智能感知在自主驾驶中的应用与挑战

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个人简历

副教授、副主任	@ 南方科技大学计算机系
助理教授	@ 美国阿拉巴马大学
博士后	@ 美国肯塔基大学
博士	@ 美国杜克大学

南科大简介

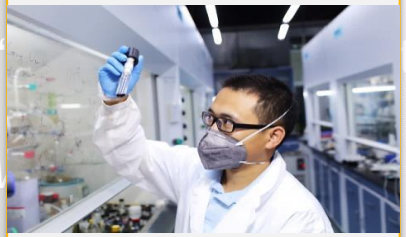
Small Size

- 1:10 Professor-student ratio
- (800-1000 faculty, 10000 students)

Global Univ.

- International Faculty and Students (20%)
- International Campus Culture

Research Innovation Entrepreneurship



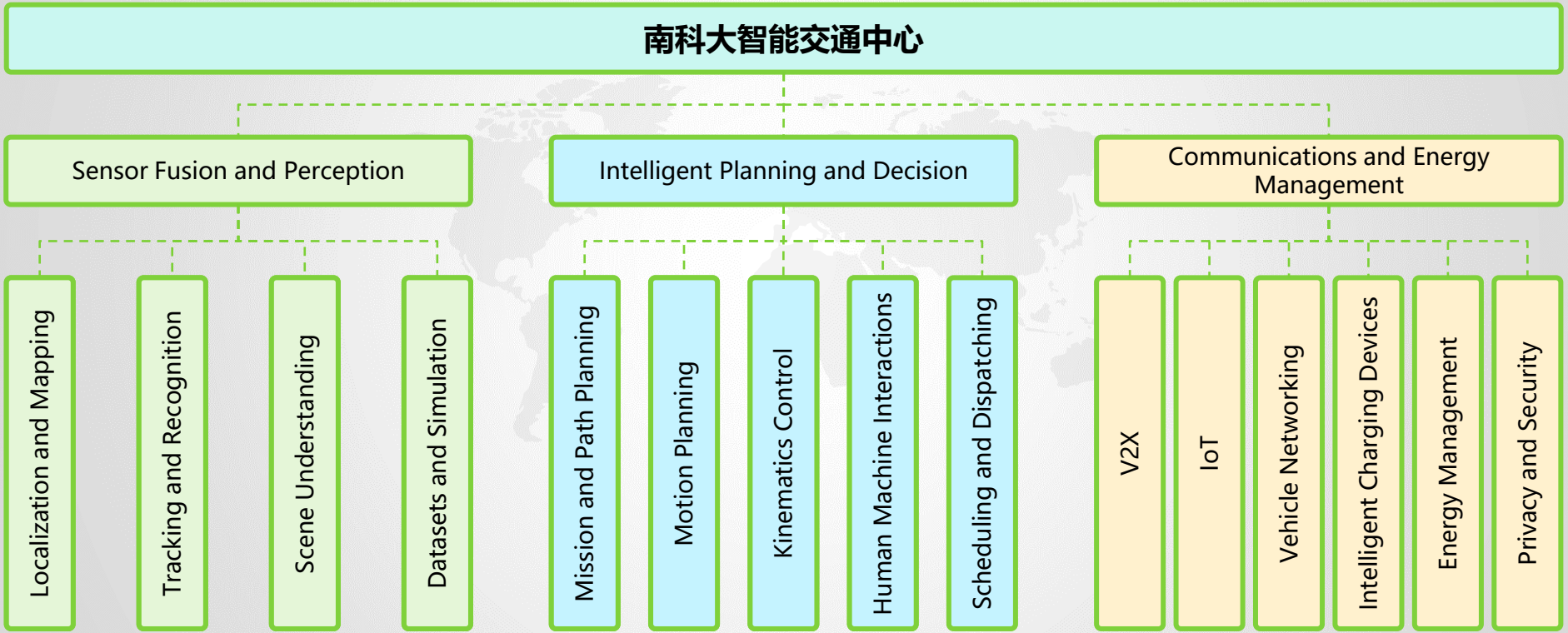
Academic Excellence

- World Class quality
- Multidisciplinary research

Entrepreneur Univ.

- Technological development
- Redefining modern technology

研究目标


南科大智能交通中心
Sensor Fusion and Perception
Intelligent Planning and Decision
Communications and Energy Management
Localization and Mapping
Tracking and Recognition
Scene Understanding
Datasets and Simulation
Mission and Path Planning
Motion Planning
Kinematics Control
Human Machine Interactions
Scheduling and Dispatching
V2X
IoT
Vehicle Networking
Intelligent Charging Devices
Energy Management
Privacy and Security

研究方向

自主系统:

- 智能感知
- 机器学习
- 决策与规划

Robots

Sensor Networks

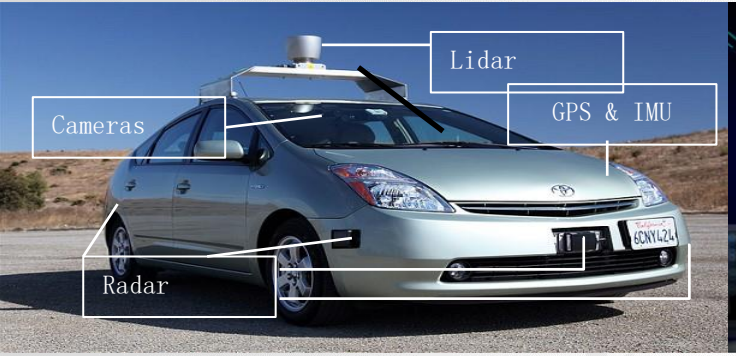
Targets & environment

Airships

Smart Space

VR & AR

人工智能发展



阶段 1：感知智能
从自身与环境采集重要信息

阶段 2：计算智能
将数据转换为知识模型

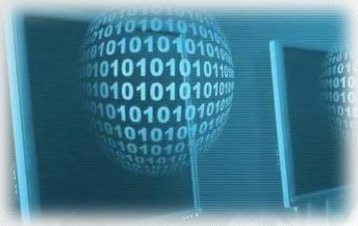
阶段 3：认知智能
运用知识推理、规划与决策

- ✓ 数据：采集、挖掘 与学习
- ✓ 知识：描述与抽象、推理与决策
- ✓ 共融：智能人机交互

数据与人工智能

1 传感阵列

- 主动/被动
- 视觉/听觉
- 毫米波/激光雷达
- 器件选型
- 阵列位置
- 连接安装
- 同步测量
- 校准标定



2 数据采集

- 复杂度/多样性
- 异常事件
- 反常事件
- 复杂场景
- 极端天气
- 信息增益
- 数据采样
- 智能/随机采样

3 数据存储

- 数据压缩
- 数据冗余
- 数据分布
- 数据安全
- 数据隐私
- 标注/格式
- 云/雾服务
- 边缘计算

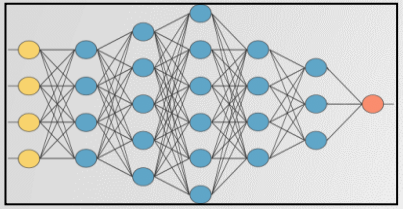
4 模型更新

- 参数优化
- 特征/模型融合
- 主动学习
- 半/弱监督学习
- 非监督学习
- 增强学习
- 高精建图

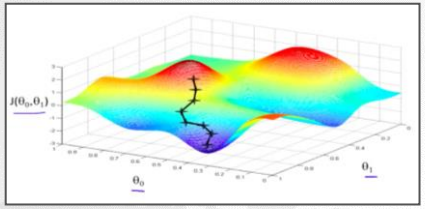
5 模型应用

- 高精定位/里程计
- 实例/语义分割
- 目标检测与识别
- 目标追踪与管理
- 场景理解与预测
- 运动规划与避障
- 数据与算法评估
- 资源调度与分配
- 车辆遣调

机器学习发展



模型拓扑

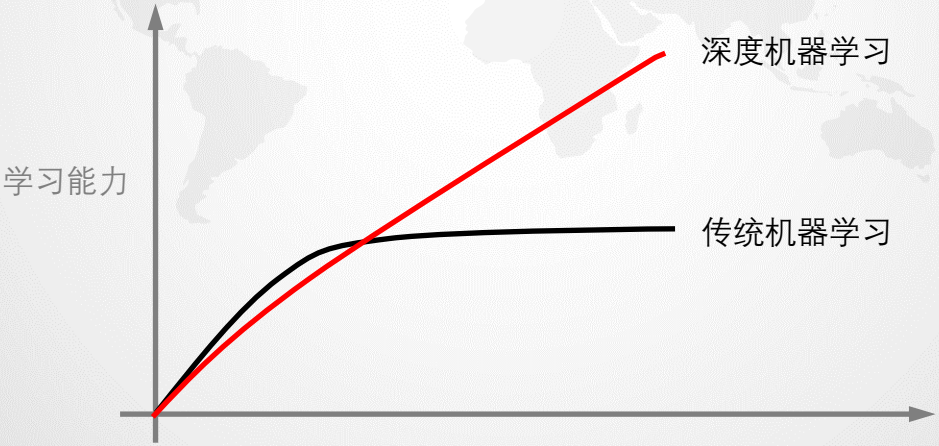


优化算法

模型数据

计算资源

- **CNN**
- **RNN**
- **LSTM**
- **Auto Encoder**
- **GAN**
- **DRL**



- **GPU & TPU**
- **Cloud Computing**
- **Data Visualization**
- **Elastic GPU Service**
- **TensorFlow**
- **Caffe**

人工智能与无人系统发展趋势

人工智能

无人系统

2020 2021 2024 2025 2026 2030 2031 2035 2040 2050 2060

5G AI IC AI Net AI IoT

达到高于人类水平的翻译能力

达到高中生水平的写作能力

代替人类服务金融零售行业

具有自主实施手术的能力

达到正常人水平的写作能力

无人机市场价值达到1270亿美元

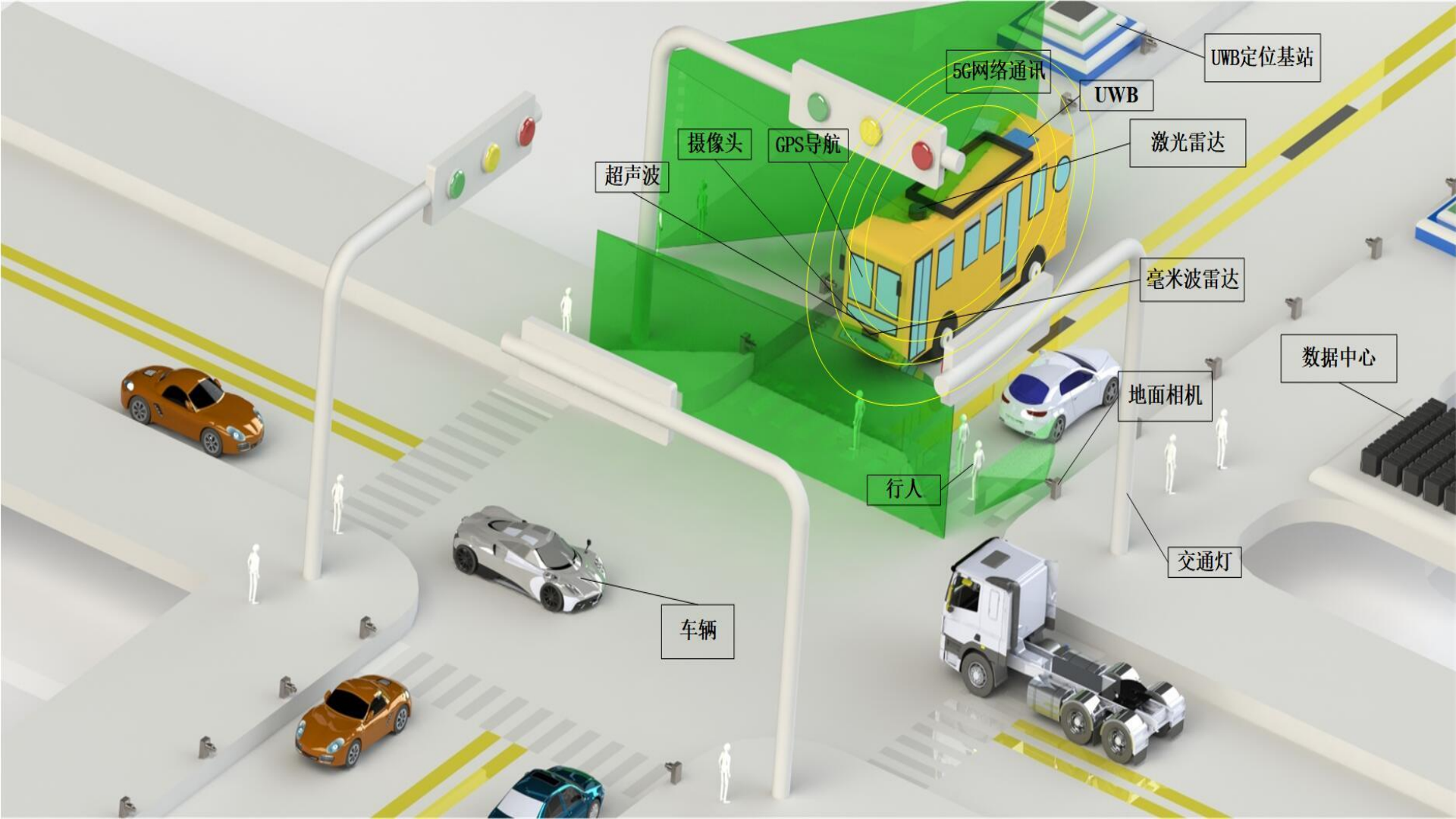
实现4级公交自动驾驶

私人5级自动驾驶、自动公交与运输实现

智能网联汽车主导交通运输

无人机群体自主作业

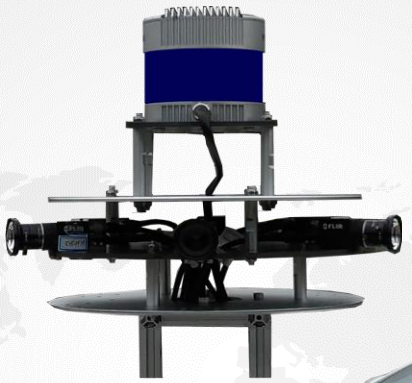
无人机航线开始管理，空中飞行不再自由


UWB定位基站
5G网络通讯
UWB
激光雷达
摄像头
GPS导航
超声波
毫米波雷达
数据中心
地面相机
行人
交通灯
车辆

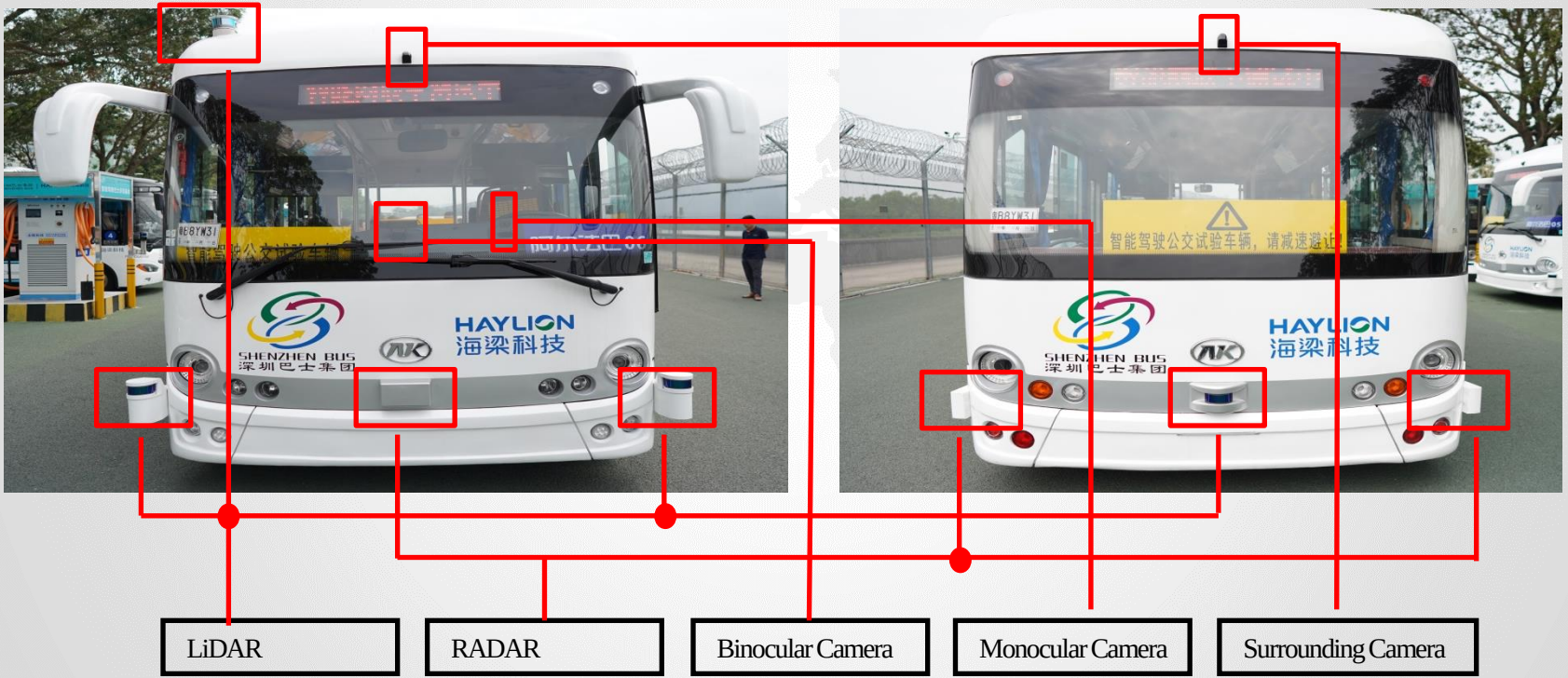
无人驾驶场地车

无人驾驶小汽车

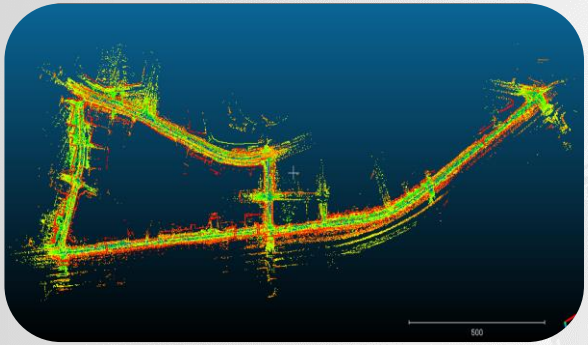
- 1 * LiDAR (64 Chan)
- 6 * camera (360 degrees)
- 6 * IR cameras (360 degrees)
- 5 * Radar
- GPS/IMU
- CAN BUS/Ethernet



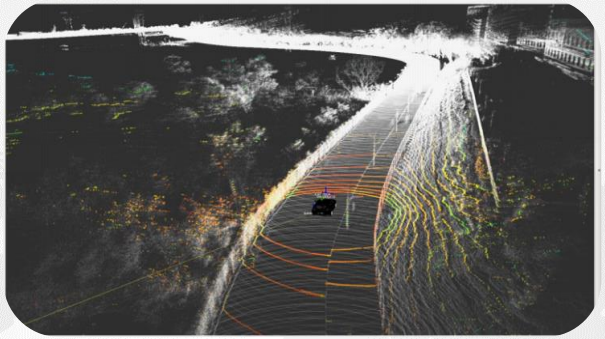
无人驾驶公交巴士


SHENZHEN BUS
深圳巴士集团
HAYLION
海梁科技
智能驾驶公交试验车辆，请减速避让
LiDAR
RADAR
Binocular Camera
Monocular Camera
Surrounding Camera

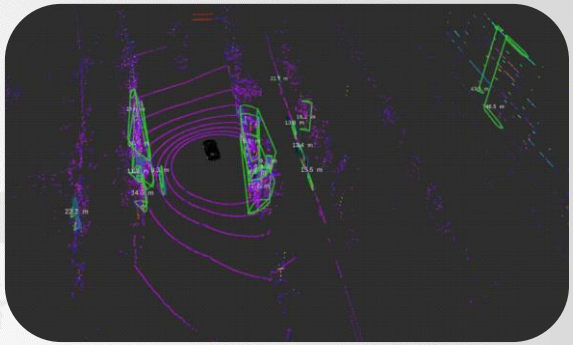
无人驾驶：关键感知模块



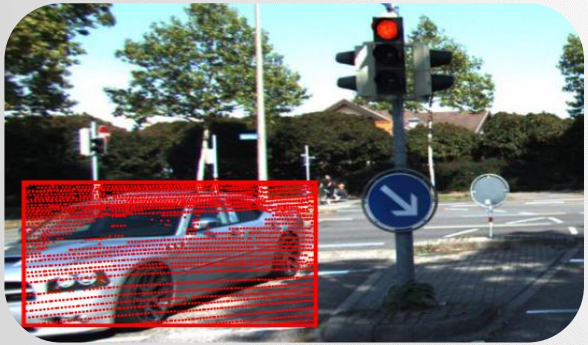
3D地图建图



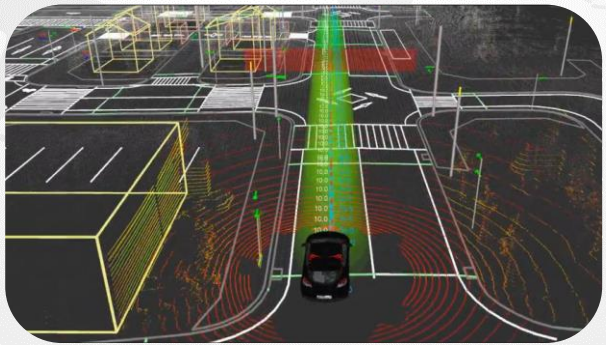
3D地图匹配定位



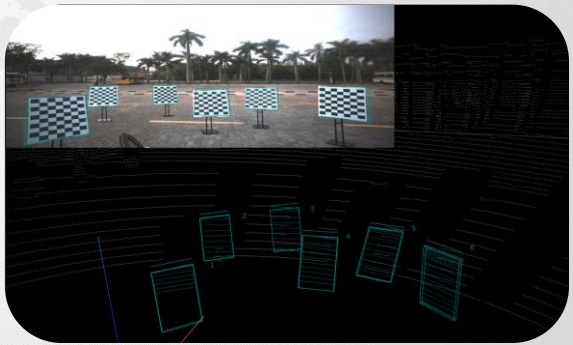
3D物体检测



基于2D-3D融合的目标检测



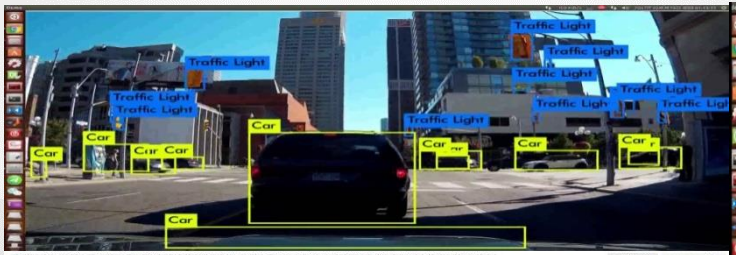
轨迹规划

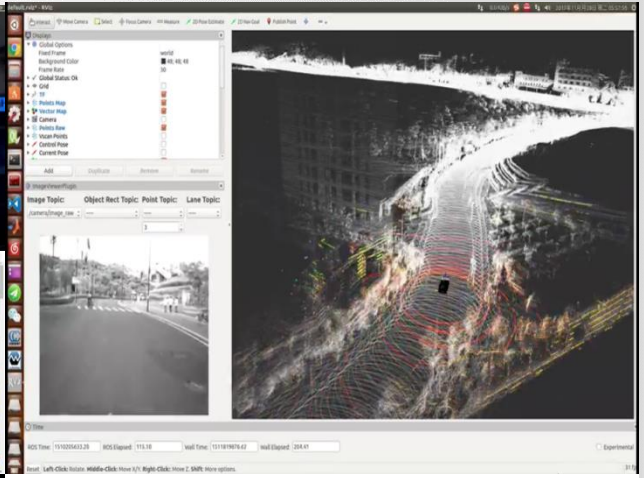


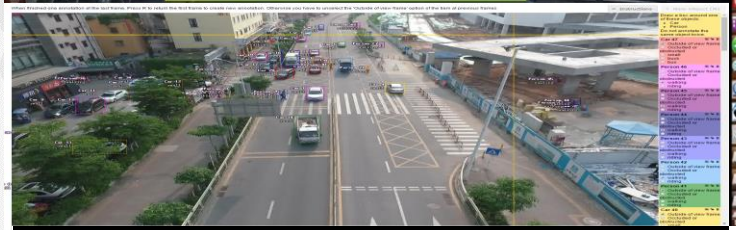
多传感器标定

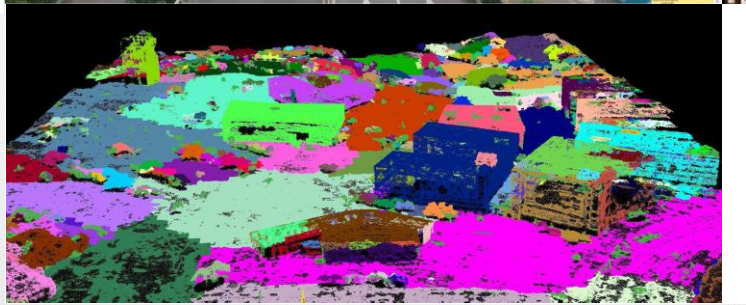
无人驾驶：数据平台

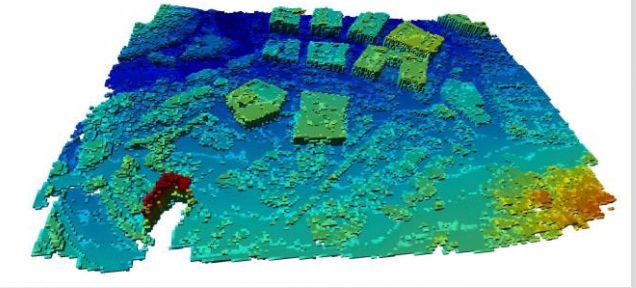
- 智能大数据采样
  - 智能数据筛选
- 智能大数据标注
  - 数据自动标注
- 多传感器数据
  - 传感器种类齐全
- 稀有实例数据生成
  - 真实与仿真数据混合





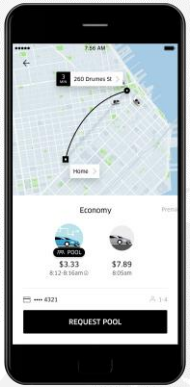


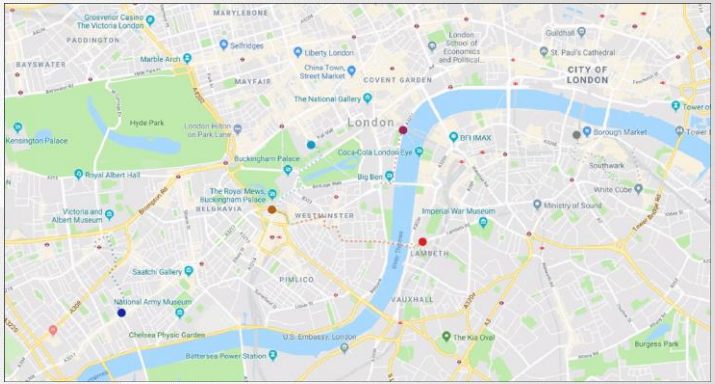




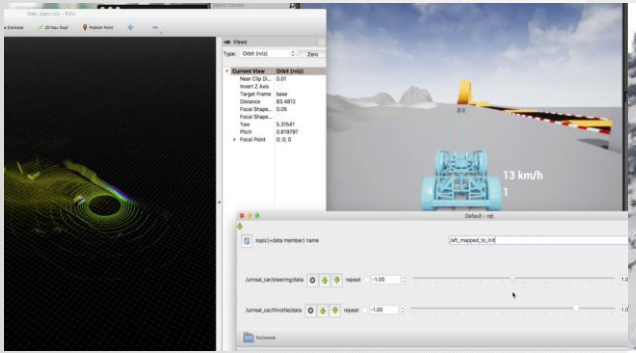
无人驾驶：仿真平台

- 软硬件在环仿真环境
  - 算法与硬件配合
- 高保真传感器物理引擎
  - 模拟真实传感器性能
- 虚拟与真实数据混合模型
  - 丰富多样的数据集
- 智能派车服务计算平台
  - 多目标多智能体路径优化



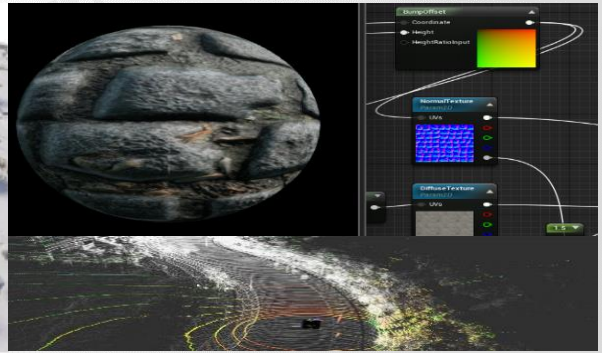


智能派车仿真



软硬件在环仿真

混合仿真地图



传感器物理引擎

无人驾驶：验证平台

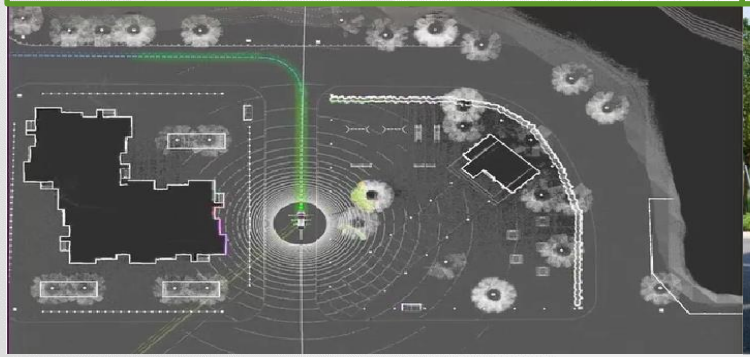
数字仿真

复杂交通场景建模

高逼真度仿真

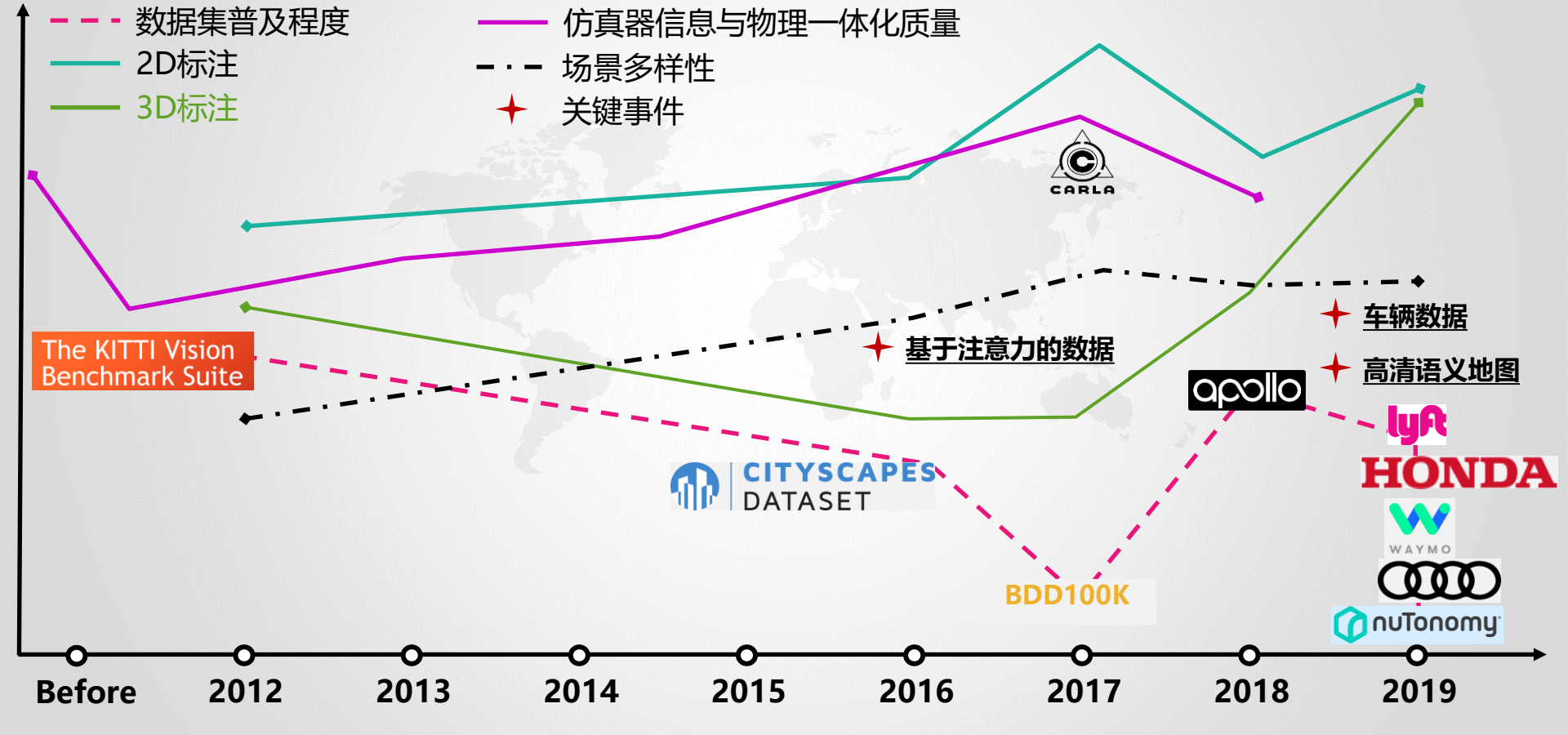
物理验证

自动驾驶软件集成环境



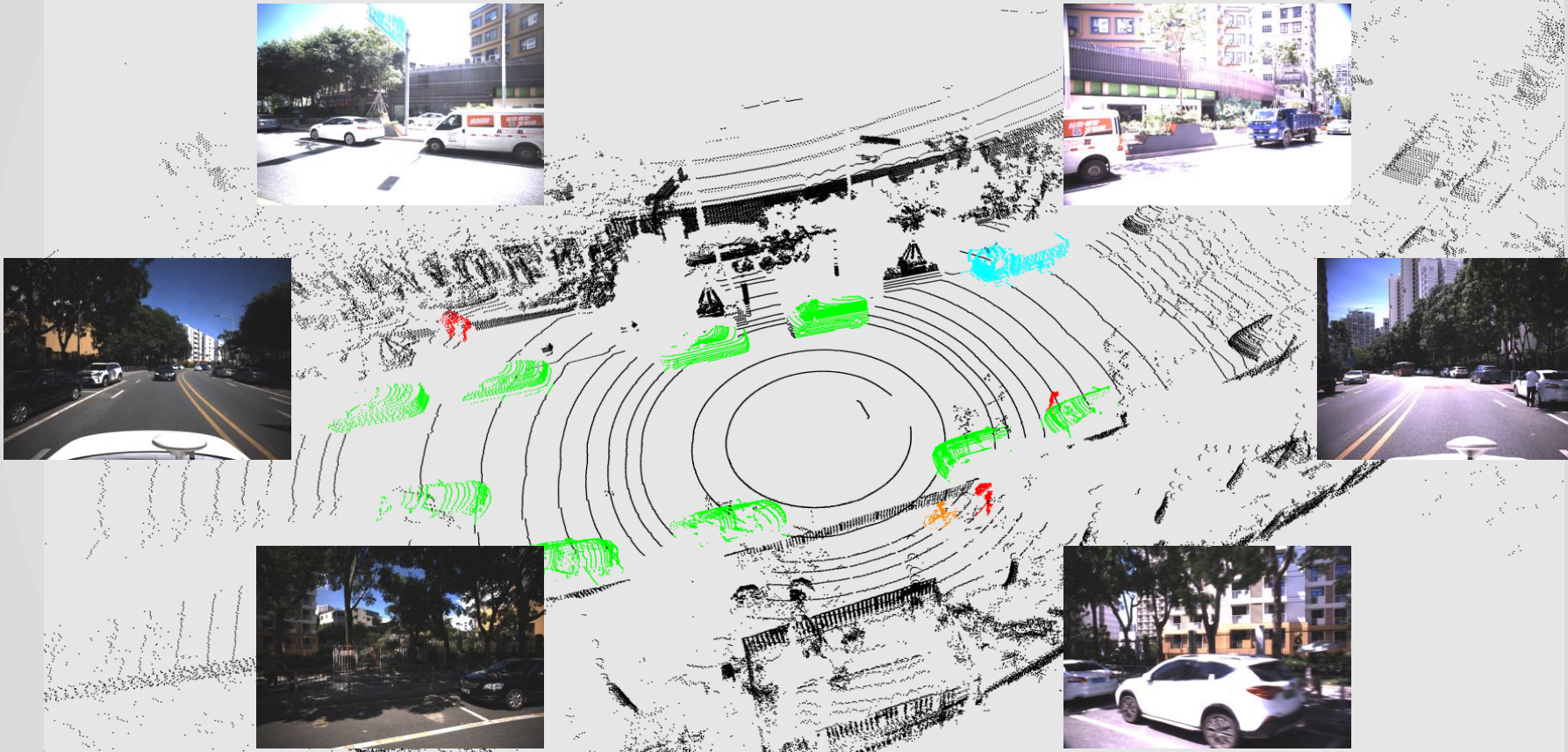
物理测试车辆平台

难点一：无人驾驶数据集

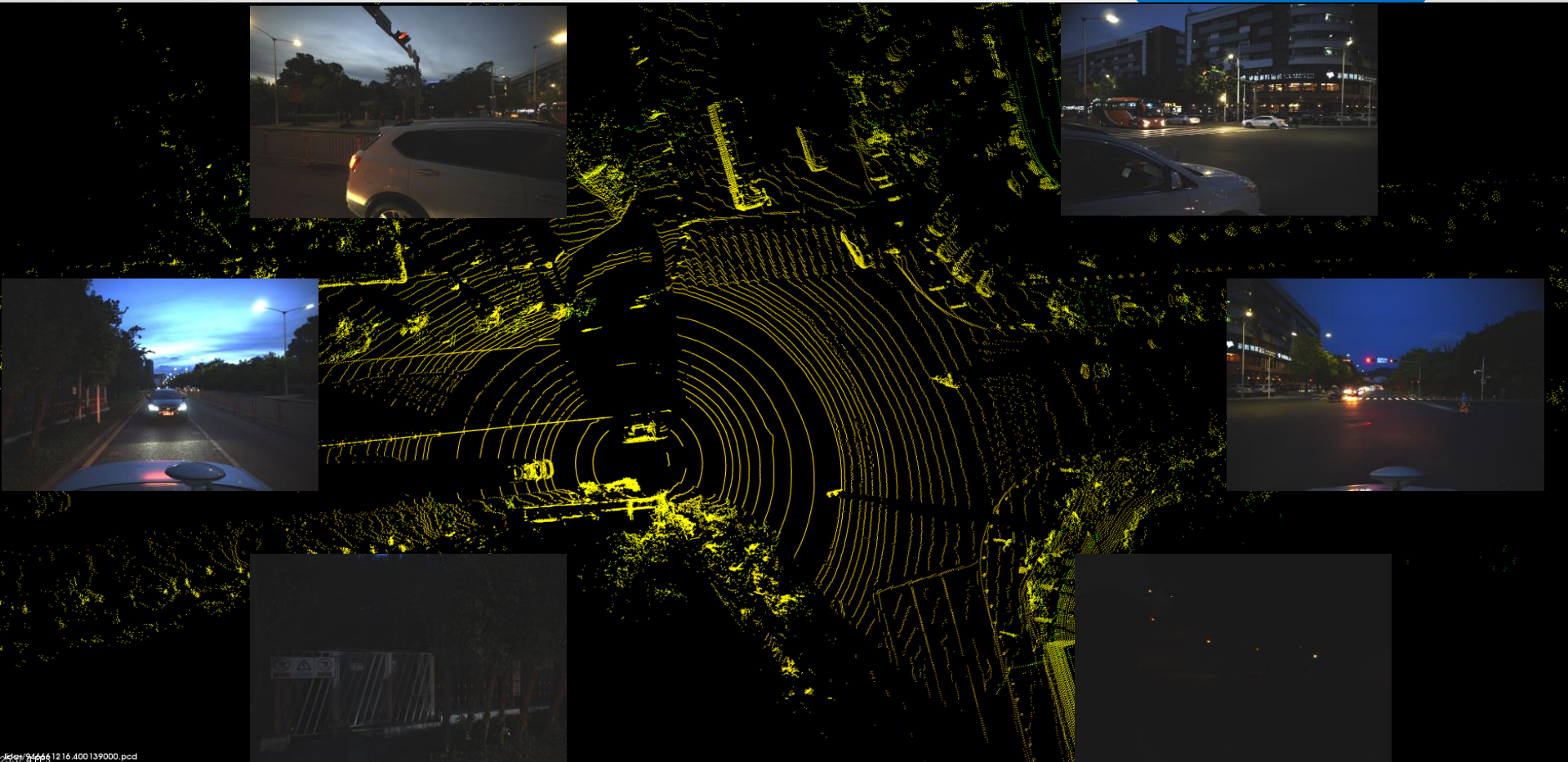

数据集普及程度
2D标注
3D标注
仿真器信息与物理一体化质量
场景多样性
关键事件
CARLA
The KITTI Vision Benchmark Suite
基于注意力的数据
车辆数据
高清语义地图
apollo
lyft
HONDA
CITYSCAPES DATASET
WAYMO
BDD100K
nuTonomy
Before
2012
2013
2014
2015
2016
2017
2018
2019


SUSTech Scape
Open Datasets for Autonomous Public Transportation with Smart Samples and Cyber-Physical Benchmarks
桃花路

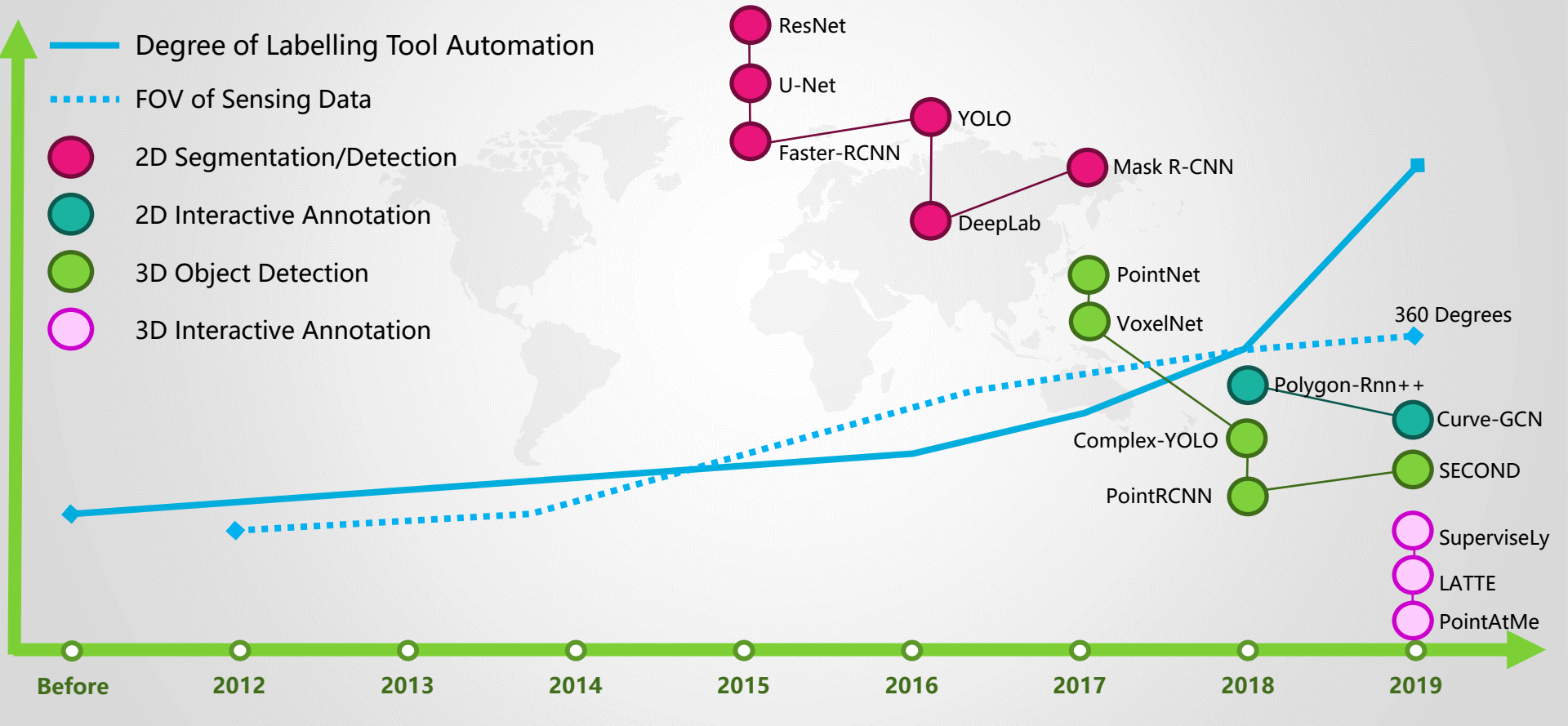
白天相机激光雷达数据



夜晚相机激光雷达数据



难点二：数据集标注工具


Degree of Labelling Tool Automation
FOV of Sensing Data
2D Segmentation/Detection
2D Interactive Annotation
3D Object Detection
3D Interactive Annotation
ResNet
U-Net
Faster-RCNN
YOLO
DeepLab
Mask R-CNN
PointNet
VoxelNet
360 Degrees
Polygon-Rnn++
Curve-GCN
Complex-YOLO
SECOND
PointRCNN
SuperviseLy
LATTE
PointAtMe
Before
2012
2013
2014
2015
2016
2017
2018
2019

SUSTech POINTS

计算机科学与工程系
Department of Computer Science and Engineering

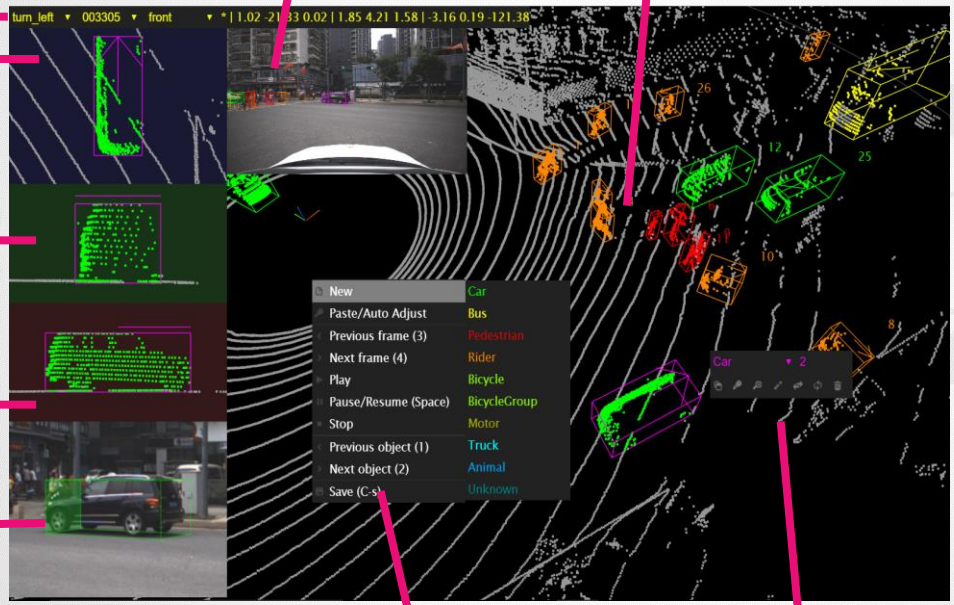
Scene & frame navigation
Box information
Camera selection

Photo context
Freely resizable
Auto-follow target obj.

Colored objects

Projective view
Auto-shrink
Rotation
Resize
Move
Keyboard fine-tune

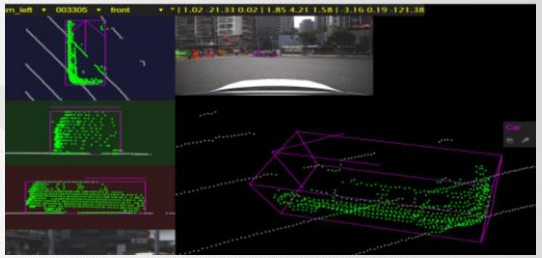
Auto-focused target object



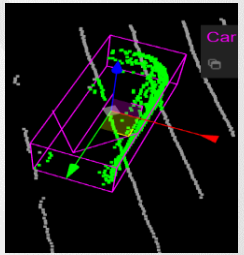
Context menu
Frame/obj. navigation
Stream play/stop
New/paste/save

Floating fast toolbox

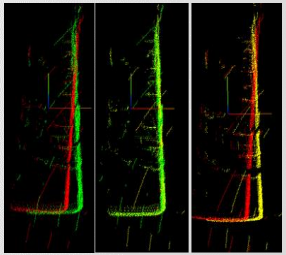
Feature Functionalities



Focus mode to hide the background for checking object details

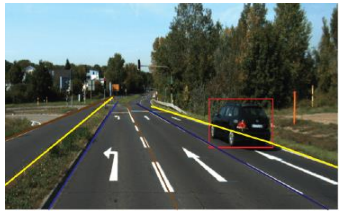


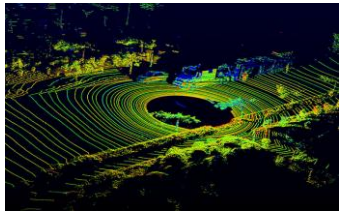
Operation in the perspective view

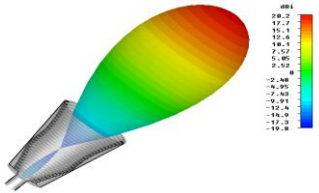


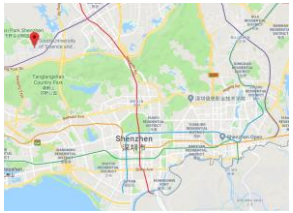
Auto annotation for same/similar objects in one sequence

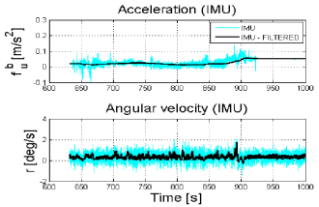
难点三：感知融合









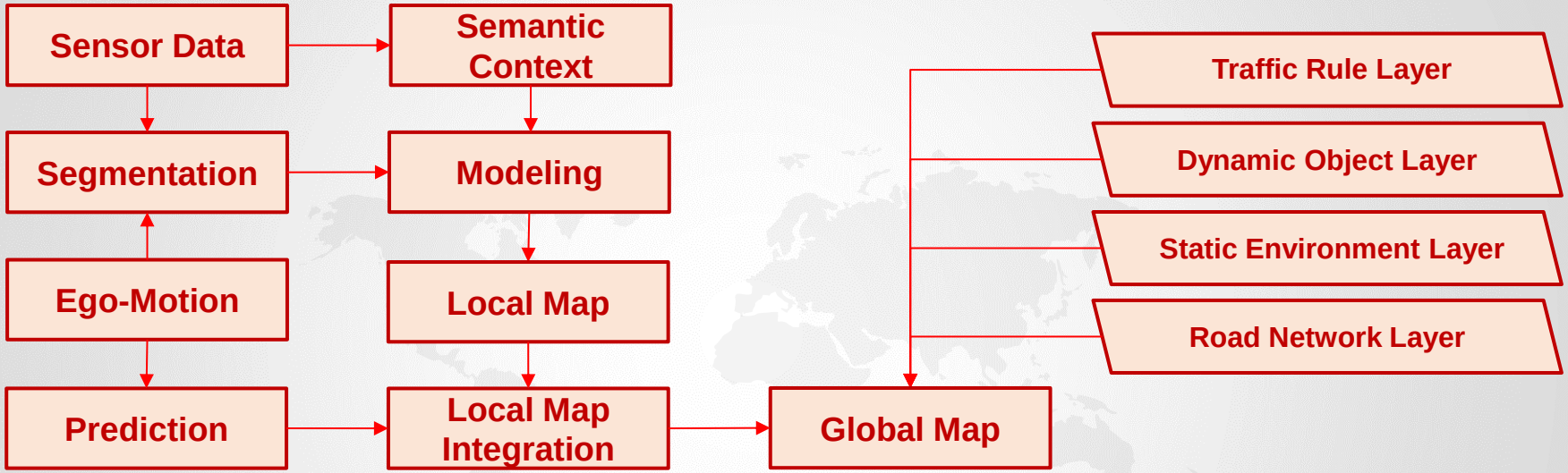


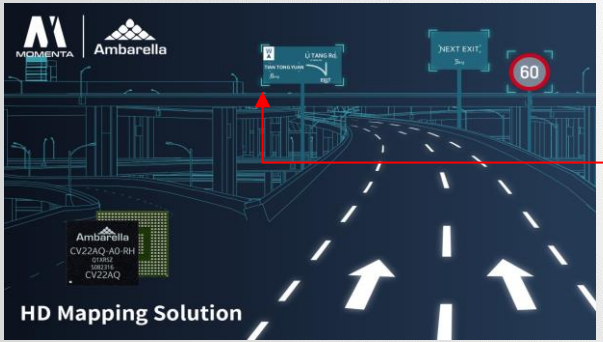
- Selection
- Position
- Calibration
- Synchronization
- Evaluation
- Fusion

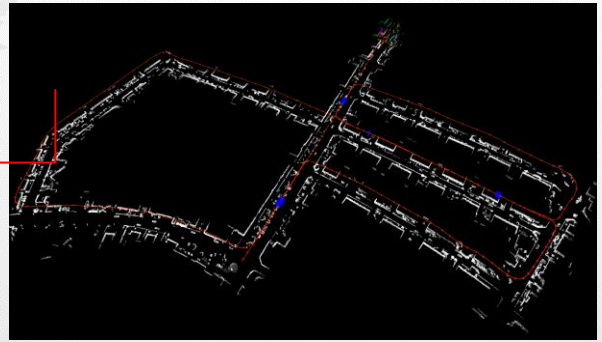
✓ Ego-System ✓ Environment ✓ Mobile Objects ✓ Traffic Signs ✓ Weather

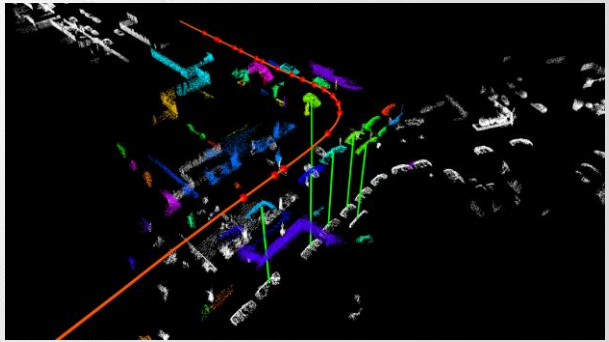
2D/3D感知融合

高清语义地图


Sensor Data
Semantic Context
Segmentation
Modeling
Ego-Motion
Local Map
Prediction
Local Map Integration
Global Map
Traffic Rule Layer
Dynamic Object Layer
Static Environment Layer
Road Network Layer


MOMENTA
Ambarella
60
HD Mapping Solution





动态地图与特征模型

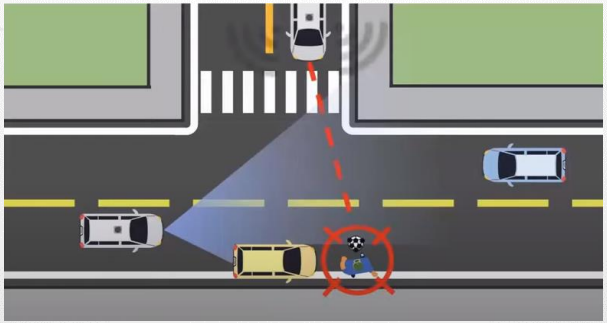
Multi-agent Data

- **Point Clouds**
- **Images**
- **GNSS**
- **Odometry**

Fusion Methods

- Data Fusion
- Feature Fusion
- Model Fusion
- Decision Fusion

- **Dynamic Map Updating**
- **Feature Model Updating**



难点四：一体化开发验证

设计与开发阶段
(基于数据训练测试)

实时与仿真阶段
（基于仿真物理实验验证测试）

验证数据集
负样本
正样本

测试数据集
正样本
负样本

数据集 (正样本)

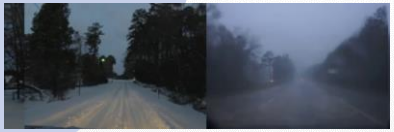
数据多样化平衡化

训练数据集
- 关键场景
- 相关场景
- 极端场景
- 类别分布
- 环境特征

负样本
正样本

数据标注工具

极端样本(正样本)



对抗样本（负样本）

形式化验证需求

可信性可靠性分析

自主驾驶仿真器 CARLA

关键场景测试

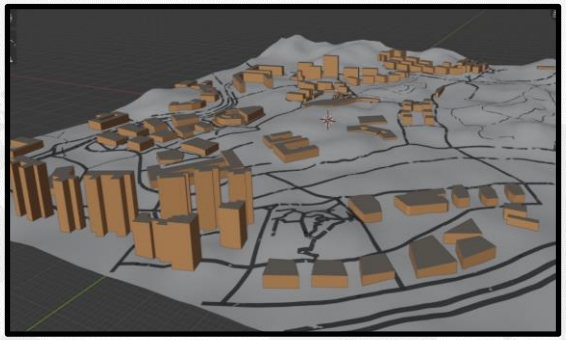
极端场景测试

混合数据合成

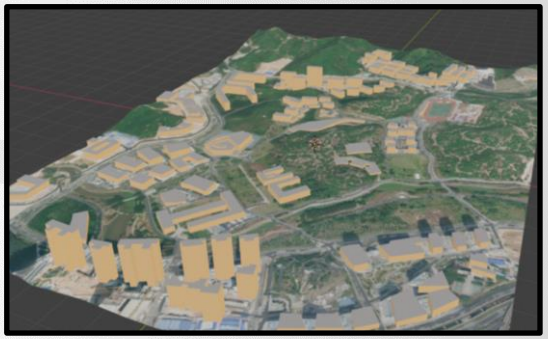
CARLA Simulation

Road Network (i.e. OpenStreetMap)

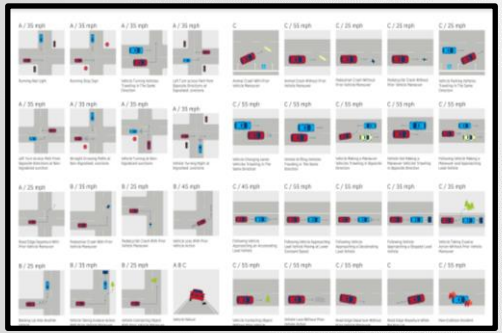
Generate Buildings and Roads 3D Models in Unreal



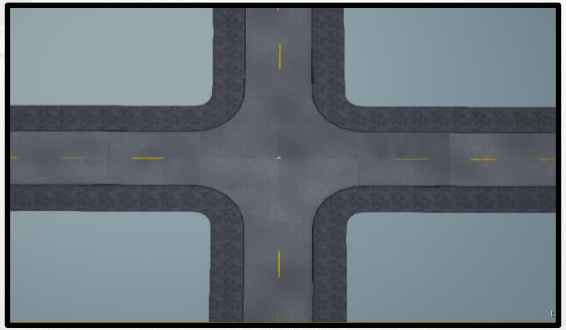
Import 3D Map Models to CARLA



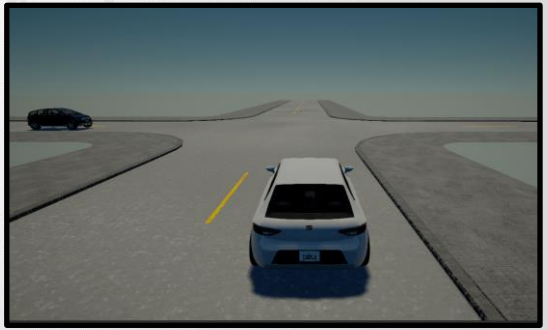
NHTSA 37 Pre-crash Scenarios



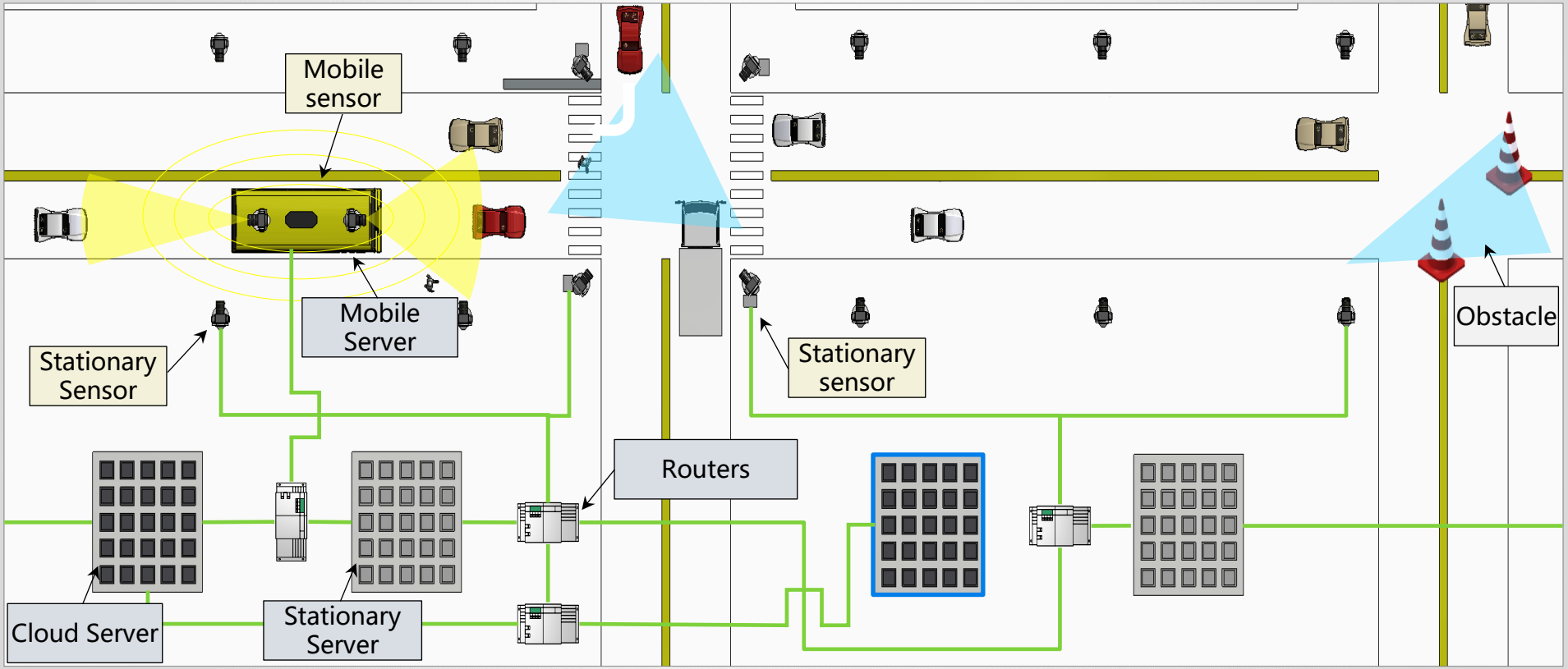
Pre-Build Map in CARLA



Set Different Complexities to Generate Testing Scenarios

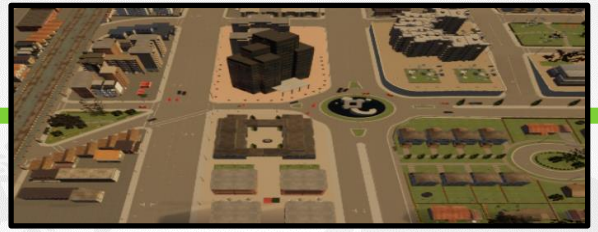


难点五：车路协同仿真


Mobile sensor
Mobile Server
Stationary Sensor
Stationary sensor
Obstacle
Routers
Cloud Server
Stationary Server

场景生成与联邦学习

High-quality Multi-agent Dataset



High-quality Dataset

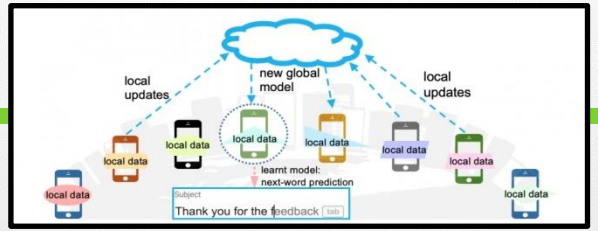
Novelty:
- ✓ Scenario generation
- ✓ Multi-agent sensor data

Distributed Data Association

Distributed Data Association

Novelty:
- ✓ Clustering algorithms
- ✓ Graph neural network

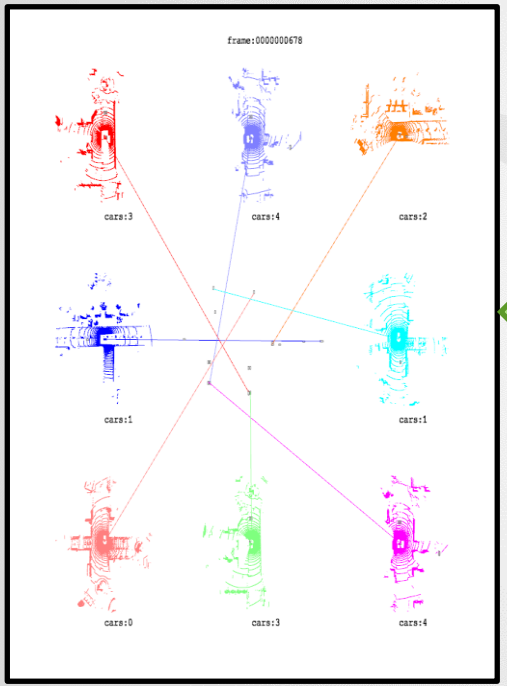
Model and Map Management



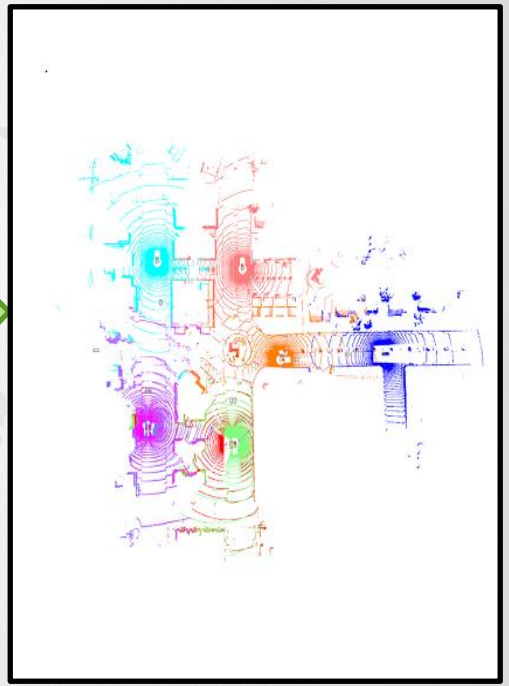
Model and Map Management

Novelty:
- ✓ Federated learning
- ✓ Knowledge distillation

分布式动态地图融合


frame:0000000678
cars:3
cars:4
cars:2
cars:1
cars:1
cars:0
cars:3
cars:4


云与边缘服务器
信息广播
信息发布
本地动态地图
物体融合
全局动态地图
感知融合
滤波估计
模型
传感数据
地图标注
联邦学习



难点七：实践验证平台

✓ 2 buses from Shenzhen Bus Group are used for data collection.

✓ 2 taxis from Shenzhen Bus Group are used for data collection.

✓ 6 buses from Haylion are used in Shenzhen Free Trade Zones.

✓ 1 car and 1 bus are used on SUSTech campus.

无人驾驶综合测试场地

难点八：人机交互

感谢聆听！


南方科技大学
SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY
3号门 GATE 3