

Donkey Car

Make an RC car drive itself with an end-to-end neural network.

Open Source (MIT)

Python

Raspberry Pi

Keras / Tensorflow

OpenCV



Agenda

One year and one day of Donkey Cars.

How the hardware and software works?

Tips to work with neural network autopilots.

What's next for DIY self driving?



Will Roscoe
Software

Adam Conway
Hardware

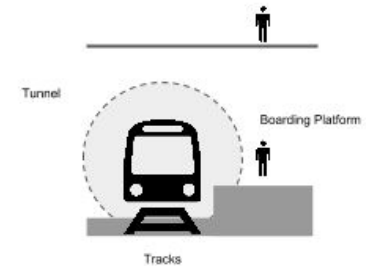
Roscoe makes pitch for competition to demonstrate AutoBART.

October, 2016

BART Station



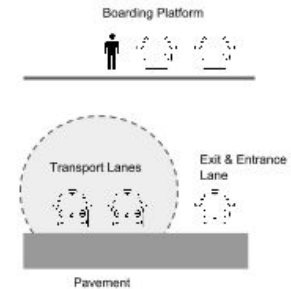
Average Speed: 33mph (BART)
Max Throughput: 30,000 people per hour.



AutoBART Station



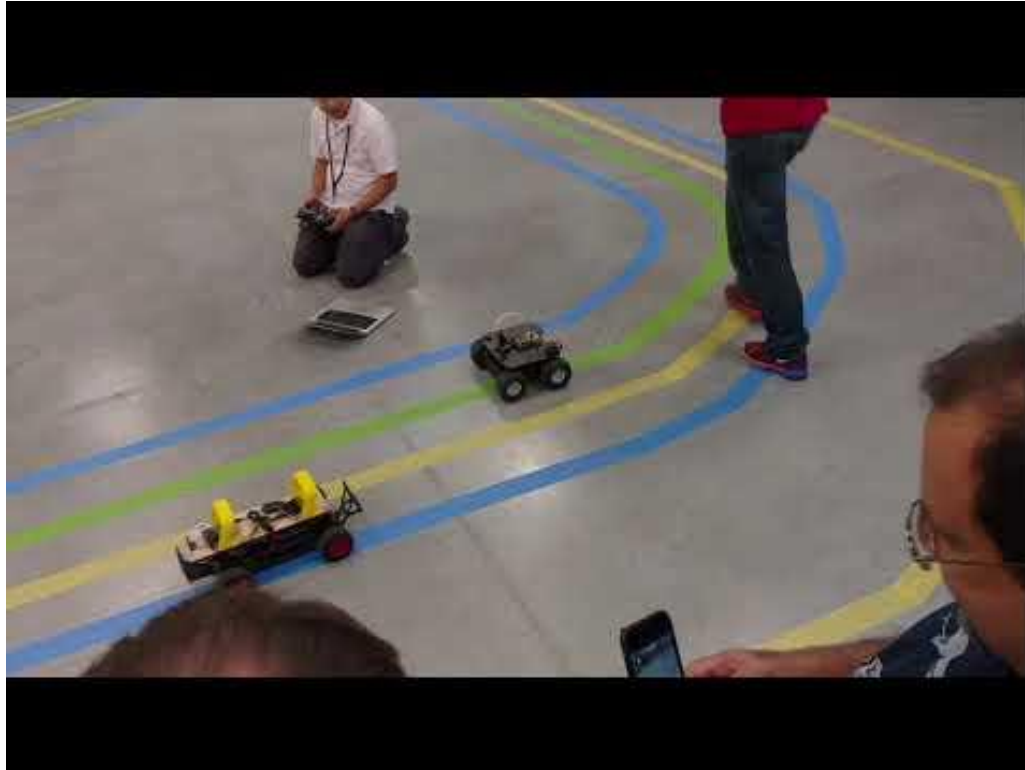
Estimated Average Speed: 60mph
Estimated Max Throughput: 60,000 people per hour



Chris Anderson hosts first DIYRobocar meetup in Carl Bass' workshop.



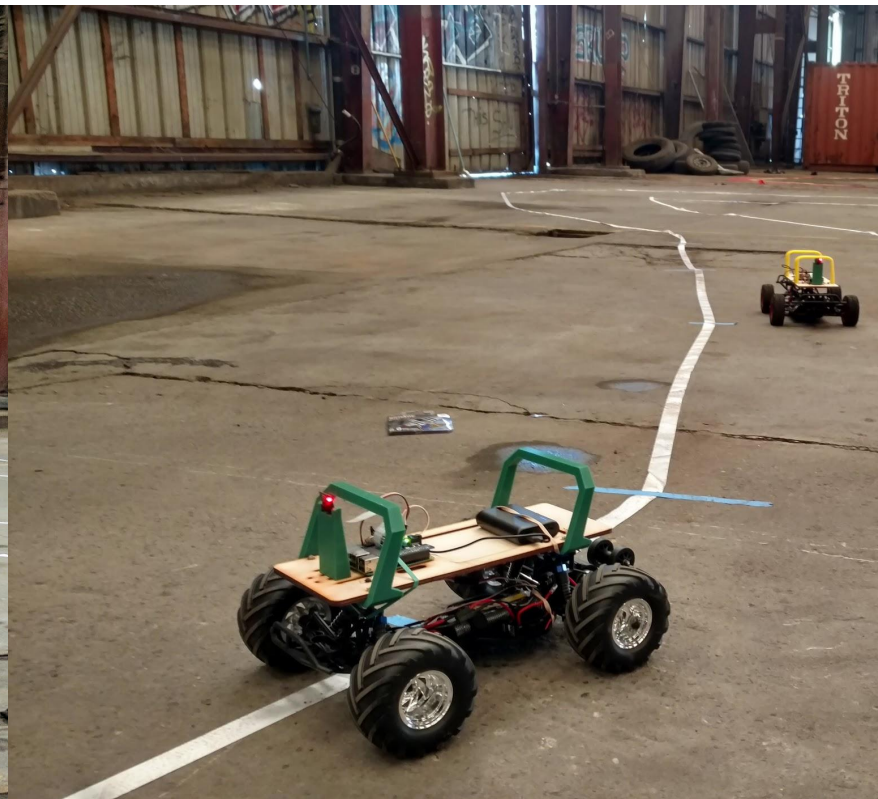
November, 2016



First time DIYRobocars raced in Oakland Pipe Factory.



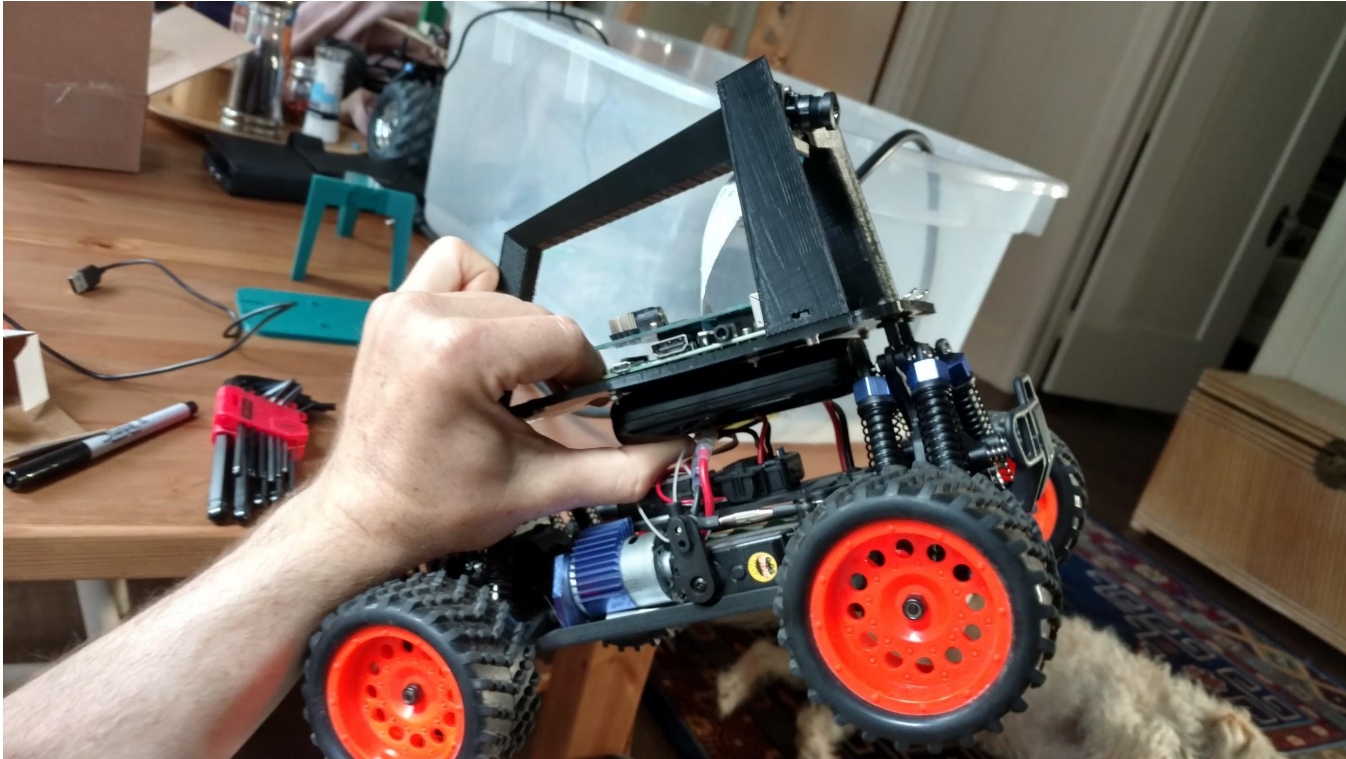
January, 2017



Improved hardware with Donkey2

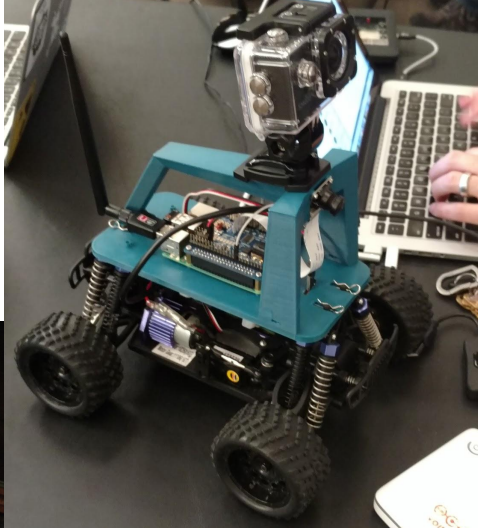


March, 2017



Many more people build donkey.

July - August, 2017



Faster and with obstacle avoidance.

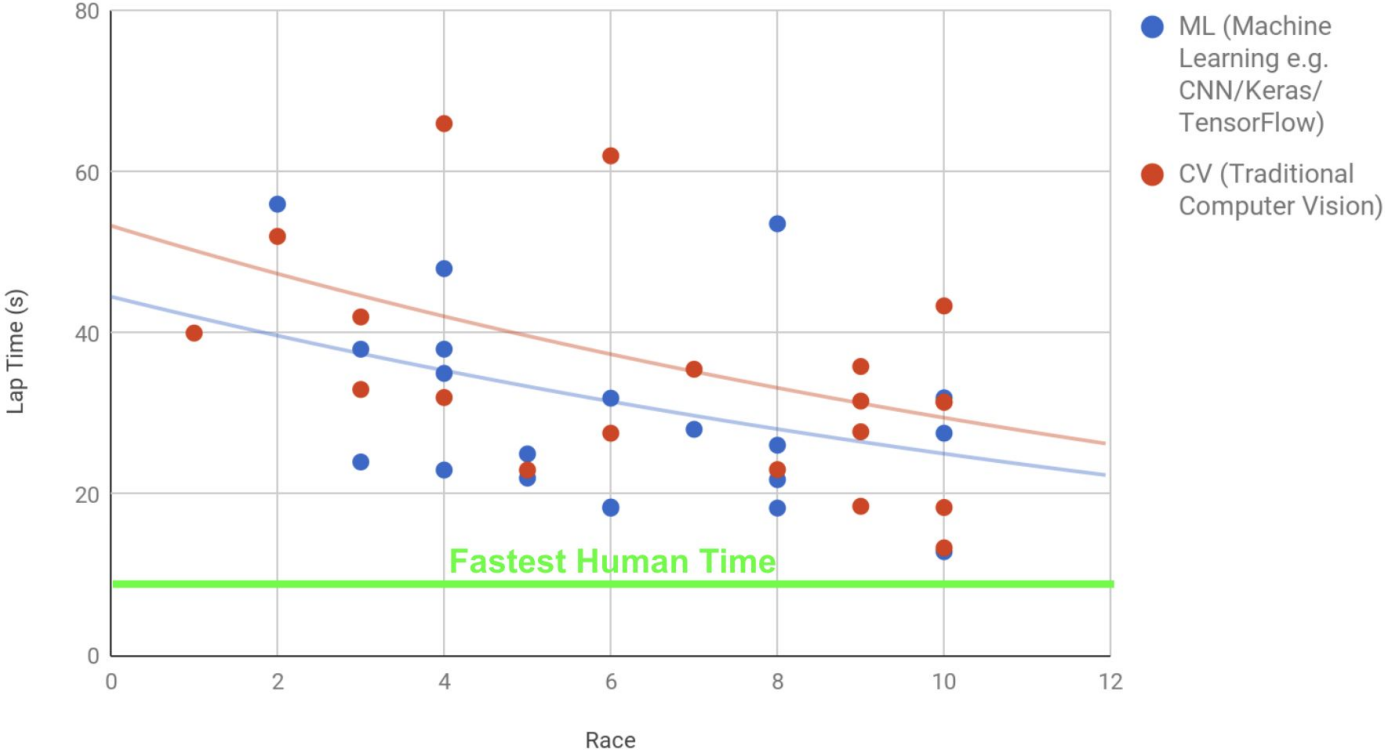


October 2017



We are approaching human level racing.

1/10 Scale Race Results



How does it work?

How to Build a Donkey V2

These same instructions can be found in this [Make Magazine article](#). The software has been updated since the article was published so use the instructions found at [docs.donkeycar.com](#) after you've built your car.

Overview

These instructions will show you how to build this car from start to finish.



Hardware instructions.

donkeycar.com

Donkey Car

Search docs

Home

- About Donkey
- Build your own Donkey2
- Hello World.
- Installation
- Why the name Donkey?

User Guide

- Build a car.
- Install the software.
- Get driving.
- Calibrate steering and throttle.
- Train an autopilot.
- Donkey Simulator.

Parts

- About
- Actuators
- Controllers
- Stores
- IMU
- Utilities

donkey

- Contribute
- Tests
- Releases
- FAQ

Docs » Home [Edit on GitHub](#)

About Donkey

Donkey is a high level self driving library written in Python. It was developed with a focus on enabling fast experimentation and easy contribution.

Build your own Donkey2

Donkey2 is the standard car that most people build first. The parts cost \$200 and take 2 hours to assemble. Here are the main steps to build your own car:

1. Assemble hardware.
2. Install software.
3. Calibrate your car.
4. Start driving.
5. Train an autopilot.
6. Experiment with simulator.

Hello World.

Donkeycar is designed to make adding new parts to your car easy. Here's an example car application that captures images from the camera and saves them.

```
import donkey as dk

#initialize the vehicle
V = dk.Vehicle()

#add a camera part
cam = dk.parts.PiCamera()
V.add(cam, outputs=['image'], threaded=True)

#add sub part to record images
V.add(dk.parts.PiCameraRecorder())
```

Software Docs

Donkey

- wroscow

All Unreads

All Threads

Channels

- # avc
- # datasets
- # dev
- # docs
- # events
- # features
- # general
- # github-master
- # help
- # introductions
- # jobs
- # marketplace
- # models
- # pictures
- # random
- # reinvent
- # tracks

Direct Messages

- # slackbot
- wroscow (you)
- actool
- almwells
- Aryn
- asioane

#help

Yesterday

- zuliani 12:02 AM joined #help along with 8 others.
- doug 6:54 PM anyone know what's required to get the web control working in Firefox on Ubuntu? I'm not getting any video.
- Yi Lee 6:56 PM joined #help.
- Tawn 9:38 PM anyone notice that training is slower on 2.2? I'm seeing epochs of 85s vs 25s on the same data set. (edited)
- doug 10:12 PM on one small tub of 4255 images I see 8s vs 9s epoch times with 2.2 giving 9s and 2.1.5 giving 8s.
- doug 10:17 PM did you remember to install tensorflow-gpu for the 2.2 environment?
- 1 reply Today at 11:25 AM

Today

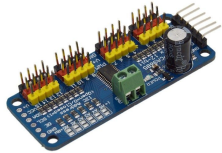
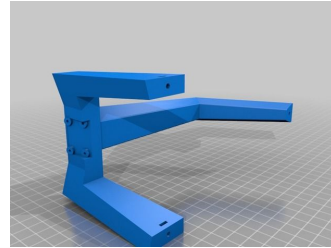
- Arndt 12:55 AM What is the currently (software version 2.2) recommend driving mode, please:
 - * Local Angle
 - * Local Pilot
 - * Auto Angle
 - * Auto PilotAre the "Auto" modes still supported? They don't show up in my web controller drop down. Documentation: http://docs.donkeycar.com/guide/train_autopilot/#training-tips
- wroscow 1:10:55 AM @Arndt: Use the "Local Pilot" to have the autopilot control the angle and throttle. Use the "Local Angle" to have the autopilot control only the steering angle. I'll remove those old options from the docs. Thanks.
- 1 reply Today at 1:09 AM
- Laura 3:28 AM joined #help along with 3 others.

+ Message #help

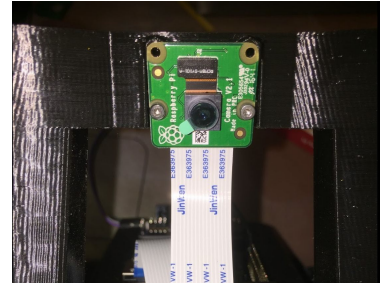
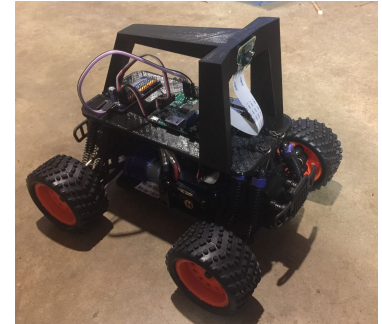
Help Brawl

1. Get Parts (\$200)

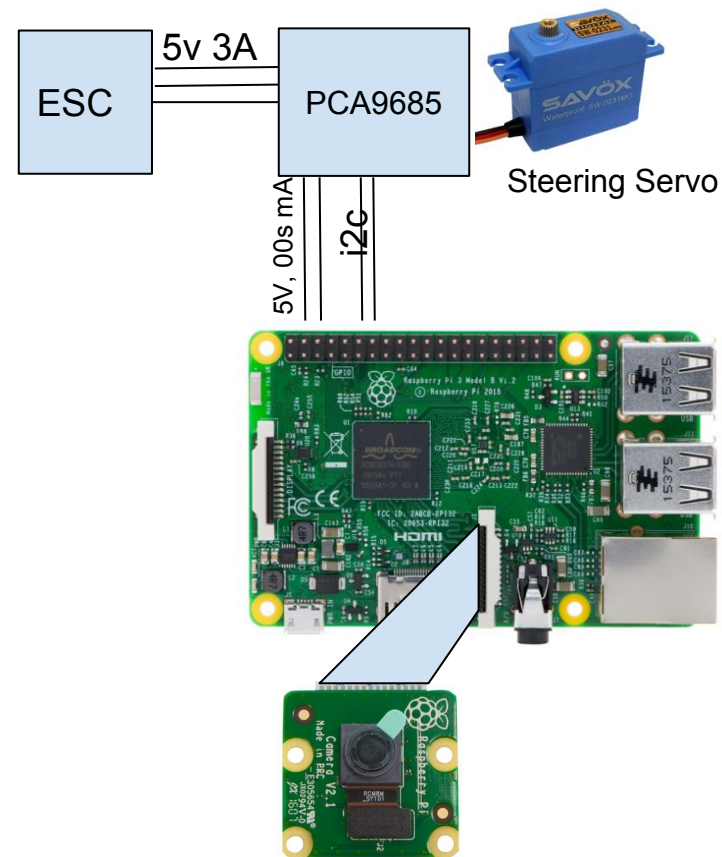
Part Description	Link	Approximate Cost
Magnet Car	https://www.amazon.com/gp/product/B026863775	\$92
M2x4 screws (4)	https://www.mcmaster.com/911282a81c1173k4p	\$6.38 *
M2.5x12 screws (8)	https://www.mcmaster.com/911282a01c1173514	\$4.80 *
M2.5 nuts (8)	https://www.mcmaster.com/911838a11c117372ex	\$5.64 *
M2.5 washers (8)	https://www.mcmaster.com/9193475a190c117372x	\$1.58 **
USB Battery with microUSB cable (any battery capable of 2A 5V output is sufficient)	https://www.amazon.com/gp/product/B09P7N6S90	\$17
Raspberry Pi 3	https://www.amazon.com/gp/product/B01C9Y3C92	\$38
MicroSD Card (many will work, I like this one because it boots quickly)	https://www.amazon.com/gp/product/B01H5SQ8F2	\$18.99
Wide Angle Raspberry Pi Camera	https://www.amazon.com/gp/product/B00N1Y3KFS/	\$25
Female to Female Jumper Wire	https://www.amazon.com/gp/product/B019L305E8/	\$7 *
Servo Driver PCA 9685	https://www.amazon.com/gp/product/B014KTSMLA	\$12 **
3D Printed roll cage and top plate:	CAD Files: http://a386.co/2pf3dcam STL Files: http://www.triangorse.com/blog/22809/	-

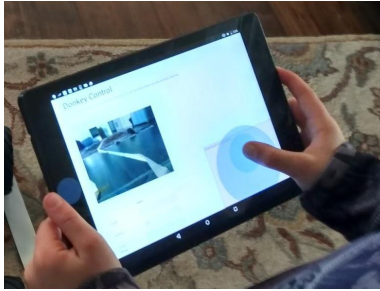


2. Assemble Parts (1 hour)



- Simplest possible hardware that we could build for a camera driven car.
- Enables Side-quests
 - Lidar
 - Odometry
 - Joystick controller
 - IMU





Steering (-1 to 1)
Throttle (-1 to 1)
Drive Mode (manual / auto)

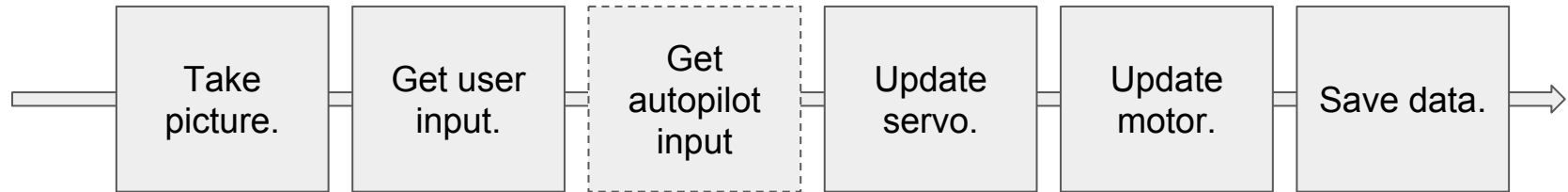


Image (120 x 160)

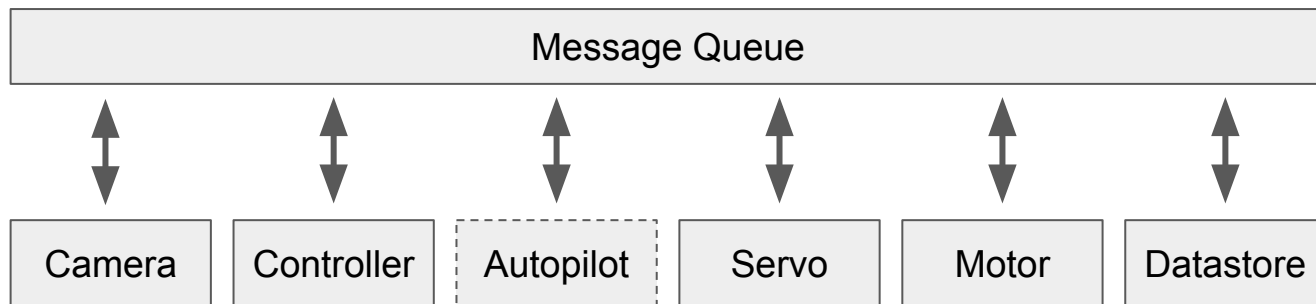


Drive
Perfectly.

Run the “vehicle loop” 30 times per second.

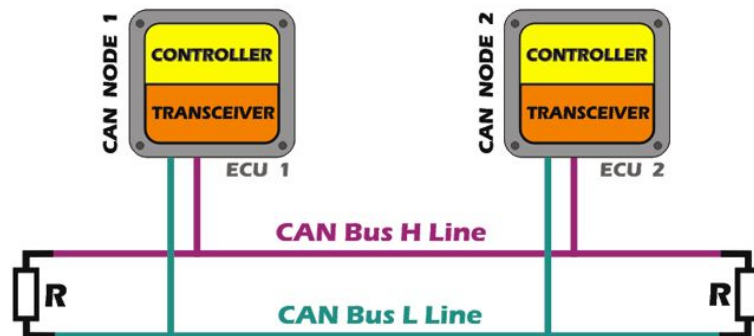


Publisher / Subscriber

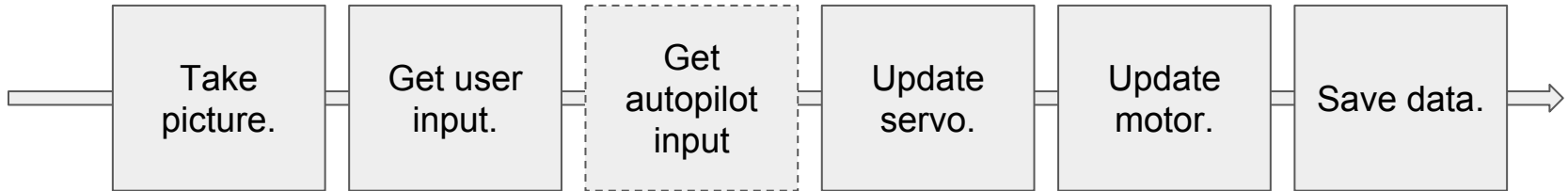


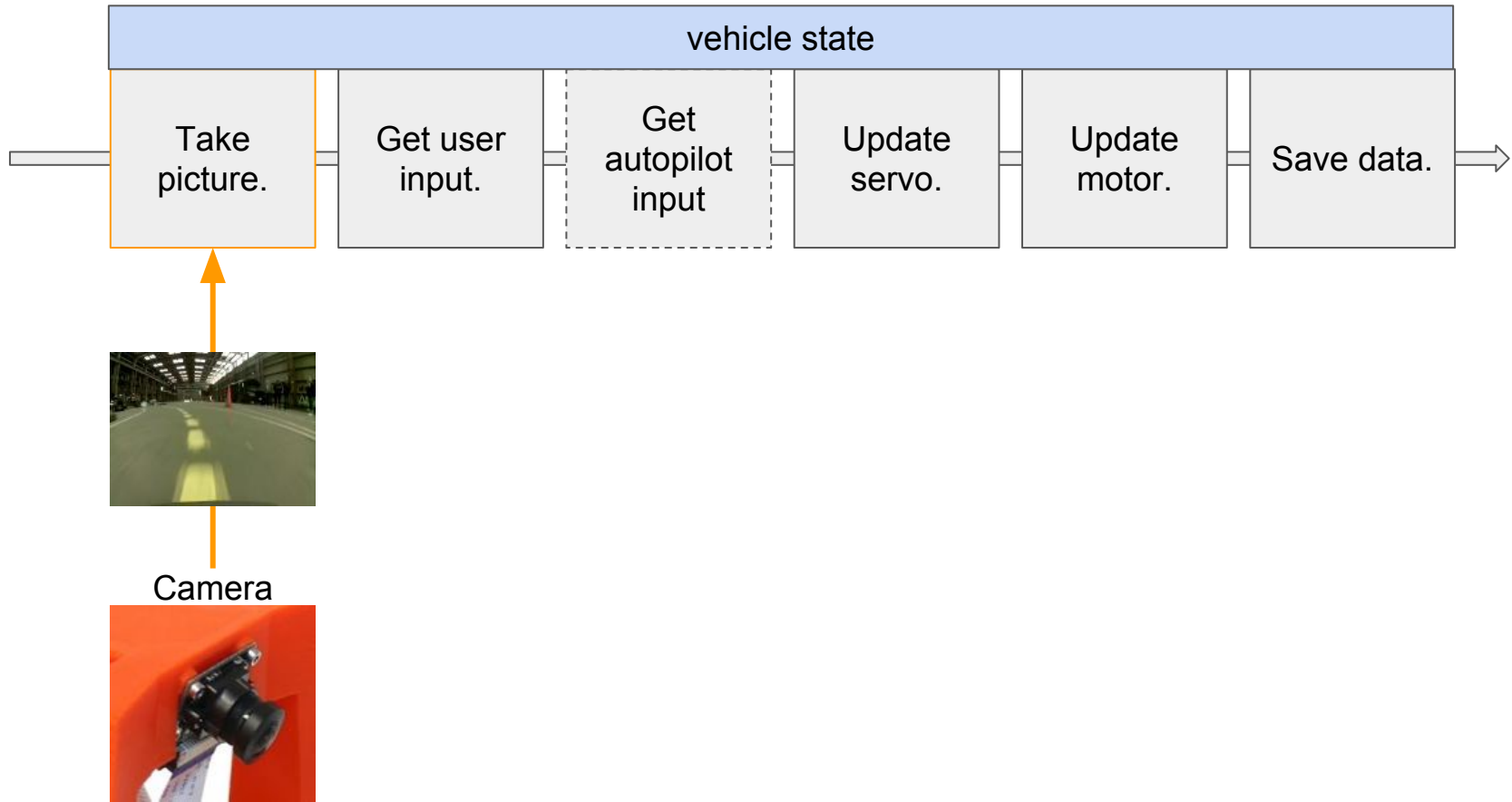
CAN Bus

Cars

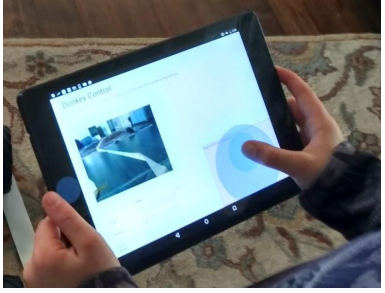
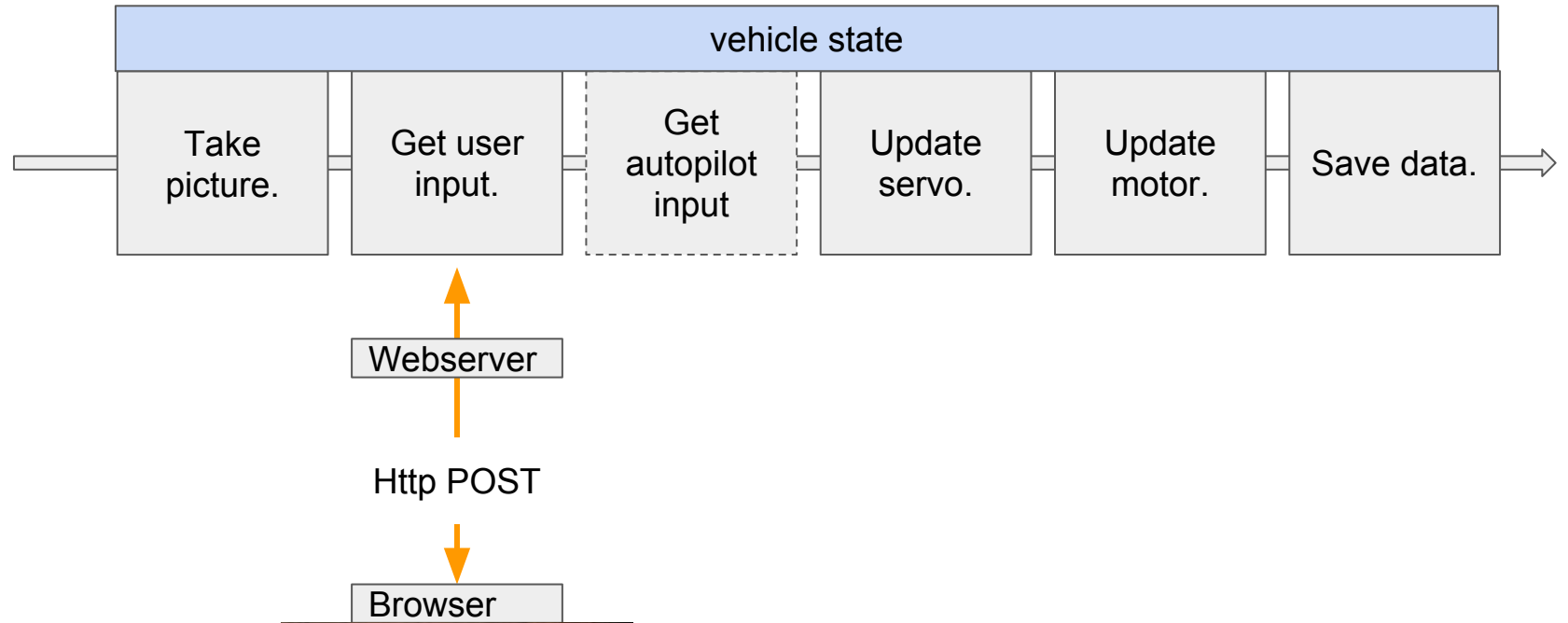


But... KISS

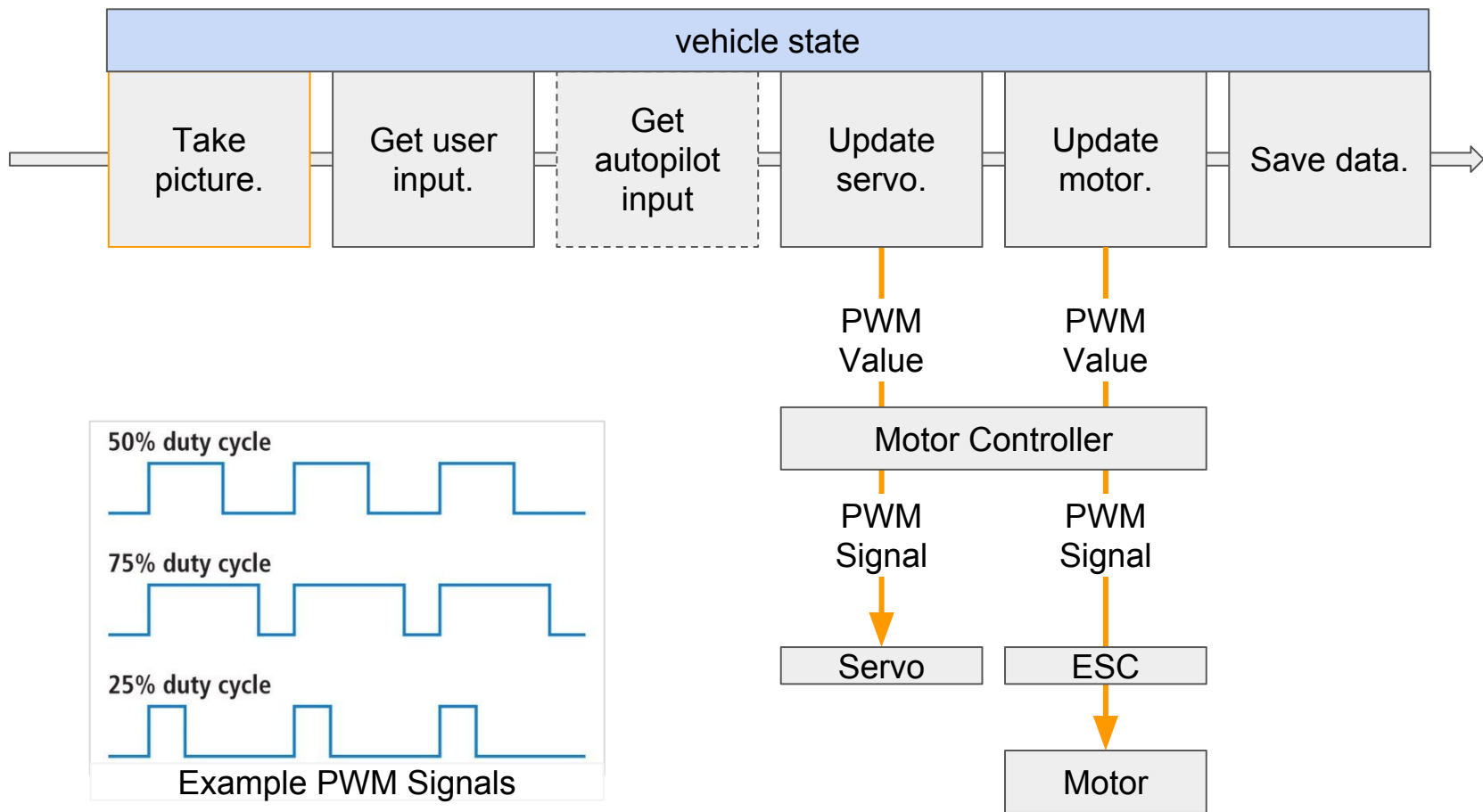


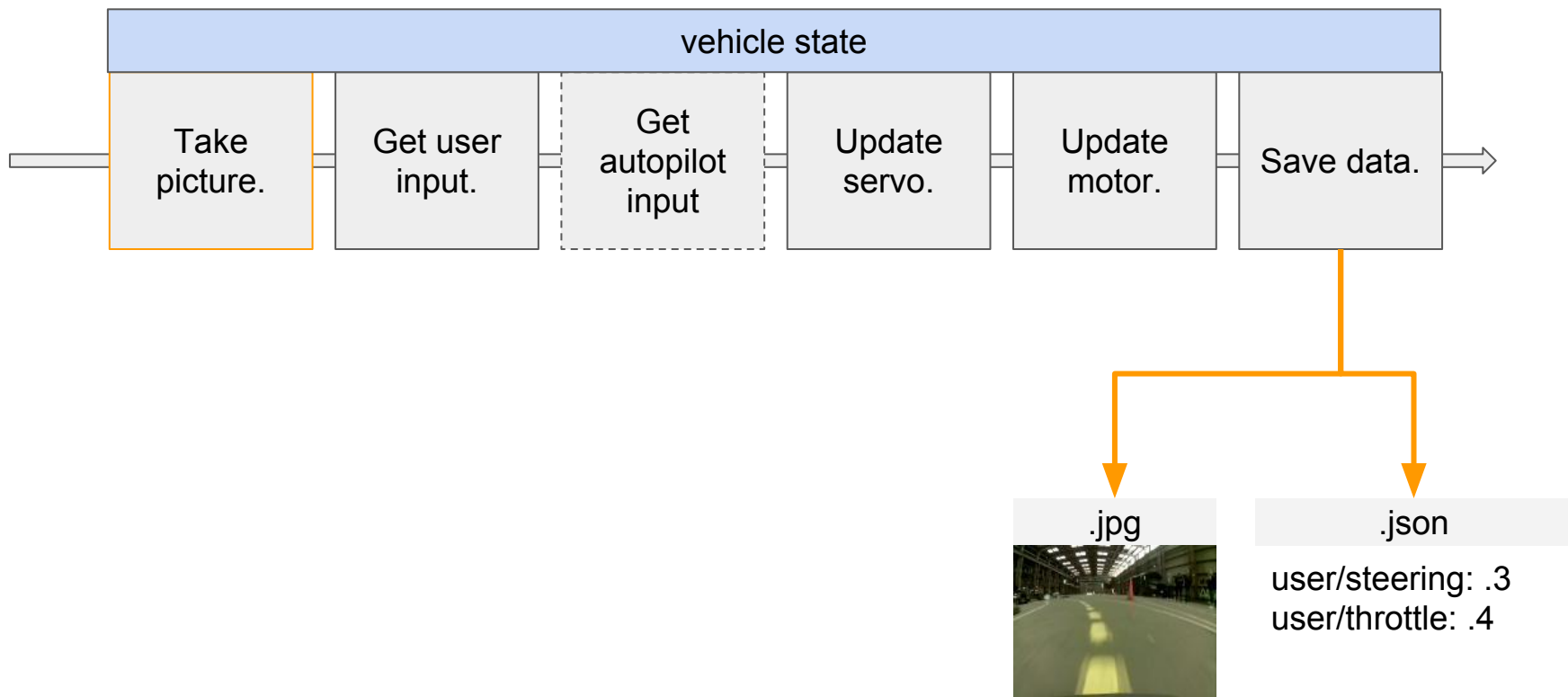


Donkey Car - Software Architecture



Donkey Car - Software Architecture





Get your donkey driving.

1. Clone donkey disk image.
2. `donkey createcar --path ~/d2`
3. `python d2/manage.py drive`
4. Go to `d2.localhost:8887` in your browser.



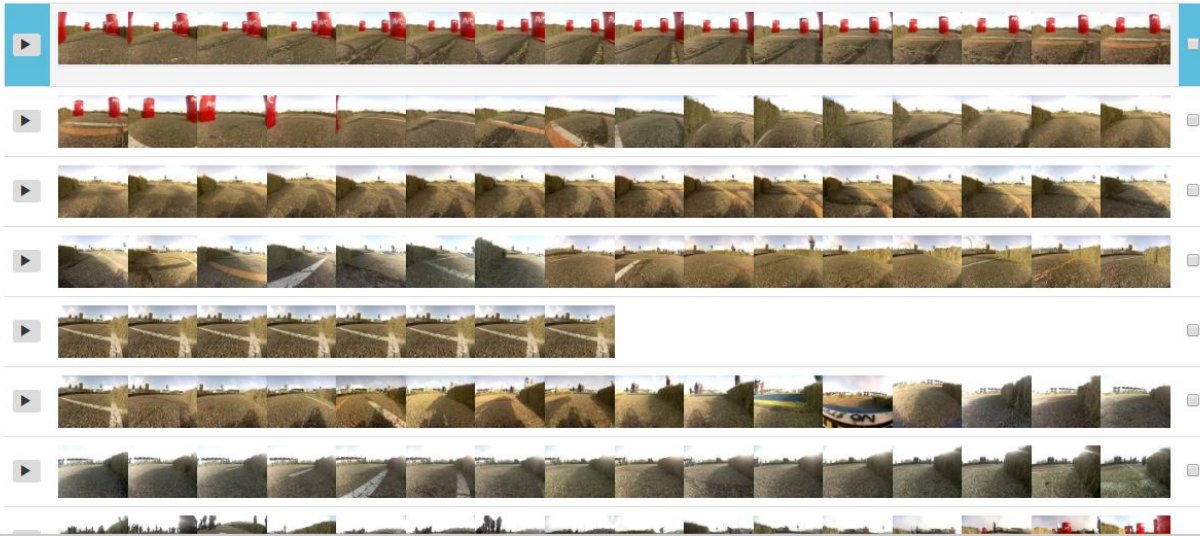
An aerial view of a small red robot with black wheels on a concrete floor. The robot is positioned on a circular track marked with yellow dashed lines. The track is surrounded by a white solid line. The robot is facing towards the bottom right of the frame.

Get training data.

Drive around the track ~20 times to collect 10-50k records.

Prepare training data.

1. Transfer records to computer.
2. Remove bad data.

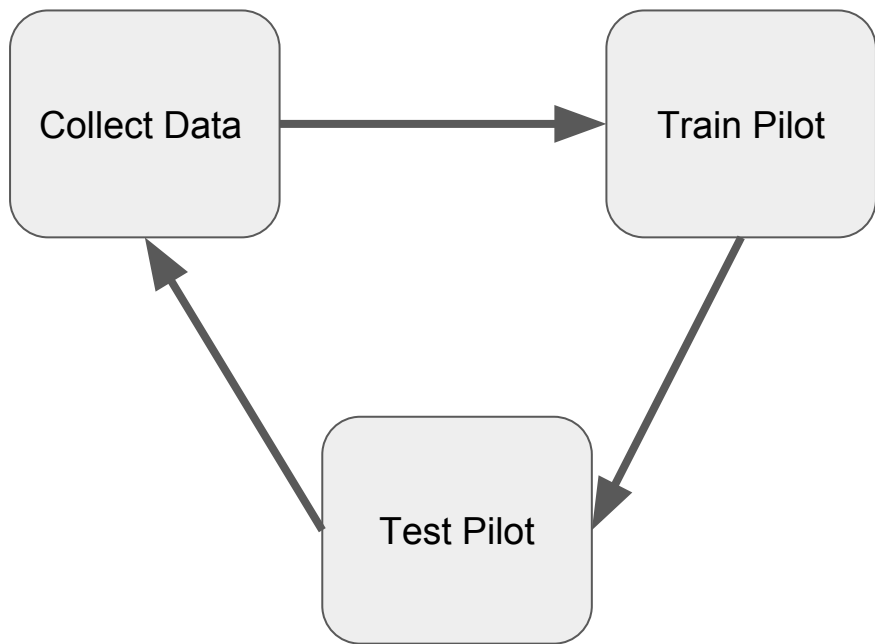


```
26/398 [=>.....] - ETA: 579s - loss: 3.3032 - angle_out_loss: 3.6691 - throttle_out_loss:
27/398 [=>.....] - ETA: 584s - loss: 3.2644 - angle_out_loss: 3.6259 - throttle_out_loss:
28/398 [=>.....] - ETA: 592s - loss: 3.2208 - angle_out_loss: 3.5774 - throttle_out_loss:
29/398 [=>.....] - ETA: 588s - loss: 3.1875 - angle_out_loss: 3.5405 - throttle_out_loss:
30/398 [=>.....] - ETA: 585s - loss: 3.1518 - angle_out_loss: 3.5009 - throttle_out_loss:
31/398 [=>.....] - ETA: 582s - loss: 3.1174 - angle_out_loss: 3.4627 - throttle_out_loss:
32/398 [=>.....] - ETA: 583s - loss: 3.0913 - angle_out_loss: 3.4337 - throttle_out_loss:
33/398 [=>.....] - ETA: 584s - loss: 3.0608 - angle_out_loss: 3.3998 - throttle_out_loss:
34/398 [=>.....] - ETA: 583s - loss: 3.0319 - angle_out_loss: 3.3677 - throttle_out_loss:
35/398 [=>.....] - ETA: 582s - loss: 3.0075 - angle_out_loss: 3.3406 - throttle_out_loss:
36/398 [=>.....] - ETA: 582s - loss: 2.9815 - angle_out_loss: 3.3118 - throttle_out_loss:
37/398 [=>.....] - ETA: 583s - loss: 2.9570 - angle_out_loss: 3.2845 - throttle_out_loss:
38/398 [=>.....] - ETA: 583s - loss: 2.9359 - angle_out_loss: 3.2611 - throttle_out_loss:
39/398 [=>.....] - ETA: 582s - loss: 2.9147 - angle_out_loss: 3.2376 - throttle_out_loss:
40/398 [==>.....] - ETA: 581s - loss: 2.8930 - angle_out_loss: 3.2134 - throttle_out_loss:
41/398 [==>.....] - ETA: 580s - loss: 2.8724 - angle_out_loss: 3.1914 - throttle_out_loss:
42/398 [==>.....] - ETA: 579s - loss: 2.8520 - angle_out_loss: 3.1714 - throttle_out_loss:
43/398 [==>.....] - ETA: 578s - loss: 2.8318 - angle_out_loss: 3.1514 - throttle_out_loss:
44/398 [==>.....] - ETA: 577s - loss: 2.8118 - angle_out_loss: 3.1314 - throttle_out_loss:
45/398 [==>.....] - ETA: 575s - loss: 2.8039 - angle_out_loss: 3.1146 - throttle_out_loss:
46/398 [==>.....] - ETA: 574s - loss: 2.7900 - angle_out_loss: 3.0990 - throttle_out_loss:
47/398 [==>.....] - ETA: 574s - loss: 2.7762 - angle_out_loss: 3.0837 - throttle_out_loss:
48/398 [==>.....] - ETA: 572s - loss: 2.7618 - angle_out_loss: 3.0678 - throttle_out_loss:
49/398 [==>.....] - ETA: 571s - loss: 2.7468 - angle_out_loss: 3.0512 - throttle_out_loss:
50/398 [==>.....] - ETA: 570s - loss: 2.7333 - angle_out_loss: 3.0361 - throttle_out_loss:
51/398 [==>.....] - ETA: 568s - loss: 2.7180 - angle_out_loss: 3.0191 - throttle_out_loss:
52/398 [==>.....] - ETA: 567s - loss: 2.7046 - angle_out_loss: 3.0043 - throttle_out_loss:
53/398 [==>.....] - ETA: 565s - loss: 2.6937 - angle_out_loss: 2.9921 - throttle_out_loss:
54/398 [===>.....] - ETA: 564s - loss: 2.6812 - angle_out_loss: 2.9783 - throttle_out_loss:
55/398 [===>.....] - ETA: 563s - loss: 2.6666 - angle_out_loss: 2.9620 - throttle_out_loss:
56/398 [===>.....] - ETA: 561s - loss: 2.6543 - angle_out_loss: 2.9484 - throttle_out_loss:
57/398 [===>.....] - ETA: 559s - loss: 2.6441 - angle_out_loss: 2.9371 - throttle_out_loss:
58/398 [===>.....] - ETA: 559s - loss: 2.6325 - angle_out_loss: 2.9241 - throttle_out_loss:
```

Train an autopilot using Keras / Tensorflow.

A small, four-wheeled robot is driving on a tiled floor, navigating a path marked by white lines. The path starts in the foreground, moves towards a large wooden display case with a glass top, circles it, and then continues. In the background, a crowd of people is gathered, some looking towards the robot. The scene appears to be an indoor exhibition or event.

Test drive... repeat.



Keras / Tensorflow Autopilots

```
img_in = Input(shape=(120, 160, 3), name='img_in')
x = img_in
x = Convolution2D(24, (5,5), strides=(2,2), activation='relu')(x)
x = Convolution2D(32, (5,5), strides=(2,2), activation='relu')(x)
x = Convolution2D(64, (5,5), strides=(2,2), activation='relu')(x)
x = Convolution2D(64, (3,3), strides=(2,2), activation='relu')(x)
x = Convolution2D(64, (3,3), strides=(1,1), activation='relu')(x)

x = Flatten(name='flattened')(x)

x = Dense(100, activation='relu')(x)
x = Dropout(.1)(x)
x = Dense(50, activation='relu')(x)
x = Dropout(.1)(x)

#categorical output of the angle
angle_out = Dense(15, activation='softmax', name='angle_out')(x)

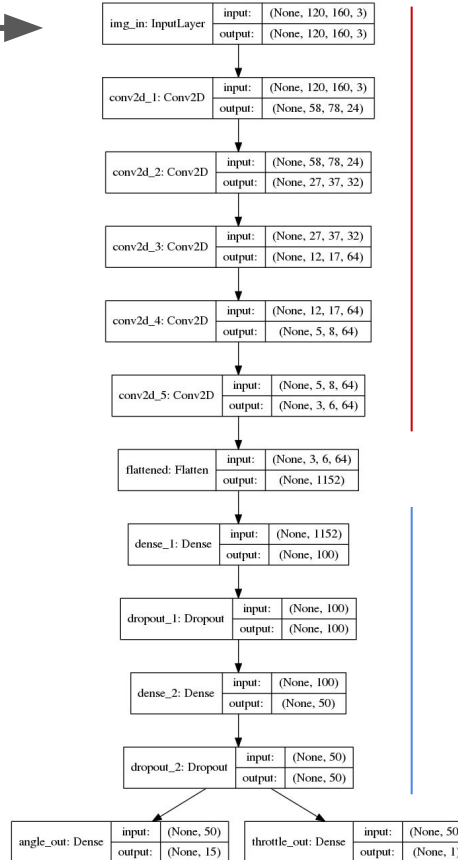
#continous output of throttle
throttle_out = Dense(1, activation='relu', name='throttle_out')(x)
```

Image Array



120 pixels high
160 pixels wide
3 RGB channels

Neural network.



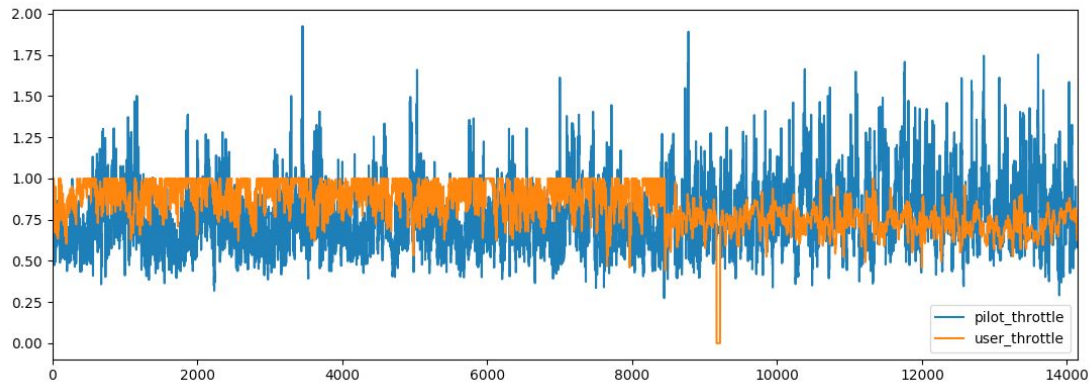
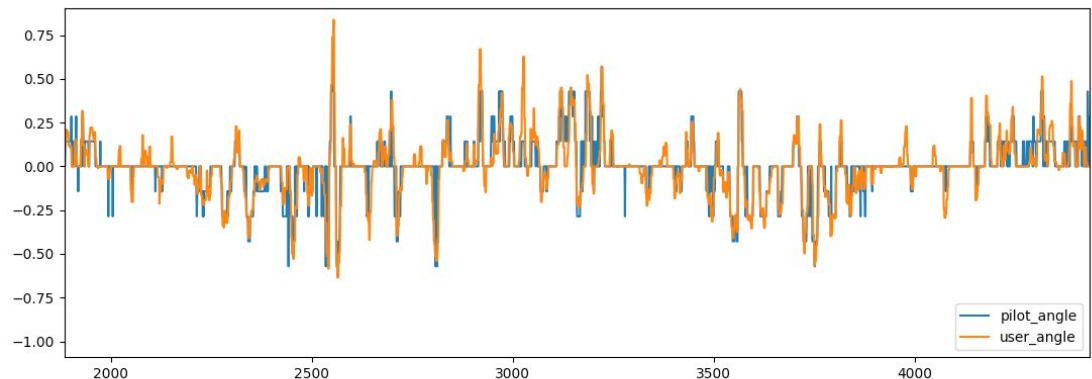
Convolution layers

Fully connected layers

Steering + Throttle

Can we test
an autopilot
without
driving?

Model Predictions
Tubs: ./data/avc/good_fast_laps_sat_at_3,./data/avc/barrels_sat_at_3
Model: ./models/avc_custom_train_r3.h5



What's next for Donkey.

More competitions.

DIYROBOCARS
FAST | CHEAP | OUT OF CONTROL
diyrobocars.com

AWS
re:Invent

Next race is this weekend in
Oakland 10am - 2pm.

2 day Hackathon in Vegas
Nov 26-27

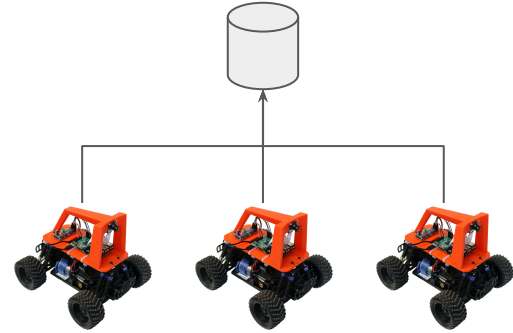
Simulators



Additional data.



More sensors.



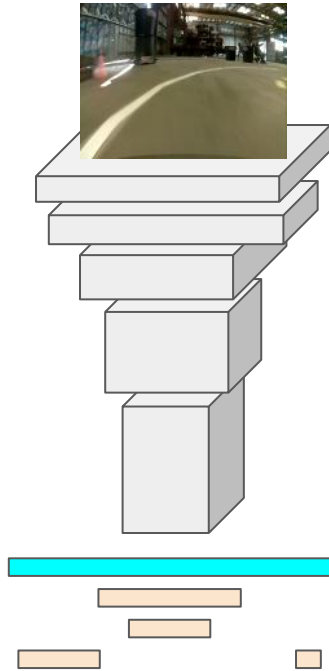
Pooling data from
multiple cars..

New Environments

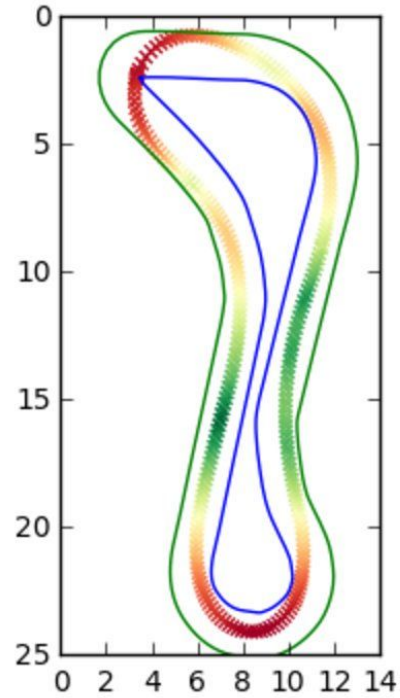


Better Autopilots

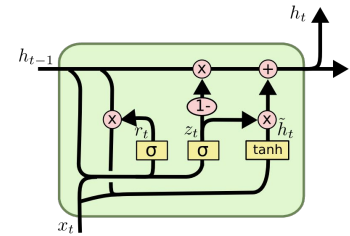
Modular Nets

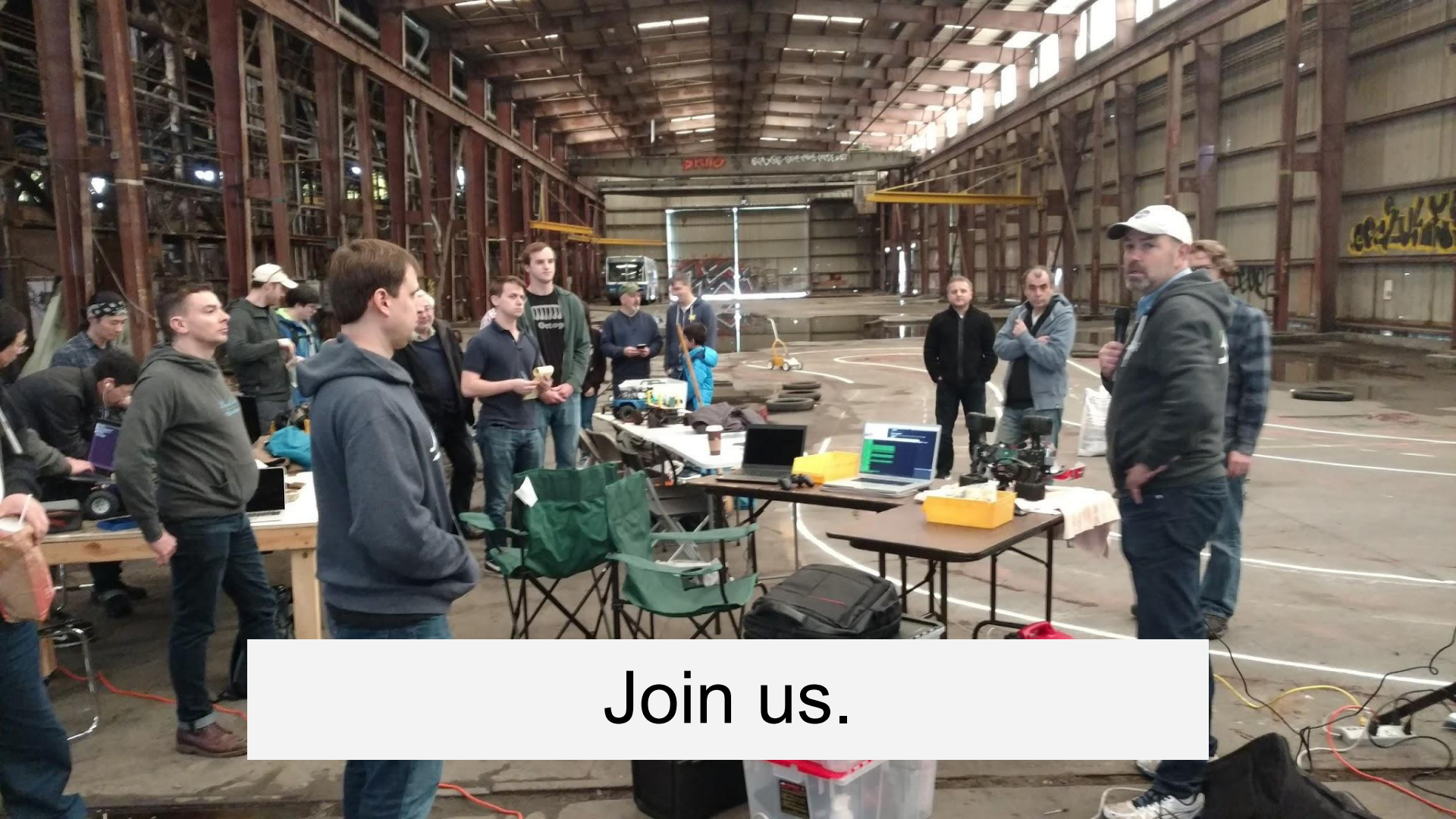


Maps



Stateful



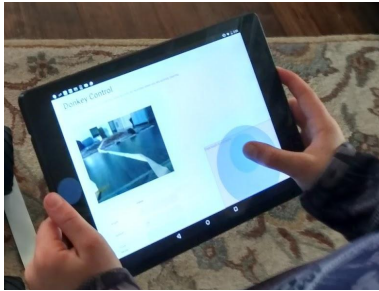


Join us.

1 - Build your own car or try to drive the simulator.

2 - Hack on any part that interests you.

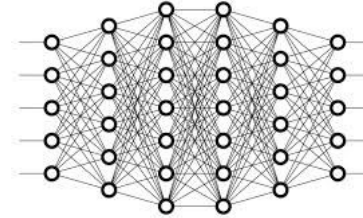
Web



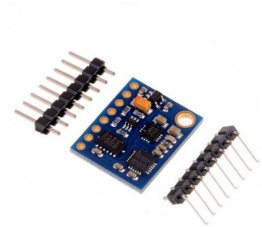
Computer Vision



Deep Learning



Hardware



Instructions to build your own car.
donkeycar.com



Race events / meetups.
diyrobocars.com



Stay in touch:

Will Roscoe: [@dataduce](https://twitter.com/dataduce)

Adam Conway [@acb0t](https://twitter.com/acb0t) (with a zero)