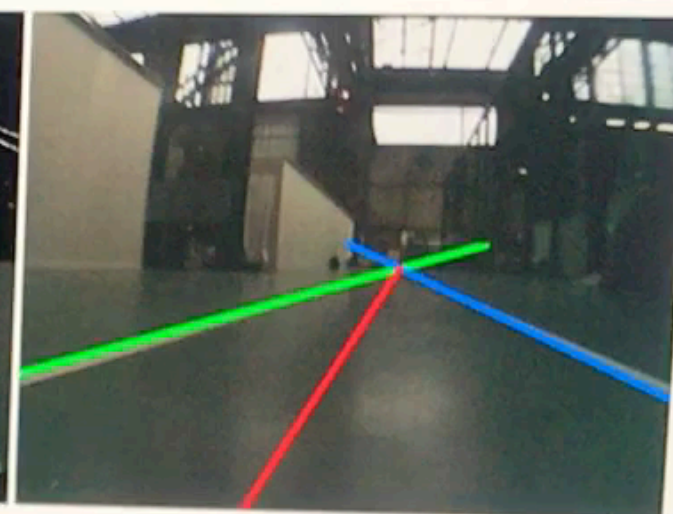
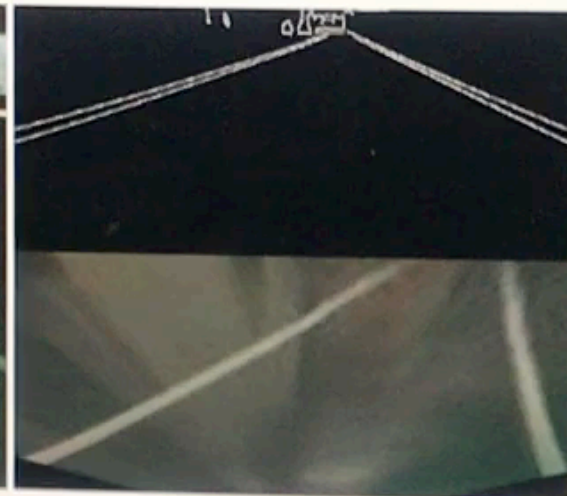


localhost:8080/

localhost:8080

Search

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



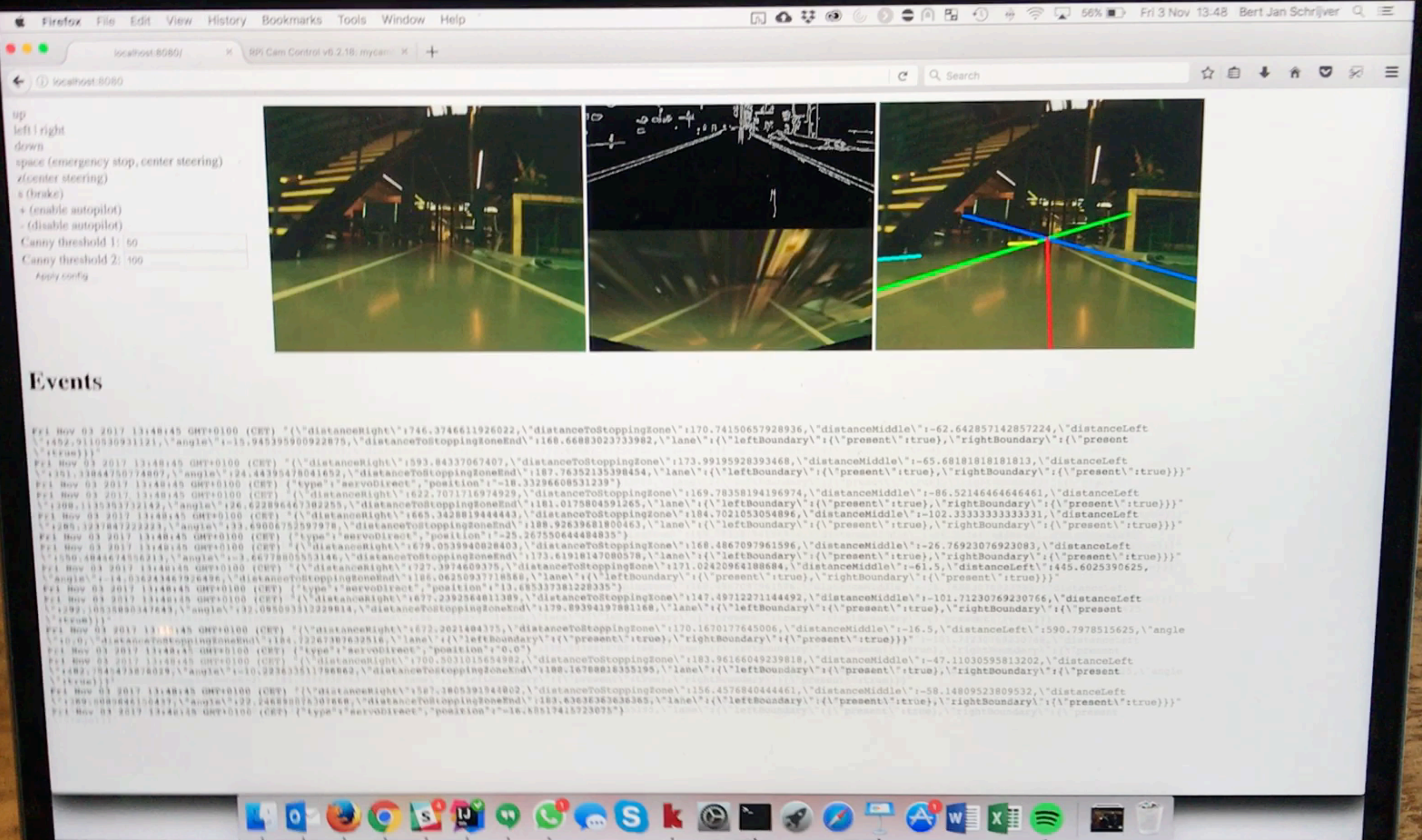
## Events

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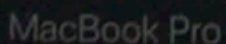










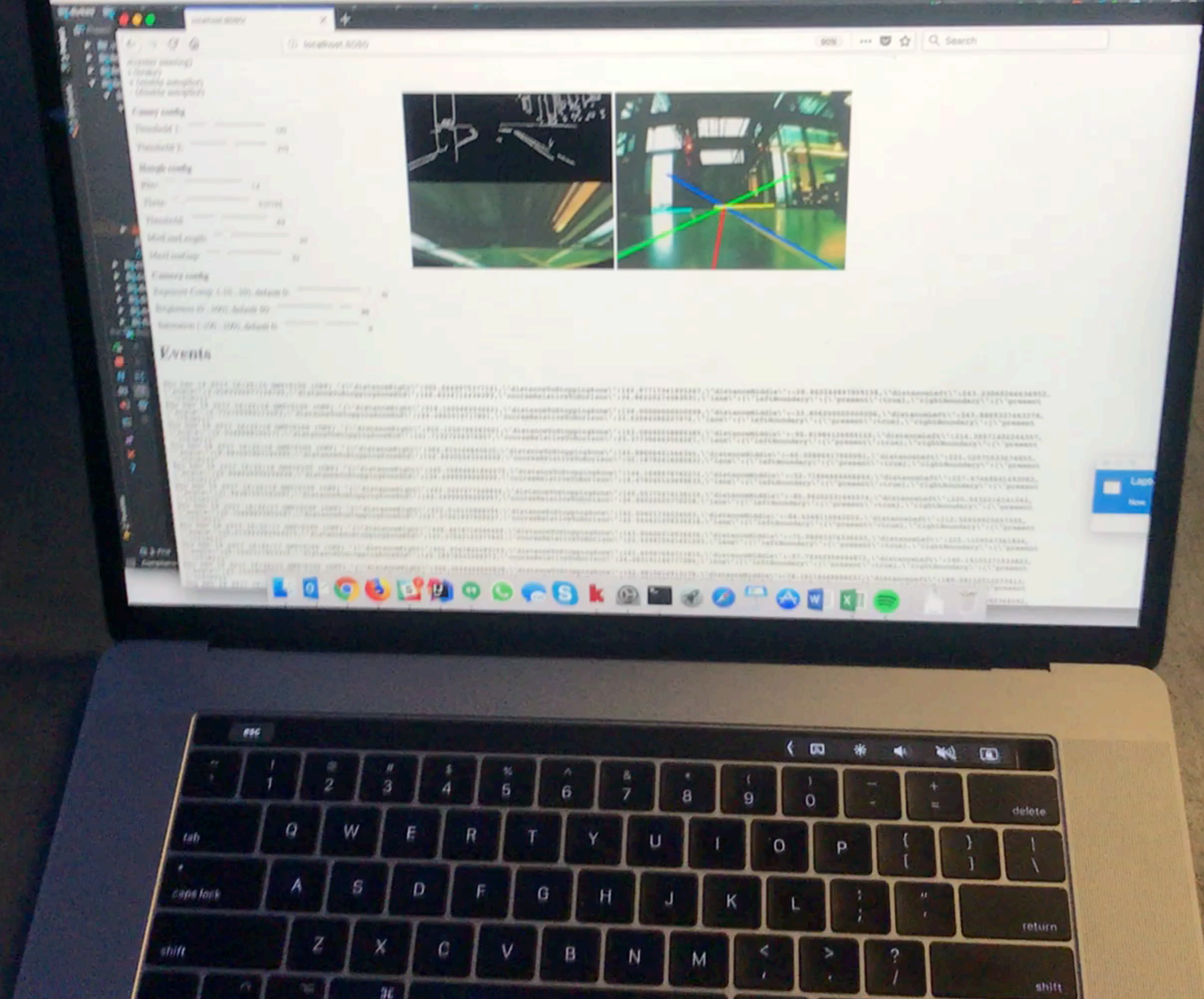




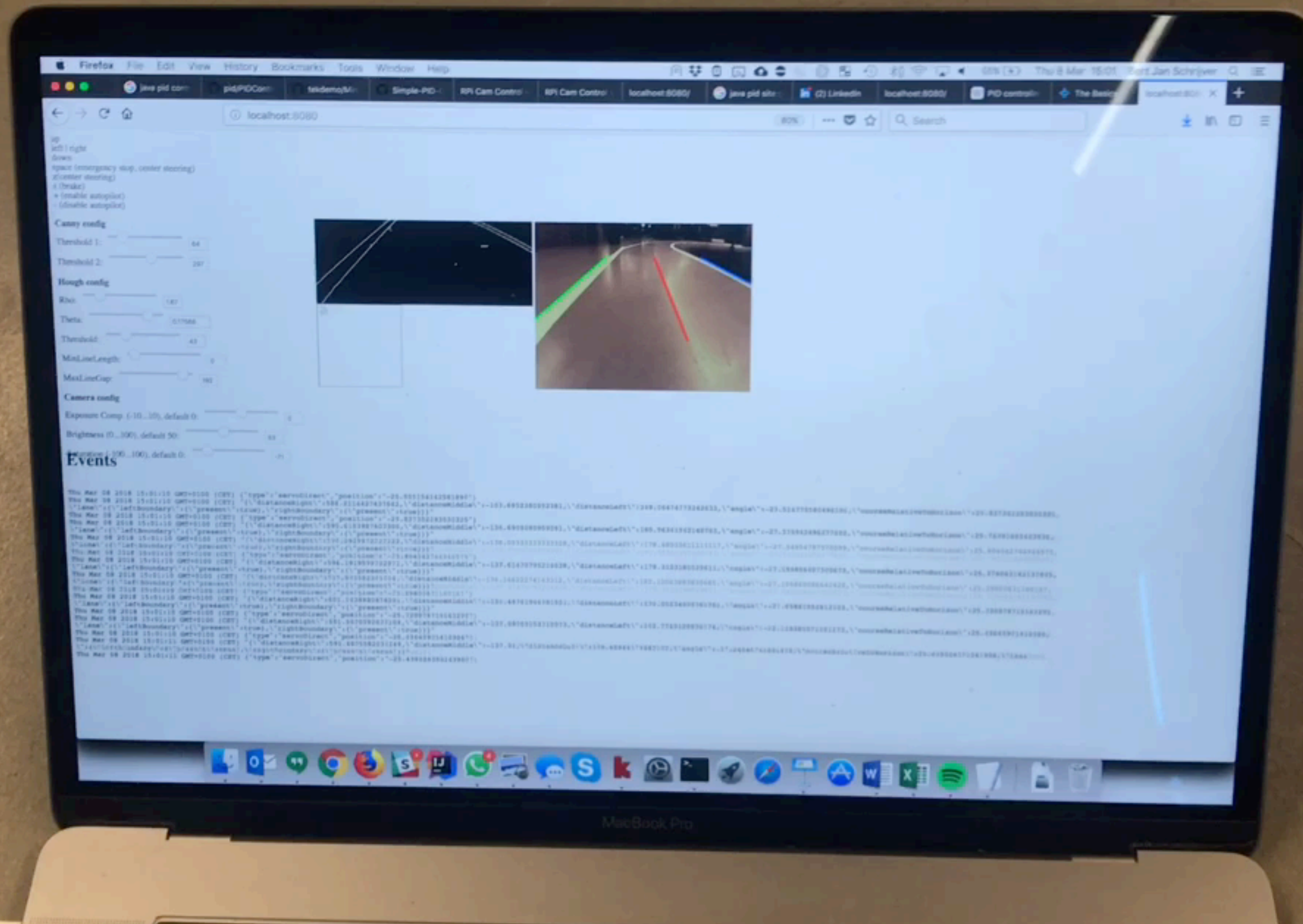
# Let's race!













# 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



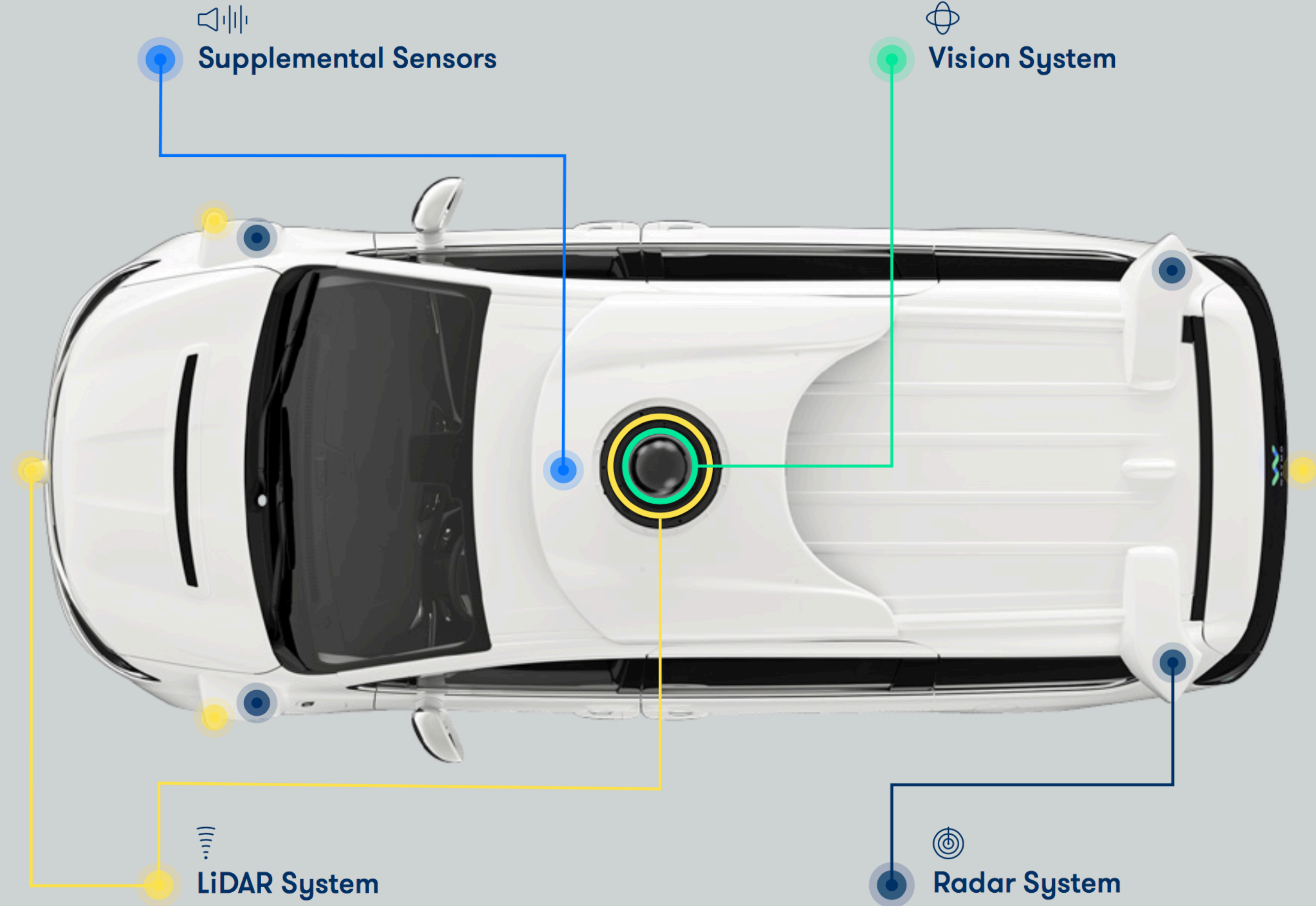
These cars are officially driverless in certain environments.

## LEVEL 5

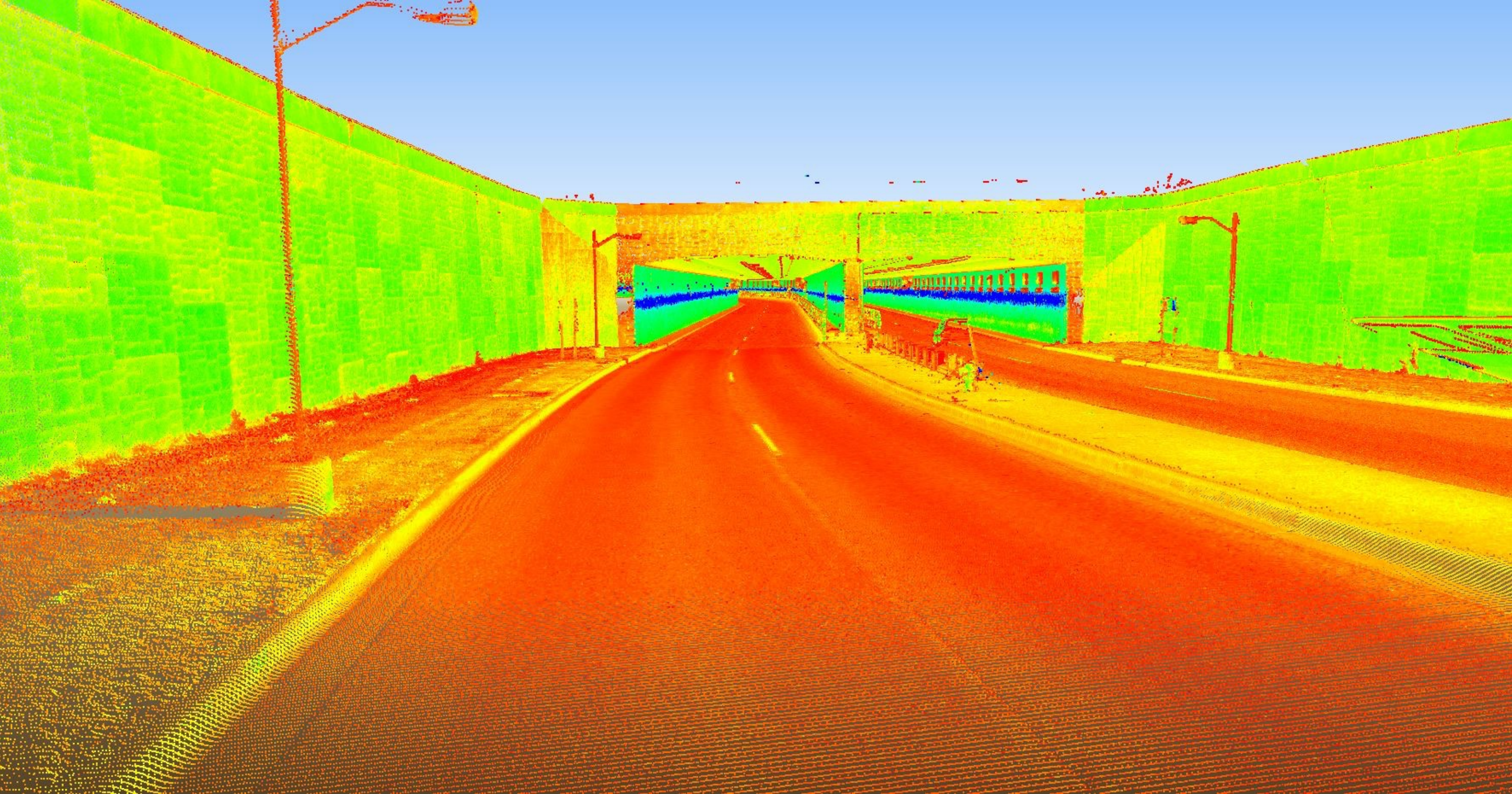


These cars can operate entirely on their own without any driver presence.











**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**

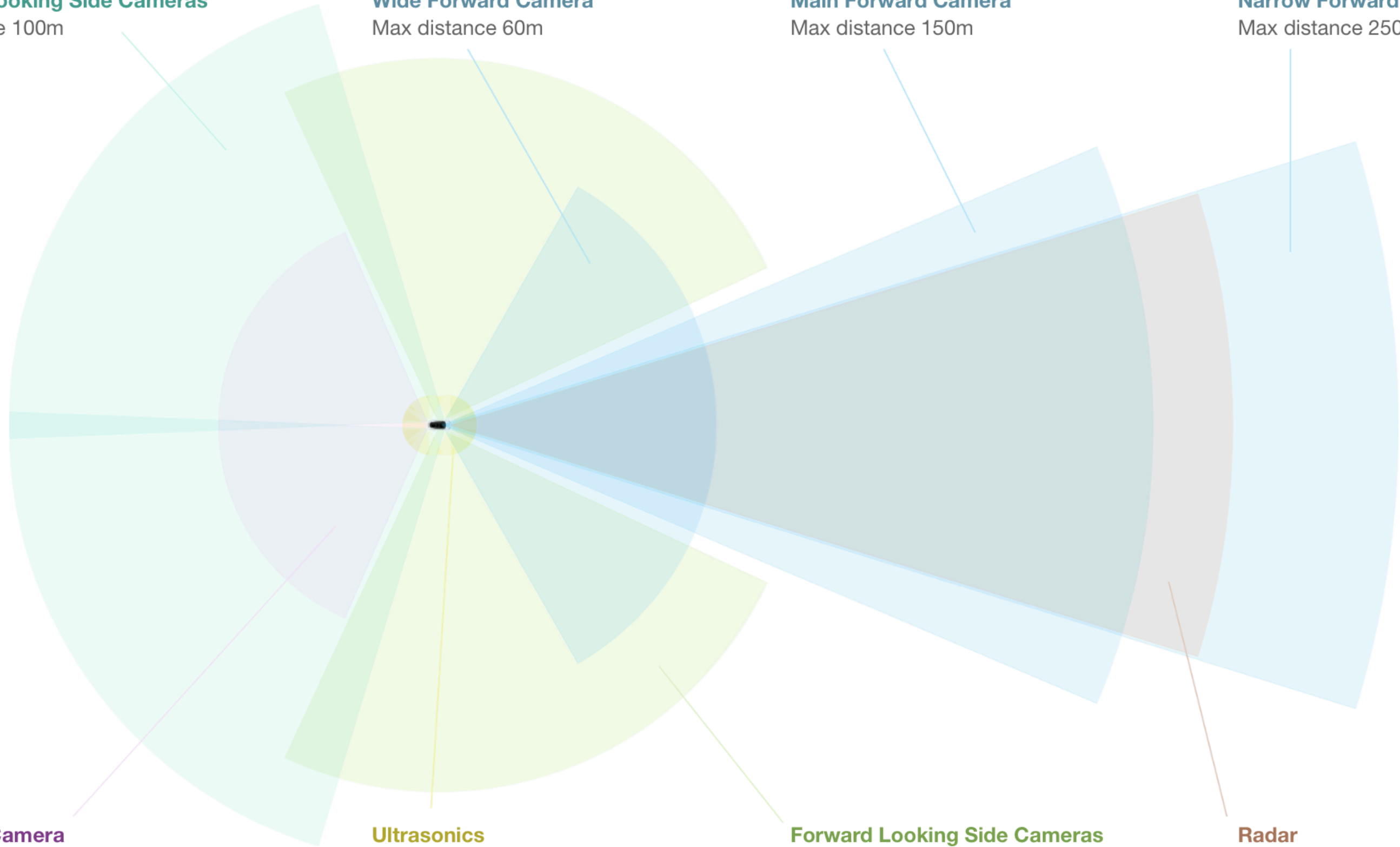
Max distance 8m

**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

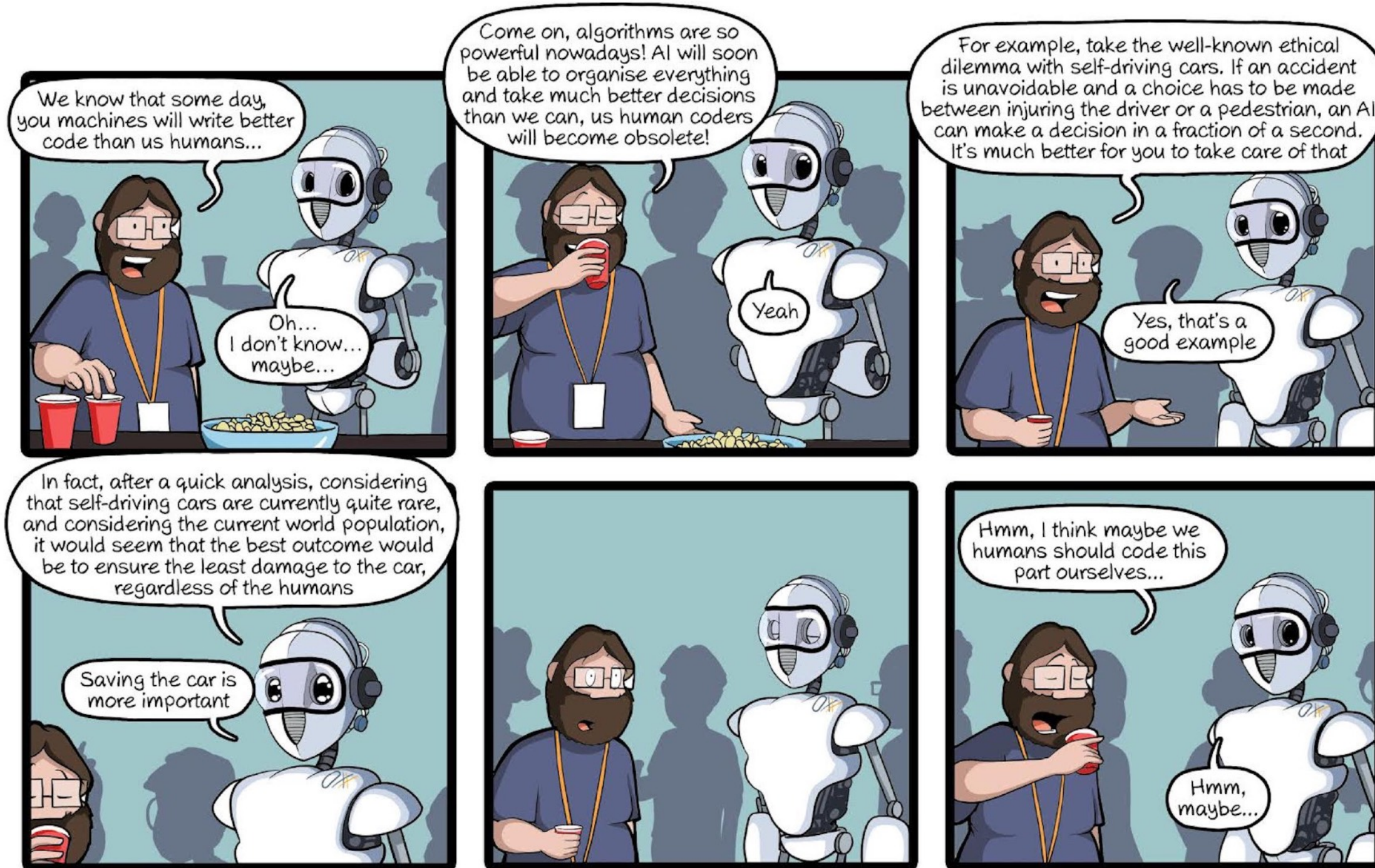


# Weakness of AI for computer vision

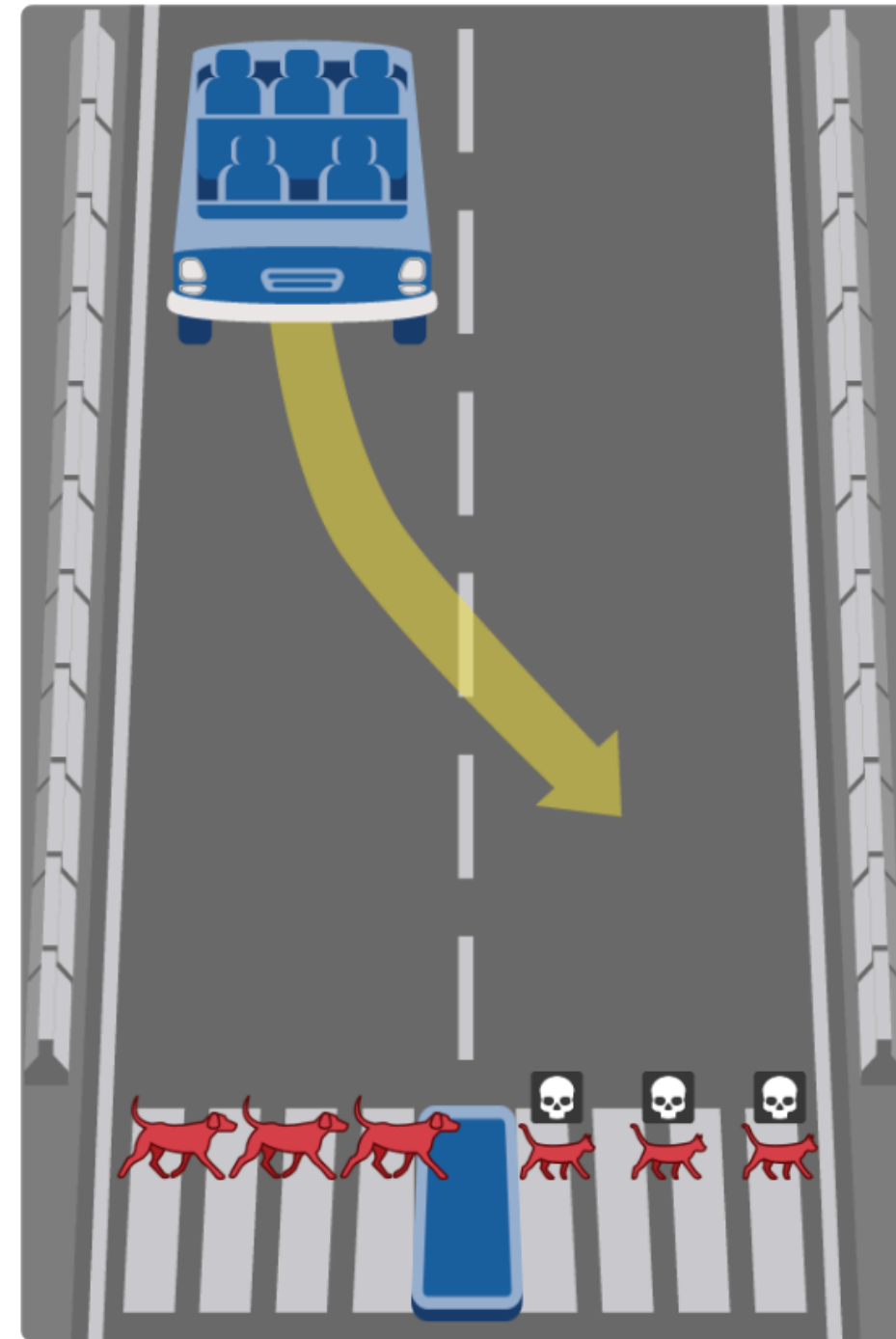
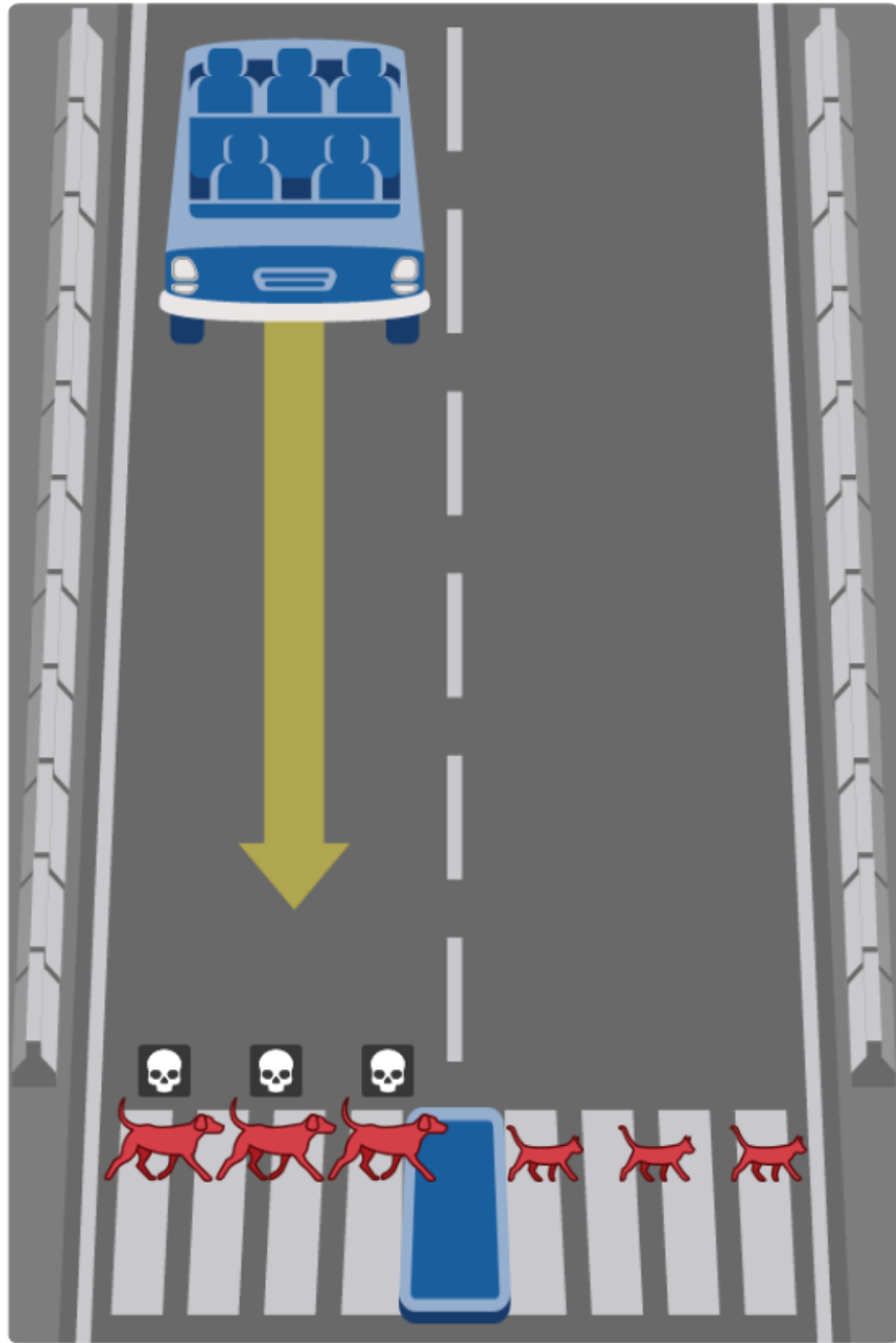




# Ethics

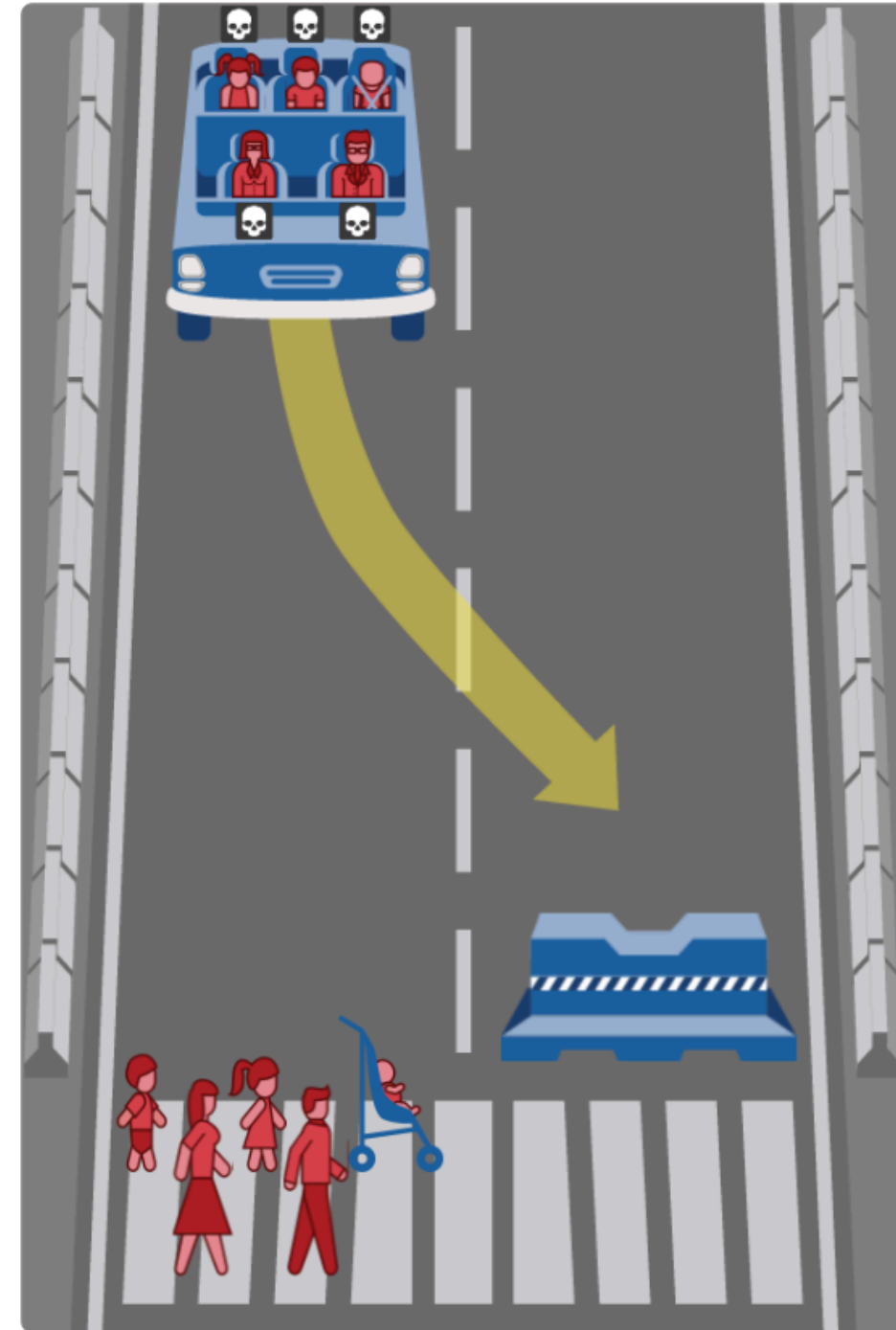
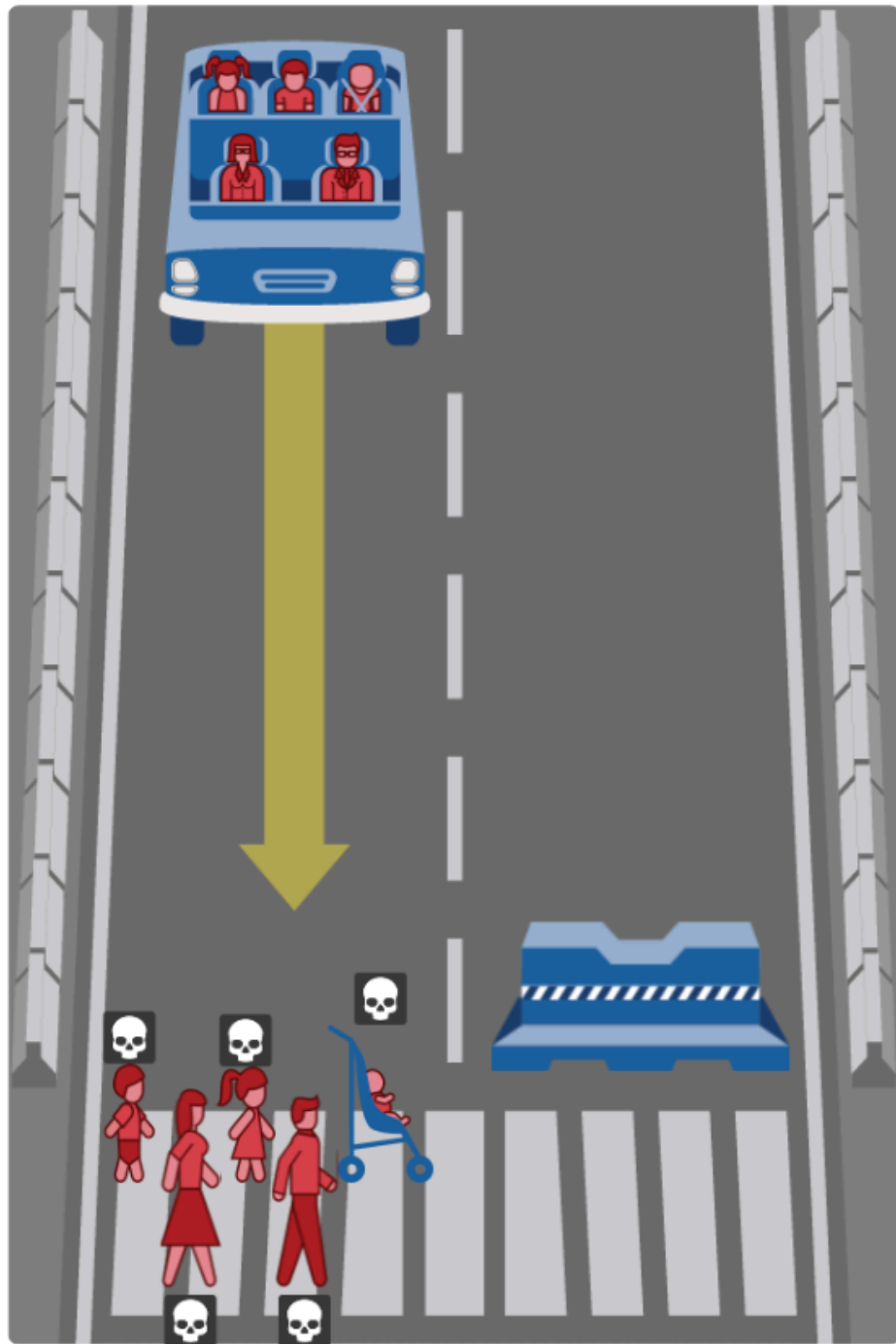






<http://moralmachine.mit.edu>





<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  
CONNECTED DRIVING



# 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





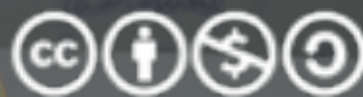
Questions?



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

Thanks for your time.

*Got feedback? Tweet it!*



All pictures belong  
to their respective  
authors

 [@bjschrijver](https://twitter.com/bjschrijver)