Autonomous Driving Ecosystem: Challenges, Opportunities, Parallels

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Billy Okal

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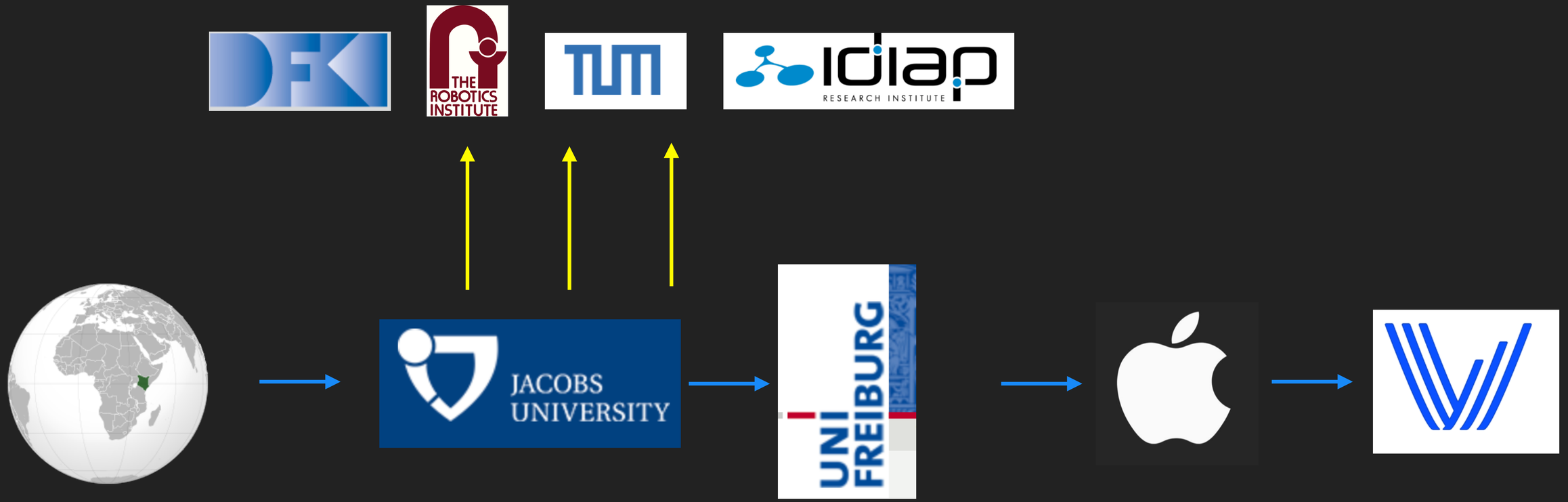
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Voyage @DSA

Voyage's mission is to super-charge communities with self-driving cars. Our fleets power essential, everyday services designed to enhance each resident's quality of life. At Voyage, we strive to become a trusted member of every community we serve.

It Starts with Communities

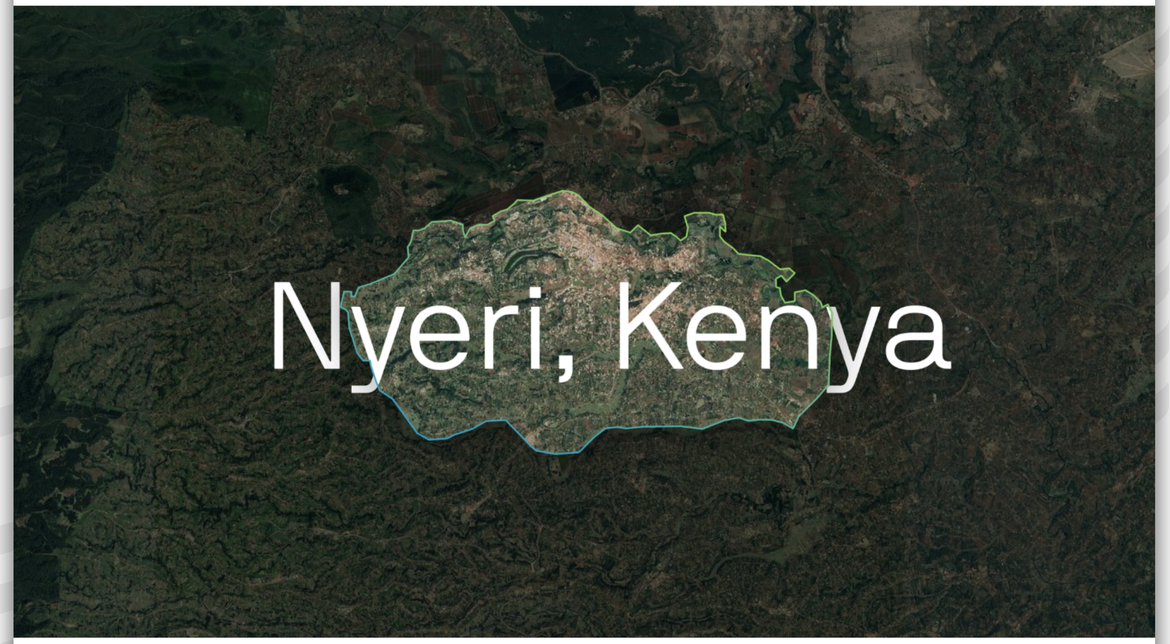
Voyage brings communities together with self-driving cars. We deliver a product that enables community members to summon an autonomous vehicle and move effortlessly from A to B.

Llamas, Machine Learning and a Trip to Kenya

Sharing Voyage's learnings with new communities

Billy Okal Follow

Jul 12, 2018 · 4 min read



At Voyage, **communities are at the heart of what we do**. Our autonomous taxi service provides safe, accessible transportation to our amazing partner communities—and we learn something new each time a passenger gets in the

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What is Autonomous Driving?

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Classification of Driving Automation Levels

0

No Automation

Zero autonomy; the driver performs all driving tasks.

1

Driver Assistance

Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design.

2

Partial Automation

Vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times.

3

Conditional Automation

Driver is a necessity, but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice.

4

High Automation

The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.

5

Full Automation

The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.

[NHTSA, https://www.nhtsa.gov]

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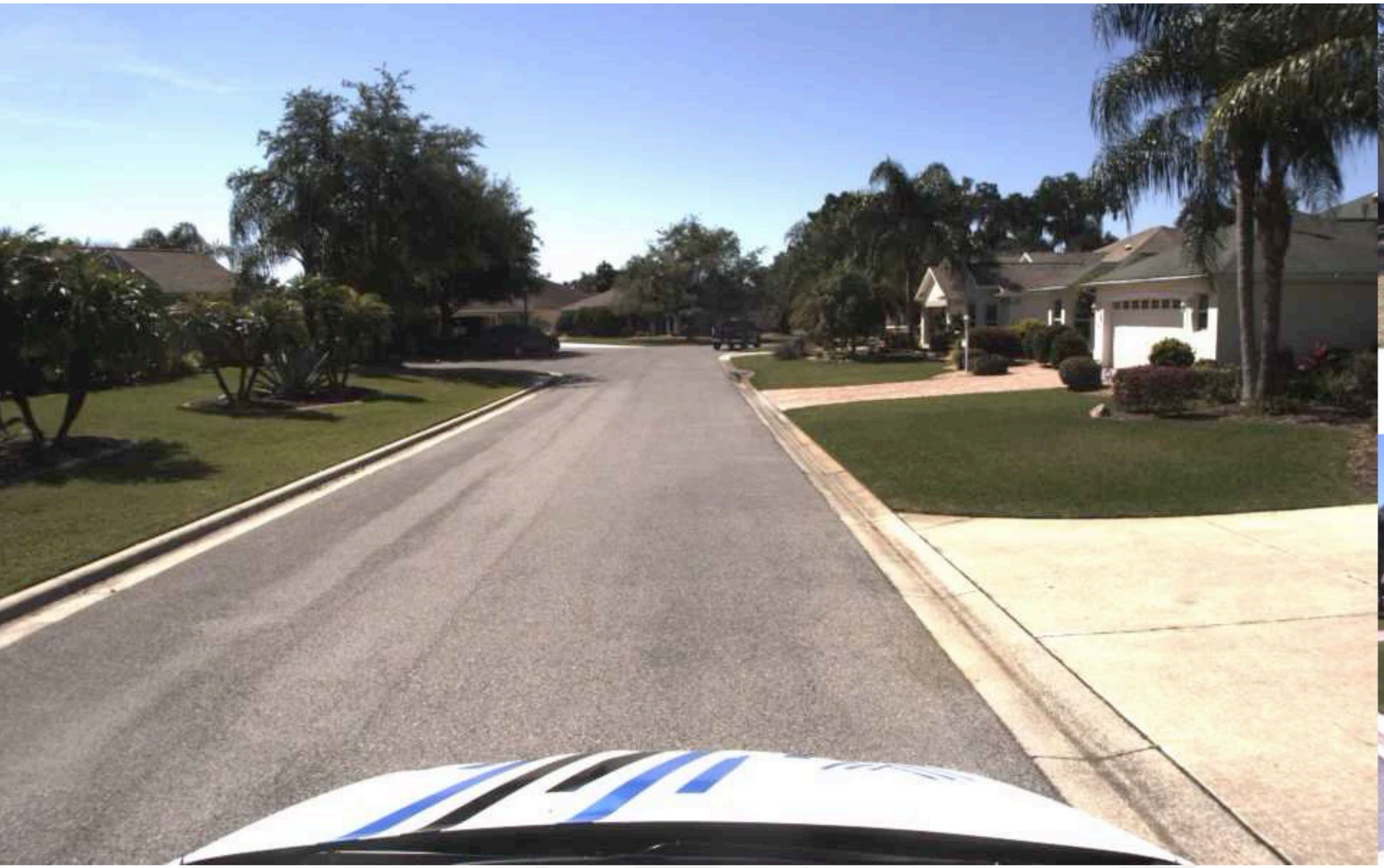
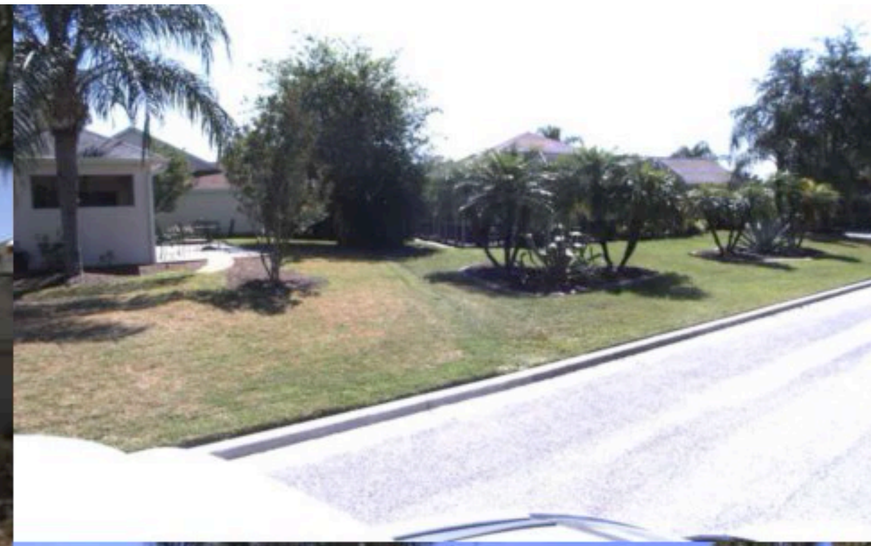
What can Level 4 do?





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Why Autonomous Driving?

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> 1.25 million

Deaths from road crashes each year, average of about 3287 per day [WHO]

Recognition errors (approx 40%)
Decision errors (approx 35%)
Performance errors (approx 10%)

Why Autonomous Driving? — continued

- **Accessibility**, especially for *vulnerable* society members
  - Older and younger population
  - People with disabilities and other mobility challenges
- **Efficiency**
  - Traffic (human and goods)
  - City planning, parking, vehicle ownership

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Outline

- What does it take to achieve autonomous driving?
  - Key technologies involved
  - Challenges: what remains, how much further?
- Bring-ins
- Take-outs

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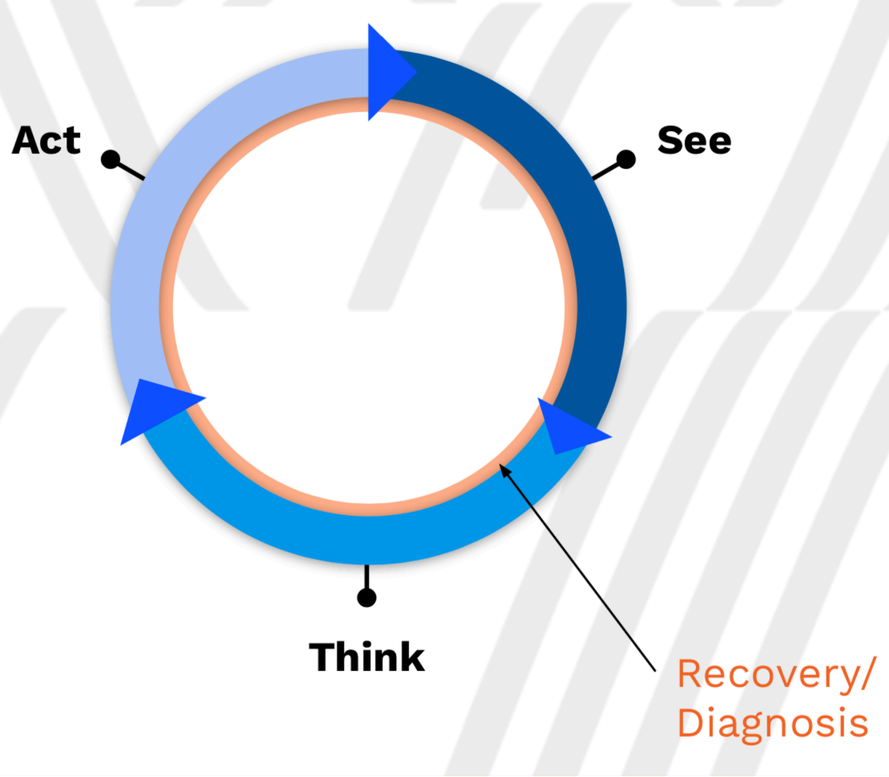
What does it take to develop AVs

- Core AV technology
  - See — object detection, classification, segmentation, tracking, localization
  - Think — route, behavior, motion planning, self-diagnosis
  - Act — tracking, control synthesis, system identification
- Hardware and services
  - Vehicle platform, compute, sensors
  - Data storage, on-board processing



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What does it take to develop AVs

- Additional AV dependencies
  - Maps, Routing, traffic control?
  - Teleoperation, remote monitoring
  - Fleet management (provisioning, maintenance, calibration)
  - HMI, Security, Verification, Certification
  - Simulation, Operating systems
  - Operations, field testing

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Think in Systems Engineering

- AVs are NOT isolated systems
- Multiple stages and paths of decisions
- Huge systems integration challenges
  - Algorithms, models
  - Software
- Design for the unexpected
- Have multiple redundancies — learning from mistakes in aviation, space flights

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AVs, Data Science & DSA

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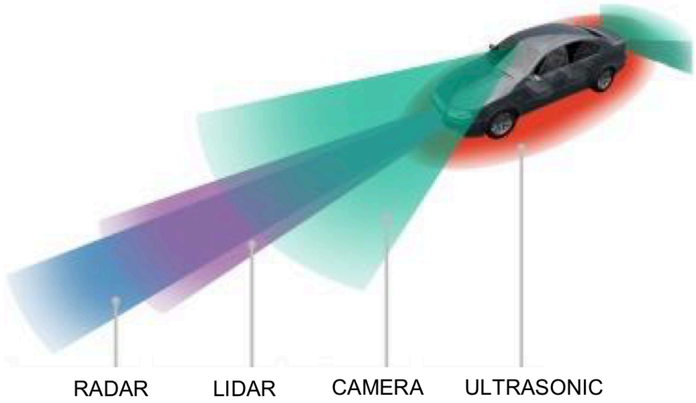
Data Sizes in AVs

NHTSA Federal Automated Vehicles Policy

September 2016

- *Vehicles should record, …,* ***all information relevant to the event… [accident, crash]***
- *… should collect, store and analyze data regarding* ***positive outcomes*** *…*
- *… explore a mechanism to facilitate anonymous* ***data sharing*** *…*

- **RADAR:**
  4-6 Sensors 0.1 - 15 Mbit/s /Sensor
- **LIDAR:**
  1-5 Sensors 20 - 100 Mbit/s /Sensor
- **CAMERA:**
  6-12 Sensors 500 - 3500 Mbit/s /Sensor
- **ULTRASONIC**
  8-16 Sensors <0.01 Mbit/s /Sensor
- **VEHICLE MOTION, GNSS, IMU**
  <0.1 Mbit/s /Sensor



TOTAL SENSOR BANDWIDTH: 3Gbit/s (~1.4TB/h) **or** 40 Gbit/s (~19 TB/h)

[Adapted from, https://www.flashmemorysummit.com/English/Collaterals/Proceedings/2017/20170808_FT12_Heinrich.pdf]

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Data Sizes in AVs

Service Notifier APP 11:06

#awesome Event Identified (388877)

Date: Thursday, June 6th 1:15:46 AM

Comment: "#awesome ego slowed for ped approaching, but then changed minds after ped reversed directions"

Service Notifier APP 04:04

#awesome Event Identified (388501)

Date: Wednesday, June 5th 10:11:07 PM

Comment: "#awesome stopped for two prehistoric birds walking across road"

See Event Details | Download Event (2394 MB)

Service Notifier APP 05:22

Intervention Event Identified (384950)

Date: Tuesday, May 21st 10:02:37 PM

Comment: "harsh brake while #overtaking #vehicle in a right turn #intervention #turning"

See Event Details | Download Event (2925 MB)

with #pedestrian, no one suspects a thing

awesome | pedestrian

Bag Context

05:05:41 PM A Attention Marker

very wide right turn

05:06:05 PM A Attention Marker

#awesome ego interacted naturally with #pedestrian, no one suspects a thing

awesome | pedestrian

Details

ID: 388930

Created: June 5th 2019, 5:06:05 pm

Deployment: vgcc

Bag: 17098

Metadata UUID: dc11ef47-0737-4775-9f6b-eae279ee7a83

Build Info

Commander: v2.2.3 SHA

Commander Timestamp: June 3rd 2019, 11:54:02 am

Annotations: vgcc:2.4.1-rc.4

PCDS: vgcc:2.4.1-rc.4

Vehicle: moe

Open in Triage

Submit for Annotations scale

Bag Slices

388930
All topics
2.25 GB

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Data Science Tasks in AVs

- Core capability development: model training, improvement, visualization, insights, etc
- Triage: explore, analyze and organize field reports, incidences, data
- Fleet management: scheduling, dispatch
- Metrics system: measuring progress in components, modules, systems
- Simulation results analysis

Autonomous Vehicles from IoT Perspective

1. Integration is at the core
   - Multiple data generation sources, rates, types, performance
   - Staged decisions, forks, merges, “hard calls”
2. Deployment in safety critical setups

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Bring-ins — How can you contribute to AVs

- Machine learning (algorithms, model compression, data handling) — everything we learned at the summer school is applicable, today
- Modeling — industry is largely driven by roboticists, we need fresh ideas, perspectives right at the foundations
- Interface with policy makers, data-driven regulation societal preparedness
- Business models, how to use this technology effectively
- Measurement of impact, progress — metrics beyond classical robotics

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Take-outs — How can you use AV technology elsewhere

- Advances in sensing, new modalities (LiDAR, RaDAR, …), algorithms
- Advances in machine learning
  - Systems/model composition, uncertainty handling, measuring task specific progress
- Advances in systems
  - Fault tolerant, low power, low-bandwidth data transfer, storage, analysis
- Advances in energy storage (battery technology)
- Speed up automation in other sectors, such as agriculture

Getting Started

- You are already equipped
  - Machine learning, data science
  - Software engineering
- Online courses, e.g. Udacity nano degrees
- Experiment with open source frameworks
  - ROS {1, 2}, Autoware, Apollo
  - Simulators: CARLA, LGSVL-sim, Gazebo
  - Datasets: KITTI, nuScenes, commonroad

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Questions, Remarks

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We are hiring!

https://voyage.auto/careers

Find me via:

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billy@voyage.auto
https://www.linkedin.com/in/bokal/