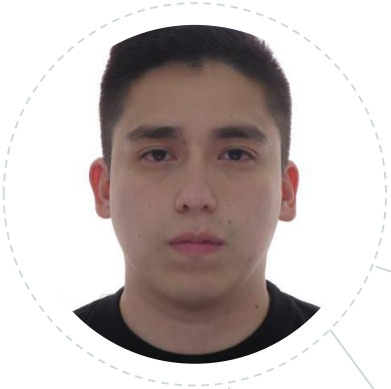
KiwiBots: Using the power of GPUs to solve the last mile delivery problem

kiwi

$whoami

My name is David Cardozo

Machine Learning
Engineer at Kiwi Campus.



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Agenda

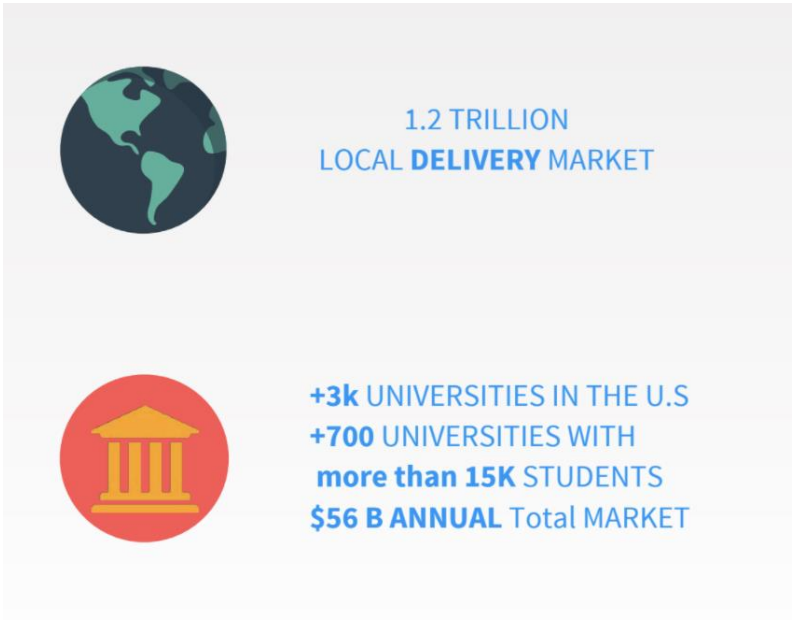
1. Kiwi in LatAm market.
2. The Last Mile Delivery Problem
3. How did we end-up in robotics.
4. Computer Vision
5. Convolutional Networks for Driving, and Image tasks
6. Jetson TX2
7. Development
8. KiwiBot

1.

Kiwi Campus? How to make deliveries in the United States?


¡Tengo hambre!
pero no quiero salir.
Pidamos en Kiwi

PLAN



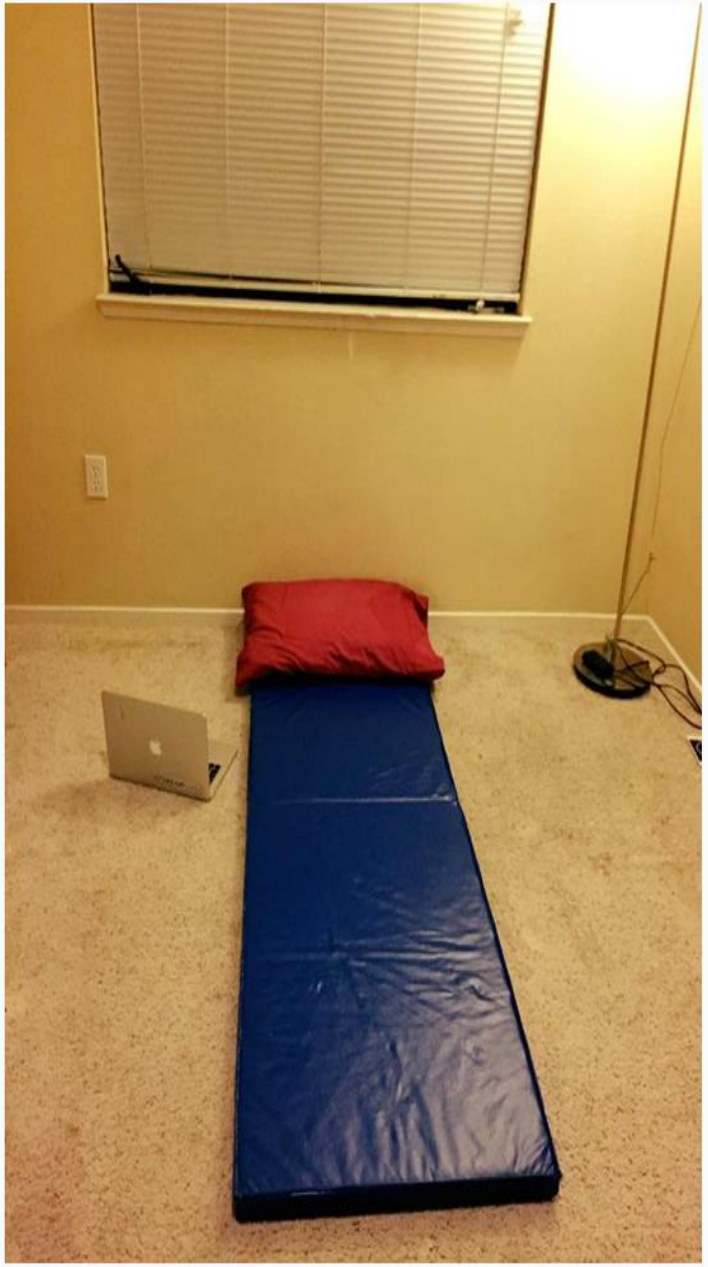
How to make deliveries < $1

Stanford	*16,132 students*	*$ 206 M*
San Francisco State University	*32,375 students*	*$ 175 M*
University of Southern California	*46,174 students*	*$ 250 M*
University of California Los Angeles	*43,378 students*	*$ 234 M*
California State University - Fullerton	*40,312 students*	*$ 217 M*
California State University - Northridge	*39,906 students*	*$ 215 M*

Felipe Chávez

Sergio Pachón

Jason oviedo




We are kiwi
kiwi
kiwi
kiwi
kiwi
kiwi
kiwi
kiwi
BERKELEY

$25

Per person

< 30

Available students

< 3 orders per hour

Extremely difficult to get to 15 deliveries per hour

“That’s the hard thing about hard things—there is no formula for dealing with them.”

$25

Per person

< 30

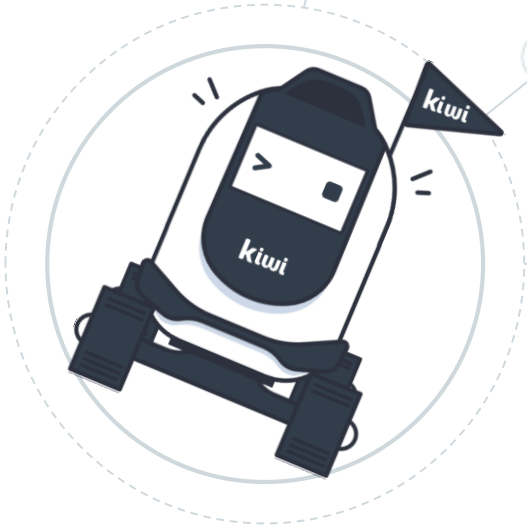
Available students

< 3 orders per hour

Extremely difficult to get to 15 deliveries per hour

The last mile delivery problem

- Less that one dollar delivery.
- Almost 40% of the cost of a delivery is on the last mile delivery.
- Robots can help us out to minimize costs and time.



Courier

$8/delivery

Need to park

Difficult access to campus

36 min avg. delivery time*


ROBOTS FOR DELIVERY?
NO, I'M SERIOUS

3.

How did we end up in robotics?

It is not rocket science…..

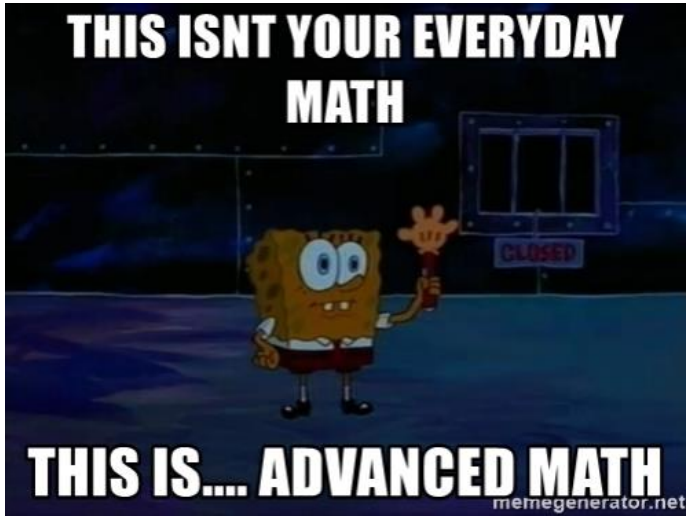

kiwibot


kiwi


Order food online
kiwicampus.com
Find us in
SCHWINN

The age of Deep Learning

1. Autonomy for navigation and delivery



Computer Vision

“So how exactly the computer sees? – The thing is most of computer vision researchers do not really understand how the computers see.

It’s like alchemy and chemistry. Alchemy came first and chemistry came then. And right now we are in the alchemy stage of computer vision, where it works but we are not sure why. And it is the chemistry stage that I look forward to.”

- Bill Freeman

Statistics of natural images obey invariants

…

Translation

Cutout

Dilatation

Contrast

Rotation

Scale

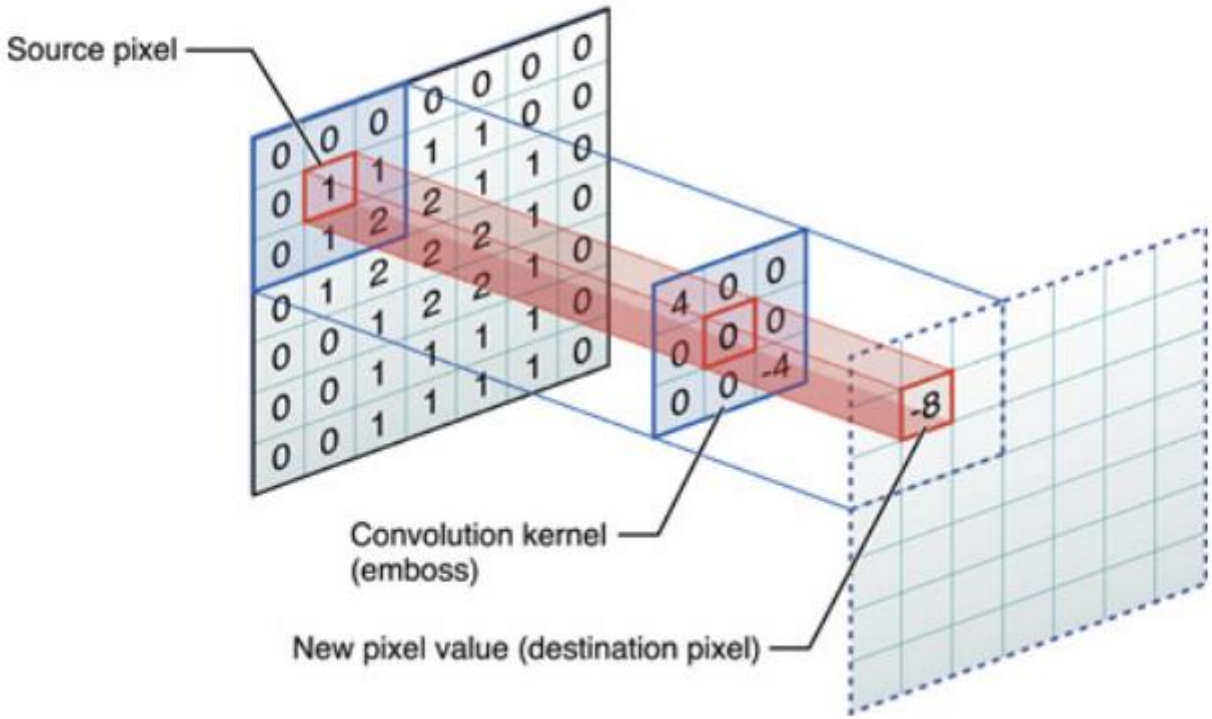
Brightness

…

Statistics of natural images: Scaling in the woods
D Ruderman and W Bialek (1994)
Natural image statistics and neural representation
E Simoncelli and B Olshausen (2001)

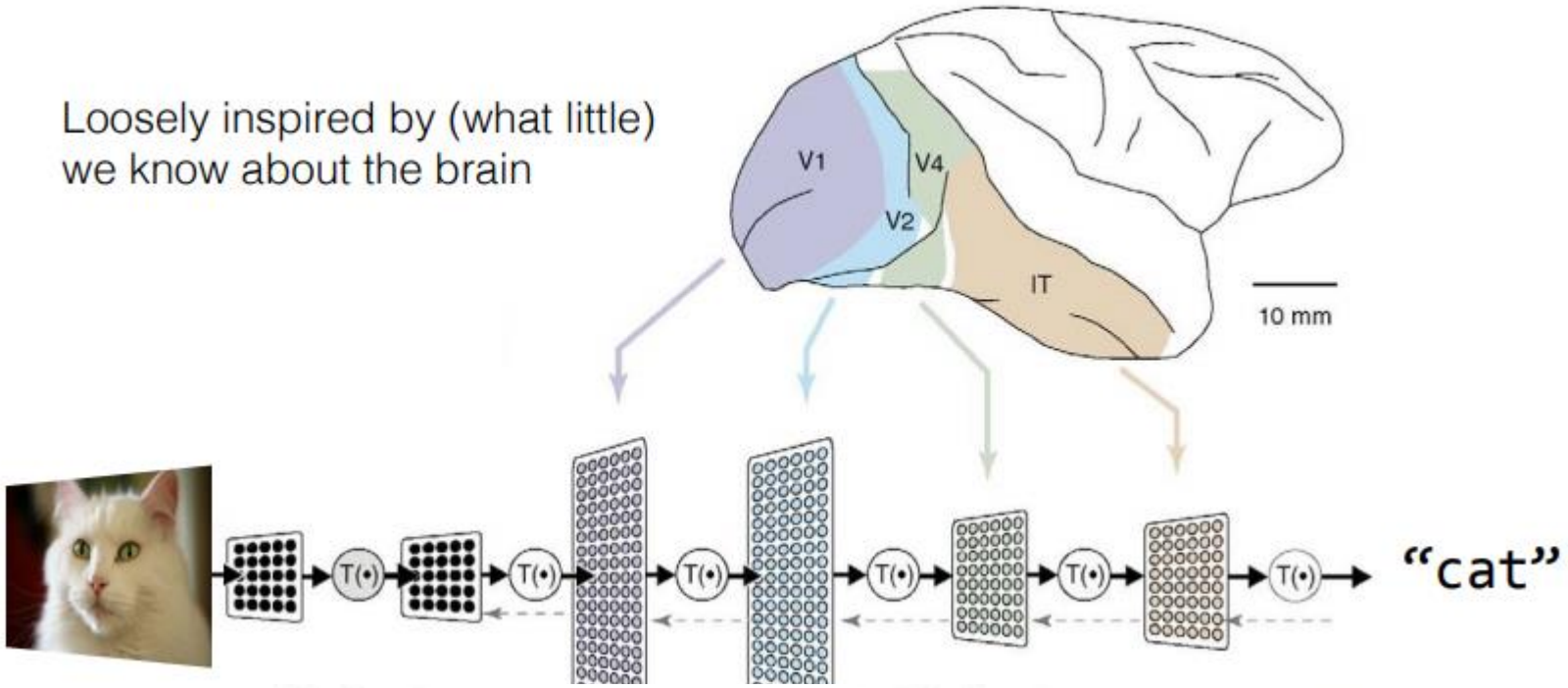
Invariant under Translation ---> Convolution (Cross-Relation)

Convolutional kernels are a *spatially localized* receptive field whose weights are *shared* across spatial locations.

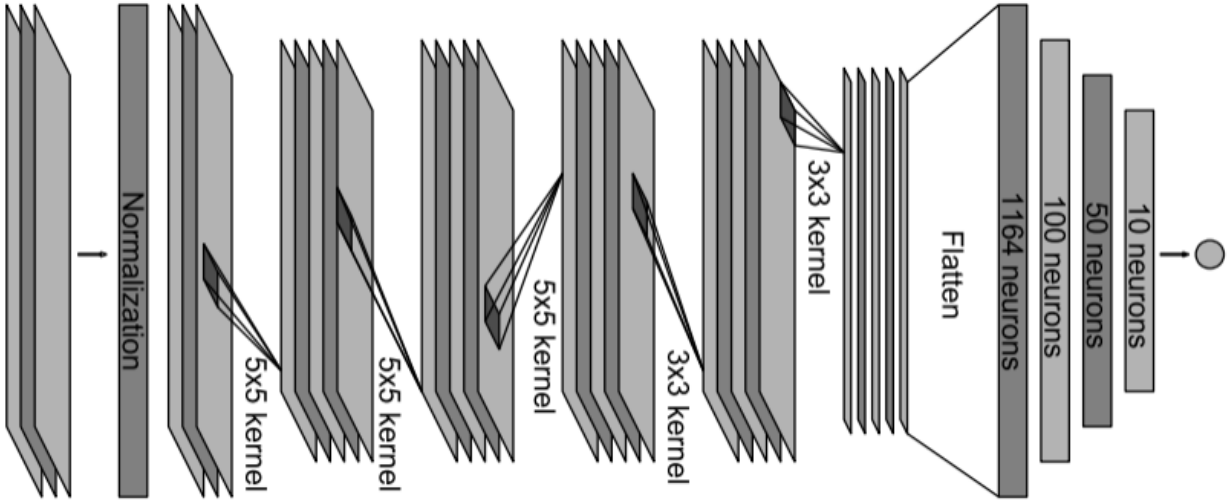


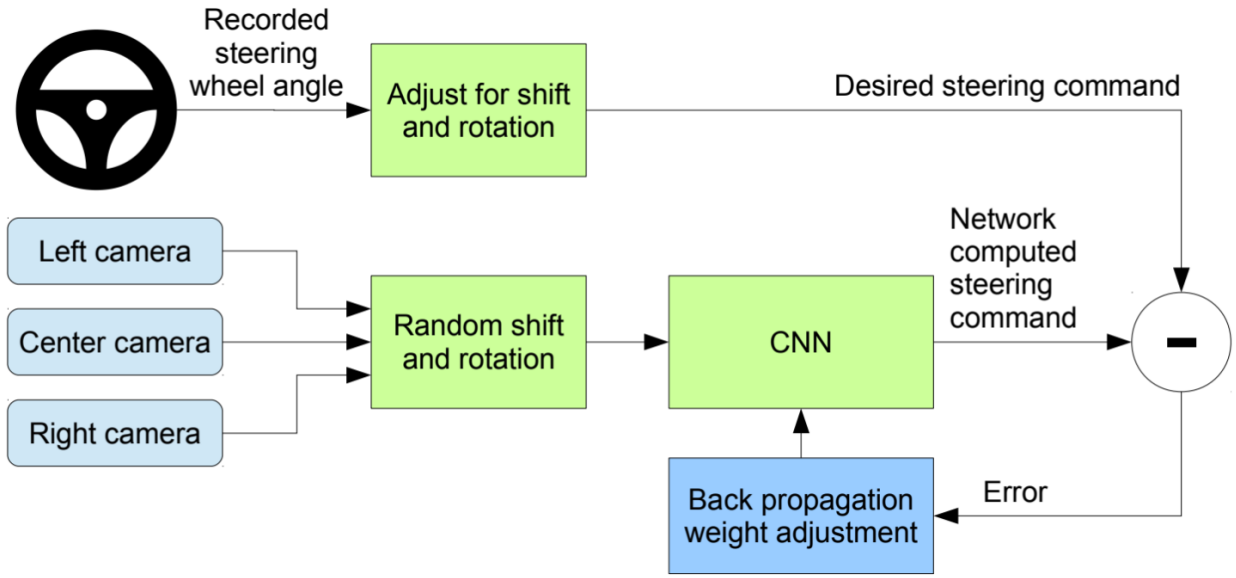
The visual pathway

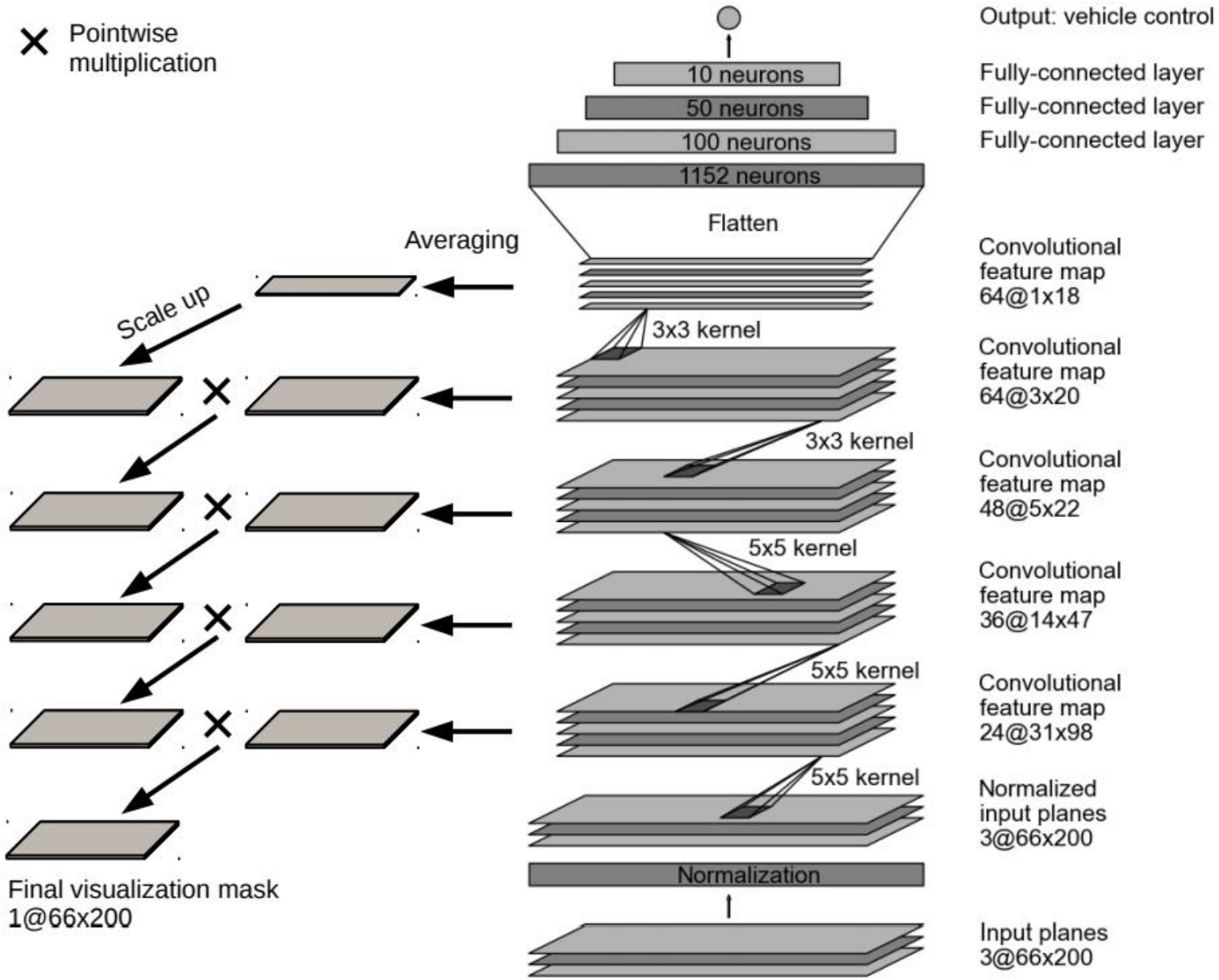
Loosely inspired by (what little) we know about the brain



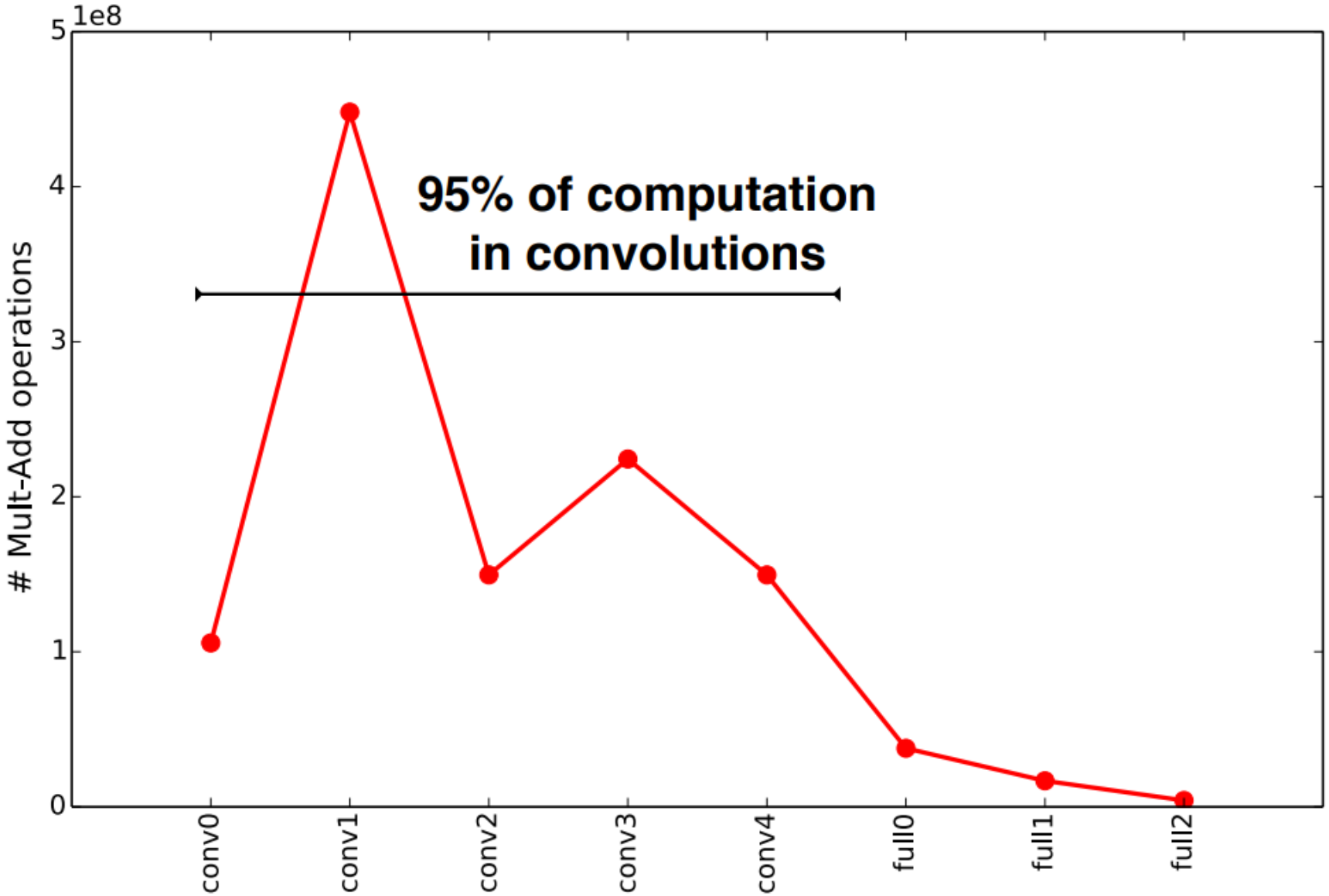
How Does the Brain Solve Visual Object Recognition?
James J. DiCarlo, Davide Zoccolan, Nicole C. Rust (2012)
Untangling Invariant Object Recognition
J DiCarlo and D Cox (2007)
Performance optimized hierarchical models predict neural responses in higher visual cortex
D Yamins, H Hong, C Cadieu, E Solomon, D Seibert, and J. DiCarlo (2014)


Normalization
5x5 kernel
5x5 kernel
5x5 kernel
3x3 kernel
3x3 kernel
Flatten
1164 neurons
100 neurons
50 neurons
10 neurons


Recorded steering wheel angle
Adjust for shift and rotation
Desired steering command
Left camera
Center camera
Right camera
Random shift and rotation
CNN
Network computed steering command
Back propagation weight adjustment
Error


Pointwise multiplication
Output: vehicle control
10 neurons
Fully-connected layer
50 neurons
Fully-connected layer
100 neurons
Fully-connected layer
1152 neurons
Flatten
Averaging
Convolutional feature map 64@1x18
Scale up
3x3 kernel
Convolutional feature map 64@3x20
3x3 kernel
Convolutional feature map 48@5x22
5x5 kernel
Convolutional feature map 36@14x47
5x5 kernel
Convolutional feature map 24@31x98
5x5 kernel
Normalized input planes 3@66x200
Normalization
Input planes 3@66x200
Final visualization mask 1@66x200


kiwi


1e8
5
4
3
2
1
0
Mult-Add operations
95% of computation
in convolutions
conv0
conv1
conv2
conv3
conv4
full0
full1
full2

kiwi Brain

Technology overview

Capable to run multiple A.I Models: Be centered in the sidewalk, street crossing mode, corner detection, localization, follow mode, and point and click for remote take over.

5x cheaper than alternatives

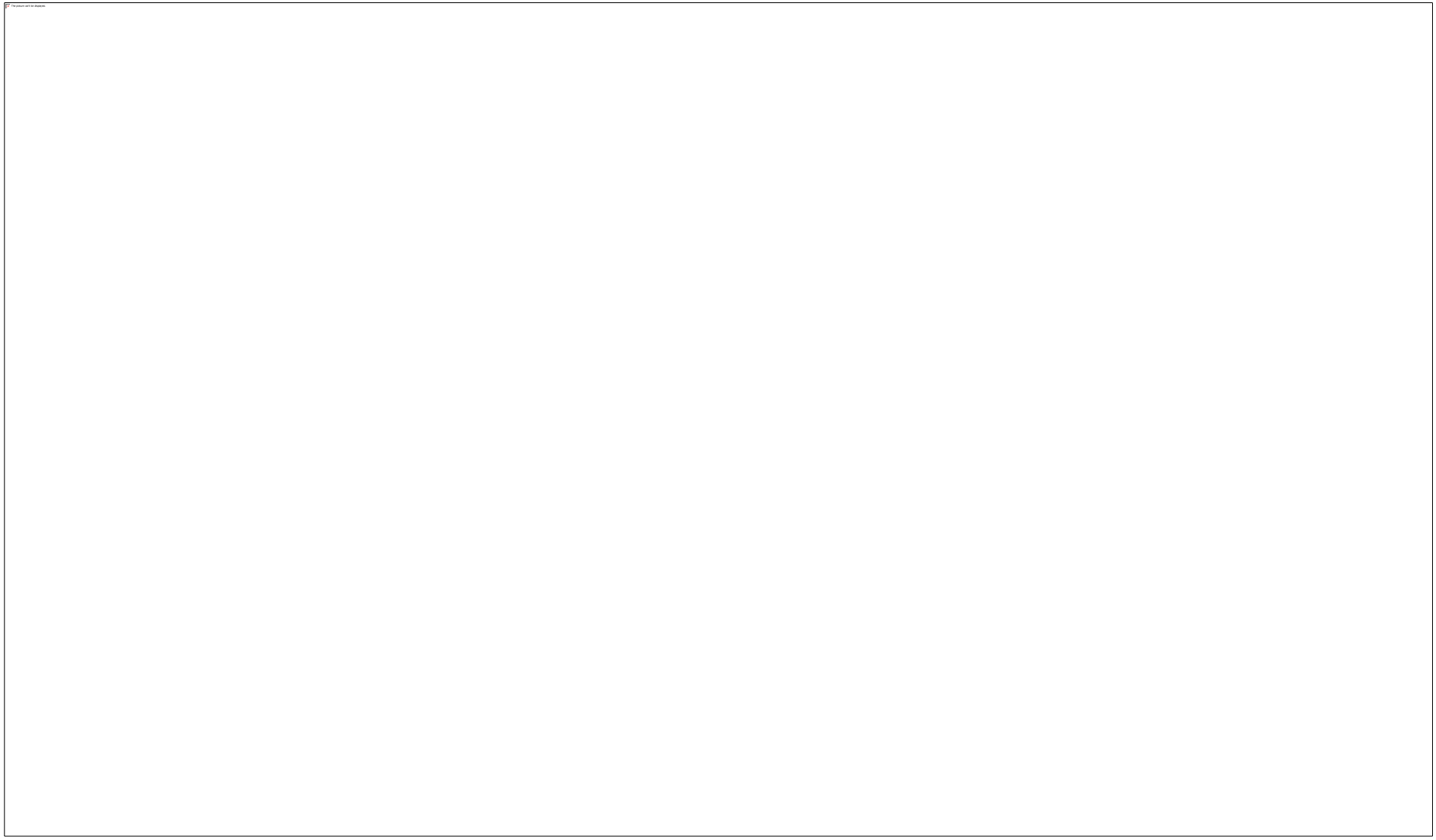
Capacity: 1 cubic feet >. 70% Packages Amazon ships every day.

Hardware design and software made in house

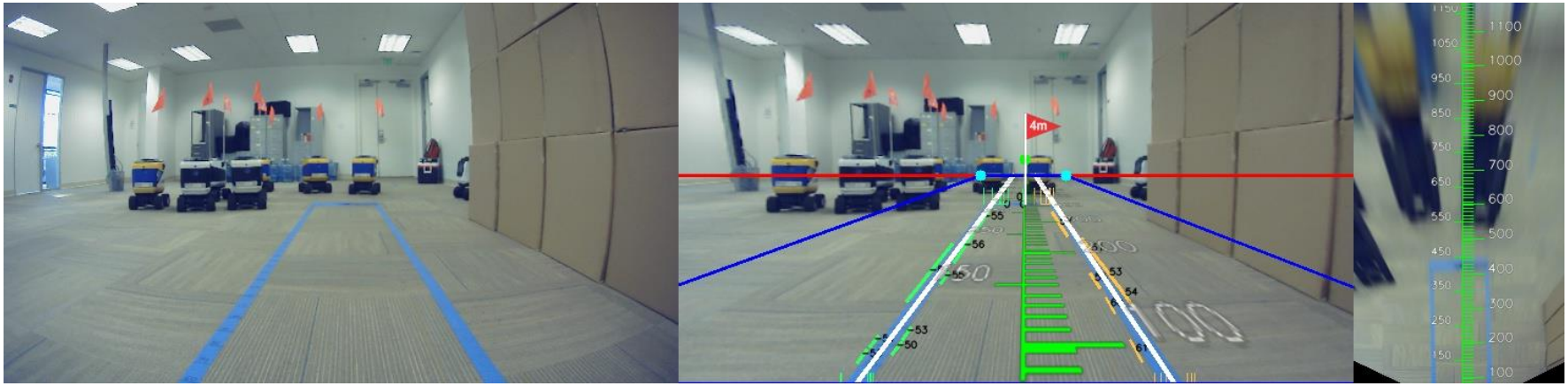
3 IP patents pending

Featured by:

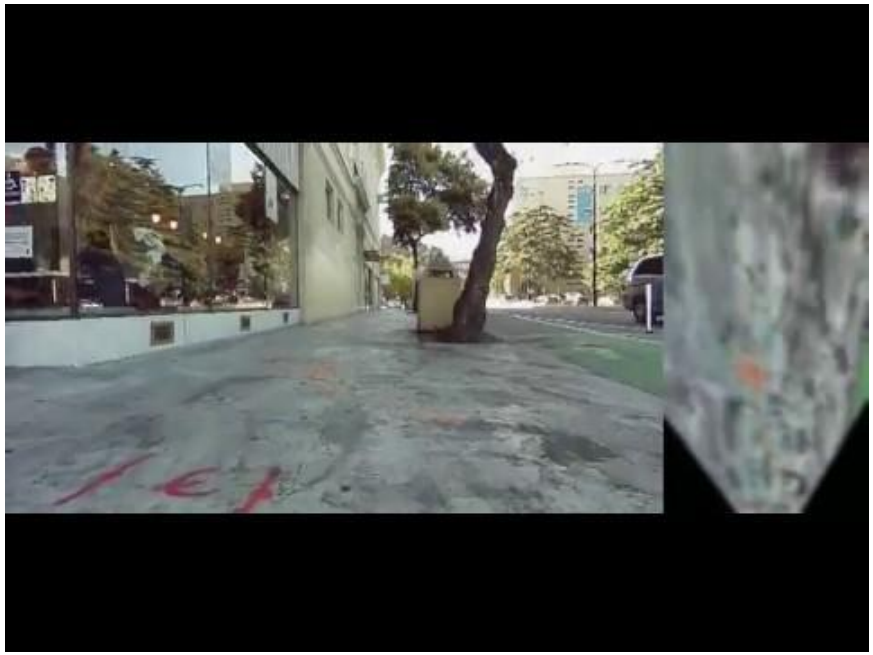
NVIDIA NewScientist

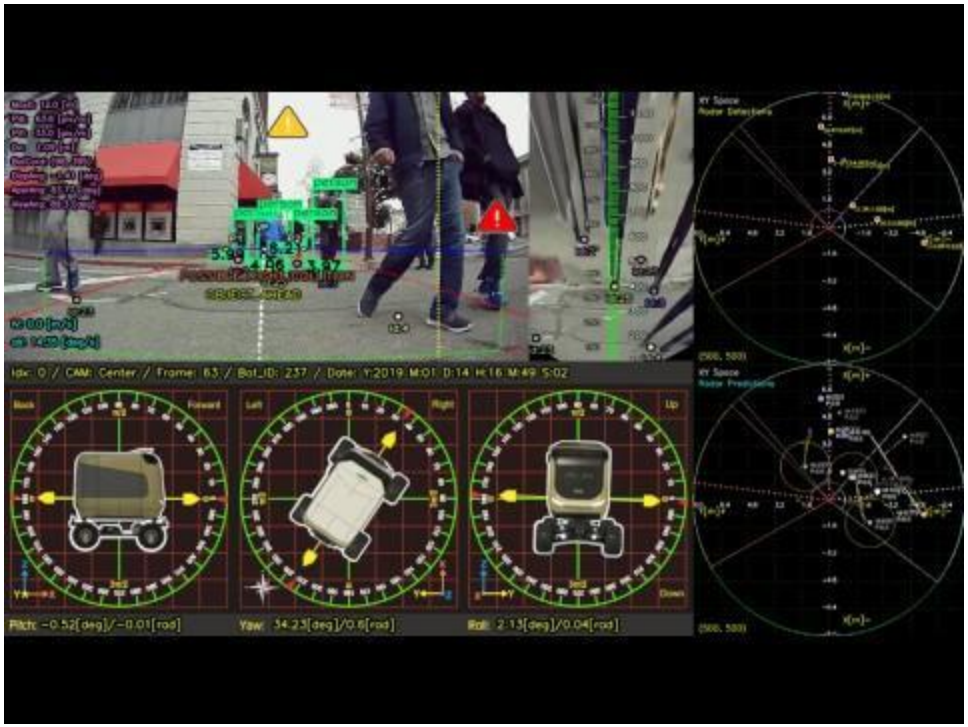

The picture can't be displayed.

Camera Calibration

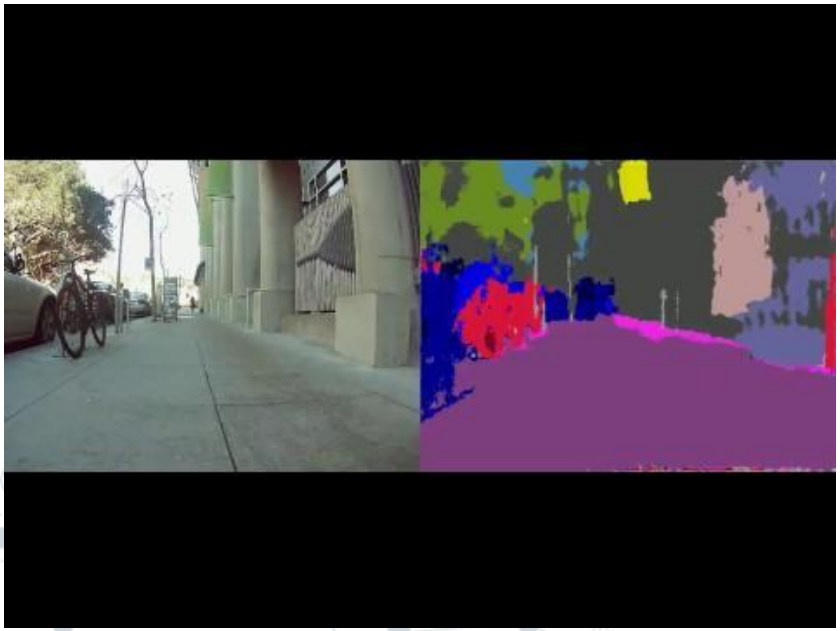



AL'S



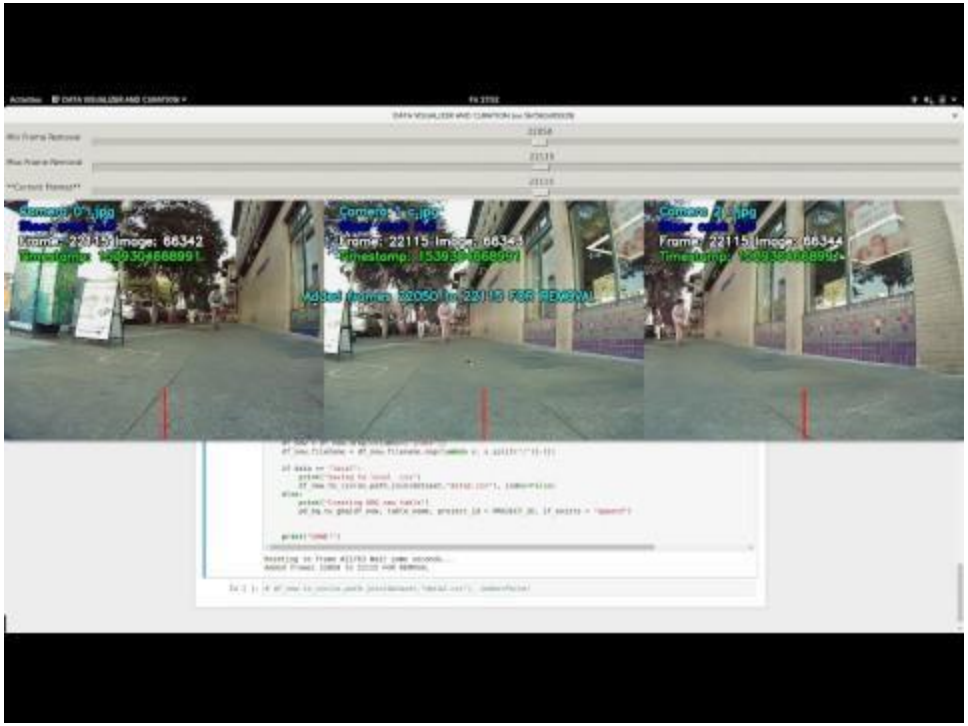

Pitch: -0.52[deg]/-0.01[rad]
Yaw: 54.23[deg]/0.6[rad]
Roll: 2.13[deg]/0.04[rad]


kiwibot1
LOW BATTERY: 0



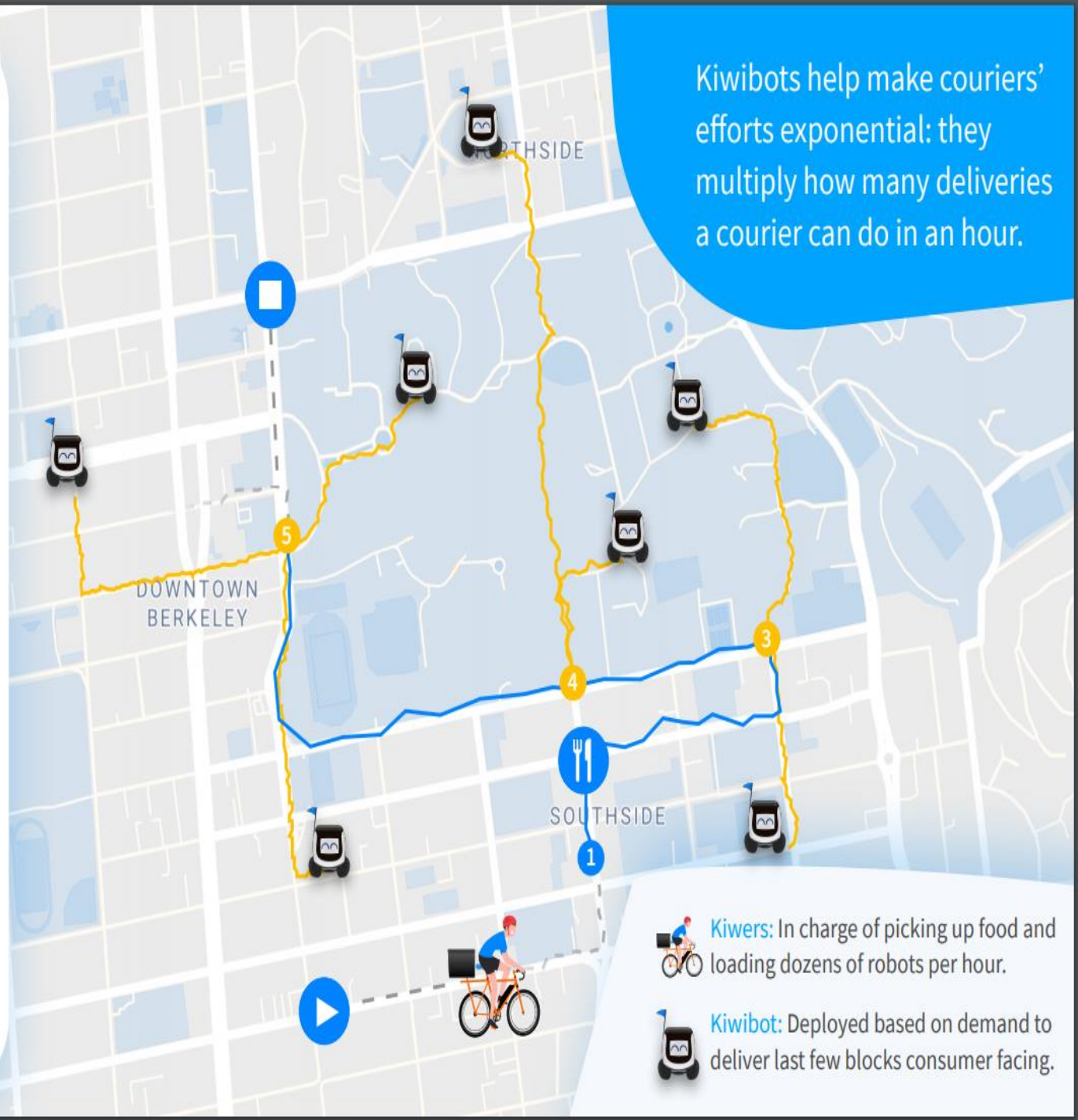

I'm delivering food

Data Curation



kiwibot Logistics

1. Pick up 4 orders from Sliver
2. Pick up 3 orders from Chipotle
3. Drop 2 orders into Kiwibots
   - Kiwibot #134 delivers Chipotle
   - Kiwibot #122 delivers Sliver
4. Drop 2 orders into Kiwibots
   - Kiwibot #103 delivers Sliver
   - Kiwibot #182 delivers Chipotle
5. Drop 3 orders into Kiwibots
   - Kiwibot #132 delivers Sliver
   - Kiwibot #157 delivers Sliver
   - Kiwibot #152 delivers Chipotle



Kiwibots help make couriers' efforts exponential: they multiply how many deliveries a courier can do in an hour.

Kiwers: In charge of picking up food and loading dozens of robots per hour.

Kiwibot: Deployed based on demand to deliver last few blocks consumer facing.

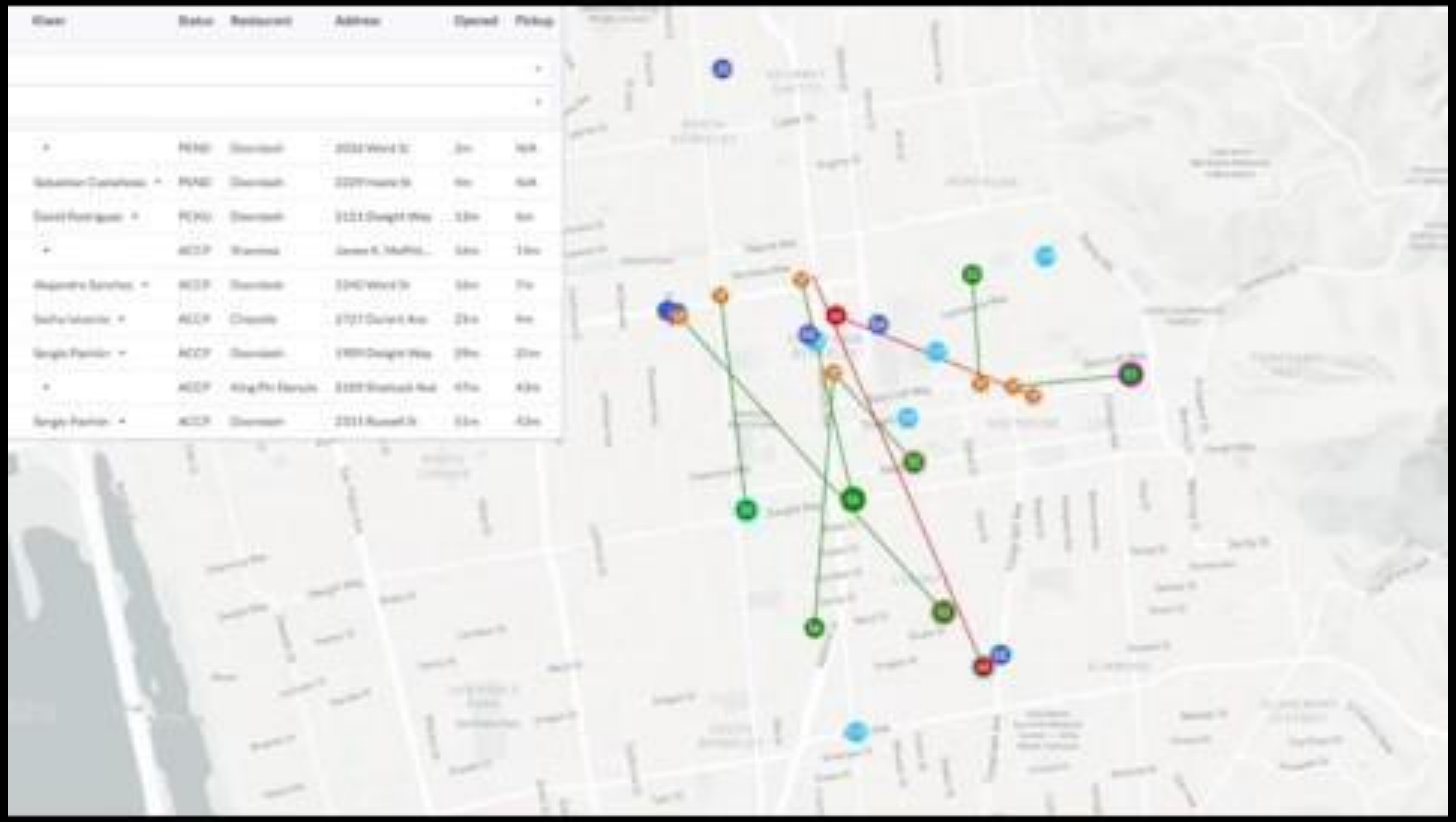
Overview

+17,000 orders delivered with Kiwibots.

5X more efficent than traditional couriers

21% WoW Growth last 13 weeks

150 robots by DEC 2018


Driver
Status
Restaurant
Address
Opened
Pickup

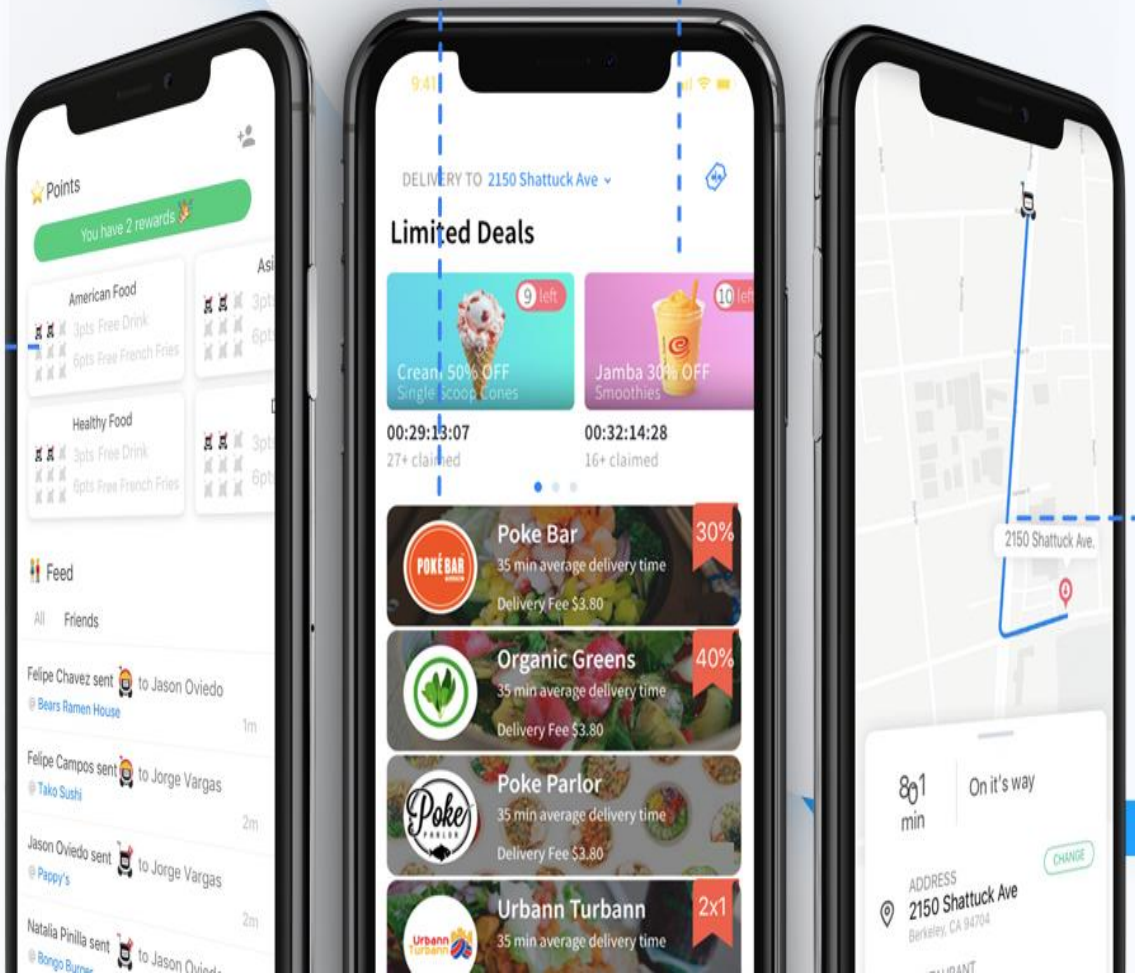
App

Offering consumers diverse selection of food

Flash sales creating a sense of

Driving engagement through social

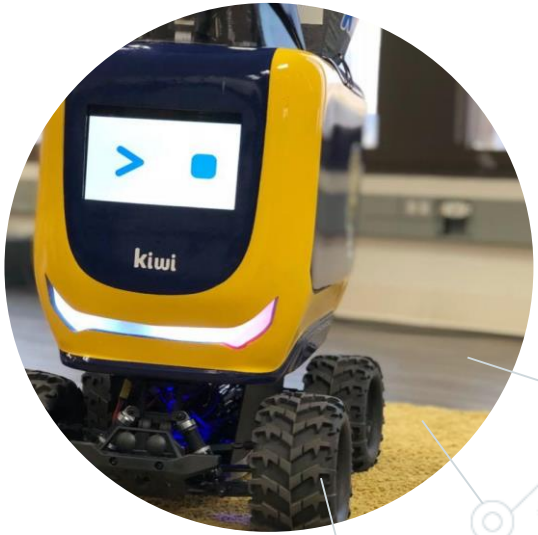
Real time tracking of delivery

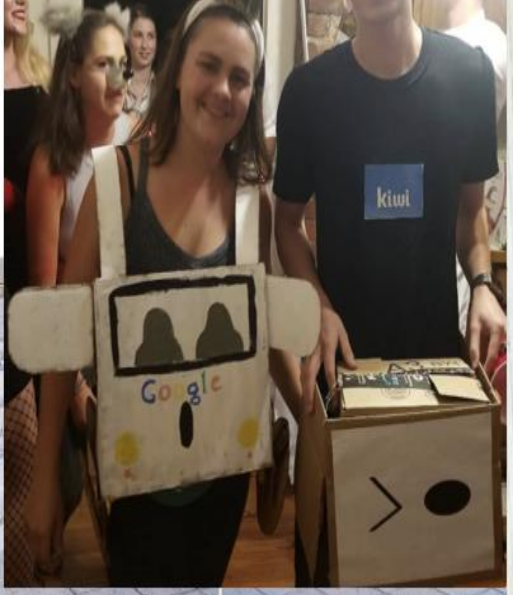


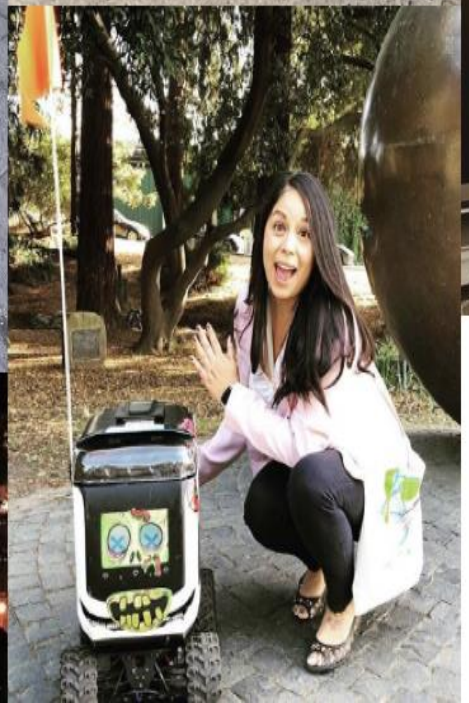
Hello!

I am a Kiwibot

- Low cost
- Navigation using machine learning.
- Currently serving students in the Bay Area.

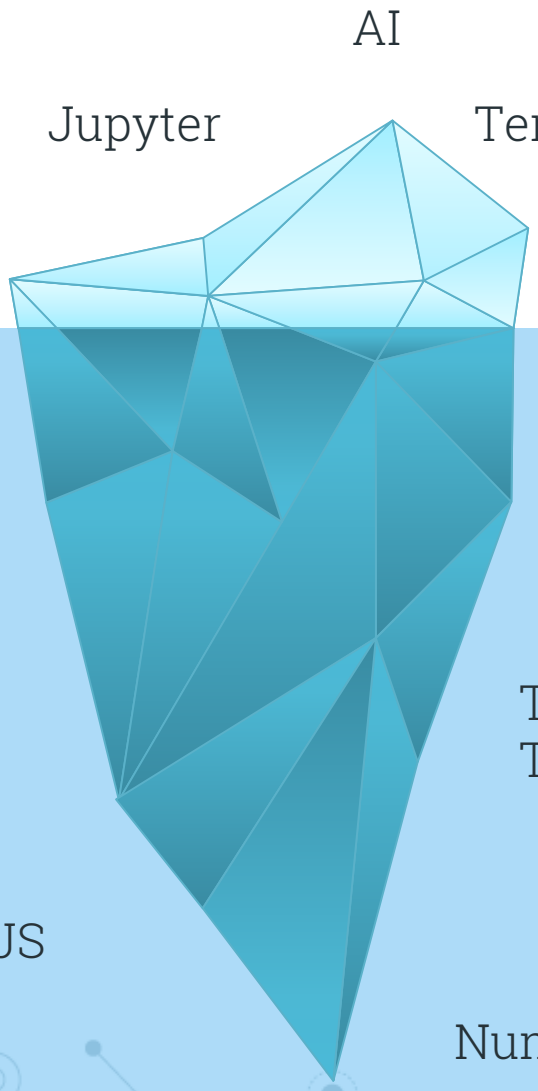






Students 1
our product.

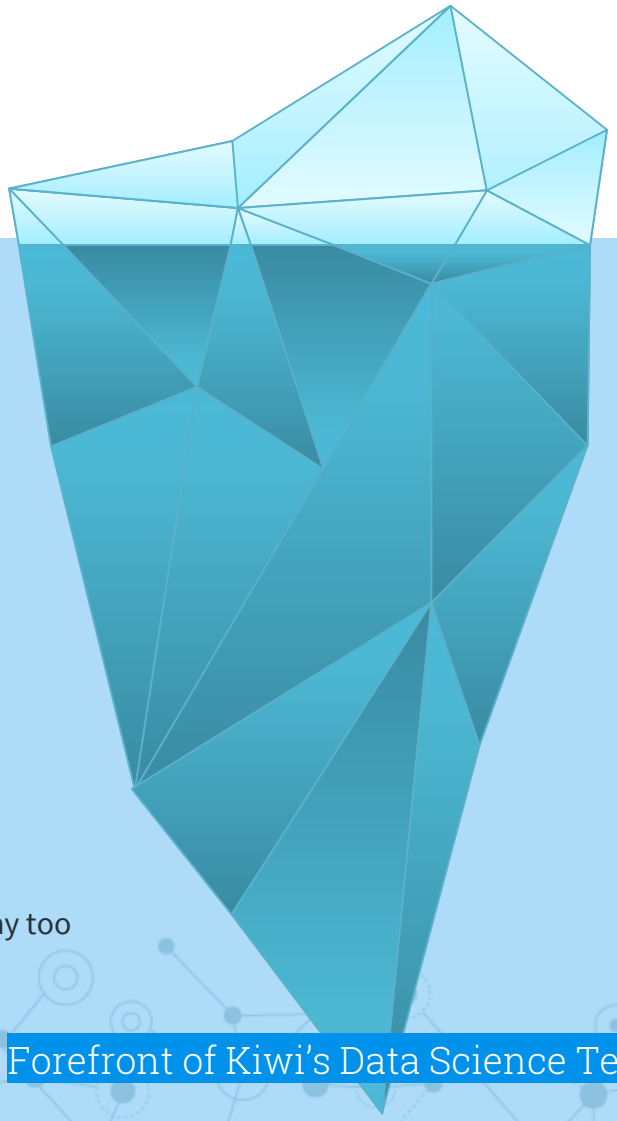
The AI Iceberg



Technology Stack

The iceberg of research

Final product:
End-to-end delivery at low cost



Crossing Detection
Image Classification

Pilot-net
Teaching a Robot to drive.

Simulation
Domain Randomization:
Real data is expensive, way too expensive

Object Detection:
Image Parsing, also Image segmentation

Reinforcement Learning
Be better that the human pilot.

Forefront of Kiwi's Data Science Team

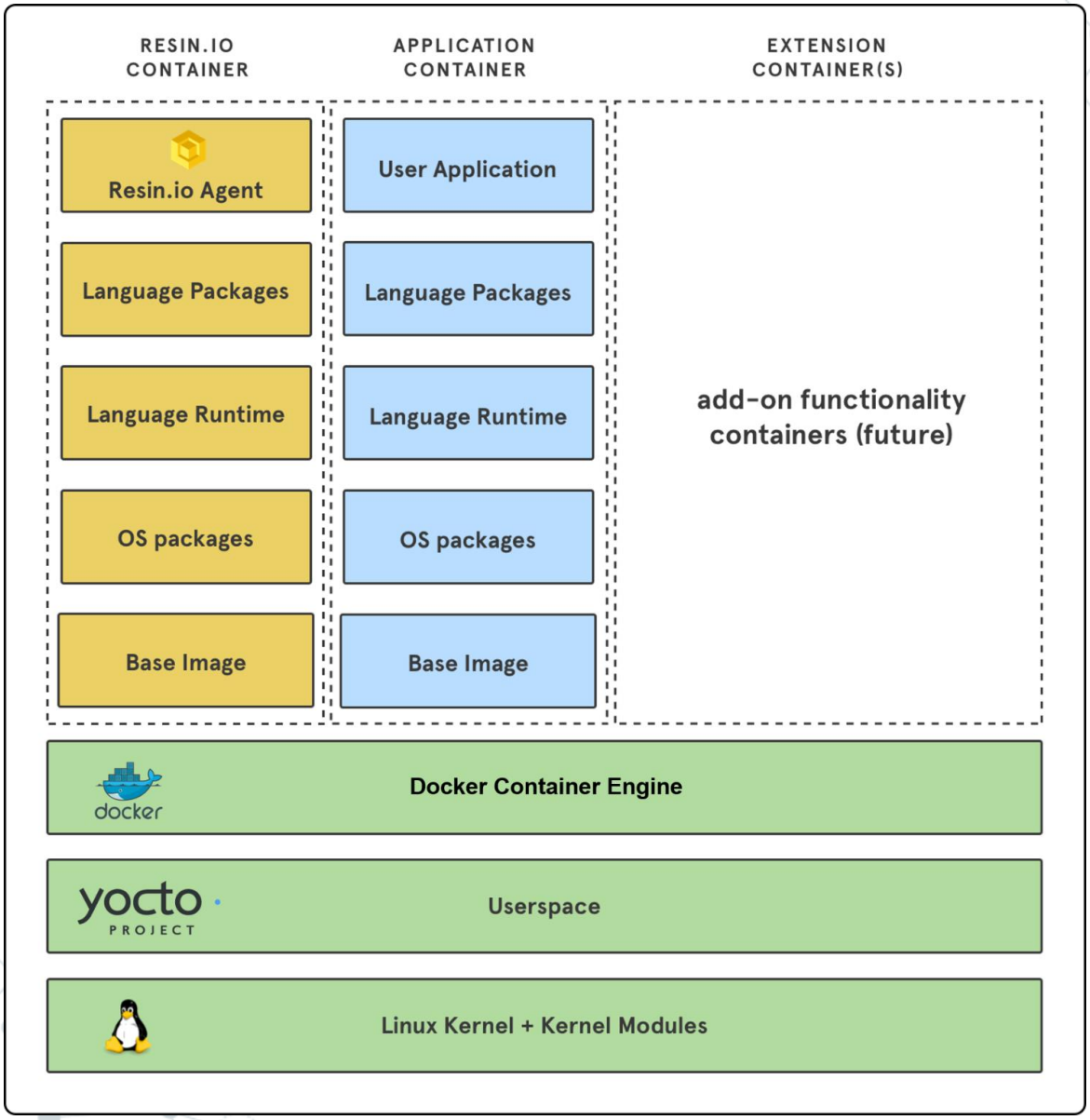
What's Next

- Temporal Analysis
- Predicting Throttle (velocity)
- Multitask Learning
- Feed GIS information to the NN
- Transfer Learning from Virtual Environments

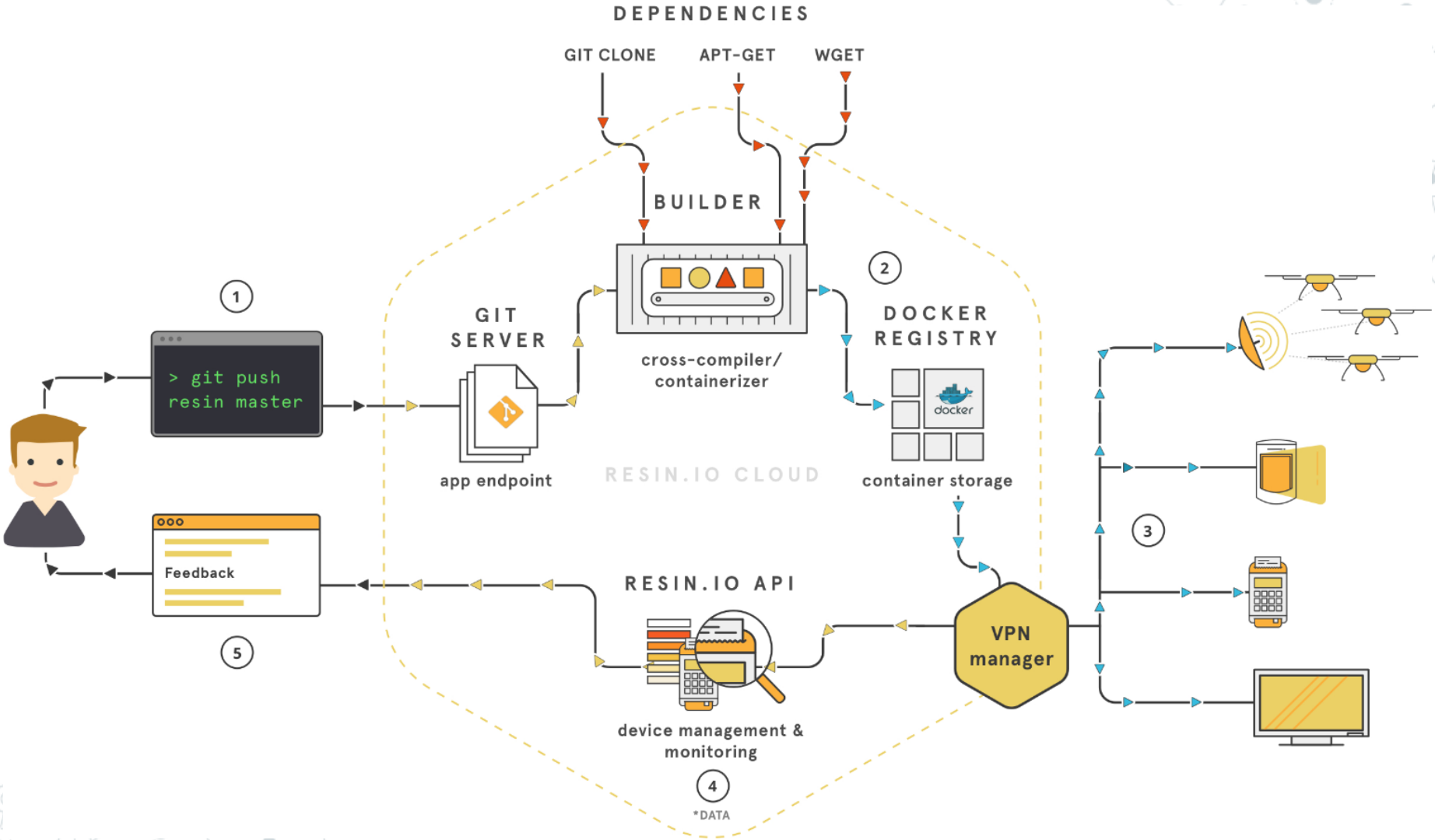
Deployment
ResinOS

- Linux containers for IoT
- Lightweight payloads
- Brick-safe deployments
- Phased deployments, scheduled updates
- Device status, location, deployment logs -
  > all on an ongoing basis

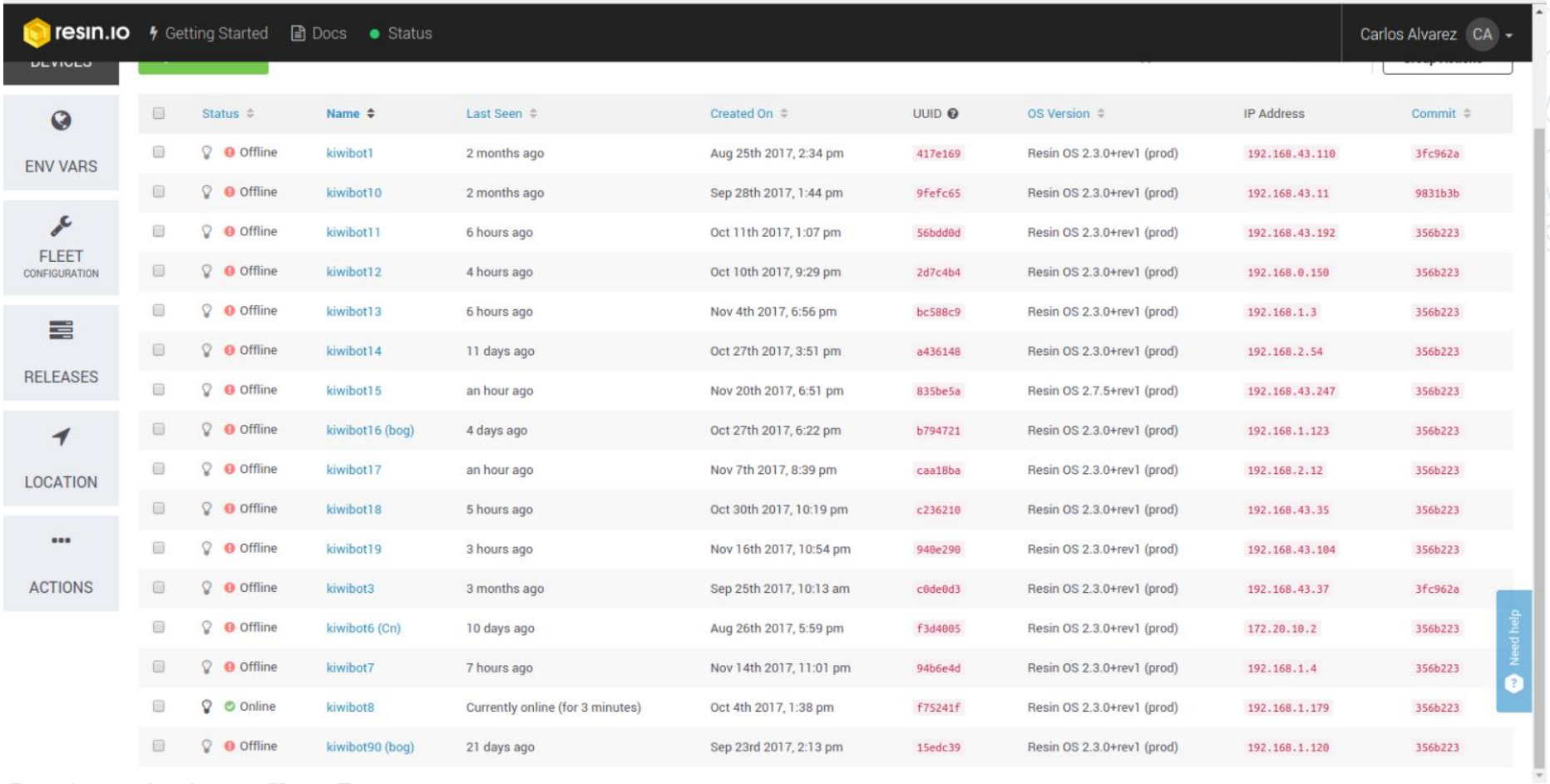
Resin OS


RESIN.IO CONTAINER
APPLICATION CONTAINER
EXTENSION CONTAINER(S)
Resin.io Agent
Language Packages
Language Runtime
OS packages
Base Image
User Application
Language Packages
Language Runtime
OS packages
Base Image
add-on functionality containers (future)
docker
Docker Container Engine
yocto PROJECT
Userspace
Linux Kernel + Kernel Modules

Resin OS


DEPENDENCIES
GIT CLONE
APT-GET
WGET
BUILDER
cross-compiler/
containerizer
GIT
SERVER
app endpoint
DOCKER
REGISTRY
container storage
docker
RESIN.IO CLOUD
1
> git push
resin master
2
3
Feedback
5
RESIN.IO API
device management &
monitoring
4
*DATA
VPN
manager

Example



Status	Name	Last Seen	Created On	UUID	OS Version	IP Address	Commit
Offline	kiwibot1	2 months ago	Aug 25th 2017, 2:34 pm	417e169	Resin OS 2.3.0+rev1 (prod)	192.168.43.110	3fc962a
Offline	kiwibot10	2 months ago	Sep 28th 2017, 1:44 pm	9fefc65	Resin OS 2.3.0+rev1 (prod)	192.168.43.11	9831b3b
Offline	kiwibot11	6 hours ago	Oct 11th 2017, 1:07 pm	56bdd0d	Resin OS 2.3.0+rev1 (prod)	192.168.43.192	356b223
Offline	kiwibot12	4 hours ago	Oct 10th 2017, 9:29 pm	2d7c4b4	Resin OS 2.3.0+rev1 (prod)	192.168.0.150	356b223
Offline	kiwibot13	6 hours ago	Nov 4th 2017, 6:56 pm	bc588c9	Resin OS 2.3.0+rev1 (prod)	192.168.1.3	356b223
Offline	kiwibot14	11 days ago	Oct 27th 2017, 3:51 pm	a436148	Resin OS 2.3.0+rev1 (prod)	192.168.2.54	356b223
Offline	kiwibot15	an hour ago	Nov 20th 2017, 6:51 pm	835be5a	Resin OS 2.7.5+rev1 (prod)	192.168.43.247	356b223
Offline	kiwibot16 (bog)	4 days ago	Oct 27th 2017, 6:22 pm	b794721	Resin OS 2.3.0+rev1 (prod)	192.168.1.123	356b223
Offline	kiwibot17	an hour ago	Nov 7th 2017, 8:39 pm	caa18ba	Resin OS 2.3.0+rev1 (prod)	192.168.2.12	356b223
Offline	kiwibot18	5 hours ago	Oct 30th 2017, 10:19 pm	c236210	Resin OS 2.3.0+rev1 (prod)	192.168.43.35	356b223
Offline	kiwibot19	3 hours ago	Nov 16th 2017, 10:54 pm	940e290	Resin OS 2.3.0+rev1 (prod)	192.168.43.104	356b223
Offline	kiwibot3	3 months ago	Sep 25th 2017, 10:13 am	c0de0d3	Resin OS 2.3.0+rev1 (prod)	192.168.43.37	3fc962a
Offline	kiwibot6 (Cn)	10 days ago	Aug 26th 2017, 5:59 pm	f3d4005	Resin OS 2.3.0+rev1 (prod)	172.20.10.2	356b223
Offline	kiwibot7	7 hours ago	Nov 14th 2017, 11:01 pm	94b6e4d	Resin OS 2.3.0+rev1 (prod)	192.168.1.4	356b223
Online	kiwibot8	Currently online (for 3 minutes)	Oct 4th 2017, 1:38 pm	f75241f	Resin OS 2.3.0+rev1 (prod)	192.168.1.179	356b223
Offline	kiwibot90 (bog)	21 days ago	Sep 23rd 2017, 2:13 pm	15edc39	Resin OS 2.3.0+rev1 (prod)	192.168.1.120	356b223

We are hiring!

Contact:

david@kiwicampus.com
f@kiwicampus.com


kiwi
kiwi
kiwicampus.com
The future today