Driving the Future: AI in Mobility Ecosystem

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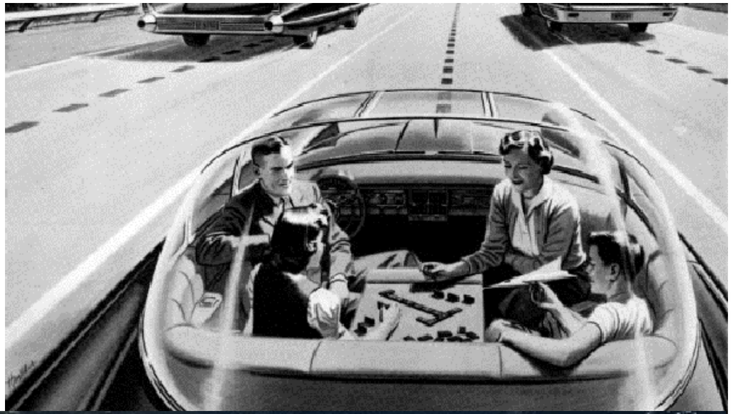
From Manual to Autonomous Driving

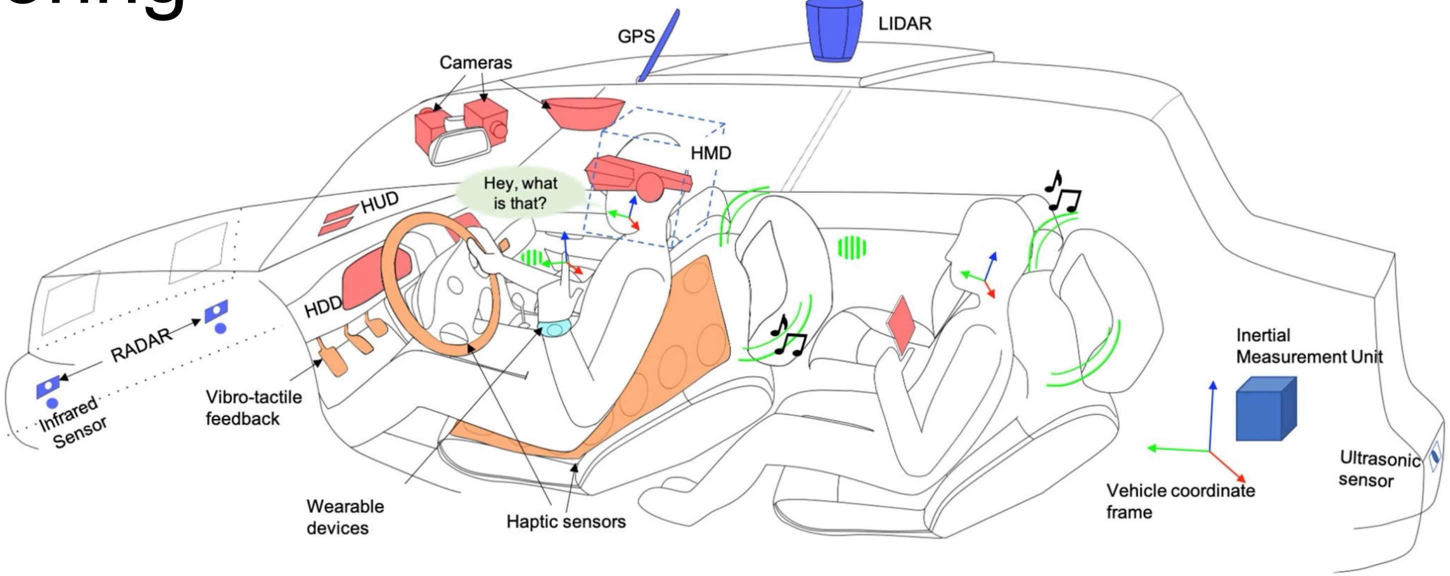
- More time for in-car entertainment
- Ownership of AVs may change
- Higher margins for driving services
- More safety & fuel efficiency



Design by Han Cheng, Li Auto

AI for Vehicles

- Driver/Passenger Monitoring
- Trust in Automation
- Scene Perception
- Ethical Considerations

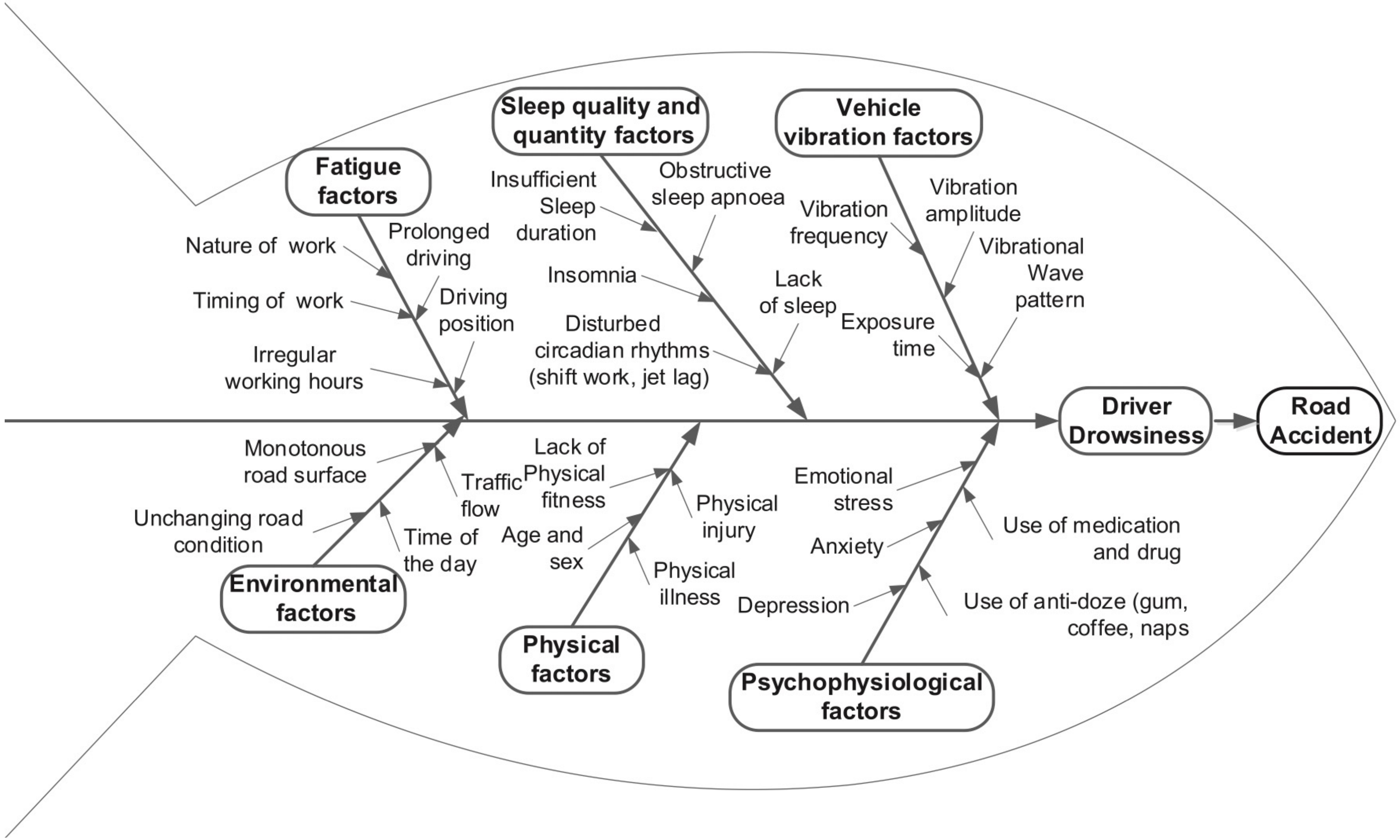


 Murali, P.K., Kaboli, M. and Dahiya, R. (2022), Intelligent In-Vehicle Interaction Technologies. Adv. Intell. Syst., 4: 2100122.

Challenge of Driver Monitoring

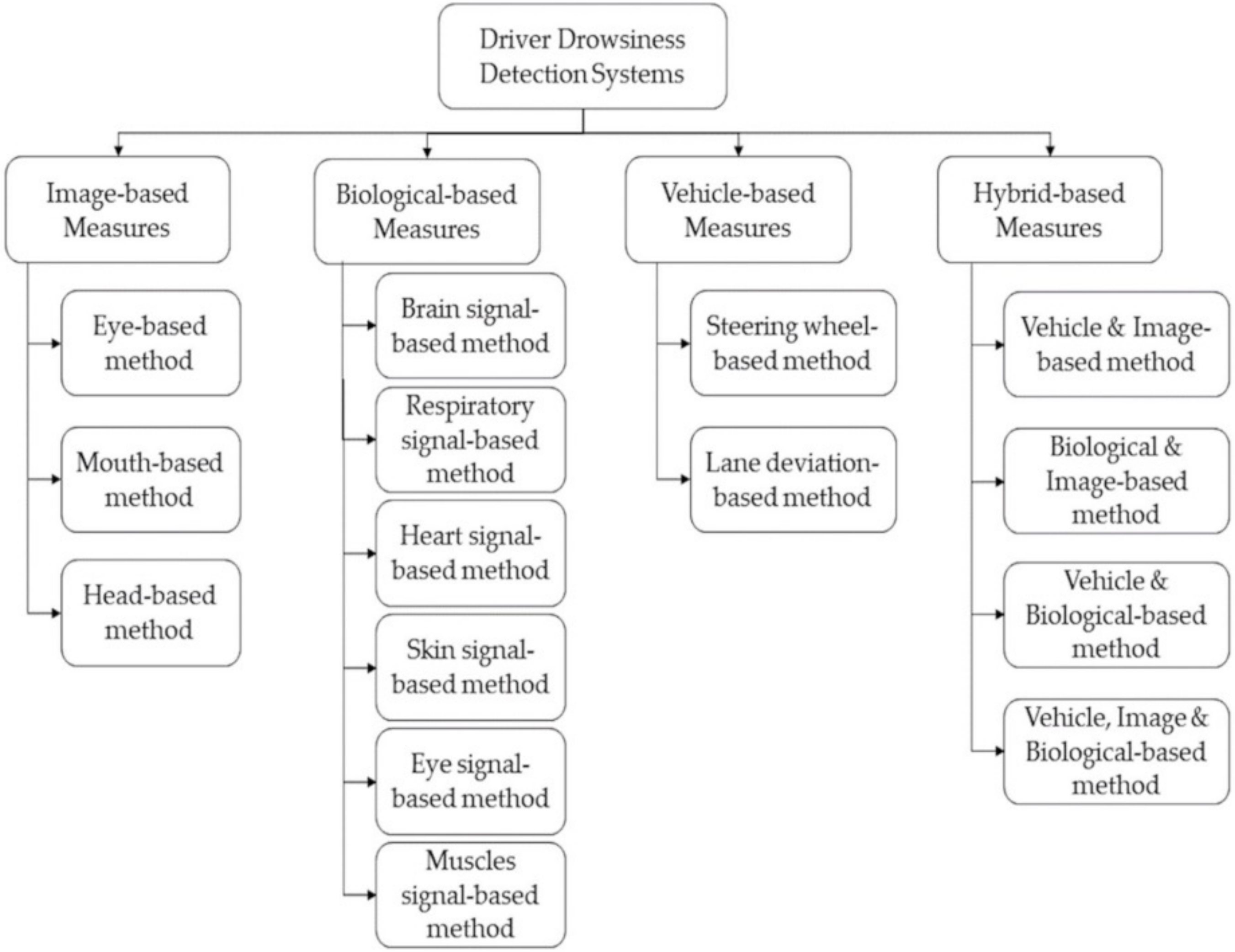
How can we assess whether a driver can respond appropriately to different situations?

Drowsiness Factors



Effects of whole-body vibration on driver drowsiness: A review, Bhuiyan et al.

Drowsiness Measurements using AI



A Review of Recent Developments in Driver Drowsiness Detection Systems; Albadawi et al.

Image-based Methods

- Non-intrusive
- Facial expressions:
  - Eyes
    - Gaze points & directions
    - Blinking, eyelid openness/closure
  - Mouth & breath
    - Yawning, breathing
  - Head
    - Nodding
    - Movements, position
  - Task (awareness detection)
    - Smoking, talking/singing
    - Phone interactions
  - Emotions (low accuracy)
    - Happy, neutral, angry, sad

System by Cipia (uses AI), https://www.youtube.com/watch?v=Qp5mAKQ7KtQ

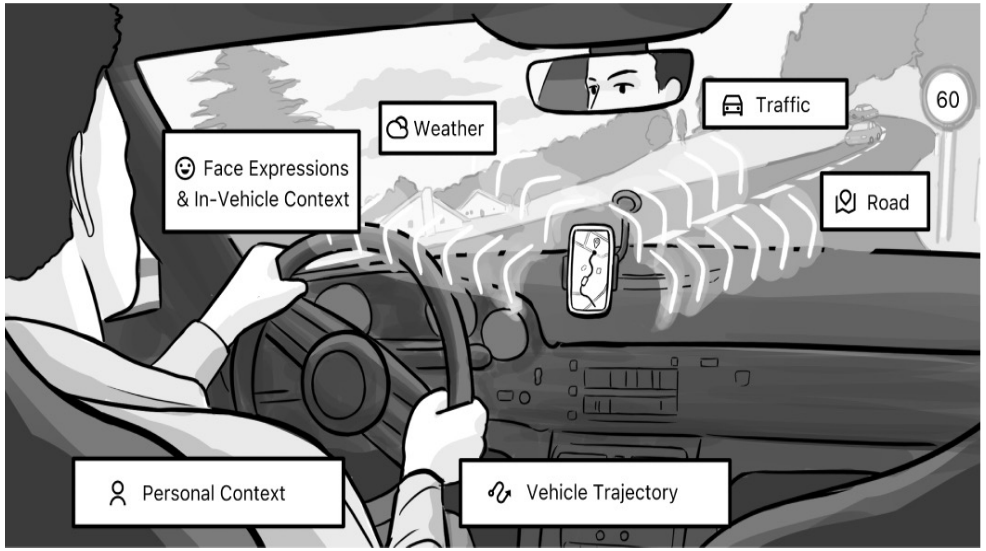
Biological Measures

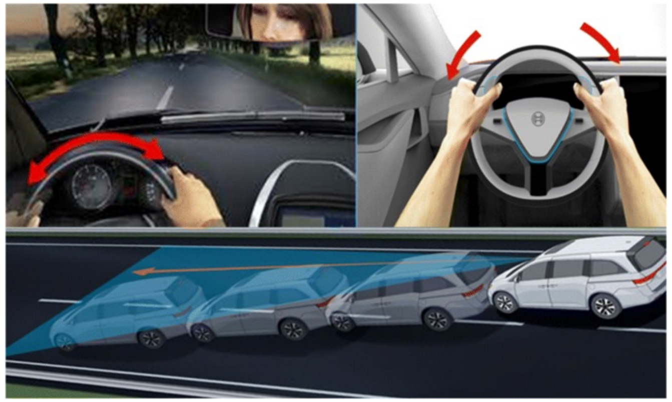
- Brain activity
- Heart rate
- Heart rate variability
- Pulse
- Body temperature
- Sweat
- Breathing

- Partly more accurate
- Early indicators
- Appear before physical signs

Vehicle-based Measures

- Tracing & analyzing driving patterns
- Often combined with image- and biological measures (hybrid)
- Steering wheel angle (SWA)
- Lane departure
- Lateral distance
- Number of times the steering wheel is held steady (NMRHOLD)
- Proportion of the time that the steering wheel remains stationary (PNS)
- Accuracy ranges from 70% to 98%





Driving Patterns

- Driving patterns change after alcohol intake
- Lane position maintenance (50.75%)
- Speed control problems (45.70%)

- Vigilance & judgement problems
- Strong indicator for drunk driving

- Study under real driving tests
- Detected with smartphone

	Abnormal Curvilinear Movements	Problems of Speed Control
FN Rate (%)	0	0
FP Rate (%)	0.49	2.39
FN Rate (%) (Phone Slides)	14.28	0
FP Rate (%) (Phone Slides)	1.09	2.72

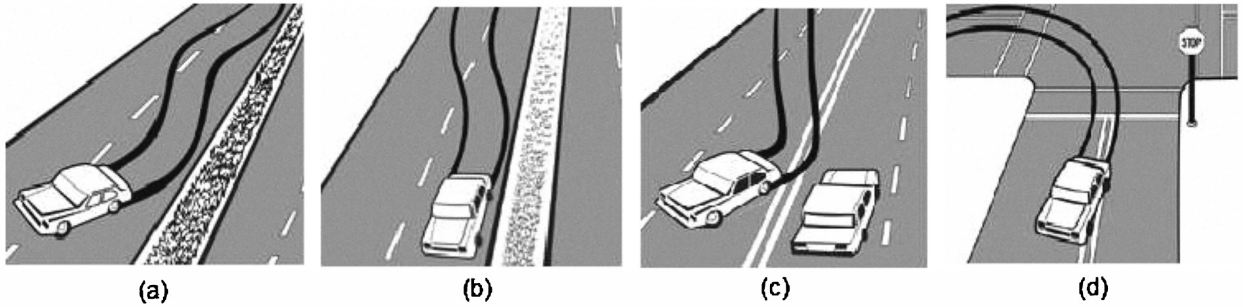


Fig. 1. Problems in maintaining the lane position : (a) weaving, (b) drifting, (c) swerving, (d) turning with a wide radius [5].

iangpeng Dai, Jin Teng, Xiaole Bai, Zhaohui Shen, Dong Xuan, "Mobile Phone Based Drunk Driving Detection", in IEEE 4th International ICST Conference on Pervasive Computing Technologies, 2010

Challenge of Trust in Autonomous Driving

How can we build trust in automated driving functions?

Definition and Factors of Trust

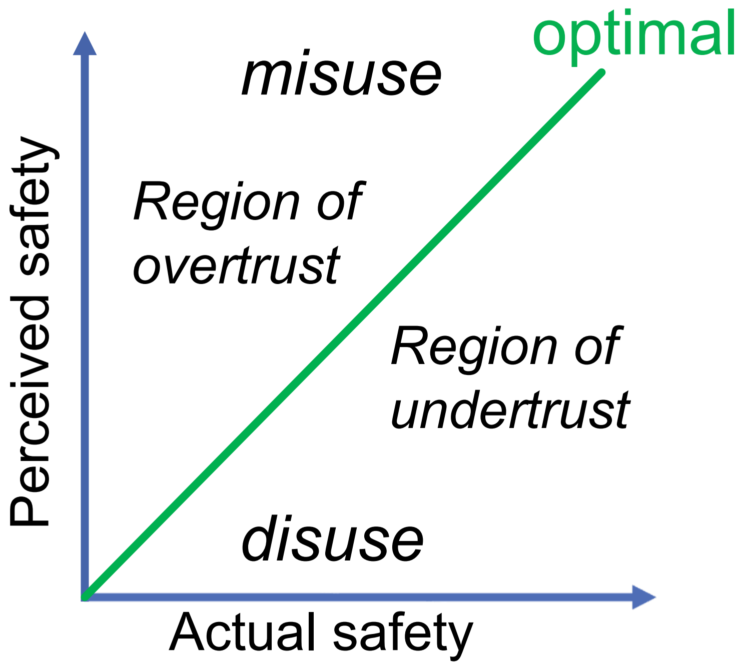
"Expectations in regard to the behavior of another entity"

- **Dispositional**
  - Cultural
  - Personal
- **Situational**
  - Situational influences
  - Individual influences
- **Learned**
  - Knowledge of the system
  - System performance
  - Design
- **System reliability**
  - Functional
  - System response

User-related (internal): Dispositional, Situational, Learned

System-related (external): System reliability

Trust balance:



Calibration of Trust: Transparent AI

- Dynamic mental process shaped by experiences
- **Optimal when expectations meet capabilities of AV**
- With every new occurring situation trust is recalibrated
- Calibration is continuous
- Dynamic balance between trust & automation capabilities

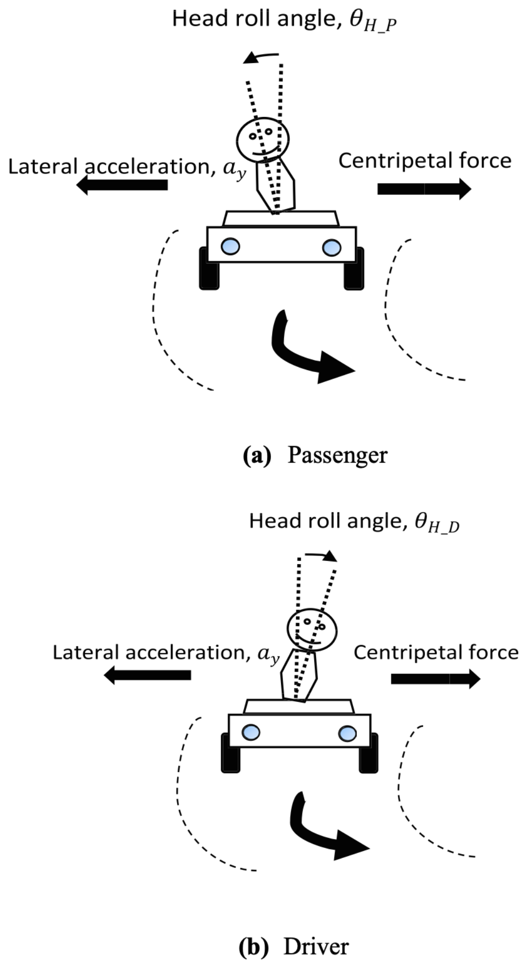
- Since errors may occur:
  - Trust recovery is an integral part of trust

- Trust calibration can differ depending on the driving situation
- Displaying driving intentions can gain trust

Häuslschmid, R., von Buelow, M., Pfleging, B., & Butz, A. (2017, March). Supporting Trust in autonomous driving. In *Proceedings of the 22nd international conference on intelligent user interfaces* (pp. 319-329).

Natural Trajectory Planning

- Passengers and drivers react differently to driving maneuvers
- Drivers know their trajectories, passengers simply experience forces
- AV‘s can track head movements and adjust turns
- Reduced Motion Sickness
- Enhanced User Experience
- Higher trust in automation
- Further feedback loops with biological data possible



Saruchi, S. A. et. al (2020). Lateral control strategy based on head movement responses for motion sickness mitigation in autonomous vehicle. *Journal of the Brazilian Society of Mechanical Sciences and Engineering*, *42*, 1-14.

Challenge in Scene Perception

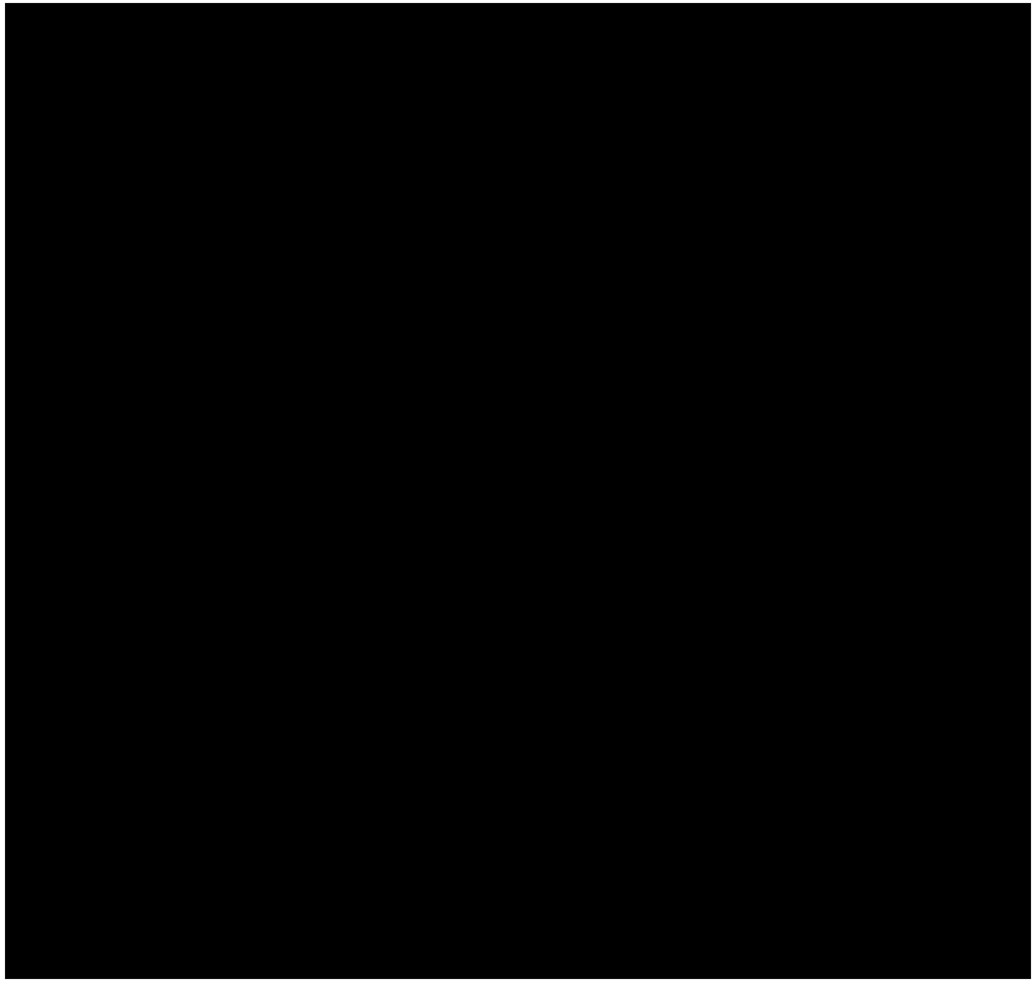
- **The driver should see:**
  - A potential risk for collisions, why? Memory!
  - Declarative memory (explicit):
    Learned situational behavior e.g. in driver school
    - Episodic memory:
      Memories of past situations
    - Semantic memory:
      Facts, interrelations in abstract form
  - Procedural memory (implicit):
    - How to drive a car
- **The autonomous vehicle (AV) sees:**
  - Sensory information analog & digital, geoposition
  - AI detects “Street with parked cars and a ball”
  - A “database entry” for emergency braking?
  - AI, indicating “immediate danger” with 83%
  - A V2X message indicating a hidden pedestrian

Manual Driving Example

- Requires high attention
- Reaction time delay
  - Decision: >350ms
  - Braking: > 550ms
- „Result“ affected by:
  - Health (phys. & mental)
  - Daytime
  - Reaction of others
  - …

(Partial) Autonomous Driving

- Requires complex processing
- Reaction time delay
  - Decision: <100ms
  - Braking: <300ms
- „Result“ affected by:
  - Developer of decision-making system
  - Sensor accuracy in environment
  - Reaction of others
  - …



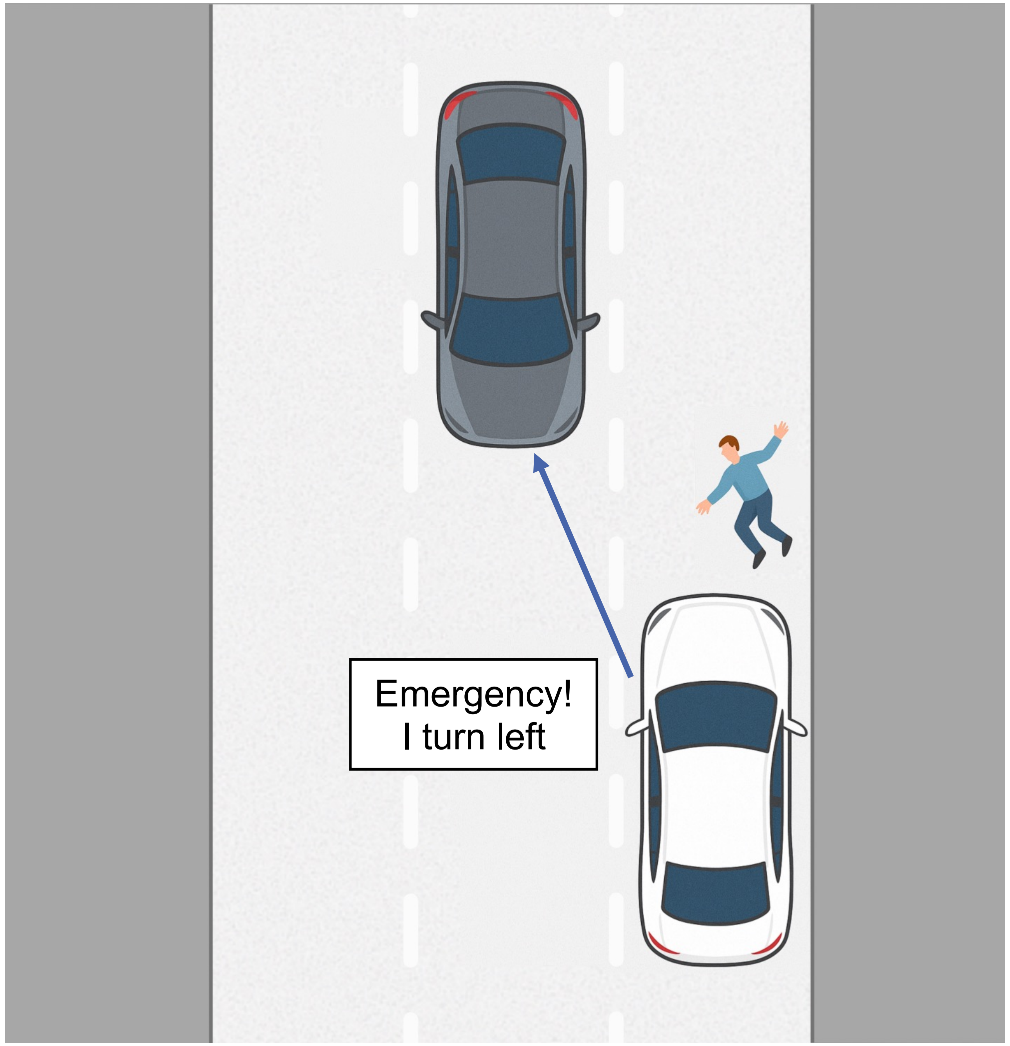
V2X Communication: Ethical Gamechanger?

- Cars communicate their intentions
- White car transmits intention over V2X
- Grey car processes received info
- Grey car initiates emergency braking

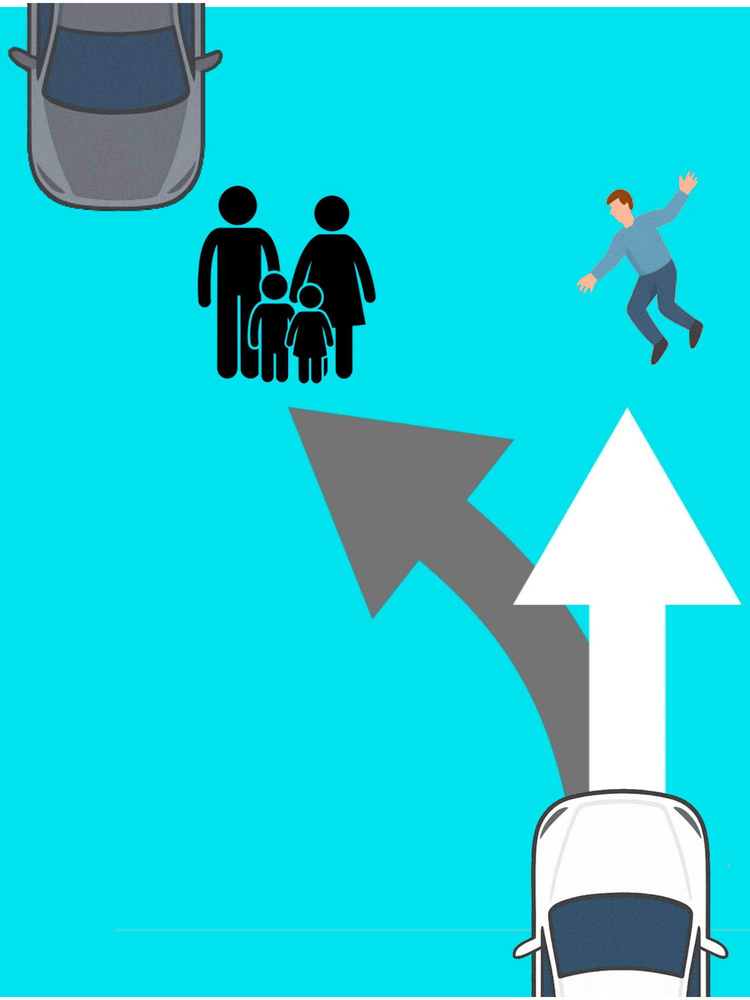
- Reaction time delay for grey car
  - Decision: <20ms

- **Result: Overall harm is reduced**

  How is „harm" estimated?
  Is the solution ethically compliant?



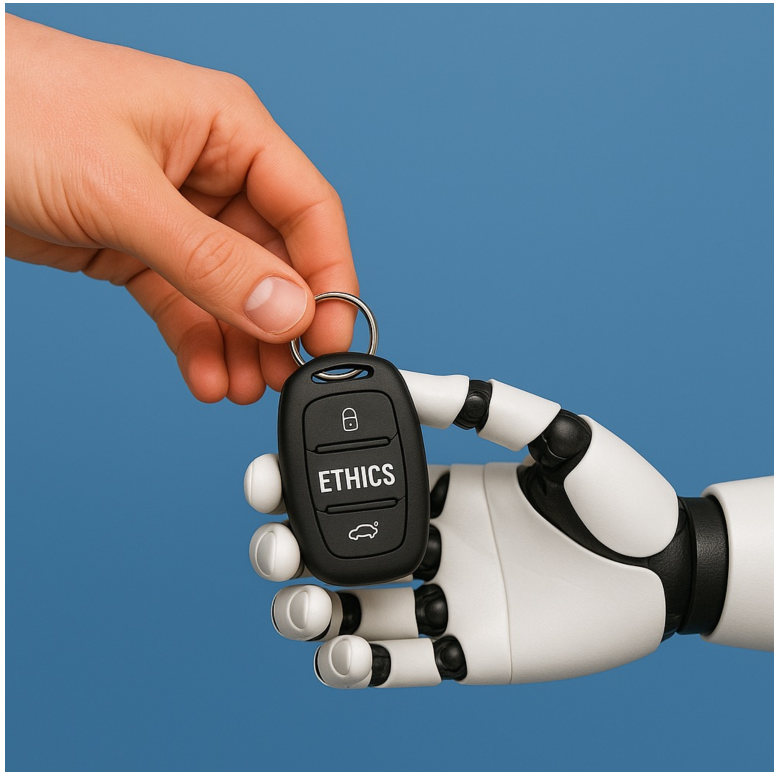
Dilemmas of Ethical Decision Making in AI



How should an AV decide?

Ethical Decision Making for AVs

- Study MIT 2016:
  - 1928 surveyed US citzens
  - ***Kill passengers or 10 pedestrians?***
    - 76% decide to kill car passengers
  - ***Buy AV with sacrifice ability?***
    - 19% agreed
  - ***Acceptance for utilitarian regulations?***
    - 21% agreed



B @BobbaFett312 7 months ago (edited)

Heroically? Audi driver could have been killed. Tesla needs to fix their cars ai, this is super dangerous

8 Reply

Perspectives change with age & relationship of passengers

Ethical perspectives are different!

Bonnefon, J. F., Shariff, A., & Rahwan, I. (2016). The social dilemma of autonomous vehicles. *Science*, *352*(6293), 1573-1576.

Ethical Approaches

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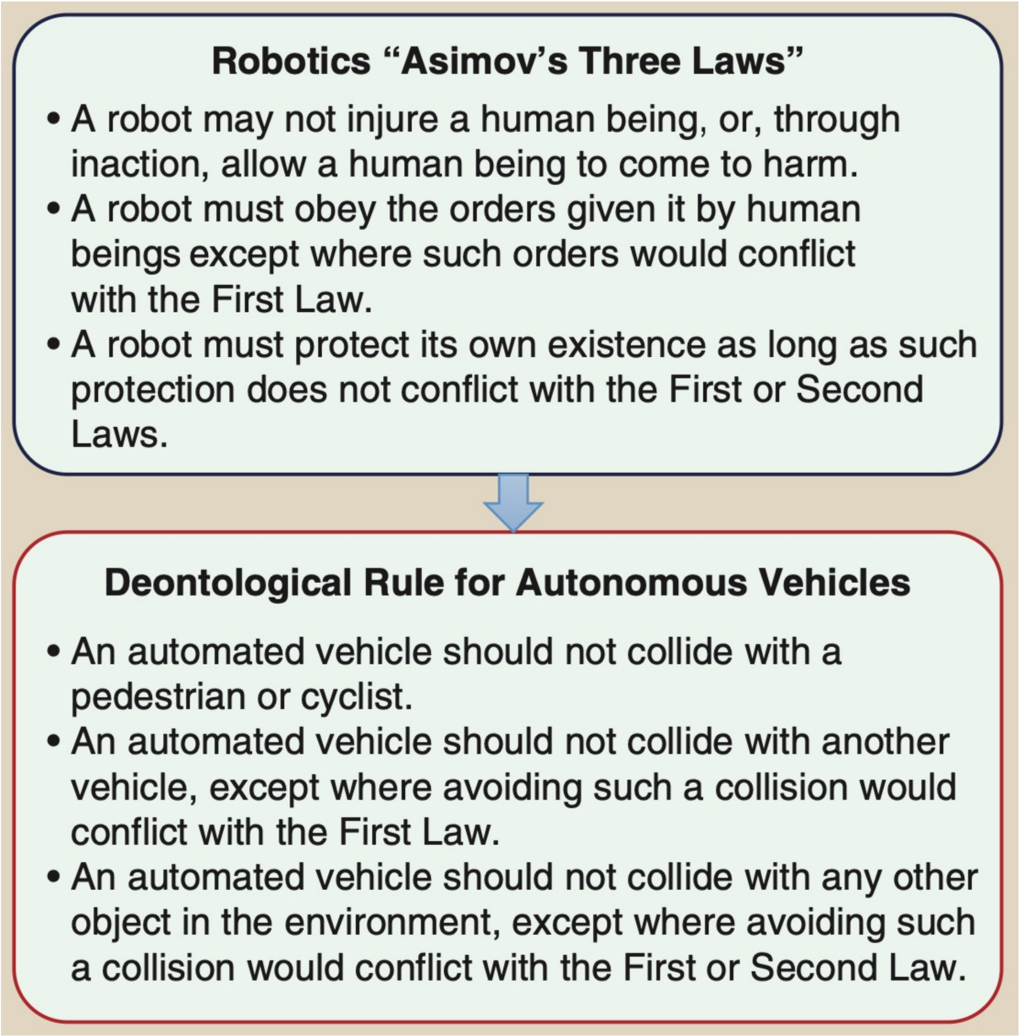
- **Rational**
  - Deontological Rule (i.e. Asimov‘ laws)
    - Easy to implement in AV‘s
  - Consequentialism
    - Evaluate the consequences of decisions
    - Difficult to define realistic consequences
- **Artificial Intelligence**
  - Learn human behavior in dilemma situations
- **Hybrid Approaches**
  - Combine rational & AI human behavior
  - Multi-Layer implementation

All ethical systems are incomplete!



Edge Cases

- Traffic is highly complex
- Unknown situations occur
- Example:
  - Bread on the road
  - Birds may stop the car
- Potential Misuse:
  - Stop car for robbery

Interacting with AVs requires a general set of rules.

Conclusion

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- AI can potentially transform mobility through
  - *automation*
  - *personalization*
  - *enhanced safety & efficiency*

- Driver/Passenger monitoring is key factor for experience & safety
- Trust in automation is an integral part for safety and acceptance
- Scenes and actions of other road users require appropriate understanding
- Ethical dilemmas remain unsolved

Trust, ethics, & human-AI collaboration are essential in the mobility ecosystem.

Thank you for your attention!