WELCOME TO COMPSOC

WEEK 4 - INTRODUCTION TO BIG TECH AND AUTONOMOUS DRIVING

WHAT CAN I DO WITH THIS INFORMATION?

- Rebuild Krapatoa (Let me know!)
- DIY Autonomous Vehicle w/Arduino, Raspberry Pi or similar (Lancaster University: Gerald Kotonya, Stephen Monk & others)
- Elden Ring playing robot (YouTube: Mike Boyd)
- Trackmania Reinforcement Learning (Youtube: Yosh)
- Deep Learning Institute Course (Nvidia)

- AI Researcher
  - Meta
  - Microsoft
- Product Manager
  - Google
  - Tesco
- Research Assistant
  - Adobe
  - Arm
- Software Engineer
  - Amazon
  - Palantir


YOU WILL NOT KNOW EVERYTHING BY THE END OF TONIGHT
AND THAT'S OK, YOU'RE NOT SUPPOSED TO

BUT HERE’S SOMEONE THAT DOES

NVIDIA

CLAYTON JORGENSEN

Intro to Big Tech and Autonomous Vehicles

Choose Your Own Adventure

Focus Areas:

- Autonomous Driving: Technical Deep Dive
- Autonomous Driving: Market Economics, Competitive landscape, Outlook
- Career Advice

Tesla 2018

- Quality Engineering Intern, Tesla Model 3 GA
- Helped ramp production from 1000-5000 cars per week during model 3 “Production Hell”
- Slept in the Fremont Factory with Elon
- Introduced me to Autonomy

Waymo 2019-2023

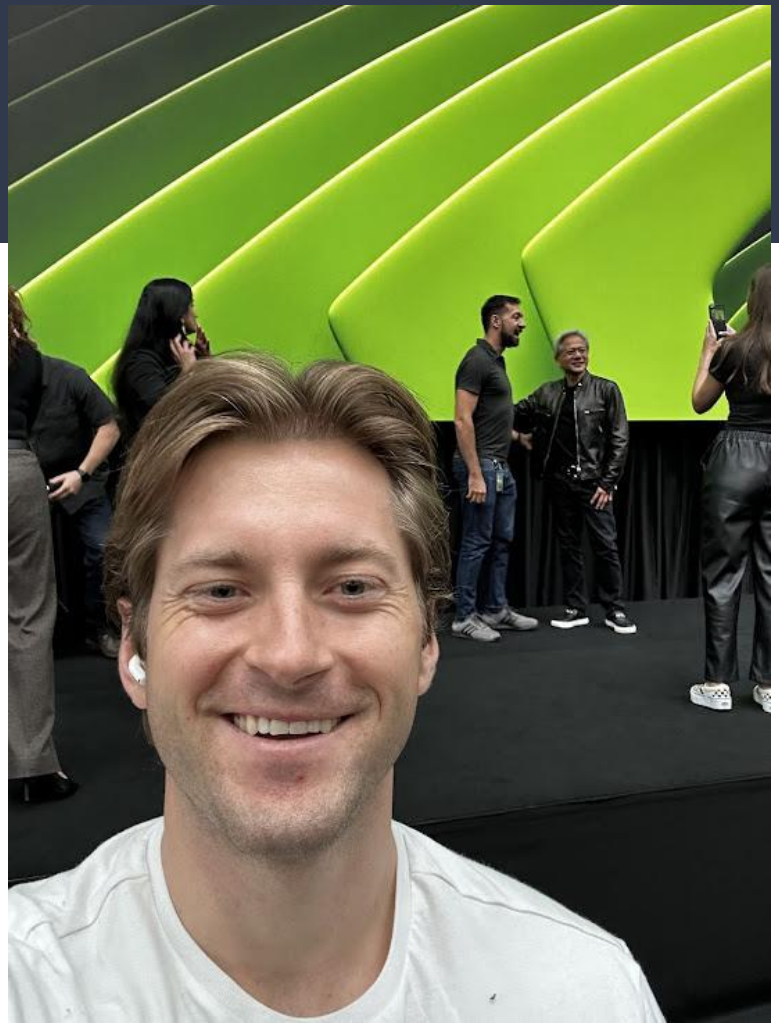
- Systems Safety Engineering Intern, Trucking
- Technical Product manager, Behavior Planner
  - Planning and control PM lead for Wet Roads, rain, puddles
  - Implemented behavior planner features for AV Trucking like smart lane selection, route optimization
  - Husky PM spokesperson at CES and *Road Dog Truckers* (15 million listeners)

Aurora 2023-2024

- Led Nominal Highway driving (ACC, Lane Keeping, Merges, Contender Handling, Lane Changes)
- Led Scenario Coverage Analysis for Autonomous Trucking Hillclimbing -> Do we have enough events / Data to prove that we are safe?

Nvidia 2024 - ?

- Technical PM lead for Nudging in classical planning
  - End to End lead
- Plannet Technical PM lead
  - Plannet will replace the Nvidia Classical planner with ML Motion Planning
- Team Mandate: Beat Tesla FSD



Project Pure

Autonomy

5 Levels of Autonomy

Level 0 - No autonomous features at all

Level 1 - Any single autonomous feature like cruise control or auto braking

Level 2 - Any combination of 2 or more autonomous features like lane keeping and ACC

Level 3 - Liability switches to the driver from the car, car must request a takeover

Level 4 - Full autonomous driving with no human intervention in limited scenarios

Level 5 - Full autonomous driving in all scenarios

The Fundamental Questions of Autonomy

Where Am I?
What's Around Me?
Where Do I Want To Go?
How Do I Get There?
Did I do It Right?

Where am I?

Mapping:

- **HD maps** are created prior to driving on a road and have many hardcoded elements embedded in the road ei lanes, stoplines, speed limits, road boundaries
- **Perception mapping** is experimental, but may allow better scalability of autonomous driving

Localization:

- Uses GPS to give a ~10m accurate placement of the car on the map
- Correlates perception data with HD map to increase precision to ~5 cm accuracy

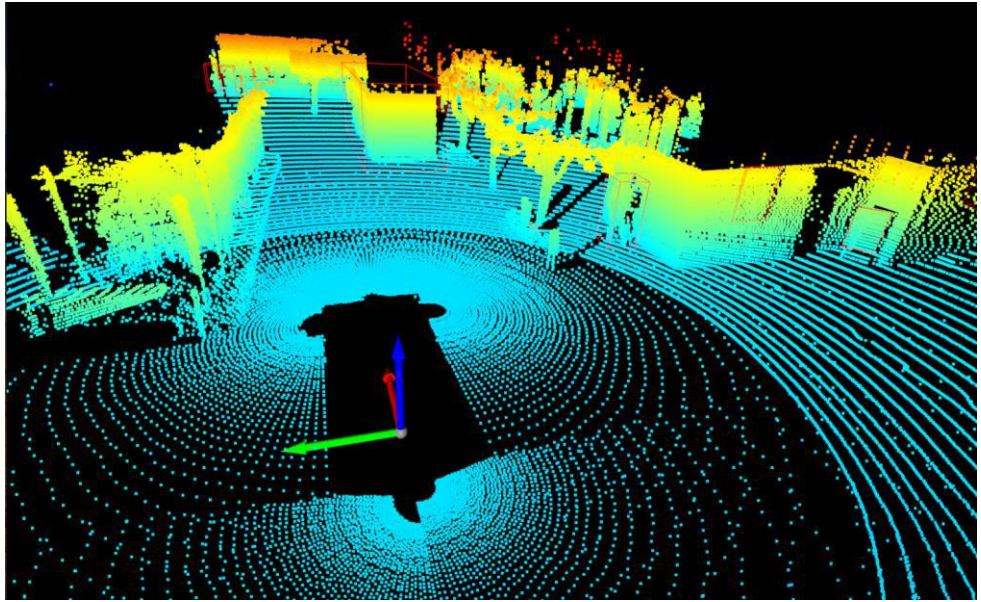
What’s Around me

Perception

- Hardware strategies: Camera, Lidar, Radar, Microphone, Ultrasonics
- Generates and consumes high density point clouds 10x per second
- Uses ML to classify points as various object types

Prediction

- Uses contextual information and doppler info from point cloud to get agent position, velocity, acceleration
- Uses existing state and ML to infer next 1-10 seconds of motion



Where Do I want to Go?

Router:

- Consumes start and end point from hailing and known safe pick up and drop off points.
- Consumes Google maps route
- Generates more detailed instructions from HD maps
- Sends waypoints of desired destination every second to Planner
- Generates a “router cost” the longer or more the planner deviates from the cost

How do I get there?

Planner Consumes

- Maps, Perception, Router, Prediction, Control / safety limits

Classical Planning:

- Utilizes above as input to a human tuned cost function that optimizes for Safety, Comfort, and Progress
- Many heuristics / tuned issues.
- Pros: you know what it's going to do
- Cons: Whack-a-mole issues

ML Planning:

- Takes raw inputs, drives outputs, which are labeled as good and bad trajectories
- Good trajectories are used to train ML to optimize for a better path
- Pros: More elegant solution, optimizes more complex paths
- You don't know exactly what you're going to get.

Controls: Consumes planner trajectory and actually moves vehicle actuators

How did I do? (Simulation and Evaluation)

Knowing if you built a good self-driving car is almost as difficult as building it in the first place:

- Difficult events are very rare: 1 fatal event / 25 million miles driven
- Getting enough exposure for training can be very expensive.
- Simulation can upsample hazardous events, but is often inaccurate
- How do you determine safe behavior?

Sim and Eval

Simulation:

- Taking onroad data that is carefully curated by engineers and building a virtual version of what happened
- Modifying the digital scene to have more challenging situations
- Running tweaks to the planner to see how it would run in hypothetical situations
- Creates “must pass sets” that gate keep the new software from regressing
- Allows the software to make mistakes that don’t harm anyone

Eval:

- Measures how the car actually performs on road (also used in simulation)
- Comfort Metrics
  - Breaking strength (m/s^2)
  - Proximity to objects
  - Gforces
  - Steering Jerk
- Progress metrics
  - Time to arrival
  - Frequency of getting stuck
- Safety metrics
  - Stopping distance
  - Wait elements ignored
  - Broken road rules

Other Considerations

- **Getting Stuck:** Level 4 companies need infrastructure to rescue stuck vehicles
- **Weather:** Lidar and other sensors degrade in rain, fog and snow. Control limits are not reliable in slippery conditions
- **Driving requires breaking the law:** Many driving situations become unsafe or impossible to navigate if you follow the letter of every law.
- **Magnified PR Risk:** Any autonomous crash is magnified in the news
    - Cruise Was killed by a single fatality
    - Uber Killed its autonomous program after a single fatality

What happens when it all comes together

Self Driving Economics

Market Segments / Players

L2
- Ford (Blue Cruise)
- GM (Super Cruise)
- Tesla (Autopilot)
- Kinda Everyone making cars

L2++
- Tesla (FSD)
- Mercedes (IDC5)
- Nvidia (DRIVEAV)
- Chinese Companies: BYD, NIO, Zeekr, Baidu, Xpeng

L3
- Mercedes (Drive Pilot)

L4
- Waymo (1000 Vehicles
- Baidu CN (500 Vehicles)
- Cruise (paused)
- Aurora (trucking)

L2++ Market

Market is underdeveloped in the US, as the tech isn't that great yet

- $99.00 / mo subscription to FSD
- 283.4 million
- TAM:
  - Current Tesla FSD Revenue: **$ 114.3 M**
  - If all US vehicles are at $99.00 /Mo Sub **$ 28.34 B**

Pros
- Requires lowest level of Tech Development
- Cheapest sensing
- No HD maps (Highly Scalable)
- Reduces cognitive load of driving

Cons
- Doesn't actually give time back to drivers
- As of Today, More dangerous than People
- Small Tam

L4 Taxi Market

Developing Market in the US

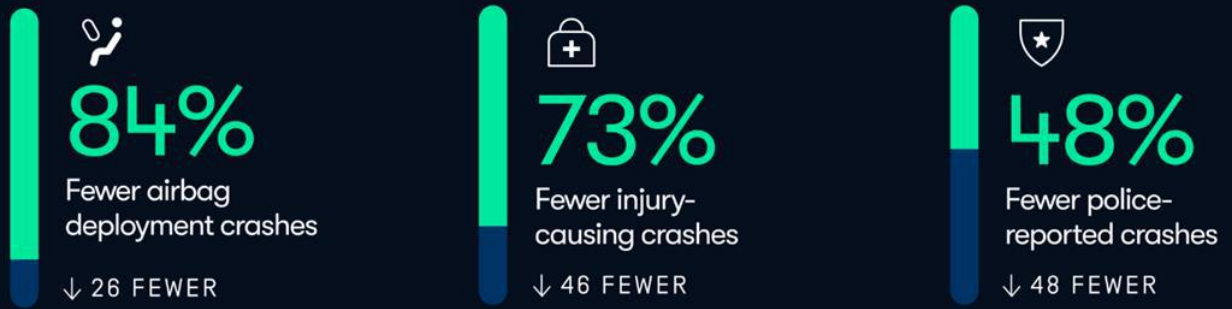
- 2023 Ride-hailing Market **$53.88B (**2023 US revenue)
- Waymo Estimates **$2T** annual Robotaxi market unlocked by lower prices for customers at scale

Pros
- Already safer than people
- Large Tam, gets even larger
- True Value added: Safety, Economics of Scale, Reduced Car Ownership, Time back to riders
- Insurance / energy savings

Cons
- Extremely difficult to do
- High operational costs, maintenance, warehouses, etc.
- Surge demand, how to store vehicles during off hours
- Not scalable (HD Maps Reliant)
- Longtail solutions are not easily solved w/out human fallback

Making roads safer for all, today

In our first 22 million miles:



compared to a human driving the same distance in the cities where we operate.

L4 Trucking Market

US Trucking Market

- 2024 **$200B Paid to Truckers**
- 2030 Target of **$1T**

Pros
- Economics driven: Saves money on 3 biggest unit costs: Drivers, Fuel, Insurance
- Saves overhead on driver turnover -> 150% average driver turnover at
- Simpler ODDs than Robotaxi
- Easier Operations management (trucking operations require little disruption)
- Improved delivery time for goods (no service hour restrictions)
- Improved

Cons
- Extremely difficult to do
- Failures are highest stakes
- Highest regulatory hurdle (Teamsters Union)
- Complicated support infrastructure (loading unloading trailers, etc.)

Career Chat

- How to get a Job: The Two Hour Job Search
- Big Company vs. Small Company
- Gradschool

COMING UP!

THIS FRIDAY:……BAR CRAWL

THIS WEEKEND:……DURHACK

NEXT WEEK:……INTRO TO OPEN SOURCE

WEEK 6:……HACK SHEFFIELD

THANKS ALL!!!

IT’S ONLY A MATTER OF TIME UNTIL SOME COUNTRY SINGER MAKES A SONG ABOUT HOW EVEN THEIR SELF-DRIVING CAR LEFT THEM