ADAS&ME : MID-TERM REVIEW
USE CASE B

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Electric Vehicle range anxiety

Anxiety: “A feeling of worry, nervousness, or unease about something with an uncertain outcome.”[1]

Root causes:
1. EV Range
   a. Limited vs ICE vehicles (at least for now)
   b. Mistrust to prediction system / Lack of experience with EVs behaviour
2. Refueling issue
   a. Charging stations network density
   b. Charging speed

Consequences:
→ Hinders EVs acceptance

1. **Range Anxiety Mitigation**
   - Range *sufficient* for trip
   - Driver anxious because of mistrust to system
   - Bring driver back to neutral state by adapting range information

2. **Range Incident Mitigation**
   - Range *insufficient* for trip
   - Support driver on recharging planification
   - Propose automation to optimize “lost” time

3. **Range Critical Protection**
   - Range is *critical*, imminent vehicle shutdown
   - Ensure vehicle’s withdrawal from traffic before immobilisation
   - Guarantee vehicle’s and driver’s safety
Targeted states

Targeted driver states:

- Emotions
- Anxiety
- Range Anxiety

Facial Expressions

Physiological reaction

Vocal Expressions

Gaze Behavior & Vehicle data

Anxiety

Range Anxiety
Two-fold process

➔ **April 2018**: small pool of participants, induction of neutral, happiness and anxiety feelings in open-road scenarios

  **Objectives**: Assess the emotions induction protocol
  Acquire data to support first phases of development

➔ **September 2018**: 24 participants, implementation of scenarios

➔ **December 2018**: 20 participants, data collection

**Results of the first data collection campaign**:

- 3TB data collected
- Range anxiety induction is not easily performed

**Results of the second data collection campaign**:

- 5TB data collected
- Range anxiety induction done
- HMI to be improved
On board sensors

Smarteye Pro: 2 cameras system
- Facial expressions
- Gaze behaviour

Shure VP82 Microphones
- Vocal emotions

Valeo Radar
- Heart rate
- Respiration rate

Empatica E4*
- Galvanic skin response
Demonstrators

Objectives
- Inducing range anxiety
- Experimenting on open roads with naive subjects in an autonomous prototype

Wizard of Oz Renault ZOE
- Joystick controlled vehicle
- Allows accurate study of driver behaviour in an automated driving context
- Vehicle dedicated to ADAS&Me
- Certification for open-road experimentation (France) in progress
1. Range Anxiety Mitigation

- Temperature: ~2 °C
- Range: ~100 km (80%)

2. Range Incident Mitigation

- Temperature: ~5 °C
- Range: ~30 km (25%) ETA: 60 km

- Battery too low.

3. Range Critical Protection

- Temperature: ~5 °C
- Range: ~5 km (8%) ETA: 45 km

Starting autonomous mode, please let go steering wheel and pedals.
Final Evaluation Plans

**Driver states:** Anxiety

**Sample:** 24 drivers | 25-40 years-old | > 5 years driving experience | No EV experience

**Design:** Only one session | Within-subjects design: all subjects perform all test cases

**Procedure:** @ Public roads Santa Oliva + IDIADA’s Proving Ground

- **Briefing**
  - @ Test-track

- **Familiarization**
  - @ Test-track

- **Public road**
  - **1st Test case:**
    - Destination is entered
    - Goes to public road
    - Range decreases dramatically
    - Anxiety recognition
    - Mitigation messages
  - **2nd Test case:**
    - Range continues decreasing (range not enough)
    - Re-routing messages (to IDIADA)
    - Automated driving once in IDIADA

- **Test-track**
  - **3rd Test case:**
    - Automated driving
    - Warnings are ignored
    - Safe stop

- **Debriefing**
Conclusion

Scope and scenario: Done
Range Anxiety architecture: On-going
Demonstrators: On-going
Data collection: On-going
HMI specifications: Done
HMI development: On-going
MQTT Communication: On-going

Next steps
Anxiety algorithms: January 2019
HMI development: February 2019
DSS: April 2019
Demonstrator: June 2018
Final review: August 2019