

Continuous Safe Learning Based on First Principles and Constraints for Autonomous Driving

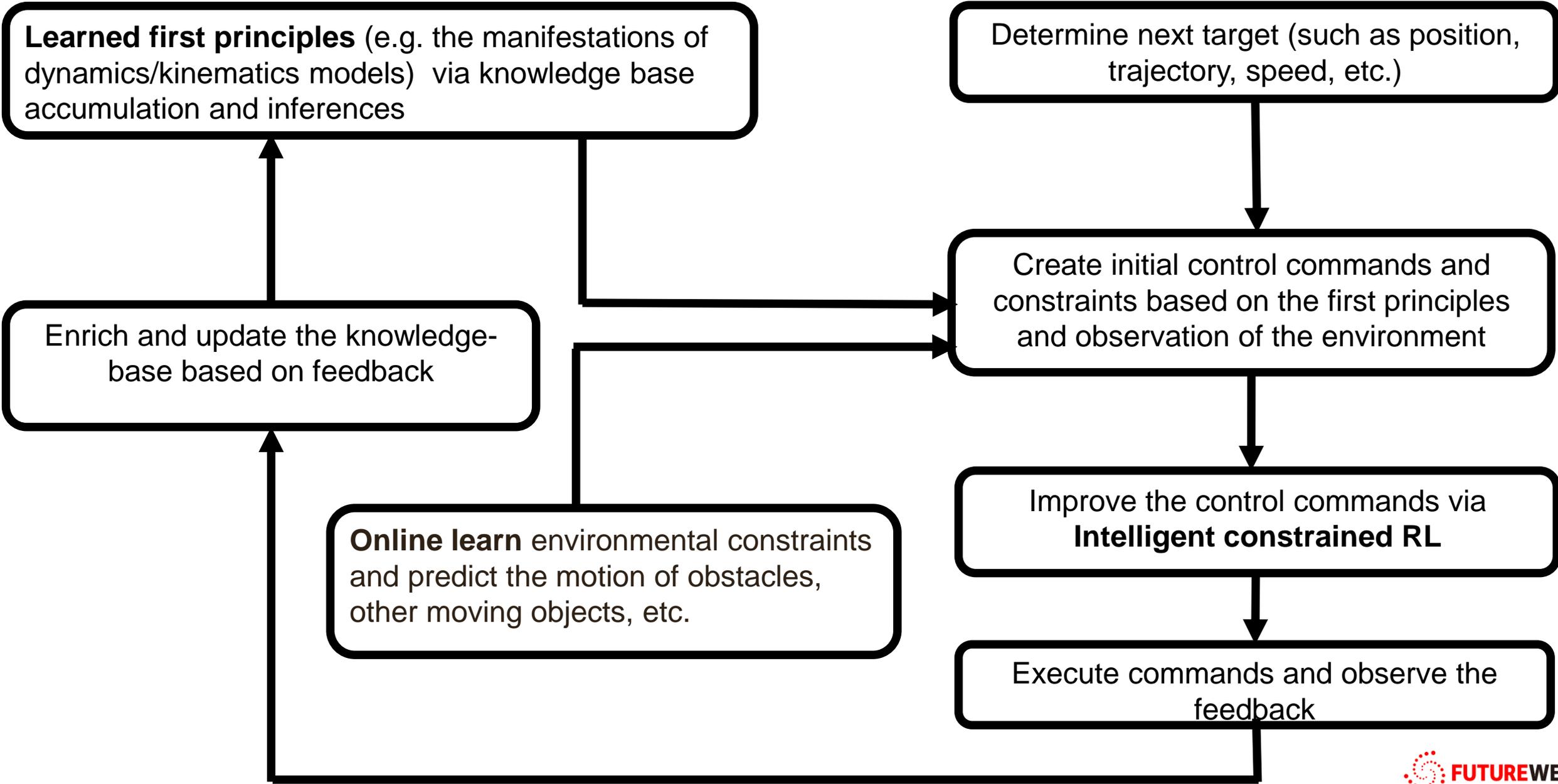
Lifeng Liu, Yingxuan Zhu, Tim Tingqiu Yuan, Jian Li

lifeng.liu@futurewei.com, yingxuan.zhu@futurewei.com,
ytq@huawei.com, jian.li@futurewei.com

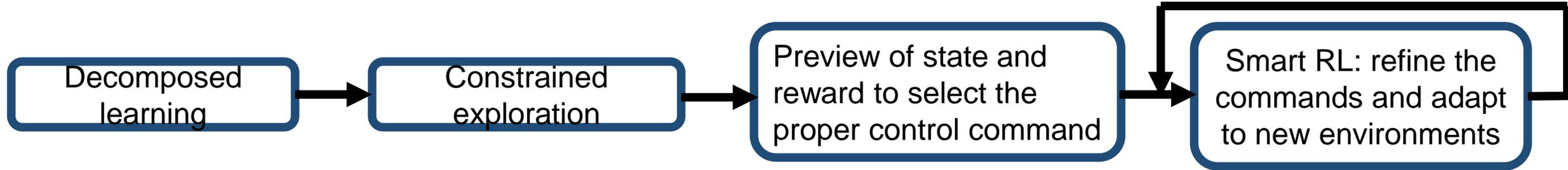
Challenges

- The “trial and error” reinforcement learning methods take a long time (a few days to several months) to learn, and have difficulties of transferring from simulation environments to real world. [*DDPG*, Lillicrap and et al. 2016]
- It is not acceptable for continuous learning errors/accidents in a real environment (such as autonomous driving). [*Automotive Safety Integrity Level (SAIL)*]
- Driving control based on accurate physical model requires time-consuming and laborious system control parameters’ calibration.
- End to end deep learning has interpretability and generalization issues [*Does computer vision matter for action*, Zhou and et al. 2019]
- Learning from the operator/human requires the use of computationally expensive anti-reinforcing learning. In addition, people may not be able to provide the best strategy for certain tasks. [*Imitation from observation*, Liu and et al. 2018]

System Overview

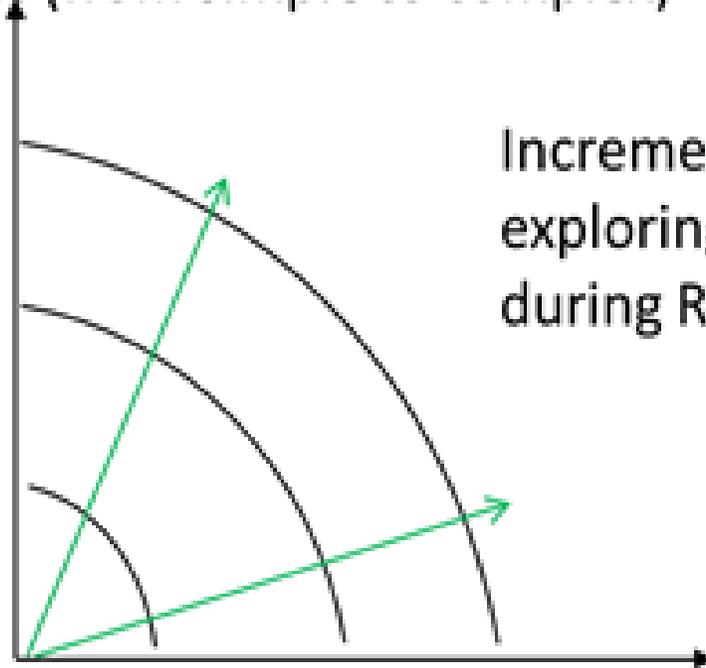


Intelligent Constrained RL



Learning and knowledge accumulation: Learn basic tasks first before learning combination tasks;

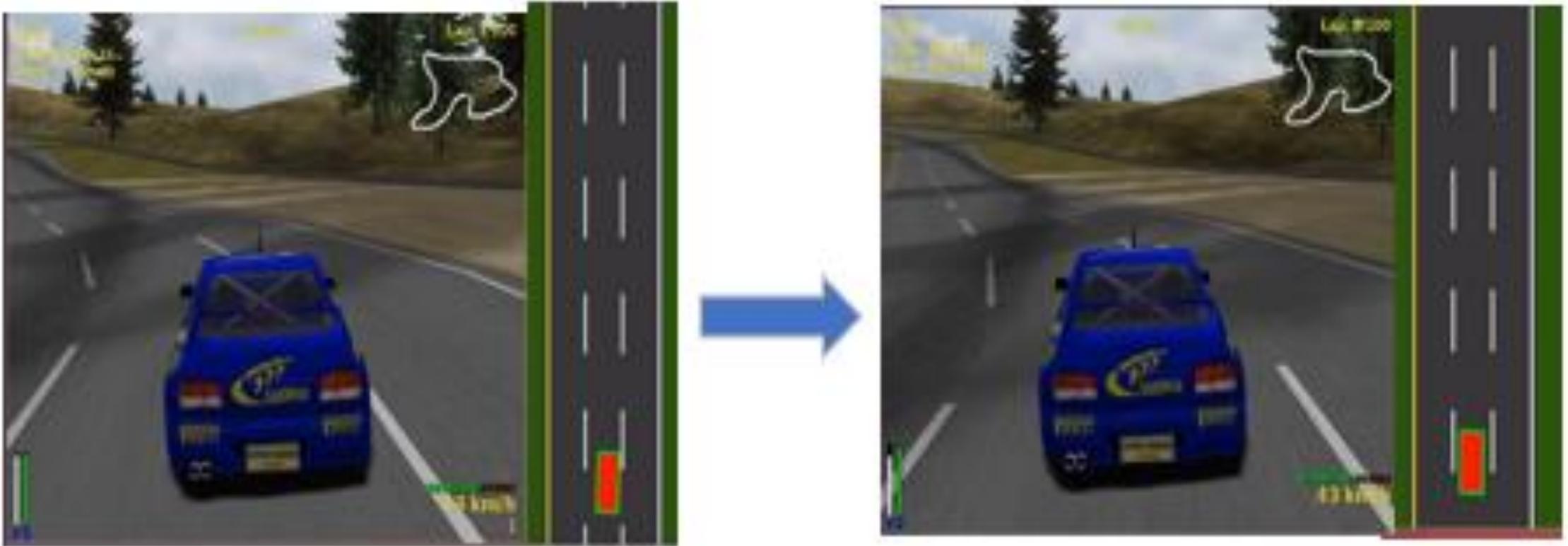
States (from simple to complex)



Incremental learning in exploring the space during RL

Actions (from small to big)

Experiments



Learning following lane in TORCS simulation environment. Left: Before the learning; Right: After the learning (less than an hour of leaning, speed 70km/h).

FILE EDIT CONFIGURATION VIEW WINDOW TOOLS SIMULATION HELP

TERRAIN VEHICLE SCENARIO SIMULATION ANALYSIS

CENARIOS BP_0115 (30)

X= 44.963, Y=-130.544, Z= -5.978 | lat=31.262161, long=121.621242

Parameters

- Simulation
- Recording
- Environment
- Ground (manka_demo_full_ele...
- User data

Scripts

- Main

Traffic Tools

Filters

Vehicles

- [0] BMW_53_Alpine_White
- [1] Citroen_C4_Oriental_Blue
- [2] Citroen_C3_Light_Grey
- [3] Citroen_C6
- [4] Citroen_C2
- [5] Citroen_C4_2010_Grey
- [6] Citroen_C2
- [7] Citroen_C3_Green

WEATHER

17:00

0

0

50000

0

0

LAYERS

- Debug Informations
- Trajectory
- Swarm
- Itinerary
- Vehicles
- Traffic Tools
- Road Objects
- Road Logical Content
- Road Axis
- Intersection Logical Con
- Background Terrain
- Rolling Surface
- Grid

RESOURCES **LAYERS**

DASHBOARD

Vehicle

pine_White

X: 31.056 m

Y: -88.283 m

Z: -5.948 m

Speed 5.550 km/h

Simulation Time

00:00:37.778

DASHBOARD **VIDEORECORD**

User data path : C:\OKTAL\SCANEstudio_1.6\data\ADAS_MUSE | Config path : C:\OKTAL\SCANEstudio_1.6/config\ADAS_MUSE

cameramodelsADAS

录制工具
KK 录像机



Following lane in real road: transfer the learned knowledge base from the simulation environment to the real car, and achieved fast transfer learning (smooth driving in its first try, speed of 45km/h).

Summary

We proposed an efficient, continuous, and safe first principles-based constrained self-learning to solve the following challenges in autonomous driving:

- Shorten the learning time;
- Learn online safely;
- Avoid complete system control parameters' calibration;
- Use transfer learning to deal with unlearned or unseen scenarios .