



# Foundations of Edge AI

# Lecture04

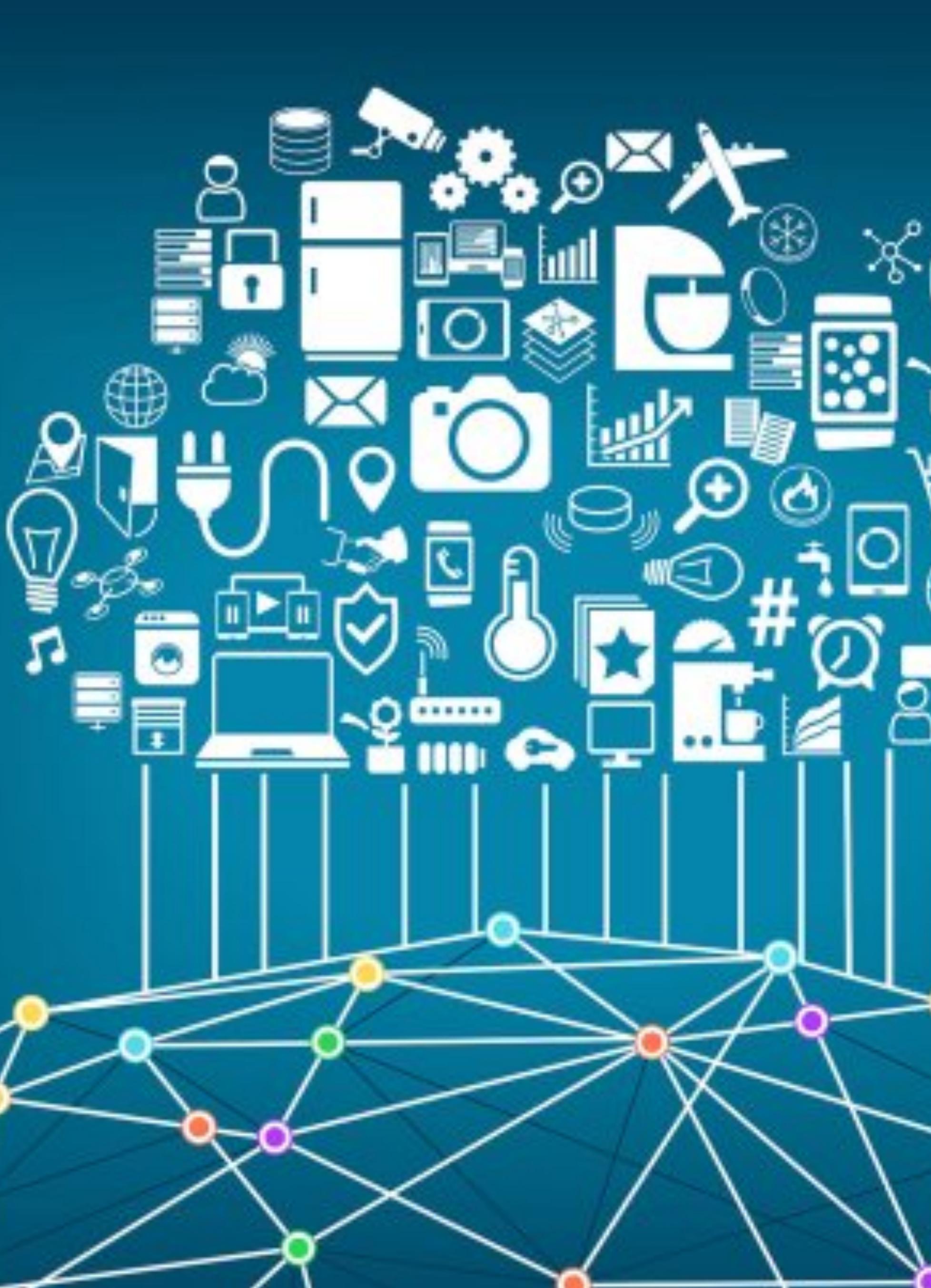
# Edge Comp

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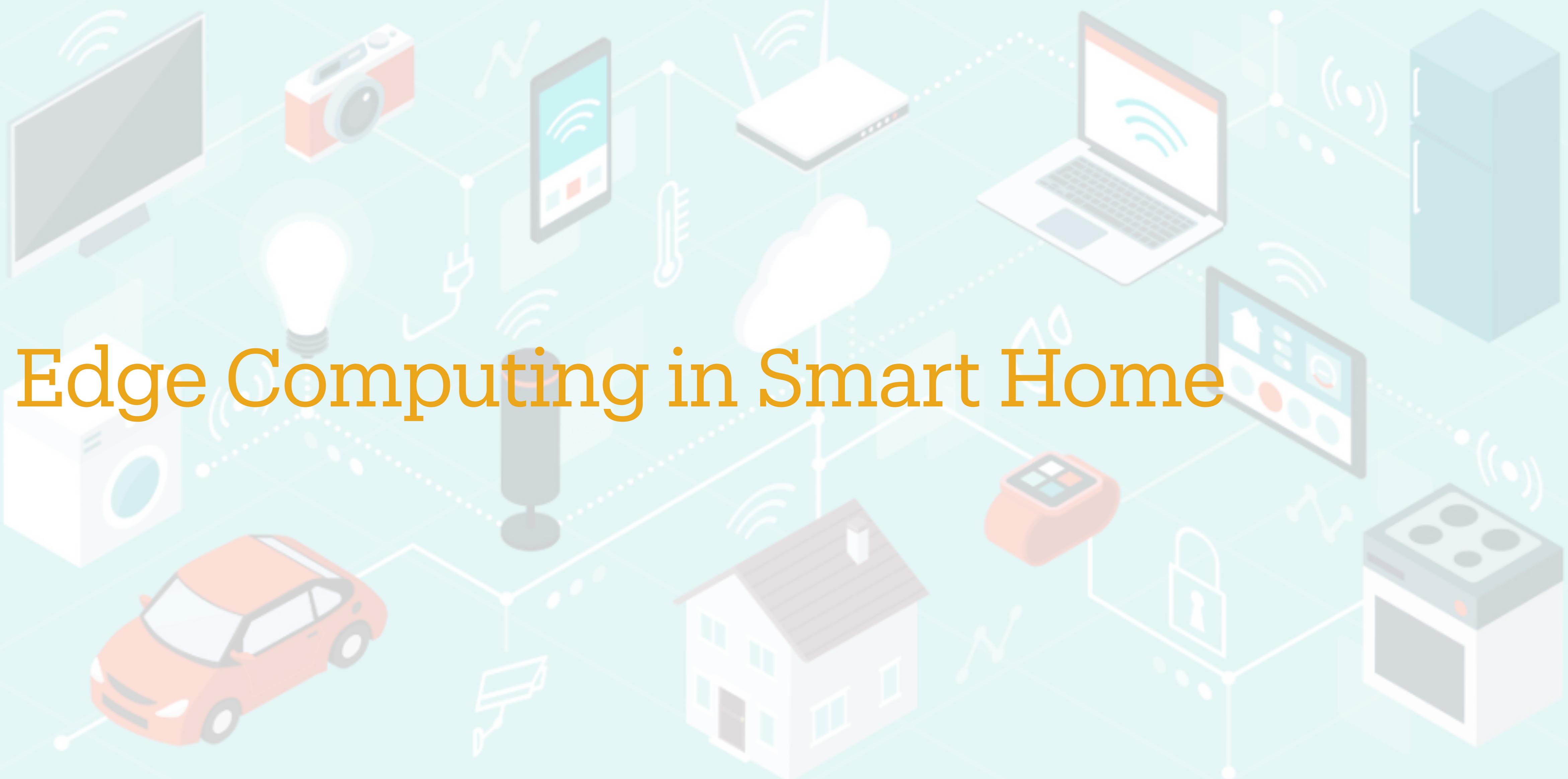
# Lab 1

**Pick your slot, now.**

# Lecture Plan

Today we will:

- Brainstorm how edge computing integrates with different areas, including
  - Smart Home
  - Augmented Reality and Virtual Reality
  - Smart Transportation
  - ...



# Edge Computing in Smart Home

# Edge AI will Forever Change Smart Home

- **Smart home**

- Use internet-connected devices to enable the remote monitoring and management of appliances and systems, such as lighting and heating.



# Potential Research Projects

- Smart home voice assistant improvement
- Elderly care monitoring system
- Smart home security surveillance
- Personalized heating, ventilation, and air conditioning (HVAC) control system
- Smart home energy management

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 **CASAS**  
Center of Advanced Studies In Adaptive System

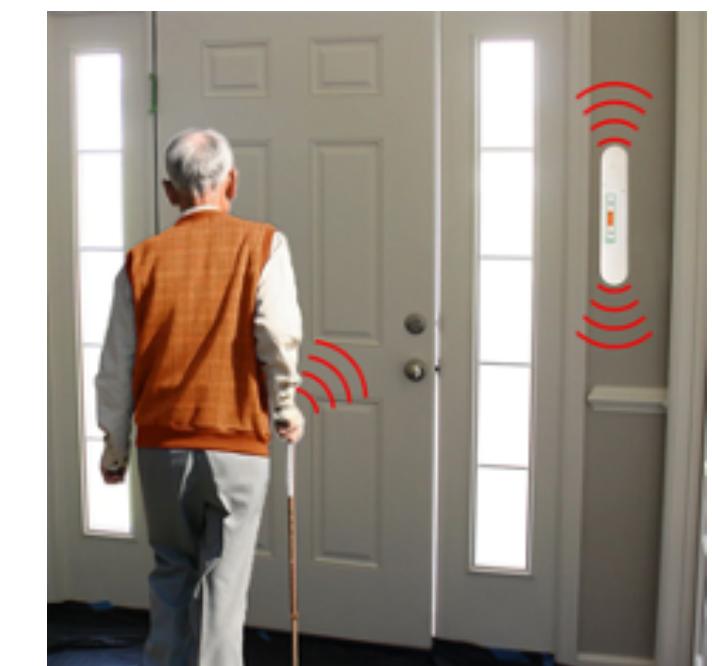
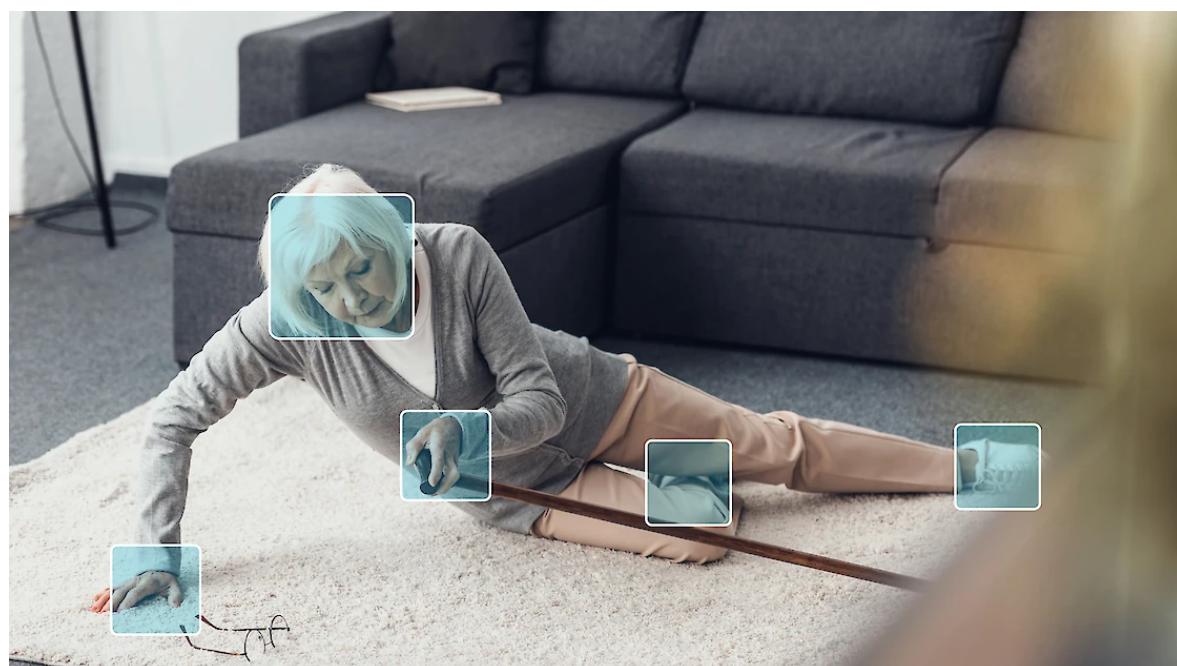
home / about / research projects / tools / datasets / publications / classes / opportunities

**CASAS DATASETS**

CASAS Smart Home Data Sets

Dataset	Testbed	#Residents	#Participants	Description	Annotated	Last Updated
1	Kyoto	20		ADL Activities	Yes	4/27/2010
2	Kyoto	20		ADL Activities with Errors	Yes	7/7/2009

[CASAS: Smart Home in a Box](#)

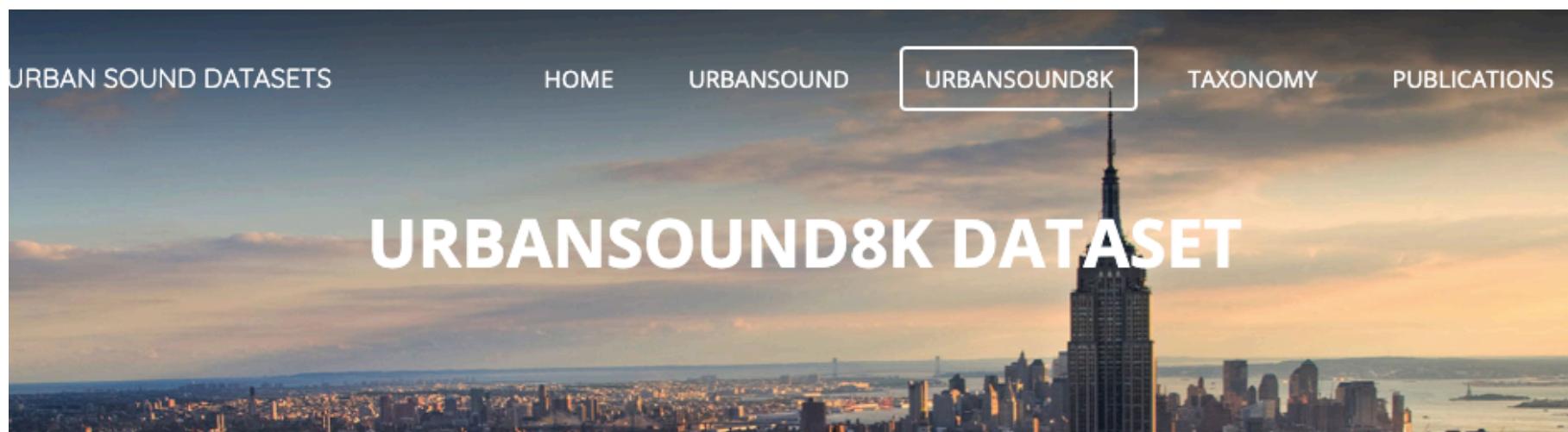


**Non-intrusive** monitoring systems detect anomalies in daily activities to ensure the safety and well-being of **elderly** individuals.

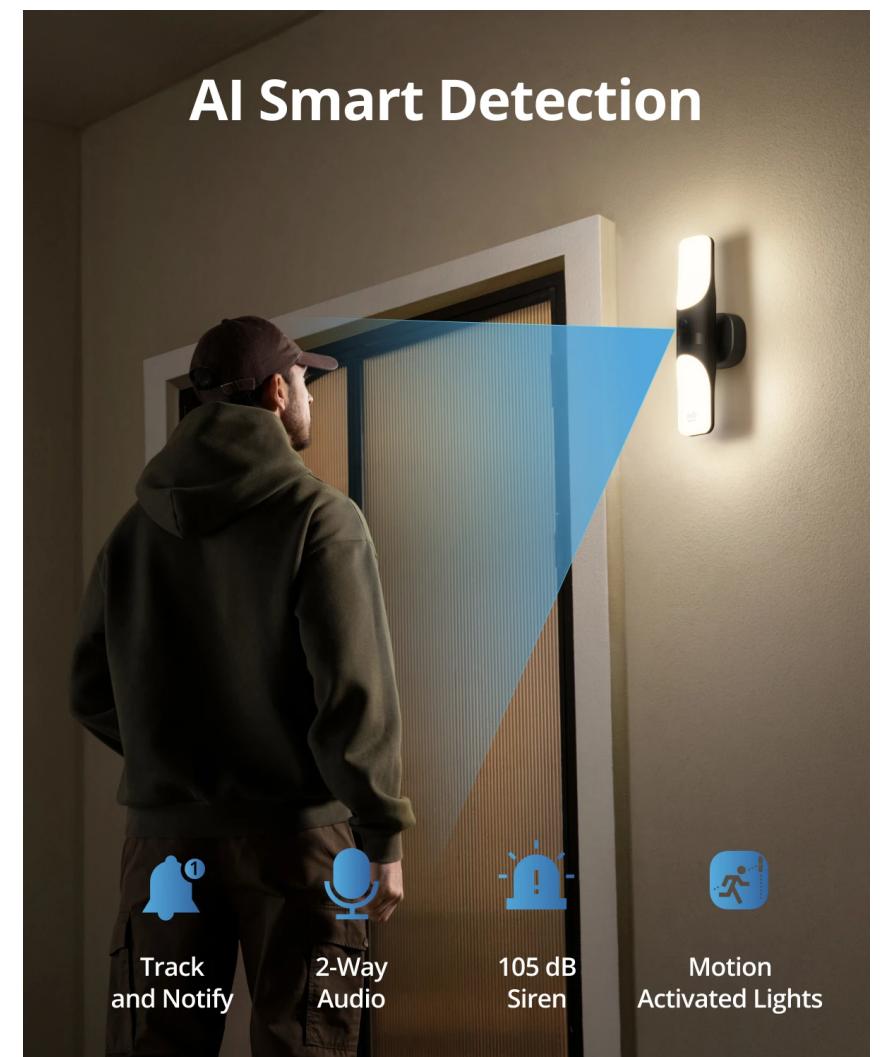


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Urban Sound Classification

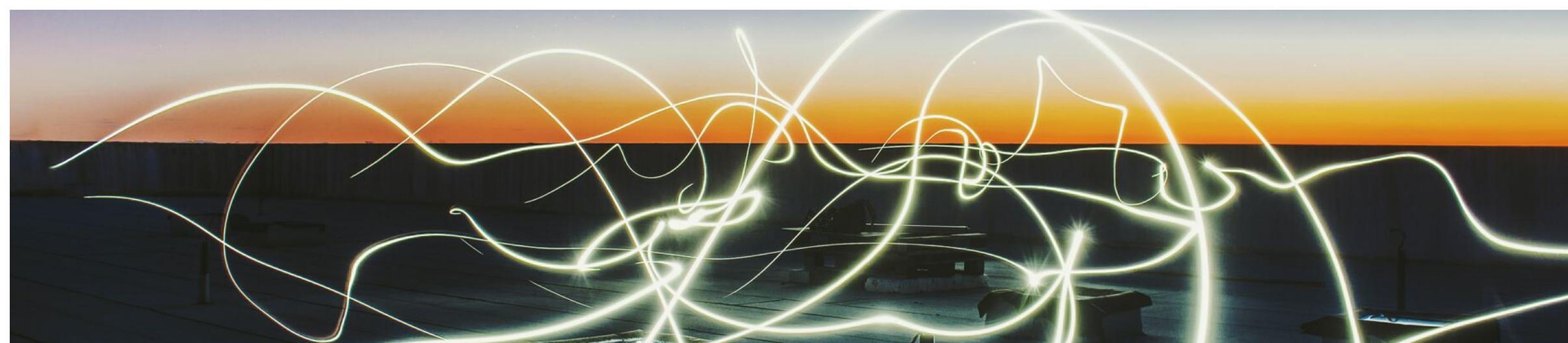


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ASHRAE Great Energy Predictor III

Learn from user behavior and environmental conditions to maintain **optimal temperature** and/or **air quality**

← Home/Away Assist

Automatically use Eco temperatures when no one's home?

Nest can save energy by automatically adjusting the temperature when you're Away.

[Learn more >](#)

Eco Temperatures 59 83

← Family Room

Home/Away Assist Off

NEST SENSE

Auto-Schedule

Auto-Schedule learns your behavior as you adjust your thermostat and automatically creates a schedule to match your heating and cooling preferences.

Time-to-Temp Ready

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[Home Assistant](#)



[openHAB](#)

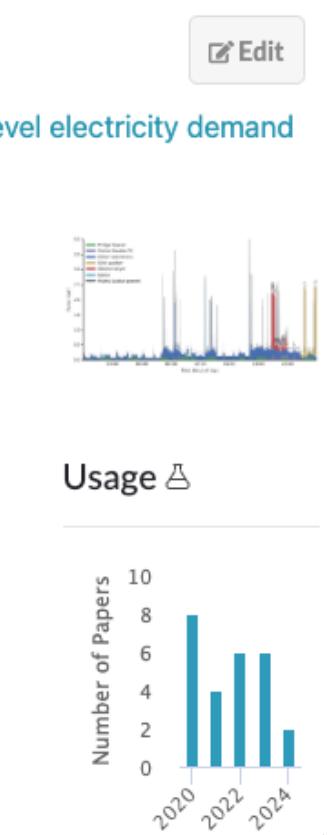
**Optimize energy consumption** in a smart home by controlling smart appliances based on user preferences, weather data, electricity prices, etc.

## UK-DALE

Introduced by Jack et al. in [The UK-DALE dataset, domestic appliance-level electricity demand and whole-house demand from five UK homes](#)

UK-DALE is an open-access dataset from the UK recording Domestic Appliance-Level Electricity to conduct research on disaggregation algorithms, with data describing not just the aggregate demand per building but also the 'ground truth' demand of individual appliances. It was built at a sample rate of 16 kHz for the whole-house and at 1/6 Hz for individual appliances. This is the first open access UK dataset at this temporal resolution. It was recorded from five houses, one of which was recorded for 655 days.

[Homepage](#)



[UK-DALE Dataset](#)

A screenshot of a mobile-style interface for a smart home. At the top, a grey header bar says "Family Room". Below it, a card for "Home/Away Assist" has "Off" next to it. Another card for "NEST SENSE" is partially visible. A large central section is titled "Auto-Schedule" with a blue gear icon. Text explains that Auto-Schedule learns behavior and creates a schedule. At the bottom, a card for "Time-to-Temp" shows a "Ready" status with a leaf and gear icon.

# Edge Computing in AR/VR

Tony Stark & Jarvis Analyze Crime Scene | Iron Man 3

# Augmented Reality (AR) and Virtual Reality (VR)

- **Augmented reality (AR)**

- AR **overlays digital content onto the real world** through devices like smartphones, tablets, or specialized AR glasses
- Allowing users to interact with both physical and virtual elements simultaneously



# Augmented Reality (AR) and Virtual Reality (VR)

- **Virtual reality (VR)**

- Creates a **completely immersive virtual environment** that users can interact with, typically using a VR headset that blocks out the physical world



Ready Player One

# Key Components in the AR System

- **A camera:** capture the real-world environment and feeds it into the AR system
- **A processor:** perform image processing on the camera's input to identify and track features in the real world
- **A display:** present the digital content and information superimposed on the real-world view. This can involve a smartphone screen, a head-mounted display (HMD), or a projected image

# Key Components in the AR System

- **Tracking and alignment:** align virtual content with the real-world environment. It uses various tracking techniques such as marker-based tracking, feature-based tracking, SLAM (simultaneous localization and mapping), etc.
- **Interaction:** enable users to interact with virtual content. This could be done through gestures, voice commands, or a handheld controller
- **Software:** the backbone of the AR system. It includes the programming that makes the AR experience possible

# AR/VR and Edge Computing



○

**5G and AR/VR:  
Uses Cases with  
Edge Computing**

○

 PARTNERS

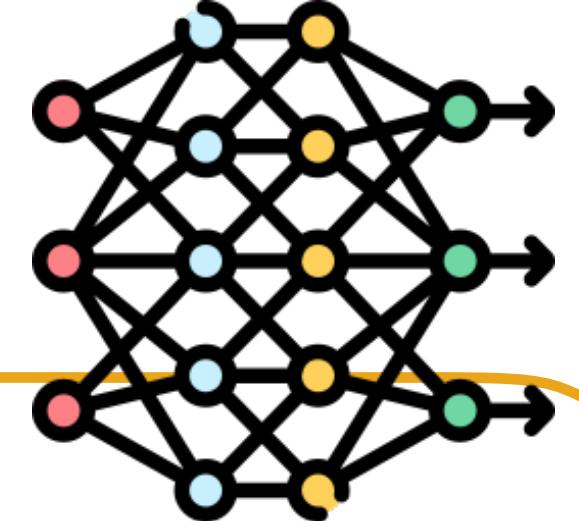
5G and AR/VR: Transformative Use Cases with Edge Computing

# Potential Research Projects

- AR indoor navigation
- VR training simulations for hazardous environments
- AR for real-time object annotation in education

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- VR training simulations for hazardous environments
- AR for real-time object annotation in education



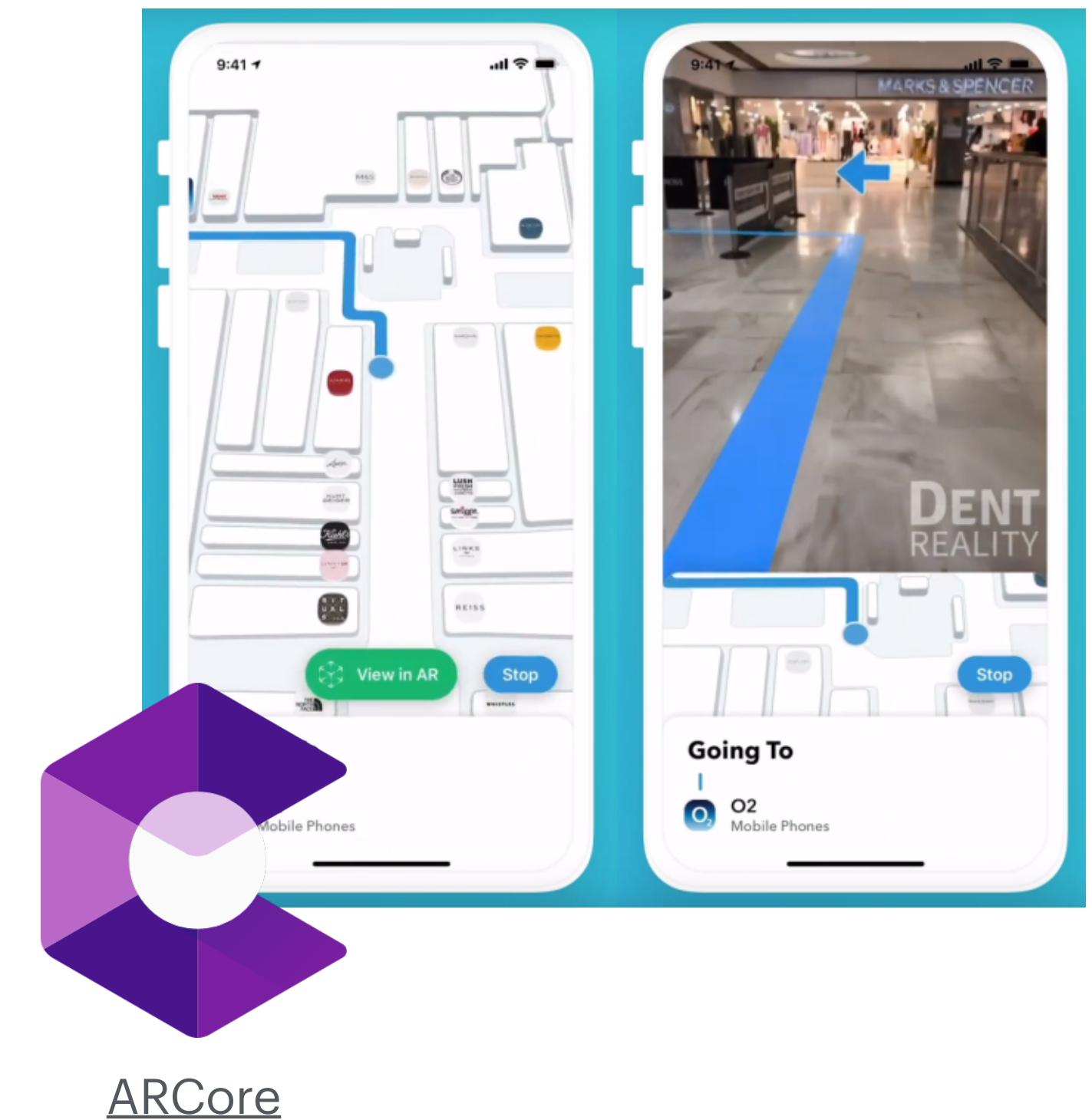
Overlay navigational cues on a mobile device's camera feed to guide users through indoor environments



**Indoor Location Dataset** [aka.ms/location20dataset](http://aka.ms/location20dataset)

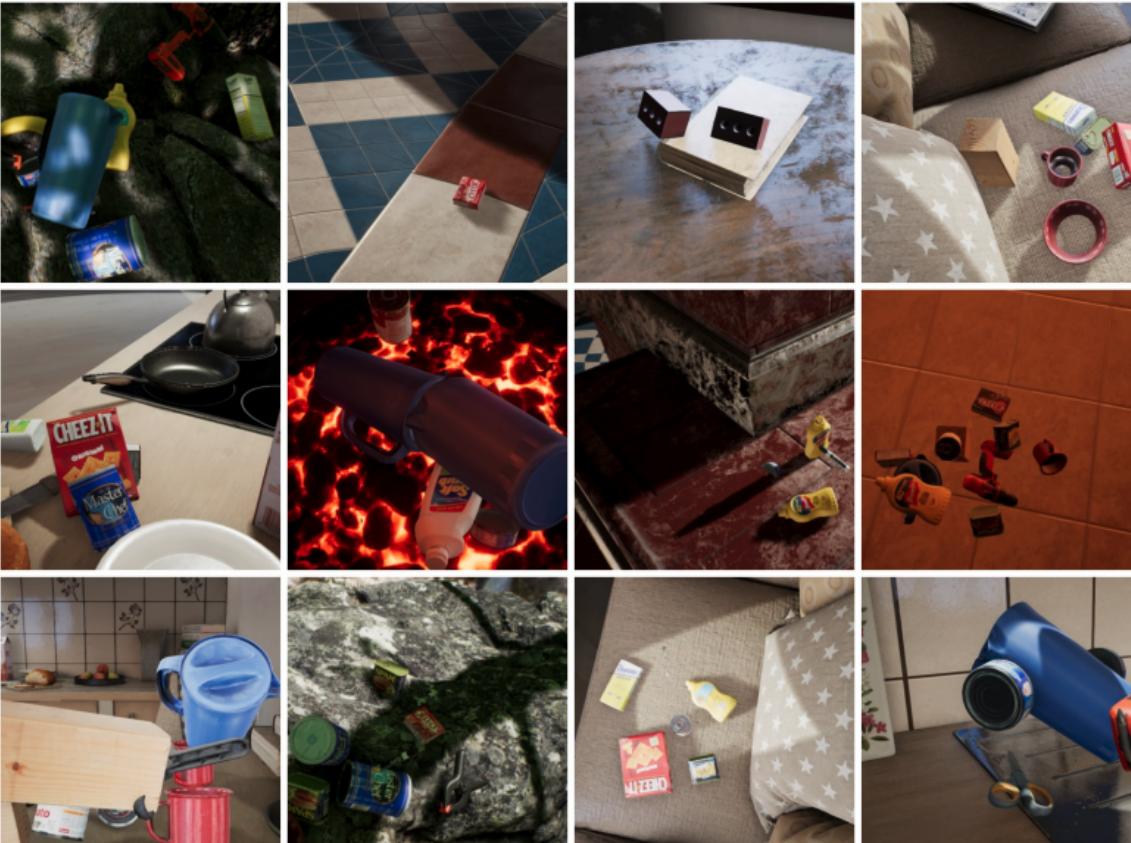
Real-world indoor walking traces collected by smartphones.  
Rich sensing information from accelerometer, gyroscope, magnetometer, WiFi, and Bluetooth iBeacon.  
Human labeled ground truth with floor plans.  
Sample data, code, and webinar.  
First-of-its-kind large-scale benchmark dataset for LBS R&D.  
Available on Kaggle and [Microsoft Research Open Data](#).

[Microsoft Indoor Location Competition](#)



# Potential Research Projects

- AR indoor navigation
- VR training simulations for hazardous environments
- AR for real-time object annotation in education



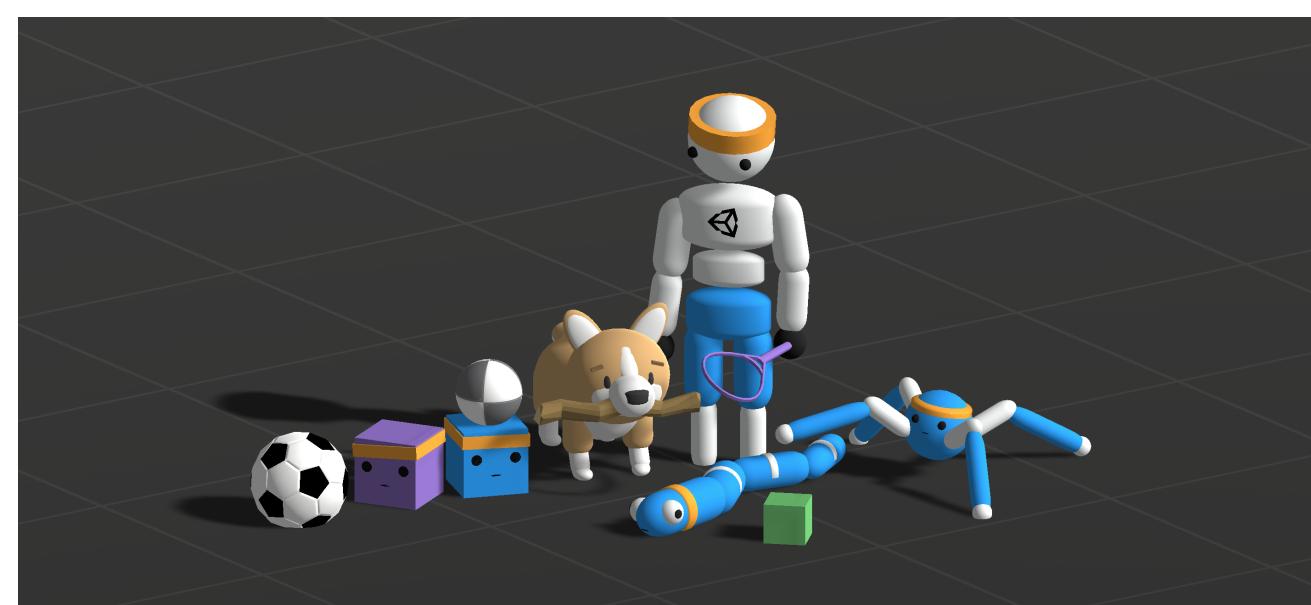
Falling Things



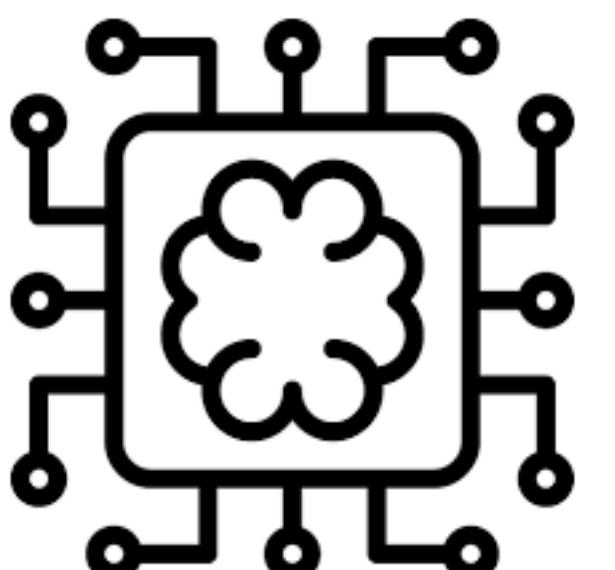
SynthHands



Create VR simulations for training individuals to operate safely in **hazardous environments** without the risk of actual exposure



Unity ML-Agents Toolkit

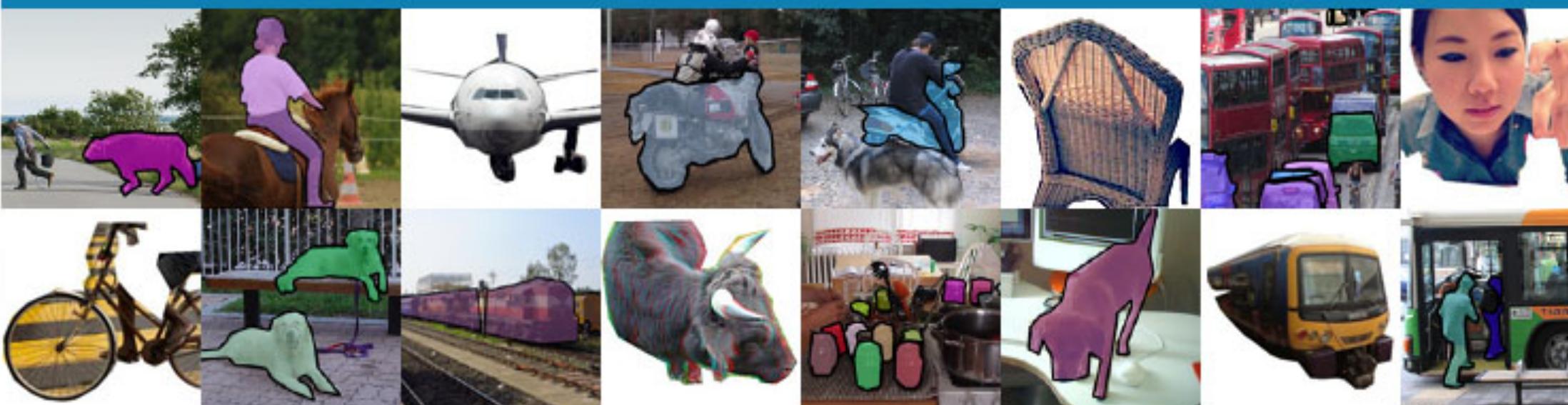


# Potential Research Projects

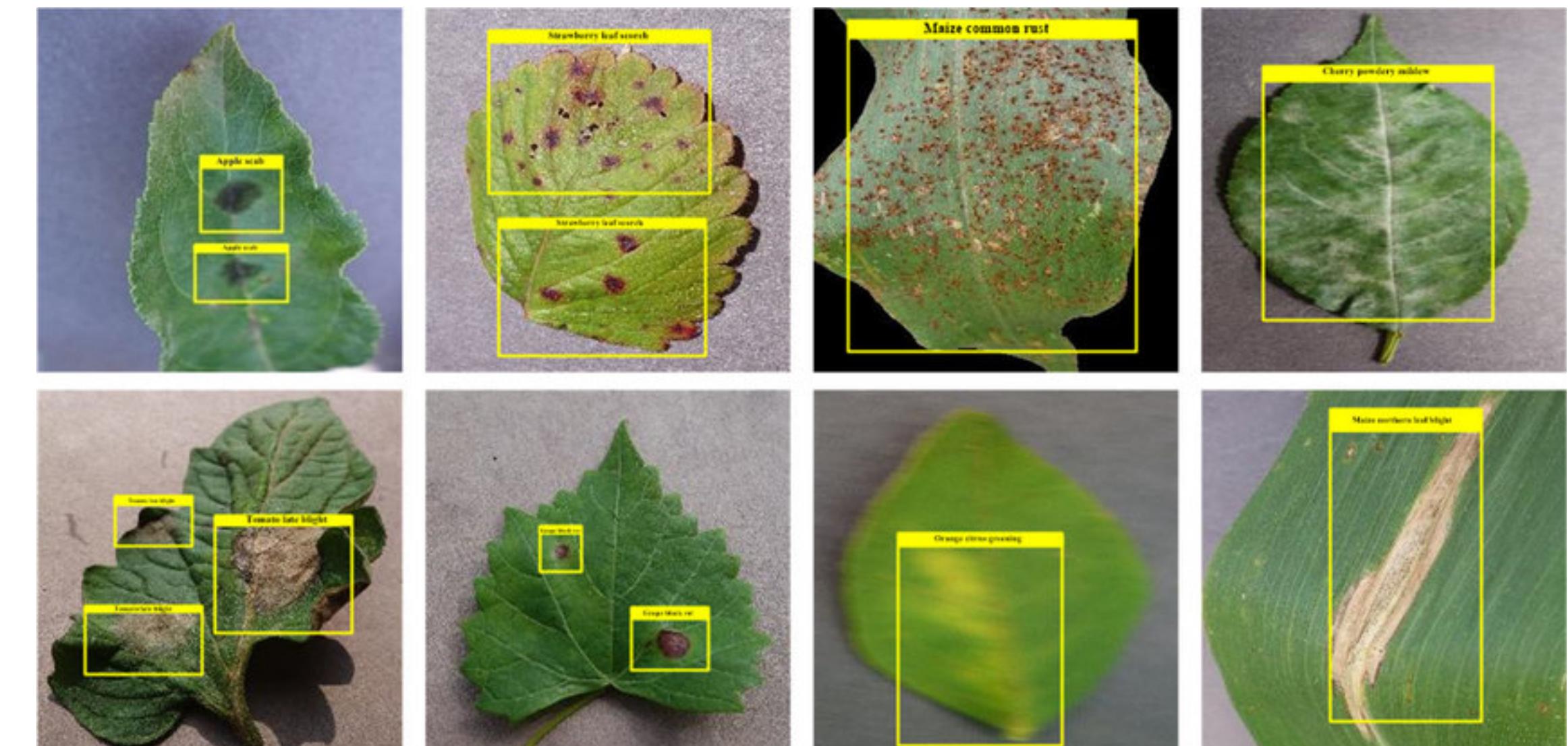
- AR indoor navigation
- VR training simulations for hazardous environments
- AR for real-time object annotation in education

Provide real-time annotations on objects viewed through a device's camera, enhancing learning experiences in educational settings

Dataset examples



coco



# Edge Computing in Smart Transportation

# Change is Happening Now

- **Traditional vehicle**
  - Vehicle-centric, closed, fixed function vehicle
- **Current/Emerging vehicles**
  - AI-centric, connected, and software-defined vehicle with dynamic functions

The screenshot shows a X (Twitter) post from the official Tesla AI account (@Tesla\_AI). The post includes a list of planned updates for September 2024, October 2024, and Q1 2025. The post has received 13.6M views.

Due to popular demand, Tesla AI team release roadmap:

September 2024

- v12.5.2 with ~3x improved miles between necessary interventions
- v12.5.2 on AI3 computer (unified models for AI3 and AI4)
- Actually Smart Summon
- Cybertruck Autopark
- Eye-tracking with sunglasses
- End-to-End network on highway
- Cybertruck FSD

October 2024

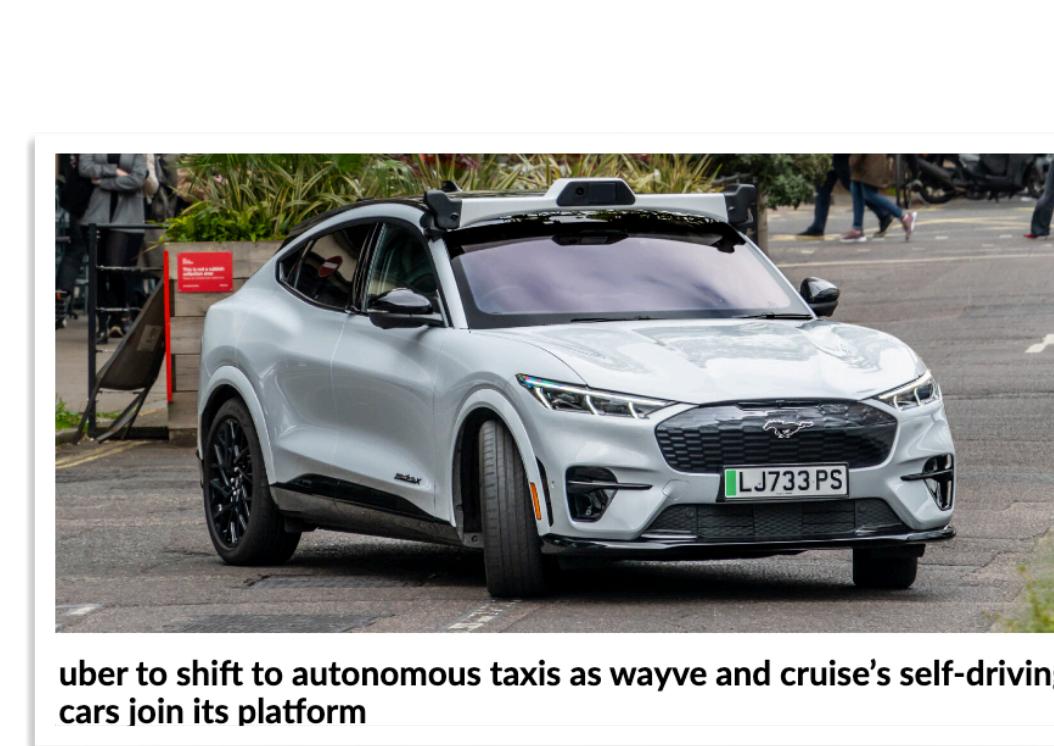
- Unpark, Park and Reverse in FSD
- v13 with ~6x improved miles between necessary interventions

Q1 2025

- FSD in Europe (pending regulatory approval)
- FSD in China (pending regulatory approval)

1:29 AM · Sep 5, 2024 · 13.6M Views

[Tesla AI X Account](#)



[News](#)

Baidu's driverless robotaxi service Apollo Go on the road in Wuhan, Hubei province, China on February 24, 2023. Josh Arslan/Reuters

Editor's Note: Sign up for CNN's Meanwhile in China newsletter which explores what you need to know about the country's rise and how it impacts the world.

**Hong Kong (CNN)** — In China, it's possible to travel six miles in a driverless taxi for just about 50 cents.

[Apollo, News](#)

NEWS SEPTEMBER 10, 2024 0

Tesla confirms robotaxi event to take place in LA, opens shareholder ticket lottery

by DARRYN JOHN

A Robotaxi concept

[News](#)

# The 6 Levels of Autonomous Vehicles



**0**  
**NO AUTOMATION**

Full manual control. The driver has full control over the vehicle and performs all driving tasks.

**1**  
**DRIVER ASSISTANCE**

The vehicle can assist the driver with a single automated system.  
(eg *adaptive cruise control*)

**2**  
**PARTIAL AUTOMATION**

The vehicle can perform both steering and power control features.  
(eg *advanced driver-assistance systems - ADAS*)

**3**  
**CONDITIONAL AUTOMATION**

The vehicle can perform the majority of driving tasks. Driver involvement is still necessary.  
(eg *ADAS with environmental detection*)

**4**  
**HIGH AUTOMATION**

The vehicle can perform all driving tasks in certain circumstances.  
(eg *ADAS with environmental monitoring*)

**5**  
**FULL AUTOMATION**

The driver is no longer necessary as the vehicle can perform all driving tasks without override.



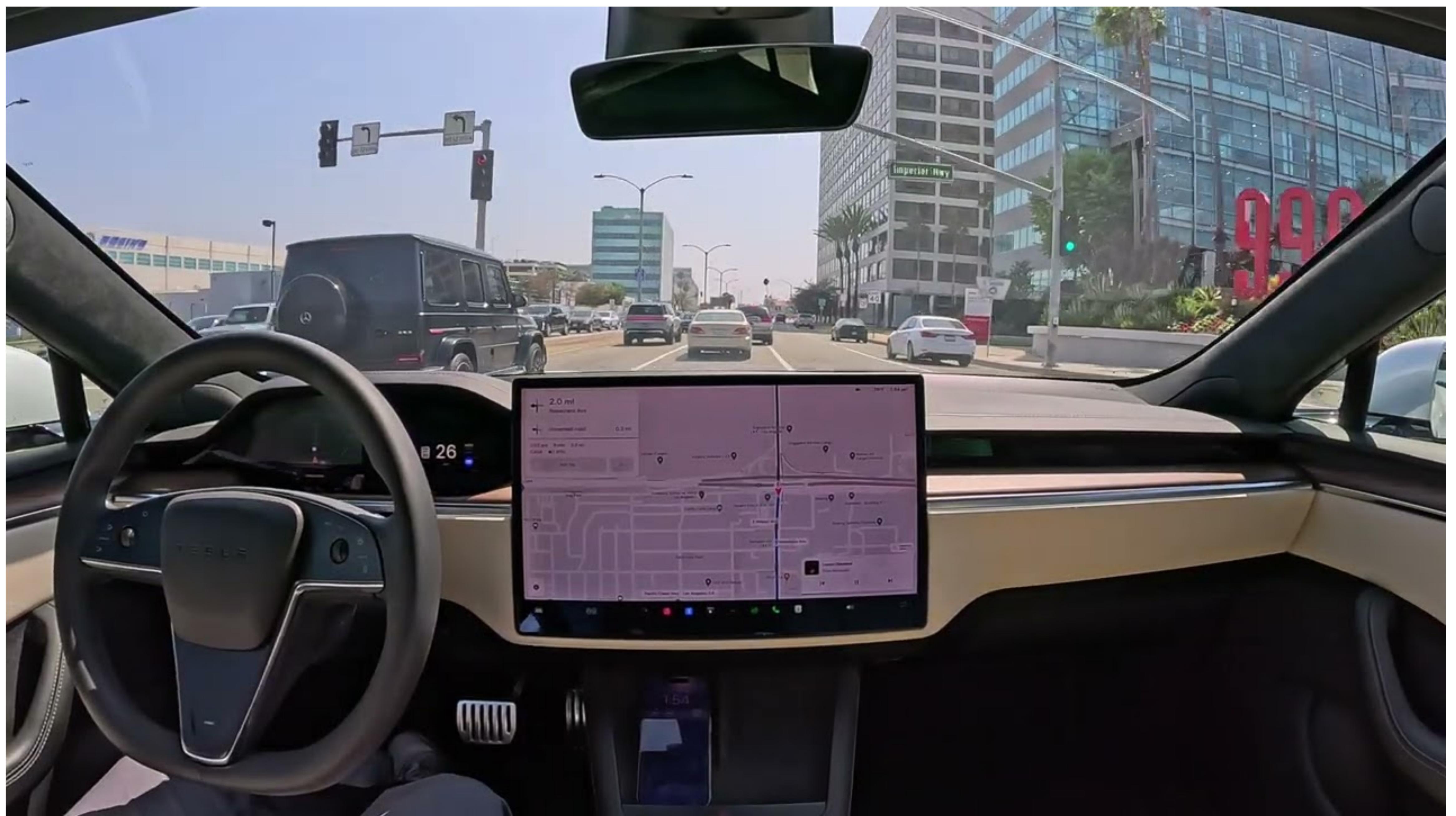
DRIVER HAS PRIMARY CONTROL, SYSTEM PROVIDES SECONDARY ASSISTANCE

SYSTEM HAS PRIMARY CONTROL, DRIVER PROVIDES SECONDARY ASSISTANCE

# Tesla Full Self-Driving (FSD) (\$15K)

The world's first end-to-end AI autonomous driving.

- **Autopilot**: the basic feature that is included with every new car
- **Enhanced Autopilot (\$6K) (<https://www.tesla.com/support/autopilot#usingautopilot>)**
  - Tap the turn signal, and the car will change lanes
  - **Navigate on Autopilot (NoA)**: the car will change lanes on its own to pass slower traffic and take exit/interchange ramps
  - **Summon and Smart Summon**: using the mobile app, pull the car forward or back, or have it navigate through parking lots to your location
  - **Autopark**: parallel and perpendicular parking between other parked cars (while you are in the car)
  - **Autosteer on City Streets** (like traffic-aware cruise control)
    - Autosteer maintains a set speed (if there is not a vehicle in front) of you)
    - Or a set following distance (if there is a vehicle in front of you)
  - **Traffic and Stop Sign Control**
    - Identifies stop signs and traffic lights
    - Automatically slows your car to a stop on approach, with your active supervision



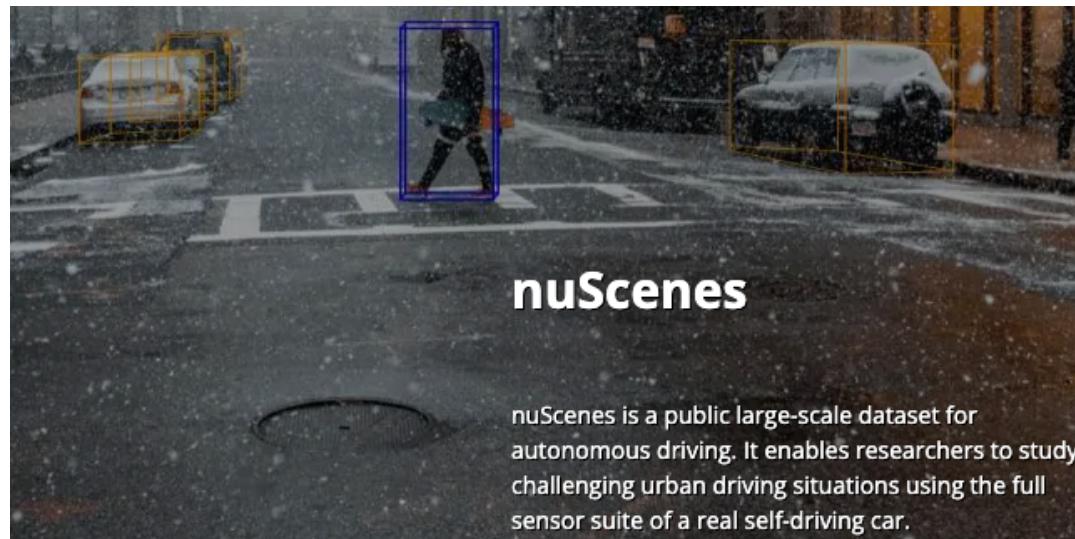
Raw 1x: Tesla FSD 12.5.2.1 on Hardware 3 First Drive (Sep 15, 2024)

# Potential Research Projects

- Autonomous vehicle path planning
- Pedestrian and cyclist detection for autonomous vehicles
- Traffic prediction and management for smart cities
- Real-time vehicle detection and classification
- Driver behavior analysis and anomaly detection
- Lane detection and following for autonomous driving

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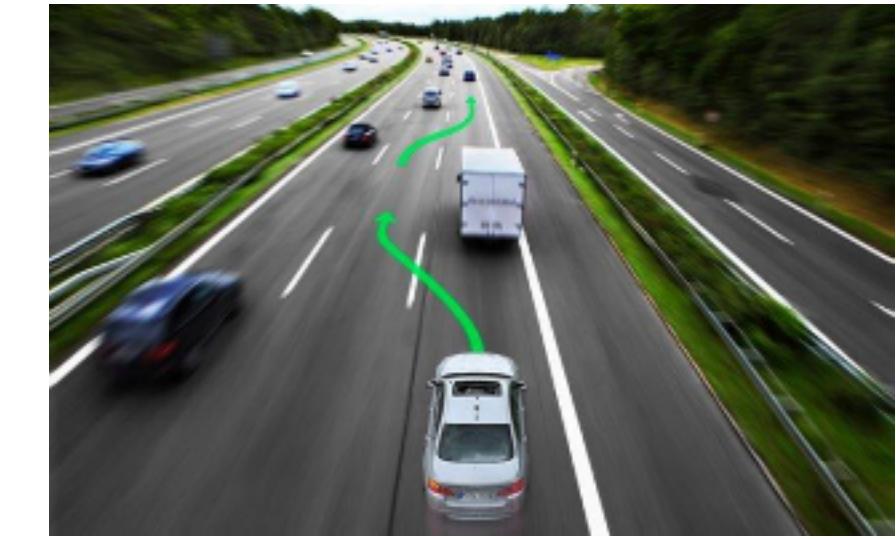
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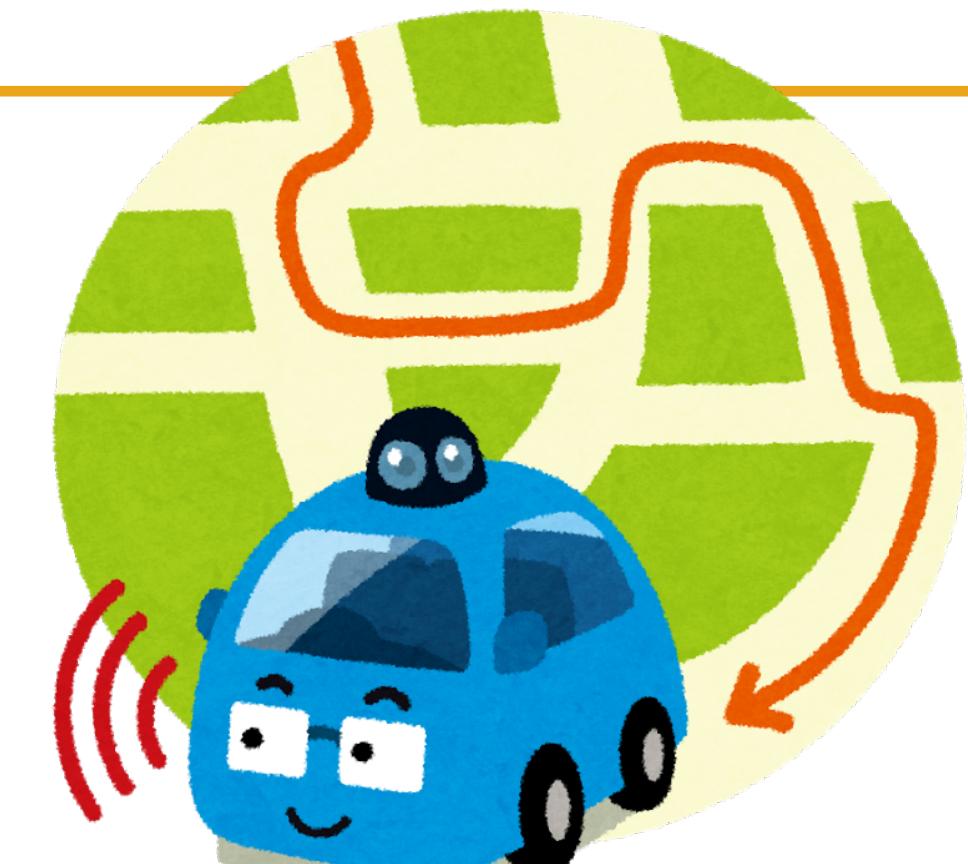
[nuScenes](#)



[Waymo Open Dataset](#)



Solutions for optimal path planning in autonomous vehicles considering traffic, obstacles, and road conditions



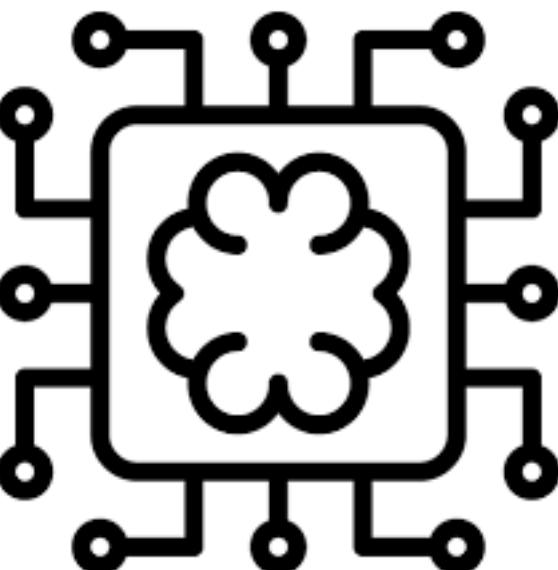
[PythonRobotics](#)

# Potential Research Projects

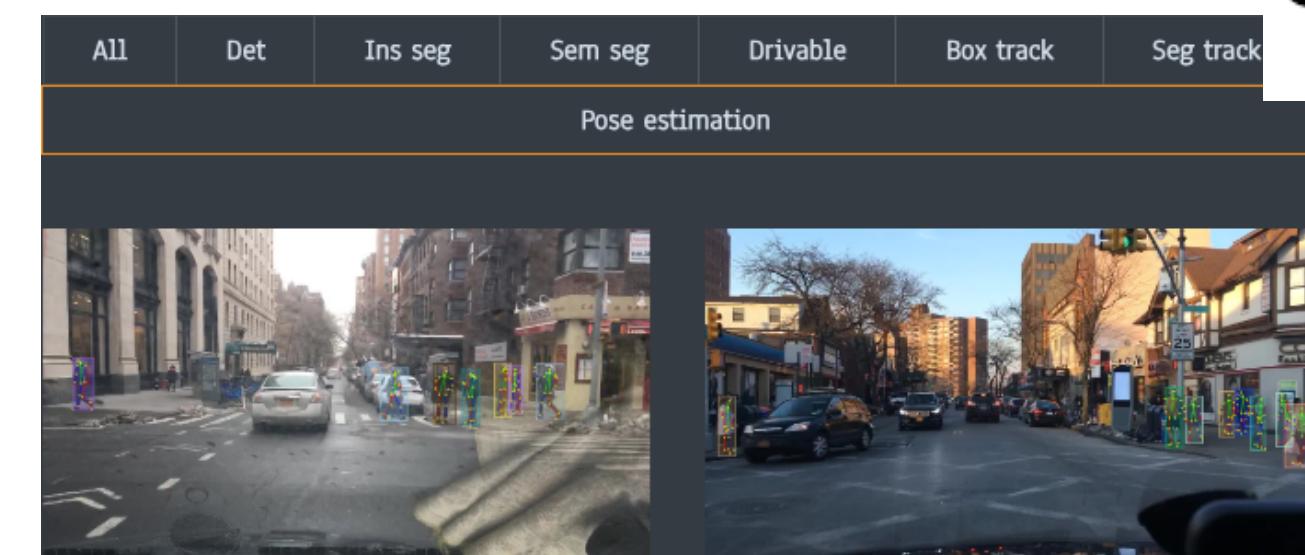
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Real-time detection solutions for pedestrians and cyclists to improve urban autonomous driving safety



Cityscapes

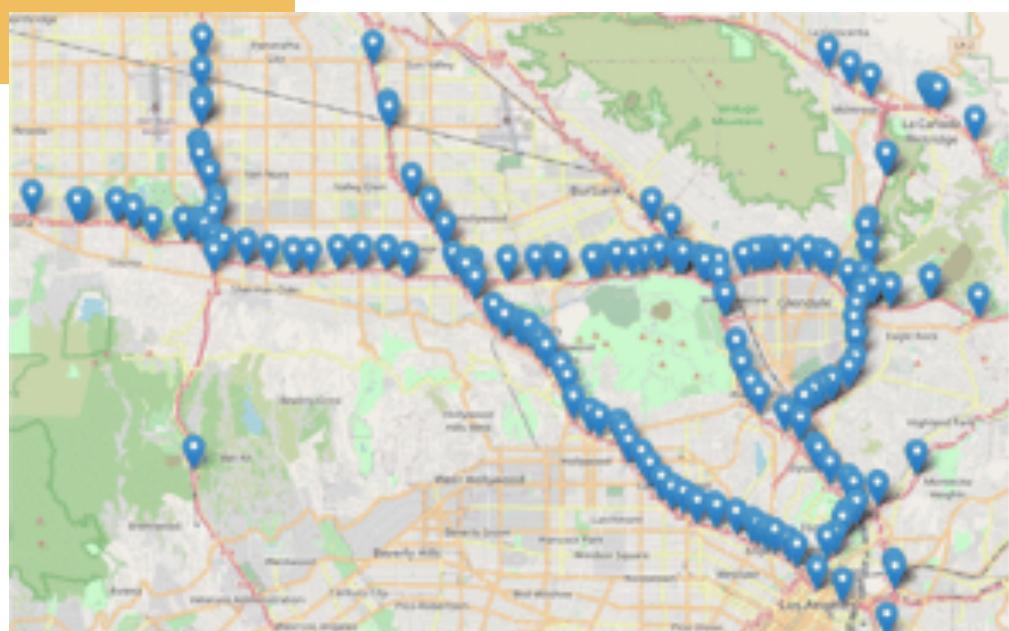


BDD100K

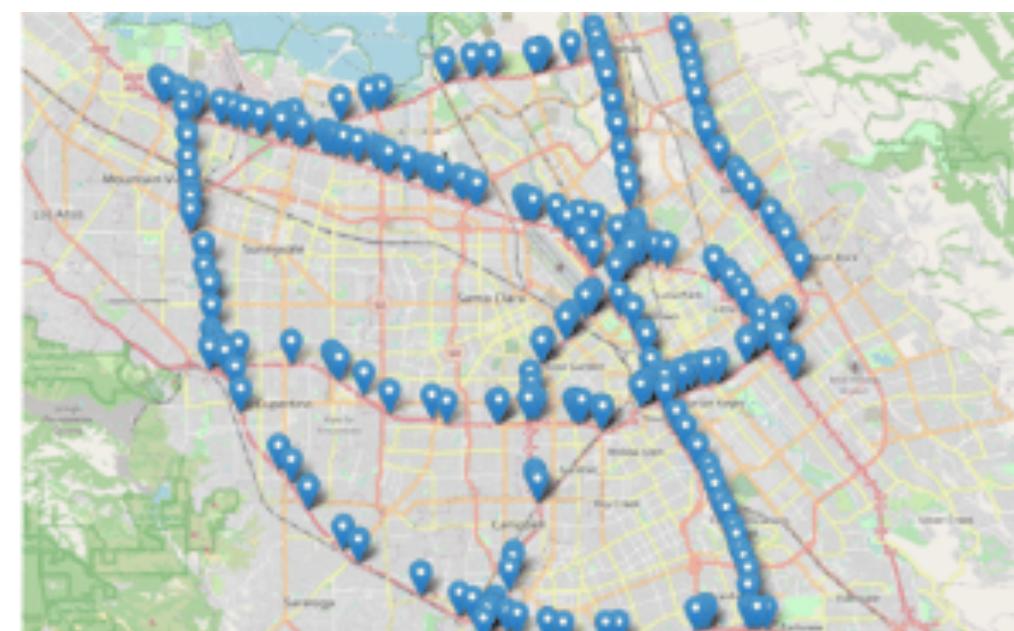
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Use historical and real-time data to predict traffic pattern and manage traffic lights and signs for optimal flow

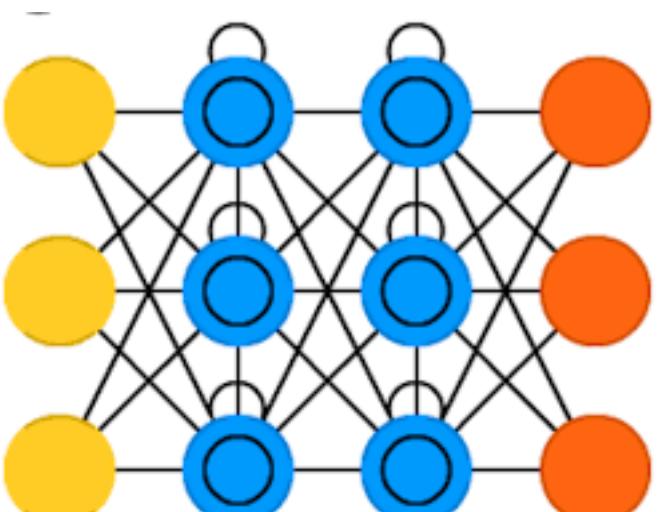


(a) METR-LA



(b) PEMS-BAY

Traffic speed data



**PyG**

PyTorch Geometric

# Potential Research Projects

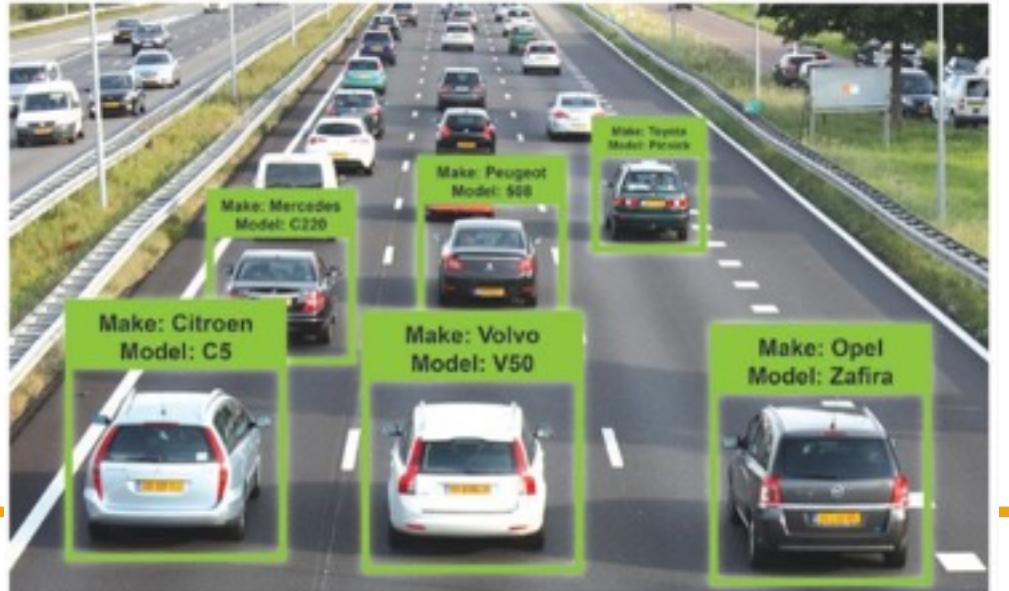
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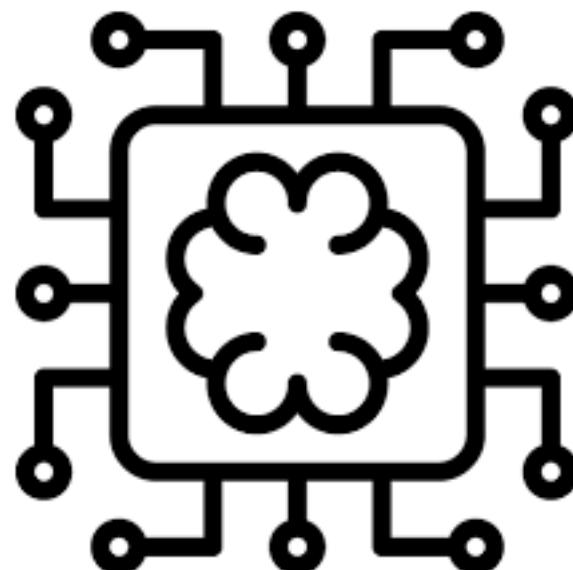
KITTI



UA-DETRAC



Solutions that detect and classifies vehicles in real-time from camera feeds for traffic monitoring and management



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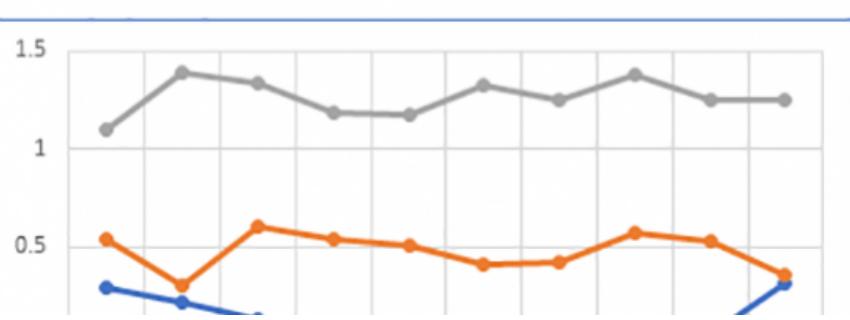
StateFarm Distracted Driver Detection



AUC Distracted Driver Dataset



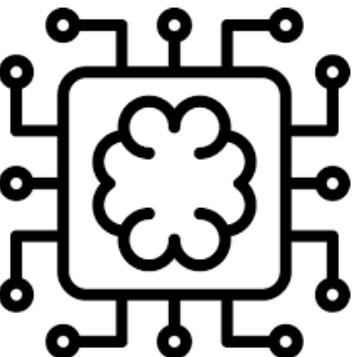
**Autonomous driving logs**



Berkeley DeepDrive



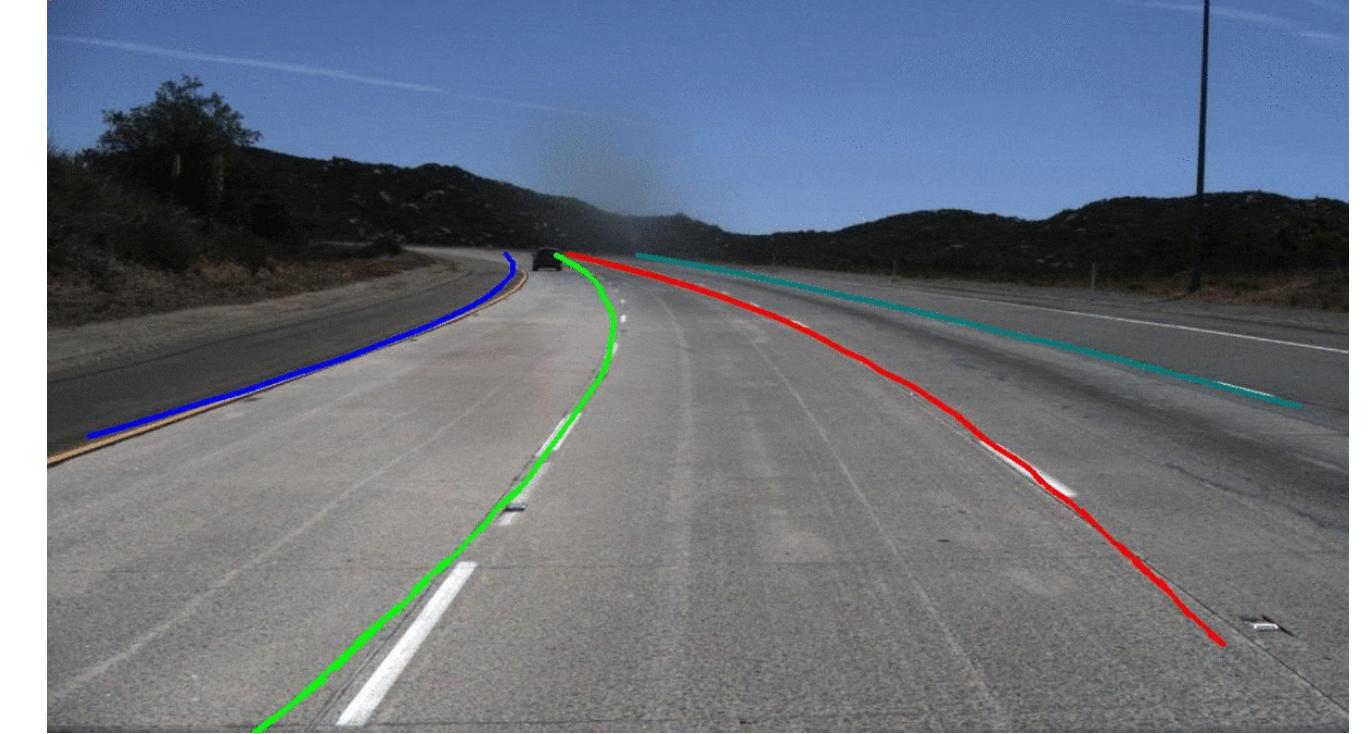
**Anomaly detection and diagnosis**



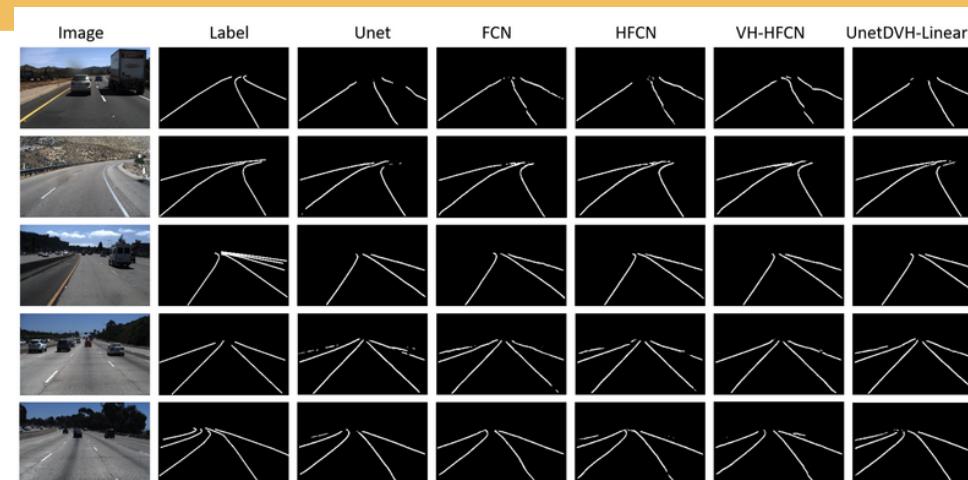
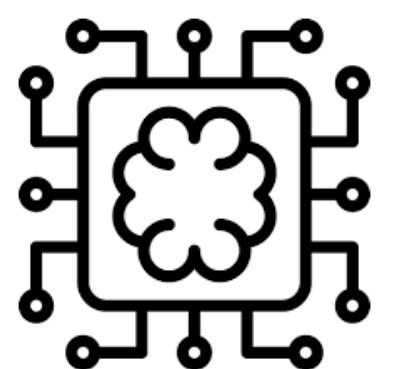
Autoencoder

# Potential Research Projects

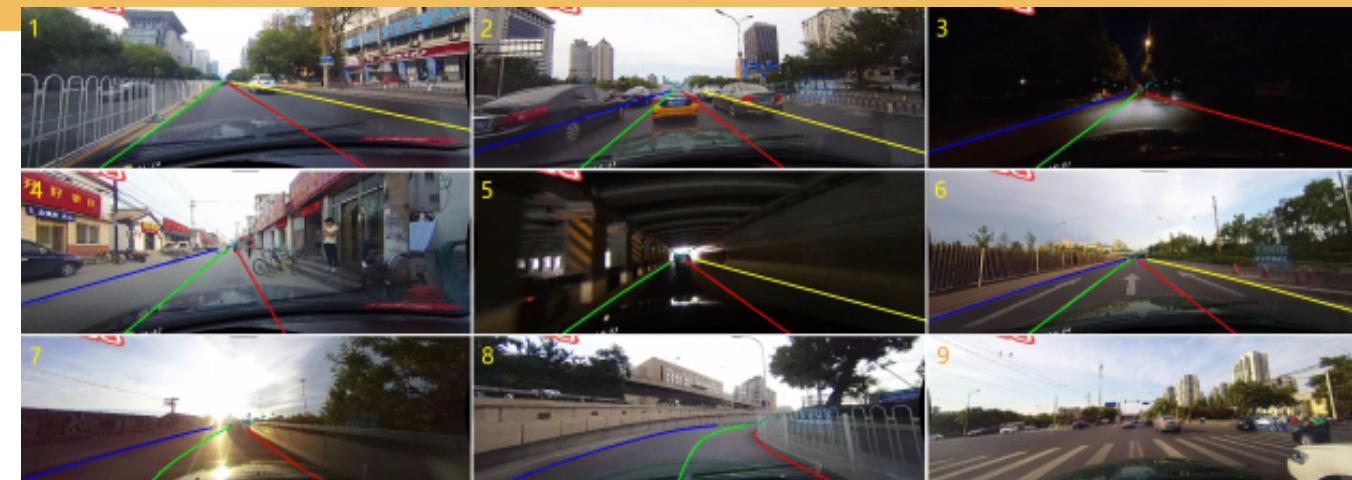
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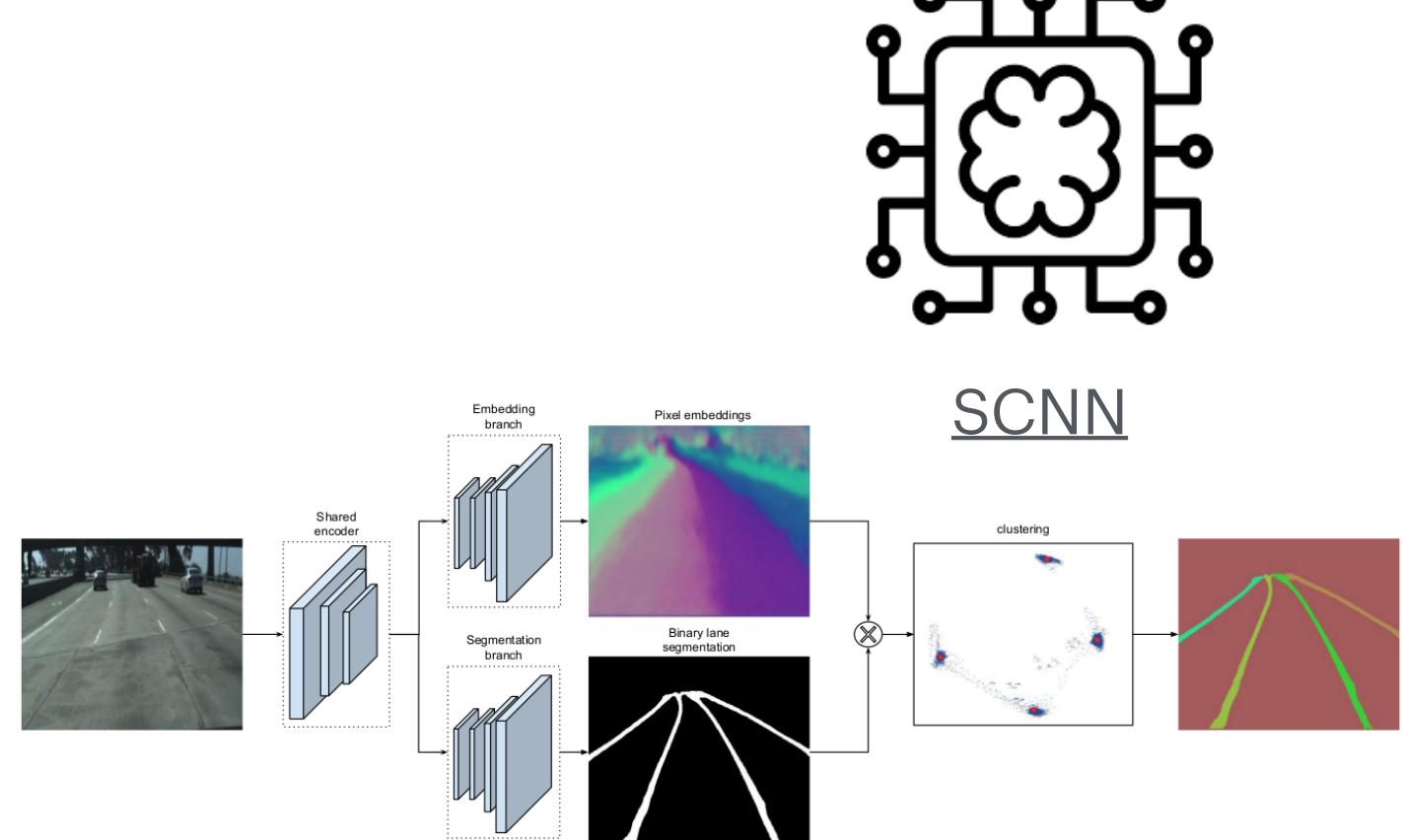
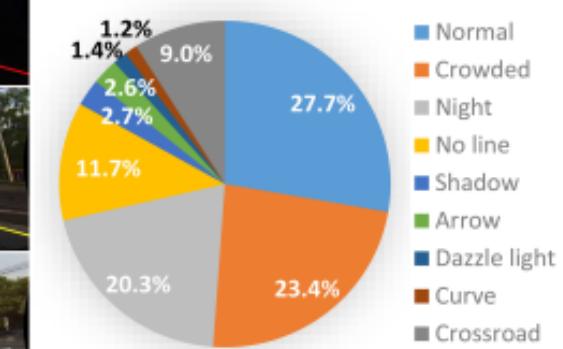
Solutions to detection road lanes and enable autonomous vehicles to follow them accurately



TuSimple



CULane



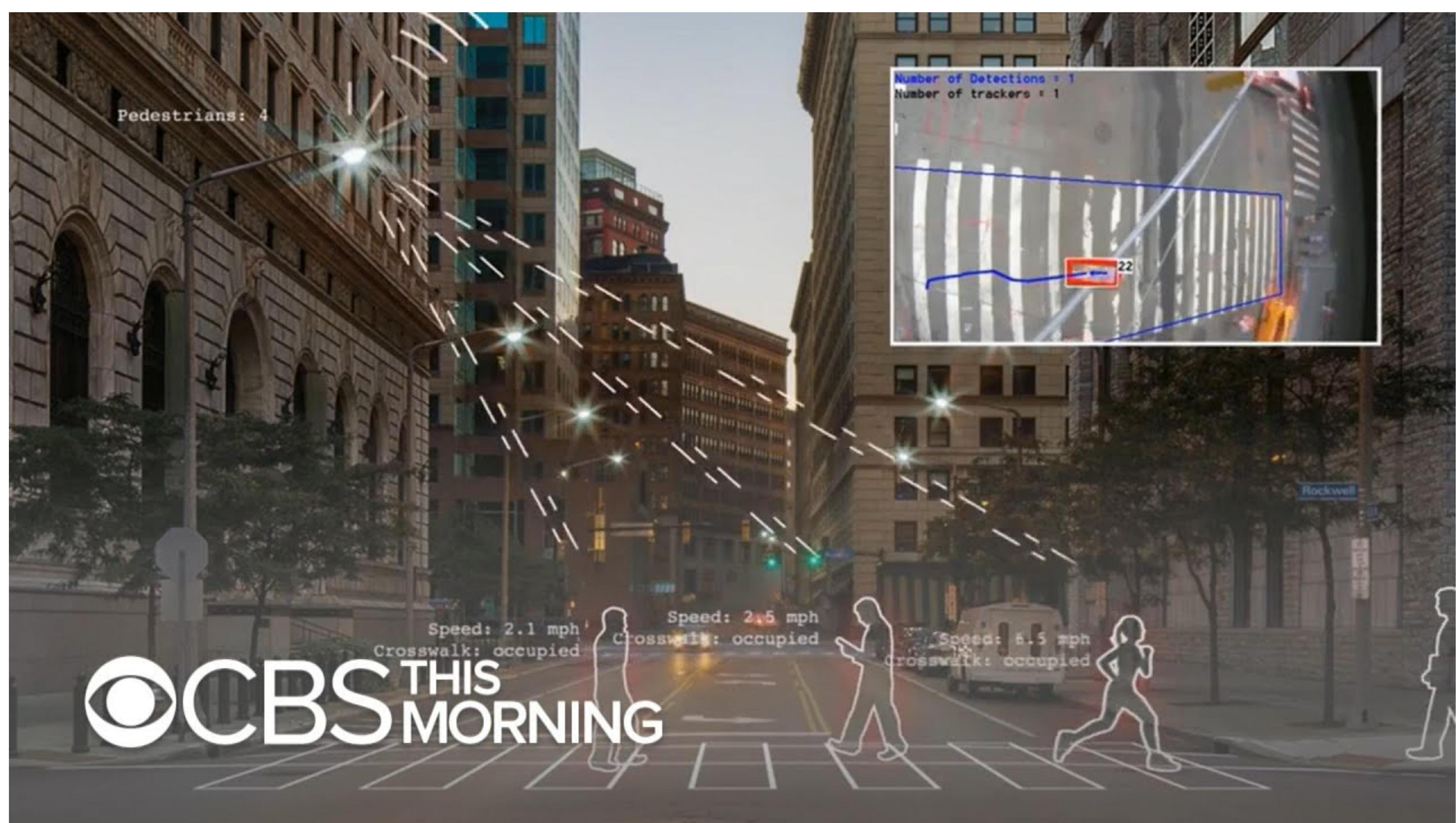
# And more?

# Edge Computing in Smart Cities



# Potential Research Projects

- Smart traffic management system
- Energy-efficient smart buildings
- Waste management optimization
- Public safety and emergency response
- Environmental monitoring and sustainability
- Smart parking solutions



San Diego hopes to become largest "smart city" in the U.S.

# Edge Computing in Smart Manufacturing

# Potential Research Projects

- Predictive Maintenance of Industrial Machines
- Quality Control in Manufacturing Lines
- Optimization of Manufacturing Processes
- Supply Chain and Inventory Management
- Worker Safety Monitoring



# Edge Computing in Financial Services



# Potential Research Projects

- Real-time Fraud Detection in Transactions
- Personalized Banking Experience
- Algorithmic Trading Strategy Optimization
- Real-time Risk Assessment for Loans and Credits
- Blockchain Transactions Validation and Analysis