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L3Pilot Driving Automation

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A methodological framework from data collection to impact assessment of autonomous vehicles

Introduction

- Autonomous vehicles will change future transportation systems and mobility patterns
- Penetration rate depends on:
  - Impact on traffic, user oriented and environmental aspects
  - Levels of public acceptance

Scope of Work

- Methodological Framework for:
  - Modelling acceptance
  - Impact assessment of AVs

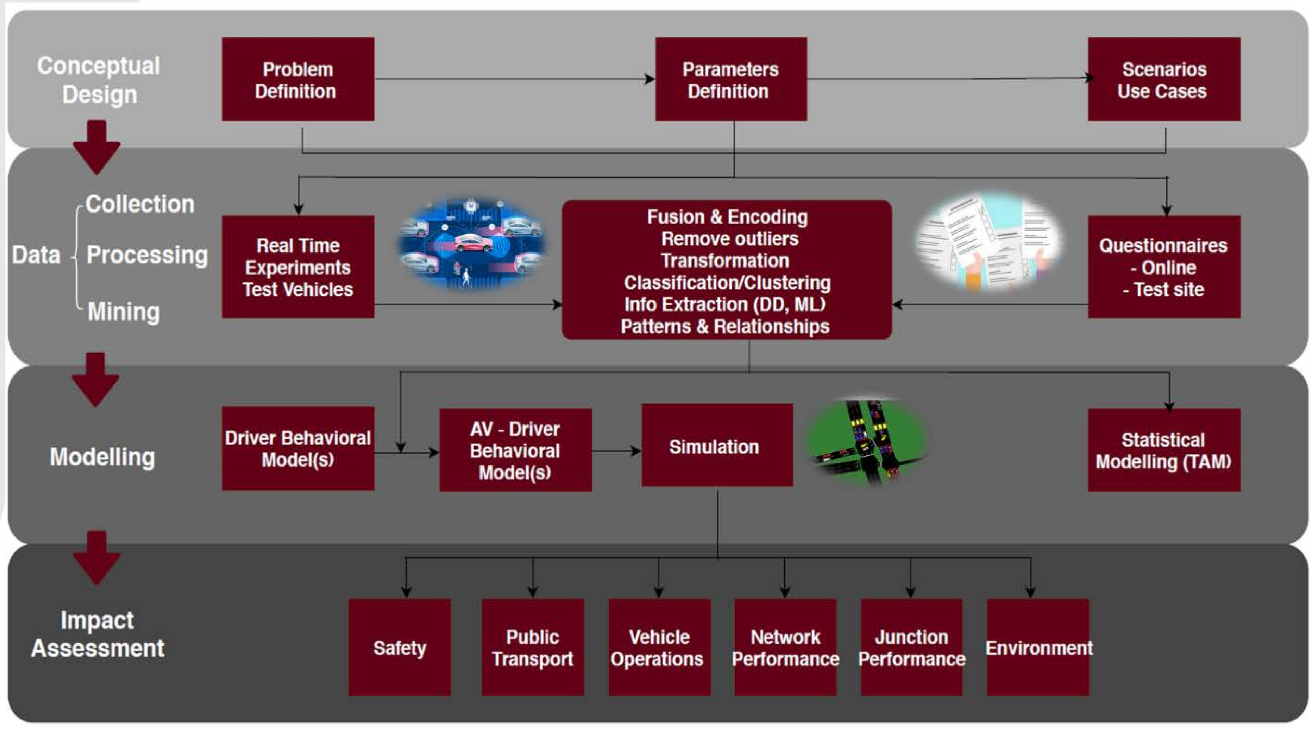
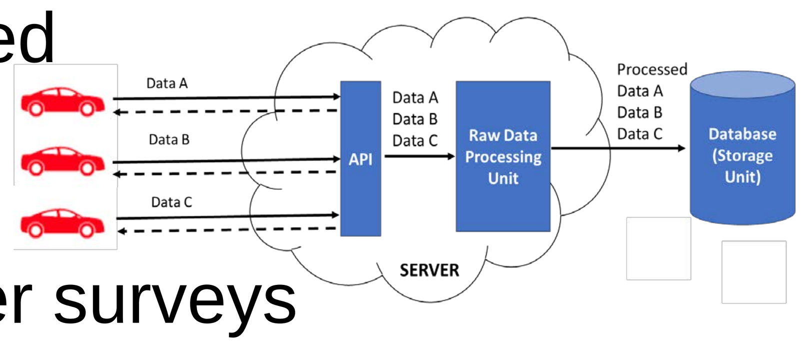


Fig. 1. Flow Diagram of the methodological framework

Data Collection

- Real world data collected from test vehicles



- Data collected from user surveys

Modelling

A. Statistical Modelling

- Confirmatory Factor Analysis (CFA)
- Technology Acceptance Models (Multinomial Logit, Machine/Deep Learning)

B. Behavioral Models

Driver Behavioral Model	*Main Indicative Model Parameters*
Adaptive Cruise Control (ACC)	max . Accel/decel, desired time gap, speed
Cooperative Adaptive Cruise Control (CACC)	max . Accel/decel, desired time gap, speed
Intelligent Driver Model (IDM)	desired speed/decel/time gap, jam distance, max. accel
MICroscopic Model for Simulation of Intelligent Cruise (MIXIC)	Accel., decel., speed, distance
Krauss Car Following Model	accel., decel., sigma, vehicle length, max speed, min Gap
Wiedemann 99 Car Following Model	Accel, decel. Speed, time gap
Cellular Automata	Max. speed, accel, decel., time headway
Gipps's Car Following Model	Speed, max accel, severe braking, reaction time, wished speed
Gipps' s Lane changing model	gap acceptance, distance zones, speed, max/min gap
Bilateral multi-anticipation model	IDM+ distance, relative speed, trust, proximity rules
Multi - agent cooparative traffic model	Physical Layer--> communication layer--> trust

C. Traffic Simulation

Simulation Approach
- Microscopic
- Macroscopic
- Agent -Based

Traffic Simulation Model
- Road network
- Traffic Data
- Demand Data
- Integration of the AV behavioral model

Simulation Development
- Scenarios
- Model | Verification / Calibration / Verification
- Sensitivity Analysis
- Simulation Run

Impact Assessment

KPIs for Safety	Stability of lateral and longitudinal position - (X, Y, Z)	Punctuality	Total time spent travelling (min, h)	Congestion phenomena, traffic oscillations (reduction of stop - and-go phenomena)
Crash probability	Accident Occurrence	Passenger waiting time (min)	Route choice	Changes in Macroscopic Fundamental Diagrams (MFDs)
Extreme maneuvers (harsh braking, max acceleration/deceleration)	AV reaction time and response to incidents and rear crash situations (s)	**KPIs for Vehicle Performance**	**KPIs for Traffic/Network Performance**	LOS
Brake intensity (m/s^2)	Clearance time of the queue (s,min)	Number of emergency decelerations per 1000km,	Traffic flow homogenization	**KPIs for Junction Performance**
Traffic violations (very low values of headway) -(m)	**KPIs for Public Transport Performance**	Mean and minimum time-headway to the preceding vehicle in front in car following situations (s)	Harmonic average speed (km/h)	Average delay (min, s)
Traffic violations (speeding) - (km/h)	Travel speed (km/h)	Minimum accepted gap at intersections or in lane changes (m)	Average delay (min, s)	Through traffic (veh)
TTC (s)	Travel time (min)	Mean and minimum distance (m) to the preceding vehicle (headway 5 s or less)	Number of stops	**KPIs for Environment**
PET (s)	Cost -per-vehicle kilometer	**KPIs for Personal Mobility and Travel Behavior**	Maximum road capacity (veh/h)	Tailpipe emissions (CO, NOx, CO2) (kg)
Range of acceleration/deceleration (m/s^2)	Delays (min)	Perception of travel time	Capacity at design speed (veh/h)	Energy consumption (kWh)
Crash occurrence/crash avoidance	LOS	Mode share/Mode choice	Average travel time on specific segments or routes (min)	Fuel consumption (mpg)
Number of lane changes	Dwell time (s)	Total distance travelled (km)	Speed profiles	Other GHG emissions (kg)
Number of crashes	Vehicle occupancy rates			

Conclusion

- Various dependencies between service goals and specifications
- Complexity of autonomous service influences all steps, chosen techniques and modeling needs
- Holistic approach is necessary
- Different AV behavioral models may need to be developed

Acknowledgements

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