# Deep Learning Autonomous Cars

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# Agenda

Fubar Labs

Types of Autonomy in Self Driving Cars

Overview of Motion Planning Paradigms

Deep Learning for Self Driving Cars

Fubar's Cars

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Disclaimer

The opinions expressed on this presentation are solely those of the authors and not necessarily those of their employers.

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# FUBAR Labs

Fair Use Building and Research (FUBAR) Labs is New Jersey's first Hackerspace, established in New Brunswick in 2009.

FUBAR Labs was formed as a non-profit community-based organization with the purpose of bringing makers, hackers, and tinkerers together to collaborate and share ideas and knowledge. We offer classes, workshops, study groups, and collaborative projects.

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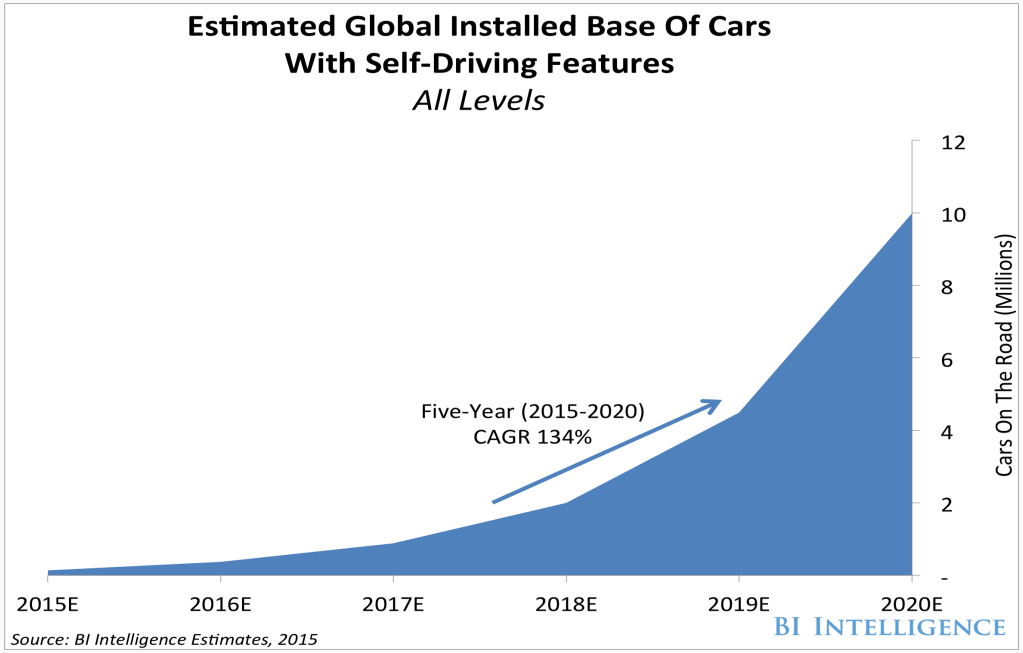
# Autonomy in Self Driving Cars

- Self-driving cars are not some futuristic auto technology. 10 million self-driving cars will be on the road by 2020
- The barriers to self-driving cars remain significant. Costs need to come down and regulations need to be clarified around certain self-driving car features before the vehicles fully take off among mainstream consumers.






Source: https://www.businessinsider.com/report-10-million-self-driving-cars-will-be-on-the-road-by-2020-2015-5-6

# Automation Levels

## 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.

SOURCE: SAE International

BUSINESS INSIDER

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# Overview of Motion Planning Paradigms

## Two Approaches: Vision vs Lidar

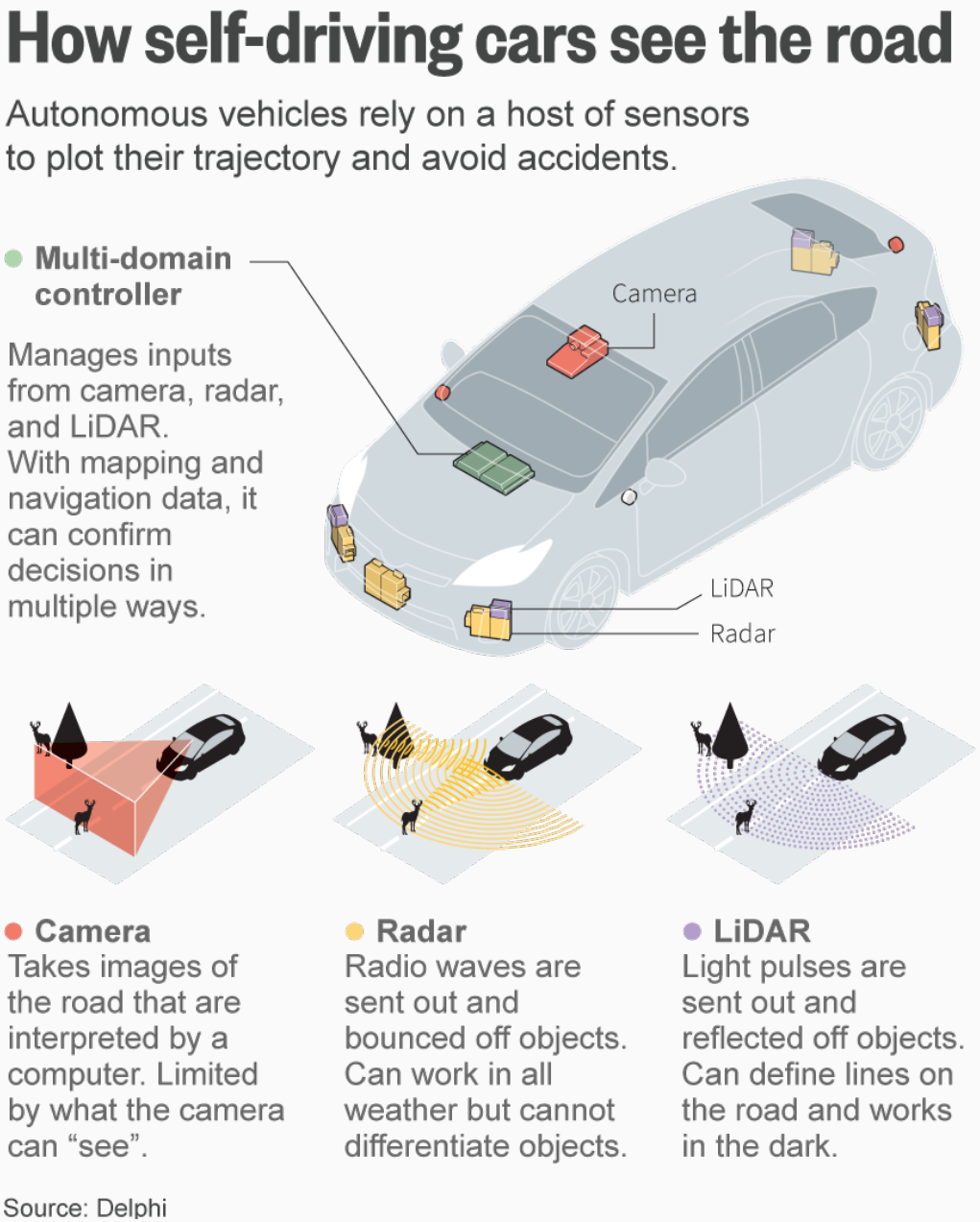
- Vision Sensors + Deep Learning
  - **Pros:**
    - Highest resolution information
    - Feasible to collect data at scale and **learn**
    - Roads are designed for human eyes
    - Cheap
  - **Cons:**
    - Not accurate (without **a lot** of data)
    - Not explainable, not consistent
- Lidar + Maps
  - **Pros:**
    - Explainable, consistent
    - Accurate
  - **Cons:**
    - Does not improve over time
    - Expensive

Camera

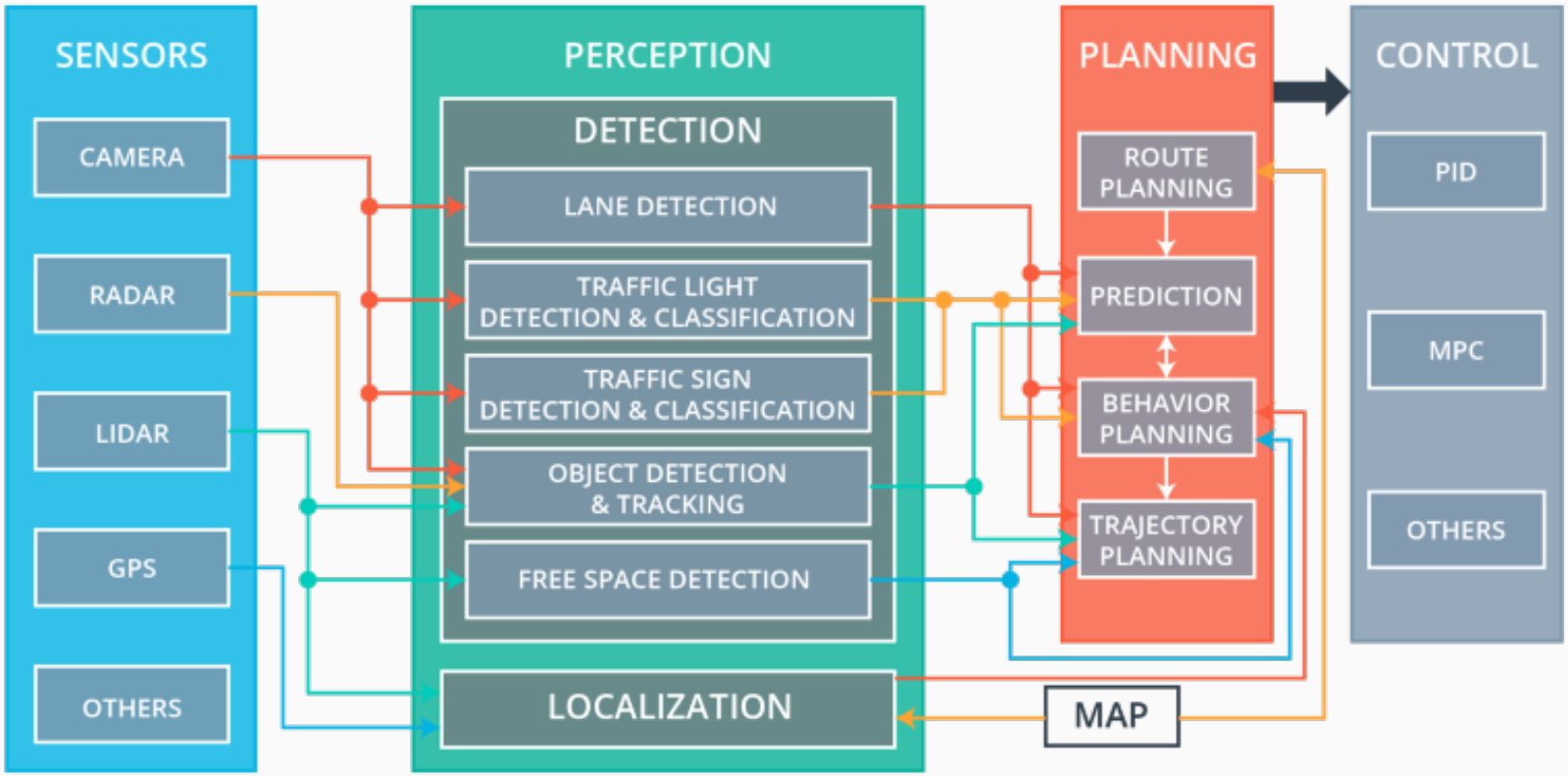
LIDAR

Radar

# Motion Planning Paradigms - Cars with Lidars -1

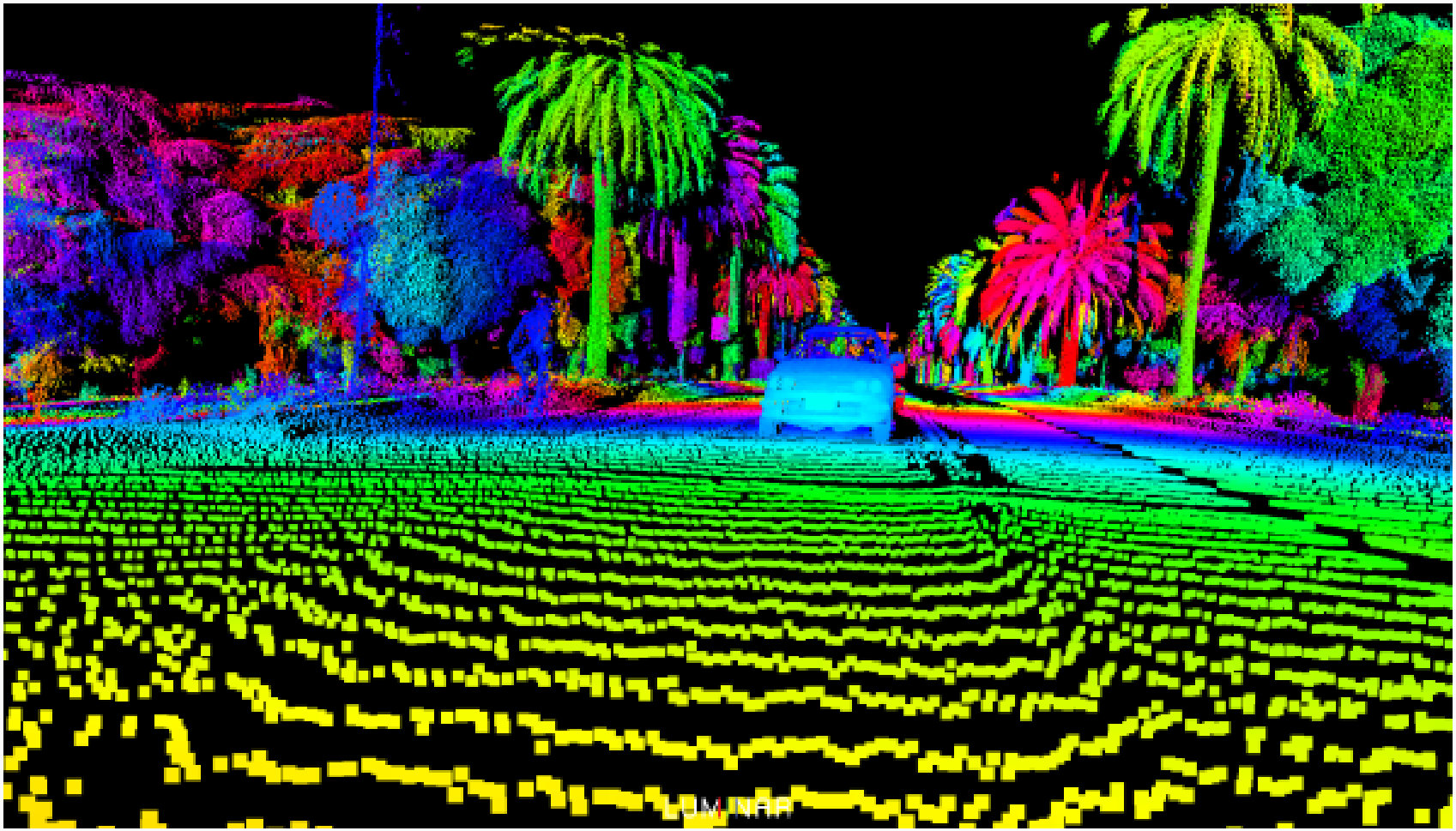


# Motion Planning Paradigms - Cars with Lidars -2



# Motion Planning Paradigms - Cars with Lidars -3

This is an example of a Lidar point cloud. The Camera images are used on top of it to do image classification.



# Motion Planning Paradigms - Cars without Lidars

**No Lidar? No problem!**

- Camera images combined with steering and throttle data
- Seminal paper: "End To End Learning for Self Driving Cars"
- Driving Paradigm: "behavioral cloning": literally cloning the behaviour of the driver. The idea is to train Convolution Neural Network(CNN) to mimic the driver based on training data from driver's driving

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## What is a Neural Network?

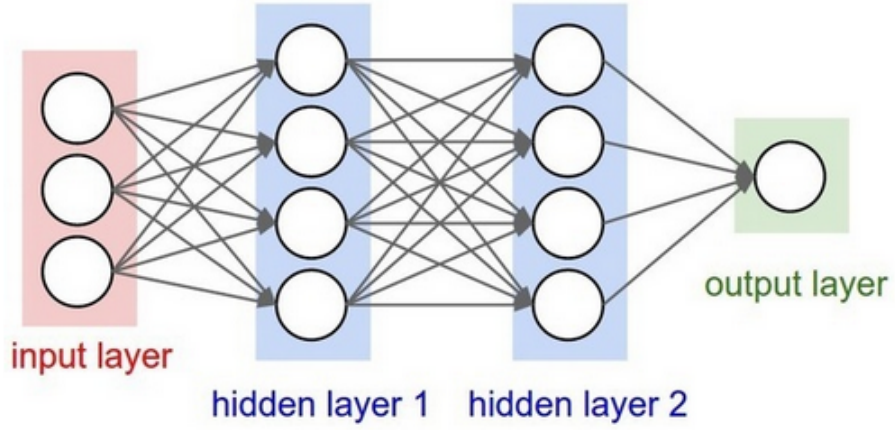
- **Short answer:**
  The neural network makes all the decisions for our autonomous car. It learns to drive the way we do.
- **Long answer:**
  - Problem solving method useful for generalizing inputs to outputs
  - Works best when relationships are unknown or difficult to determine
  - Based on biological model of a web of neurons and activation potentials
  - Training involves lots of processing power and incremental improvement
  - Models are composed of layers of neurons and connections
  - Input, output, and hidden layers of nodes and activation functions

# Deep Learning for Autonomous Cars - cont

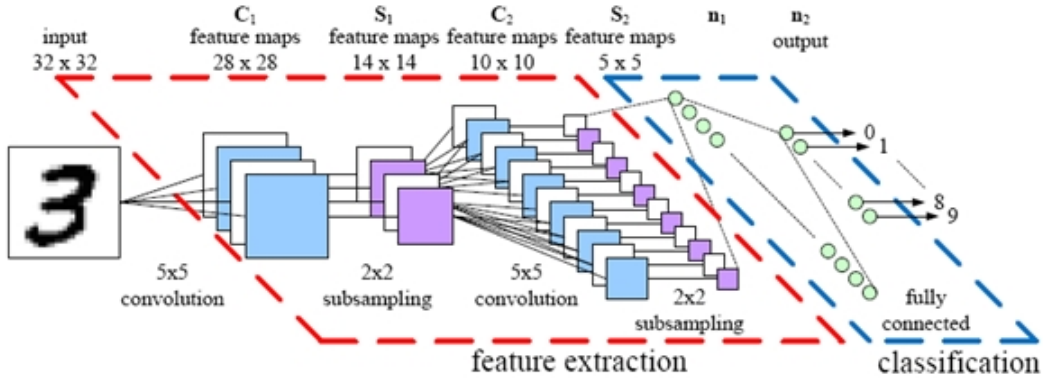
- Each node has an *activation function* determining how much signal is passed on
- Layers are connected, input values eventually reach outputs
- When finished, performance measured, error is calculated
- Network adjusted, run again ( again) until good enough, improvement stops, or  runs met
- Training is computationally intensive, running is relatively lightweight

## Example Networks

Fully connected network, also called "multi-layer perceptron" network




Convolutional neural network



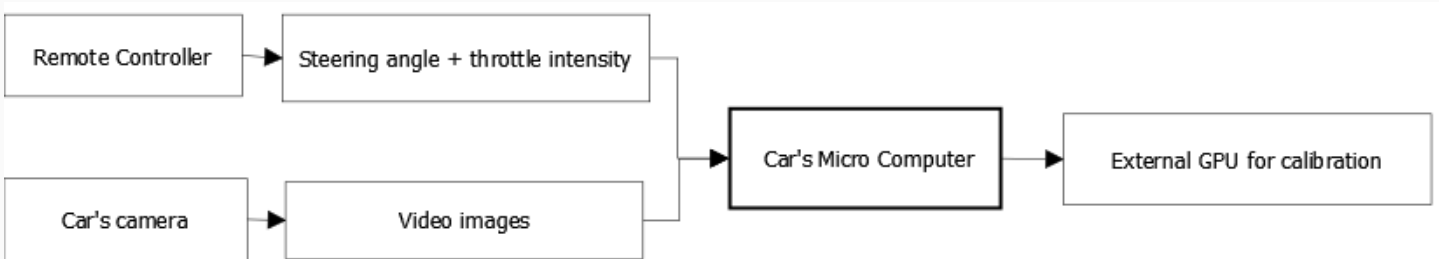
# Machine Learning Loop

## Steps

1. **Collect data**- images plus car stats
2. **Training** - training of the CNN algo
3. **Driving** - use the CNN to take driving decisions

## 1. Collect Data

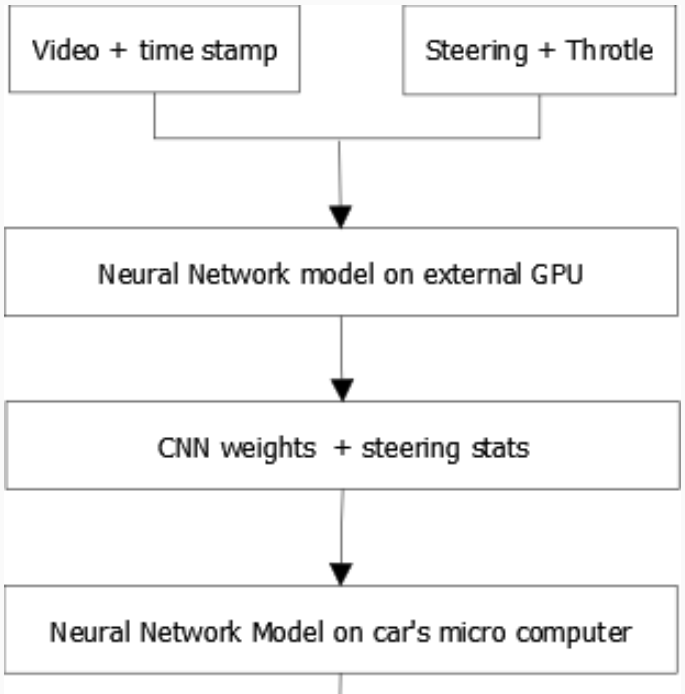
- In order to create the neural network, we need examples of how we want the car to drive– "training data"
- This data is collected by recording images from the camera along with the current values being sent by the remote control



# Machine Learning Loop - Training the Convolutional Neural Network

## 2. Training Process

- Once we're certain that we've pruned any unwanted examples from our dataset, we train the network.
- When we have a set of weights for the trained network, we transfer the weights to the car.



# Machine Learning Loop - Training the Convolutional Neural Network

3. **Driving**
   - When the car is in autonomous mode, the camera takes images which are run through the network to output a command to the steering servo.
   - While the car is in autonomous mode, it monitors the RC signal from the user for a remote kill signal.

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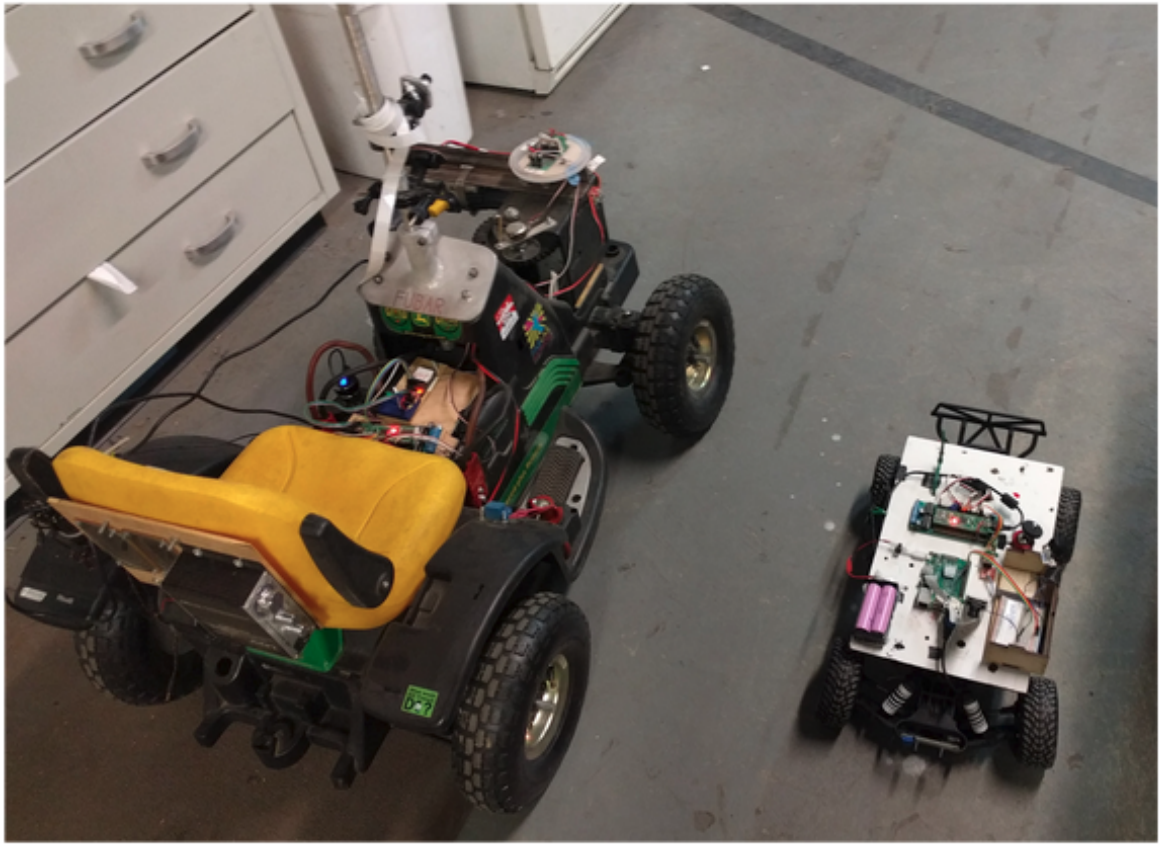
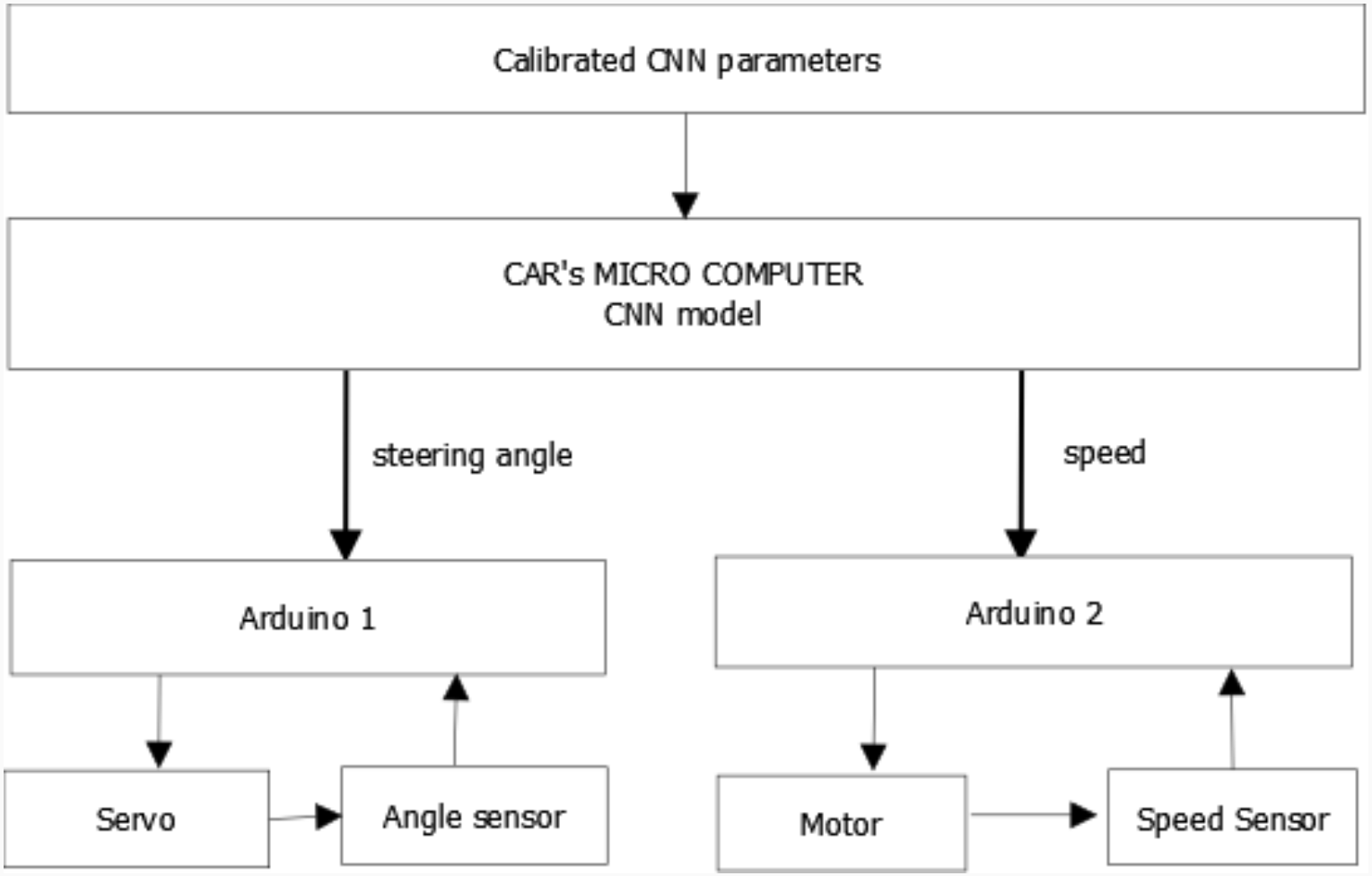
# Fubar's Cars - Foocars

## What is foocars?

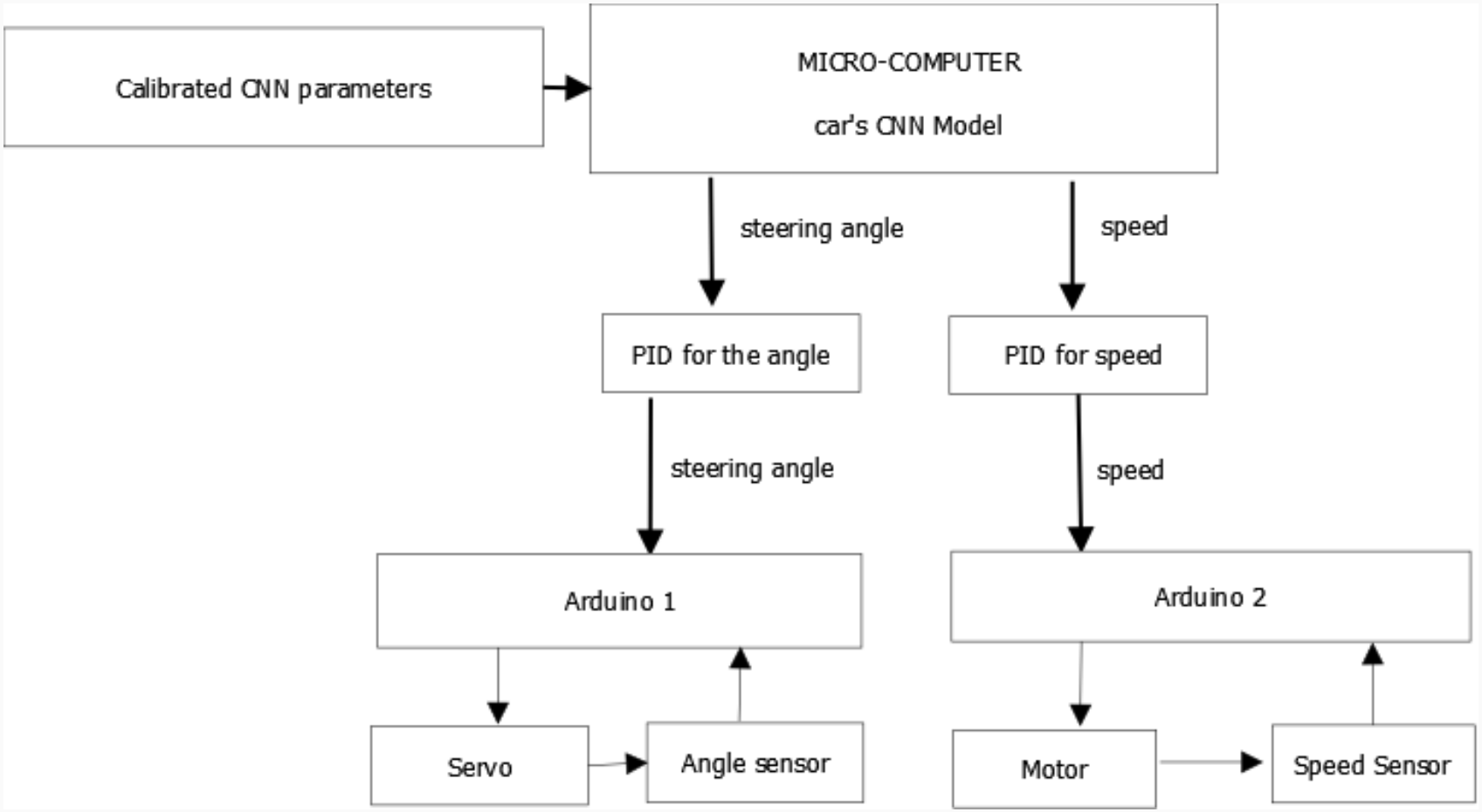
- We've been working on foocars for almost two years
- The foocars project is a codebase and a basic electronics setup:
  - RGB camera
  - Raspberry pi
  - Microcontroller
  - RC control



# Motto Car


Calibrated CNN parameters
CAR's MICRO COMPUTER
CNN model
steering angle
speed
Arduino 1
Arduino 2
Servo
Angle sensor
Motor
Speed Sensor

# Fuvette Car


Calibrated CNN parameters
MICRO-COMPUTER
car's CNN Model
steering angle
speed
PID for the angle
PID for speed
steering angle
speed
Arduino 1
Arduino 2
Servo
Angle sensor
Motor
Speed Sensor

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# Demo Time!

- **text** – Walk through our Github repo and do some running

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# Next Session

- A tour to our Github repo
  https://github.com/fubarlabs/foocars
- Open issues
  https://github.com/fubarlabs/foocars/issues
- Open projects
  https://github.com/fubarlabs/foocars/projects
- Tutorials
  https://github.com/fubarlabs/foocars/tree/master/tutorials

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Questions ?