Machine Learning Methods Towards Intention-Aware Automated Vehicles

Jorge Pardo

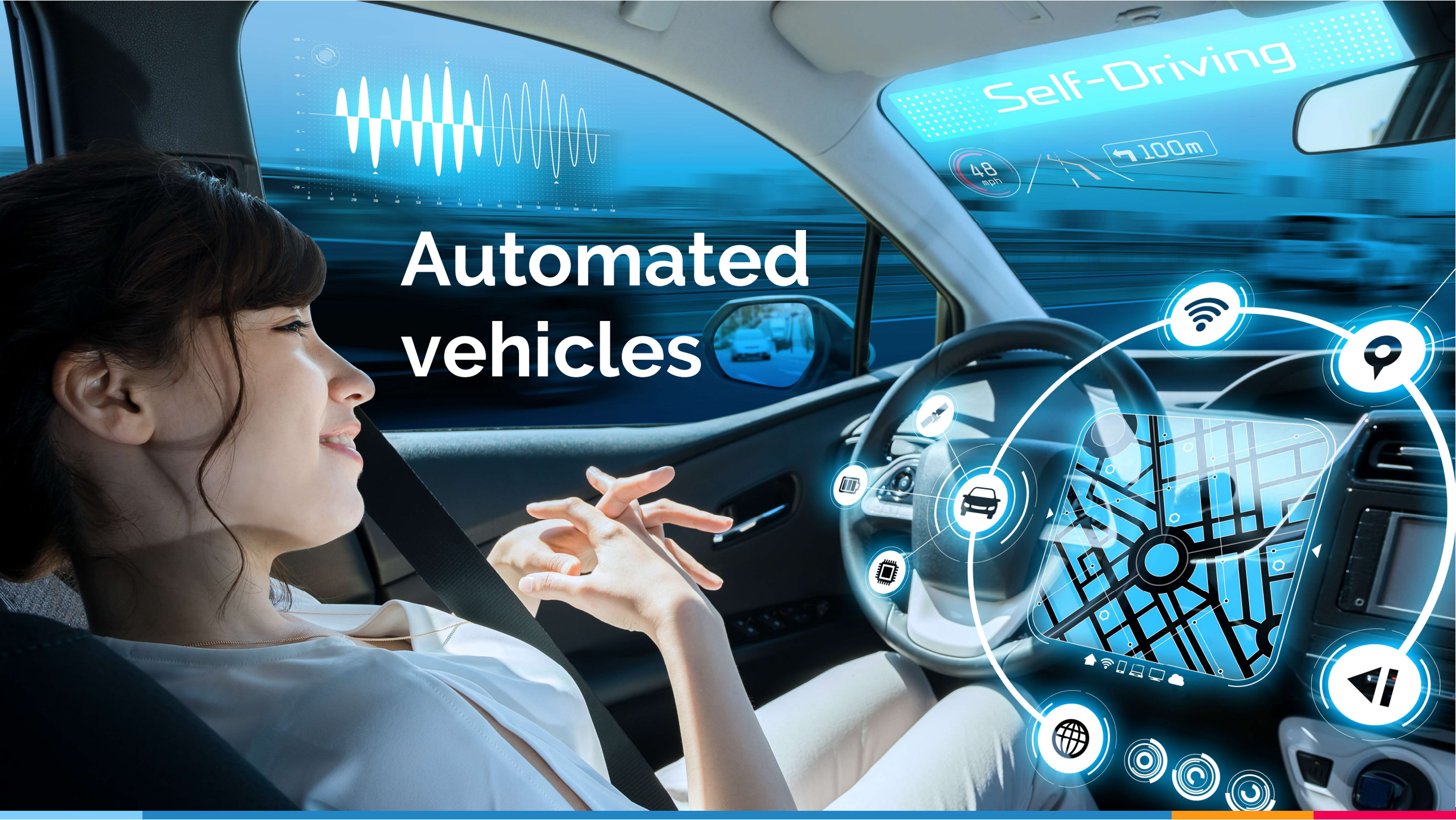
Principal Supervisor : Dr Ronald Schroeter

Associate Supervisor: Prof Andry Rakotonirainy

Associate Supervisor: Prof Sebastien Glaser

https://research.qut.edu.au/carrsq/

Talos the Automaton



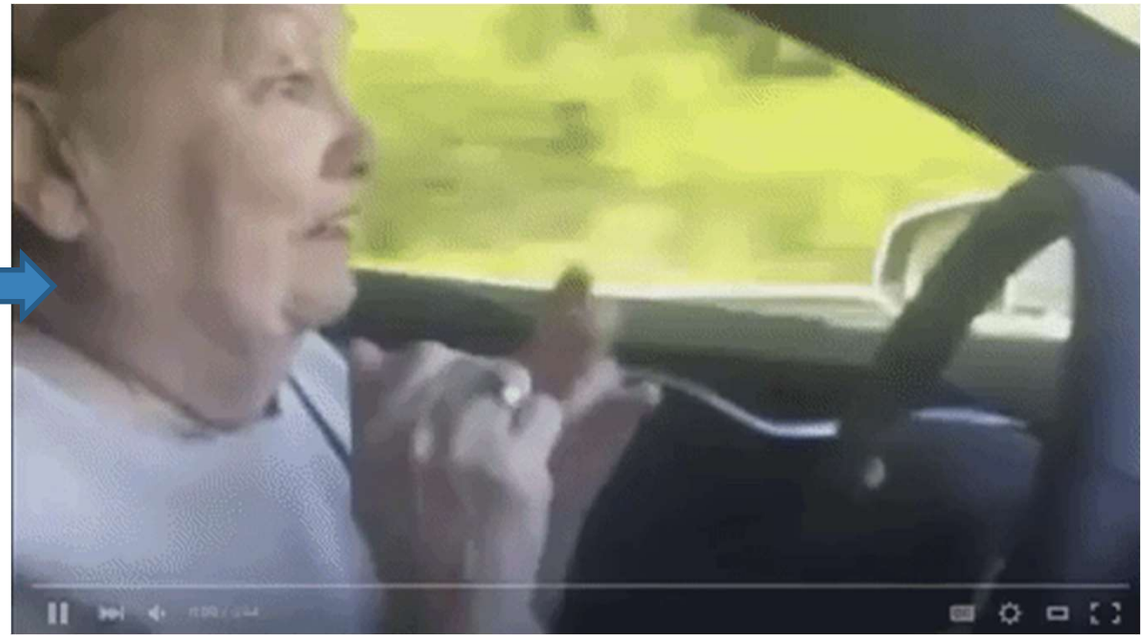
Automated vehicles

Some issues…

From this…

(Google images)

To this…



(YouTube)

Questions and uncertainty during automated driving

"If we as consumers, as humans, do not feel safe and comfortable when stepping into an AV, we are NOT going to use this technology" (Intel, 2017)

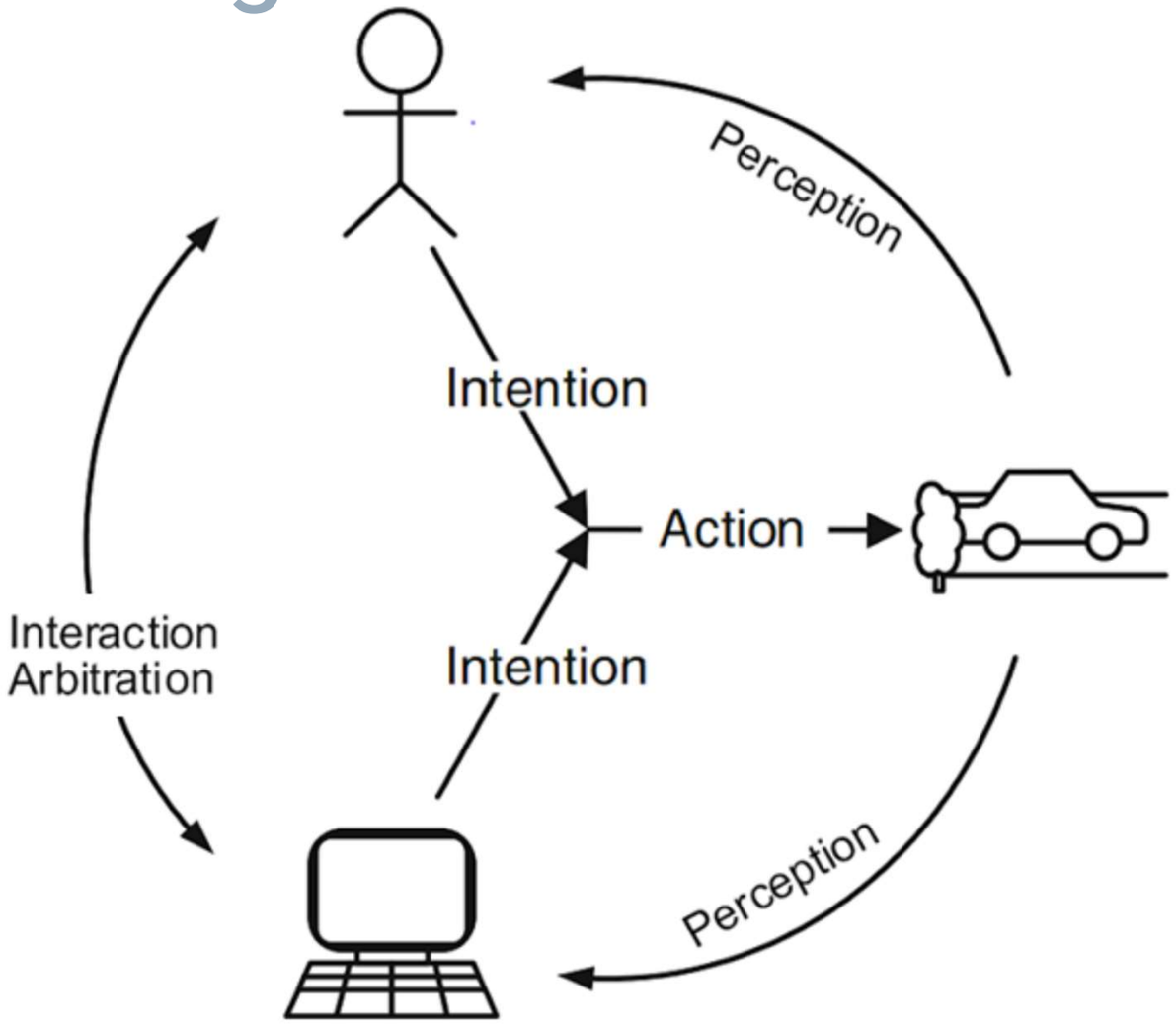
Supervisory role

The husband metaphor (Ju, 2015, p. 65).

The husband metaphor (Ju, 2015, p. 65).

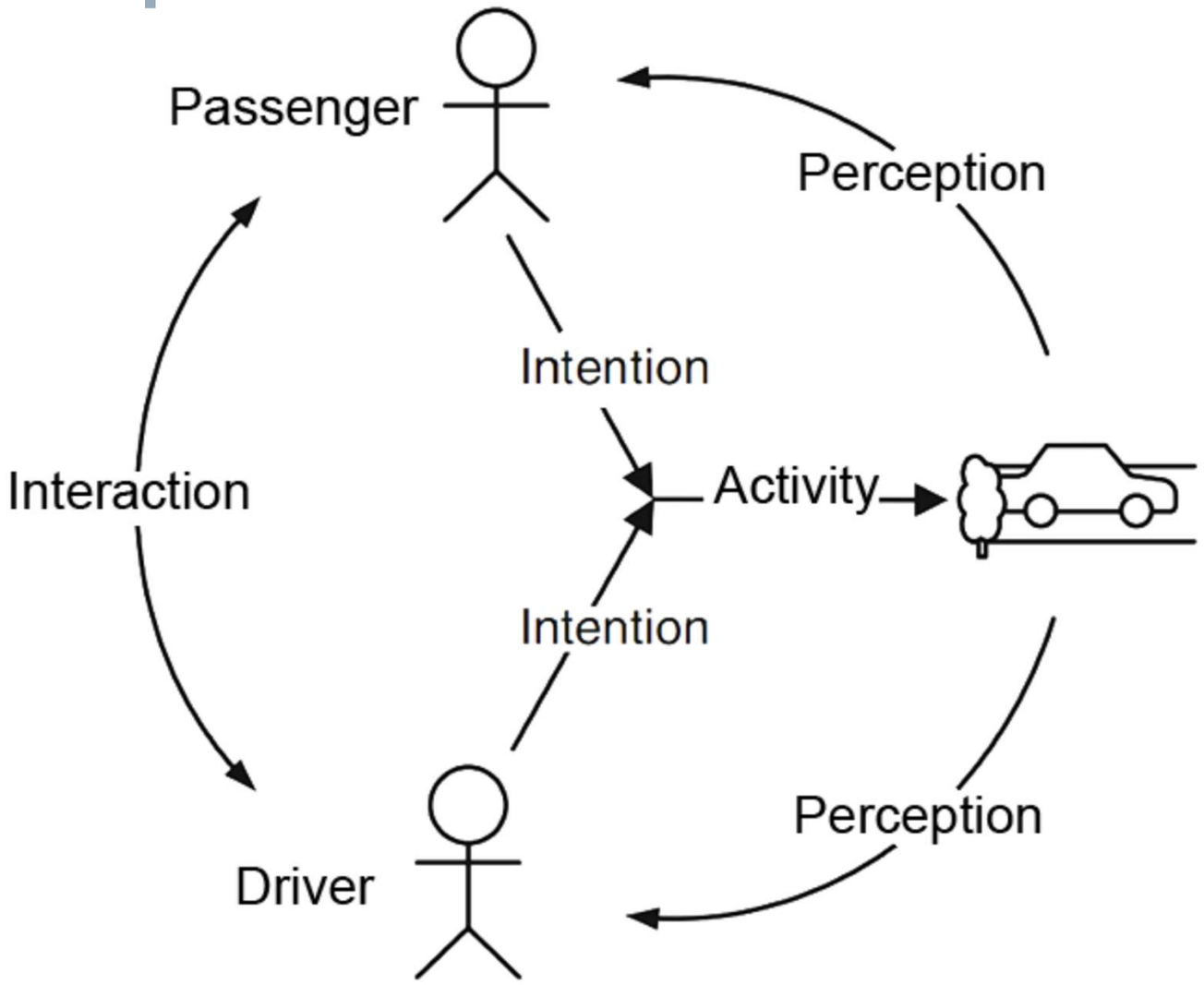
"My husband is an autonomous driver. I trust him to drive […], I never worry once about his capabilities. However, when I sit next to him in the passenger seat, I also participate in driving. I help make decisions about where to go and suggest alternative routes to take. I warn about potential issues and point out latent hazards that I think my husband might not see."

Cooperative driving



Human-machine cooperative driving (Flemisch et al. 2016)

Husband metaphor

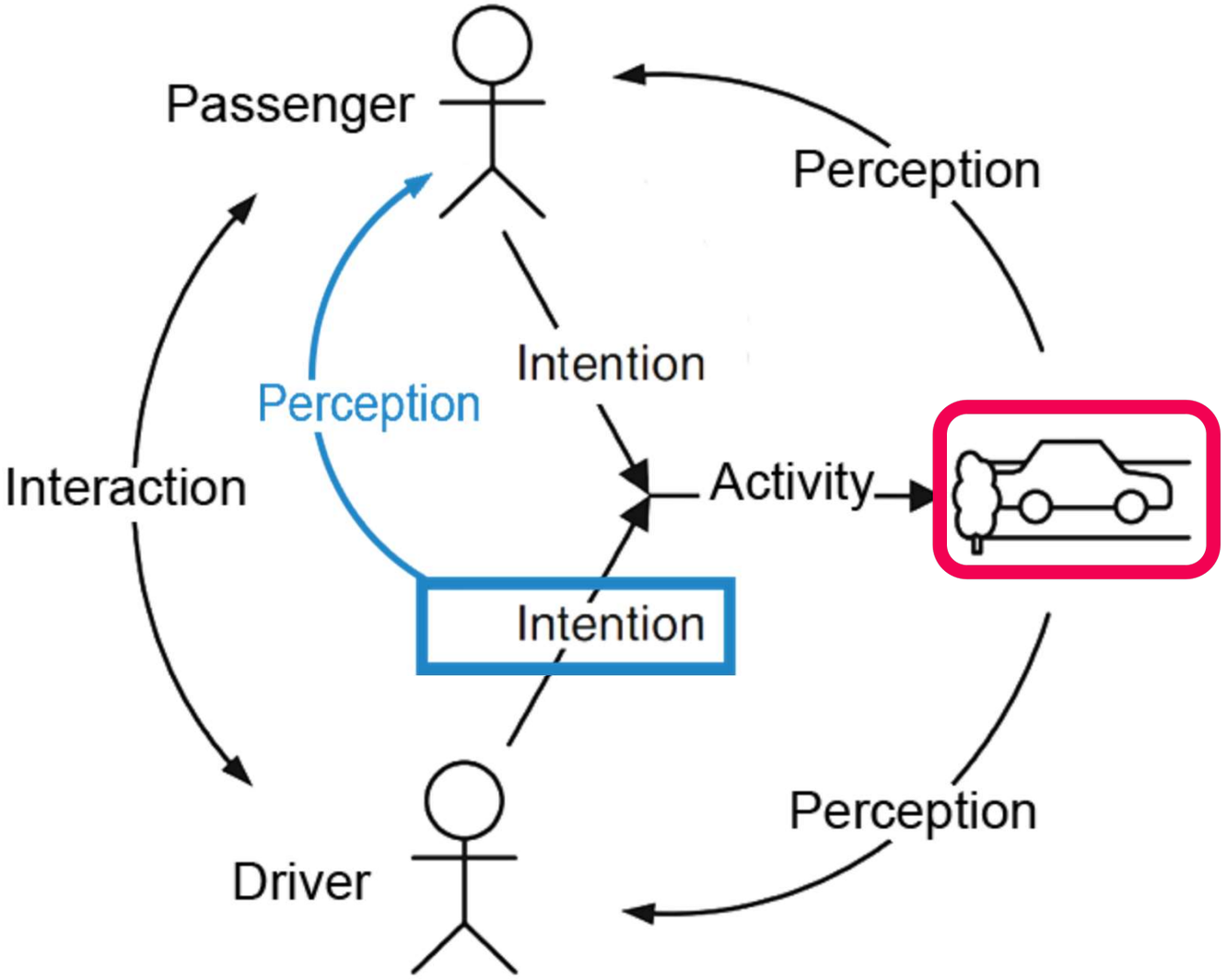


Human-human interaction during the driving task.
A variation from Flemisch et al. (2016)

An example…

Passengers are **receptive** to **cues**. For example, when the driver takes the foot off the gas pedal and hovers it over the brake pedal. This indicates their **intention** to brake. And also, it conveys their **awareness** (or lack thereof) that a pedestrian may cross the street.

Combined framework



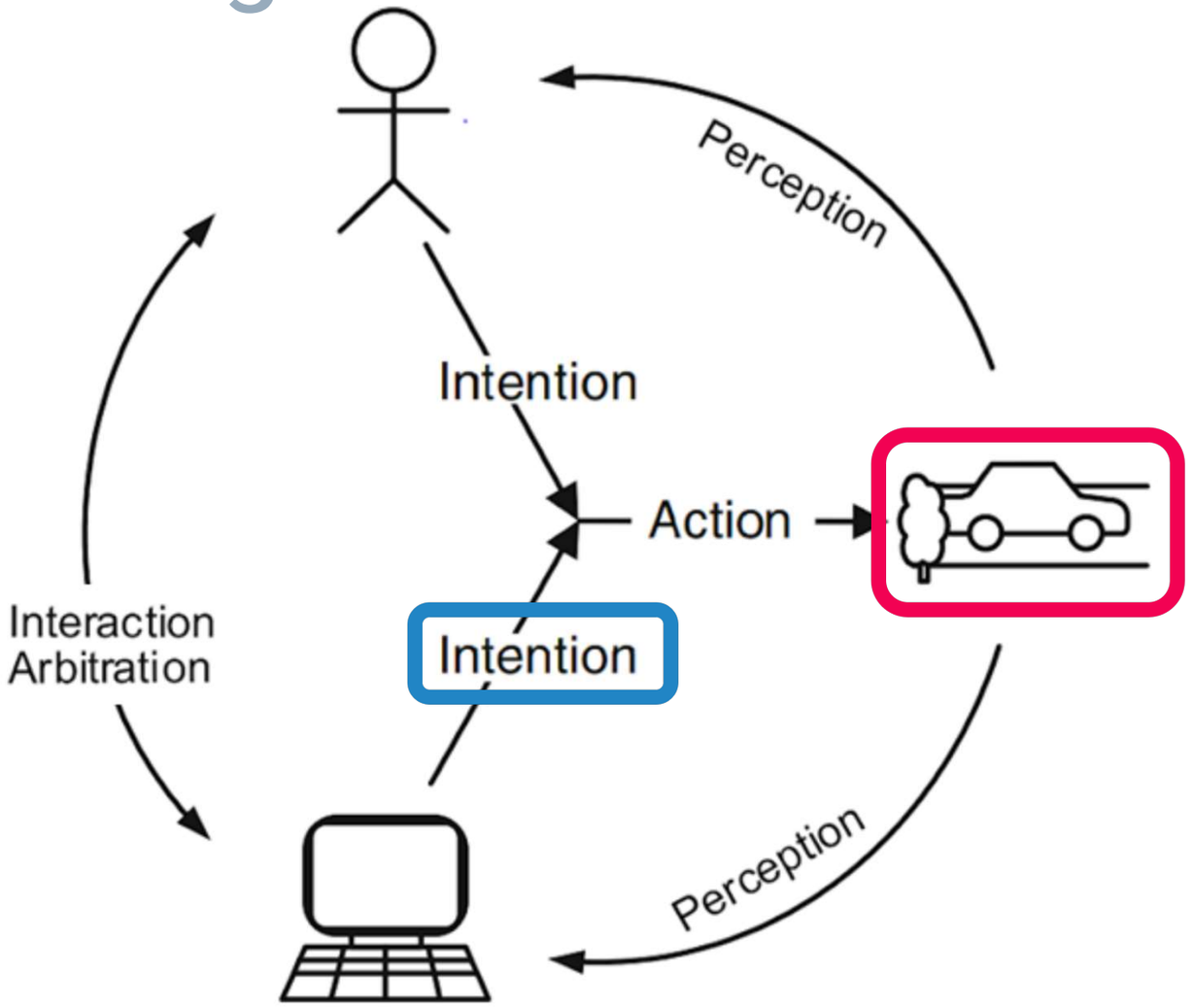
Human-human interaction during the driving task.
A variation from Flemisch et al. (2016)

“

Intention is a **concept** that specifies **what** the actor has **chosen to do**, and **how** they are **committed** to that **choice**.

(Cohen and Levesque 1990)

Cooperative driving



Human-machine cooperative driving (Flemisch et al. 2016)

Intention Awareness is

"the process of integrating ***actors' intentions***

into a ***unified view*** *of the surrounding* ***environment***"

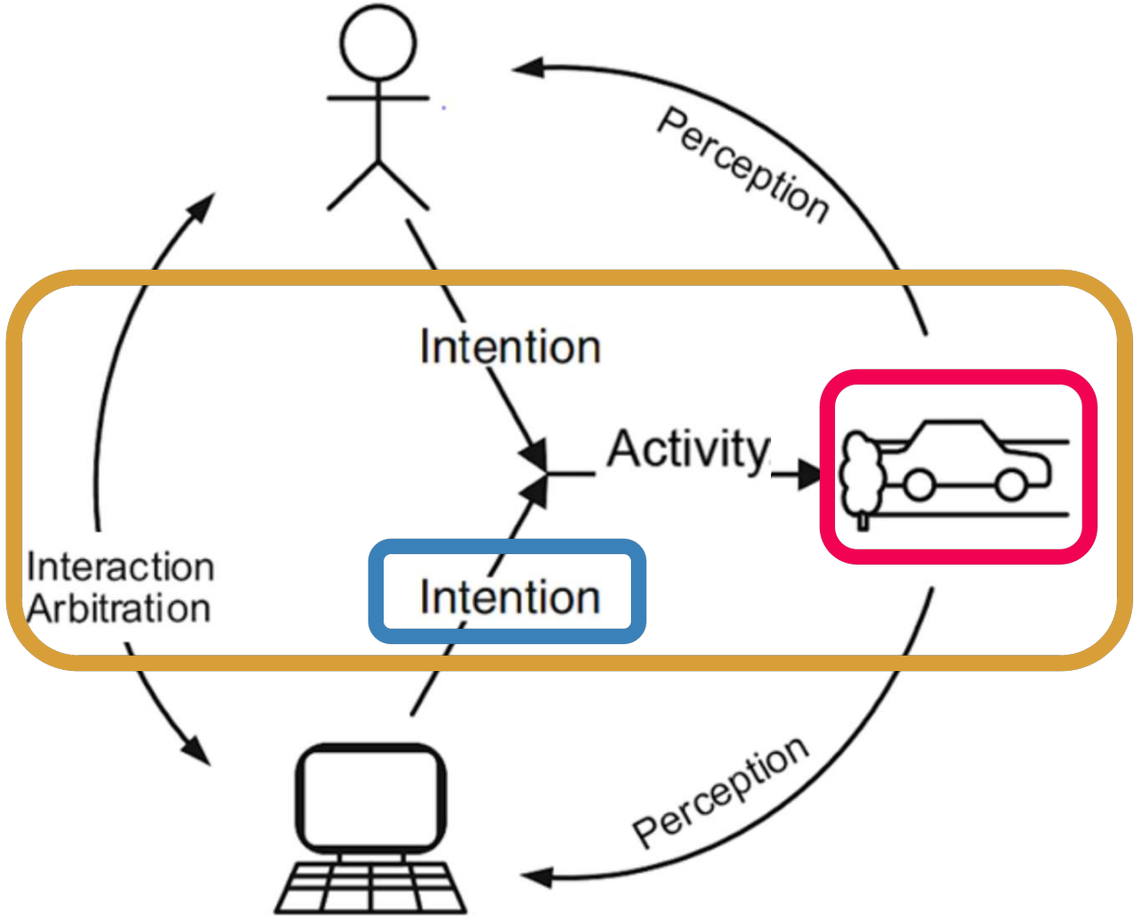
(Howard & Cambria, 2013, p. 7)

“**Intention Awareness** informs and enhances **Situation Awareness**, providing a more **comprehensive understanding** of an existing **situation**”.

(Howard 2013, p. 13)

Intention awareness to support mental models

This is where the machine may support the creation of shared mental models



Cooperative driving diagram. A variation from Flemisch et al. (2016)

Avoid:

- Possible confusion
- Possible collisions

Promote:

- Cooperation
- Comfortable drive

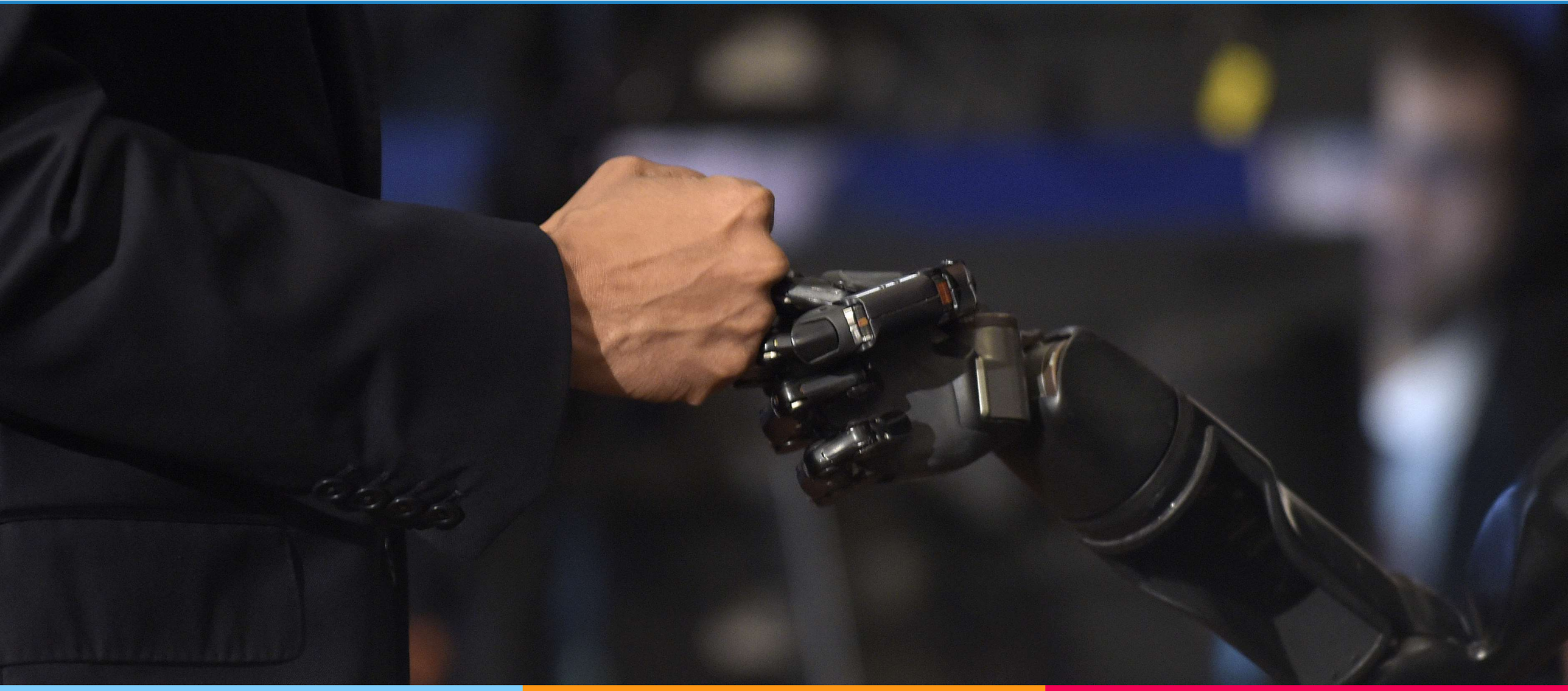
Aim of the Research

This PhD project aims to investigate the foundations of how to develop and validate a

context-dependent

intention-aware system

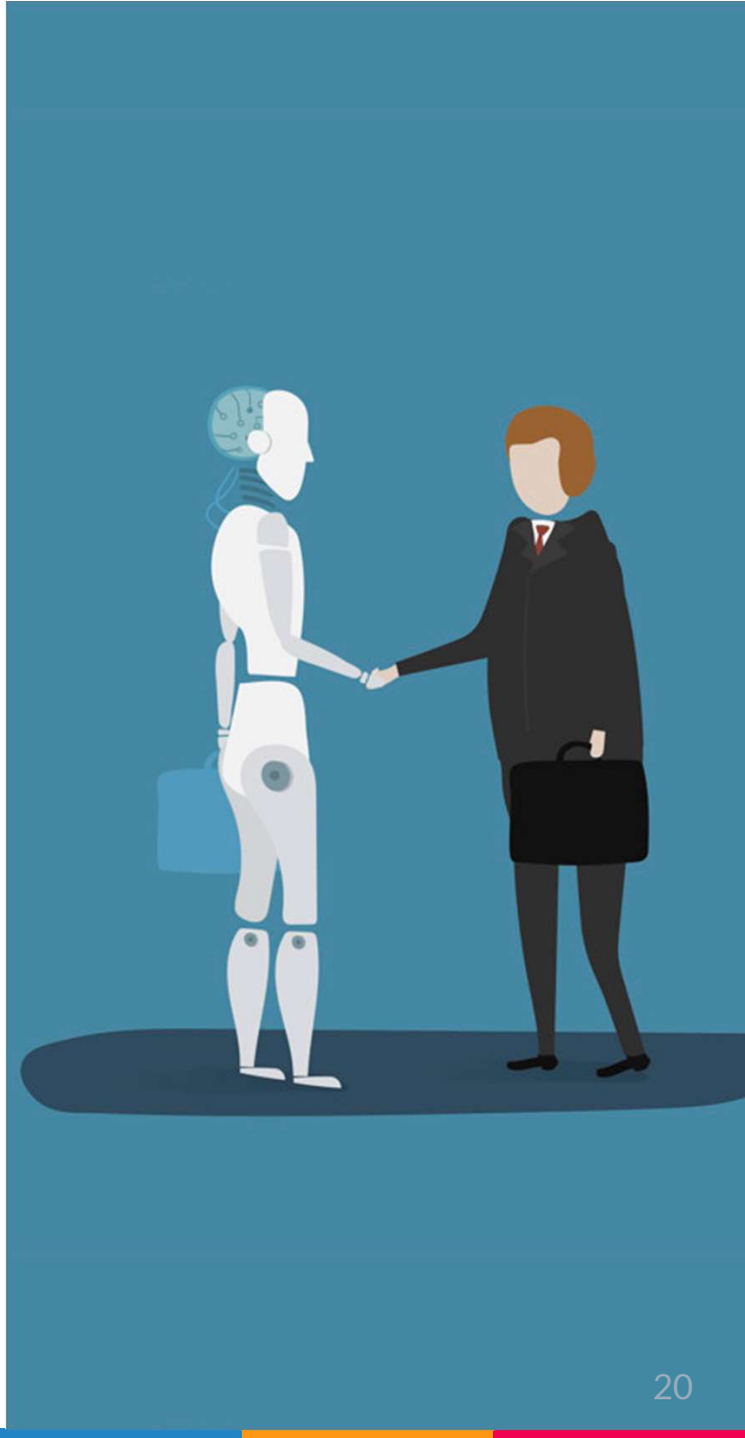
by using a **human-centric approach**.



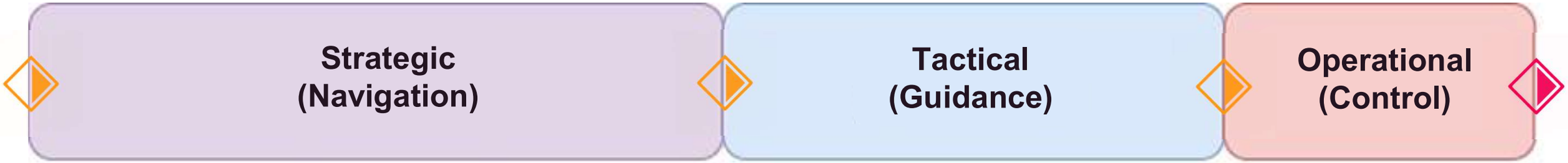
Human-machine Cooperation

Human-machine cooperation

- Know-how
- Know-how-to-cooperate



Levels of activity

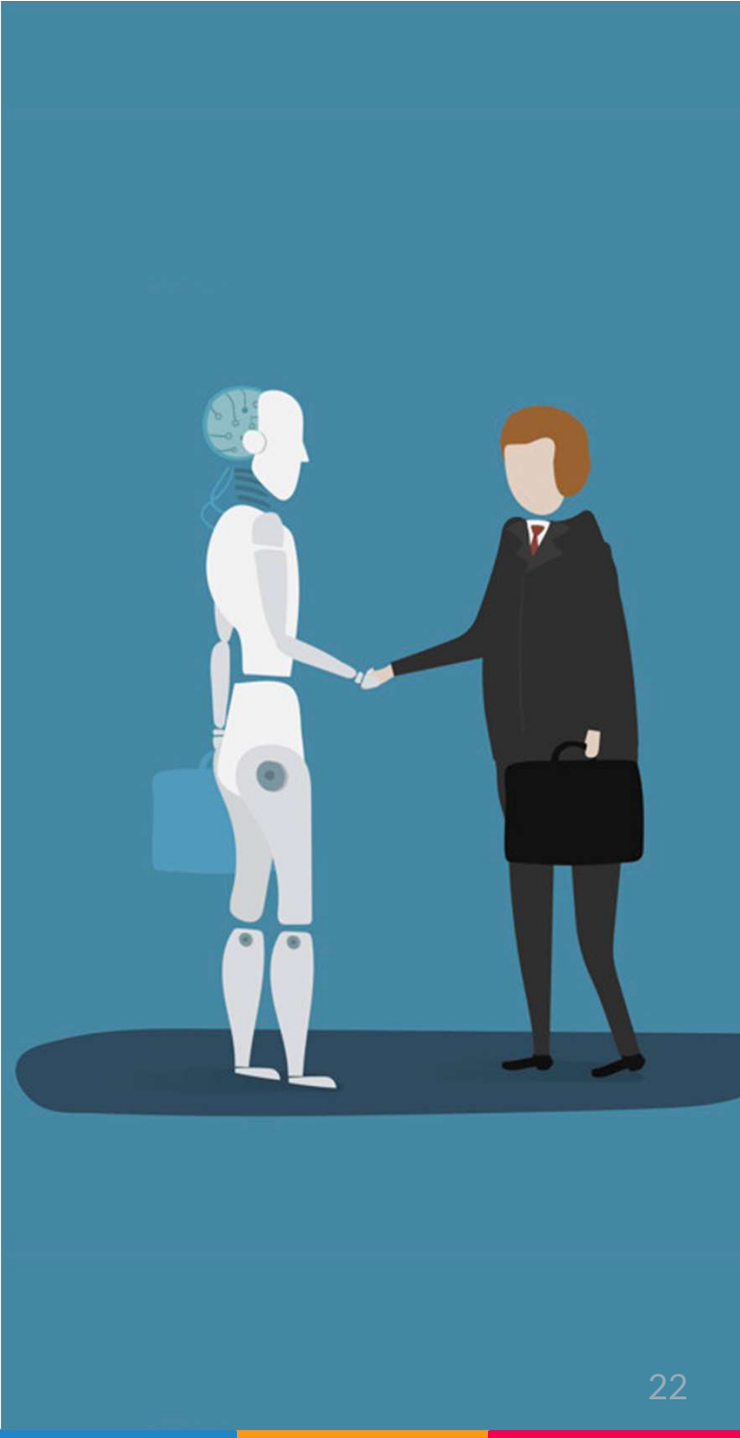


- Defining the plan to perform a task
- How to perform a task
- Performing a task

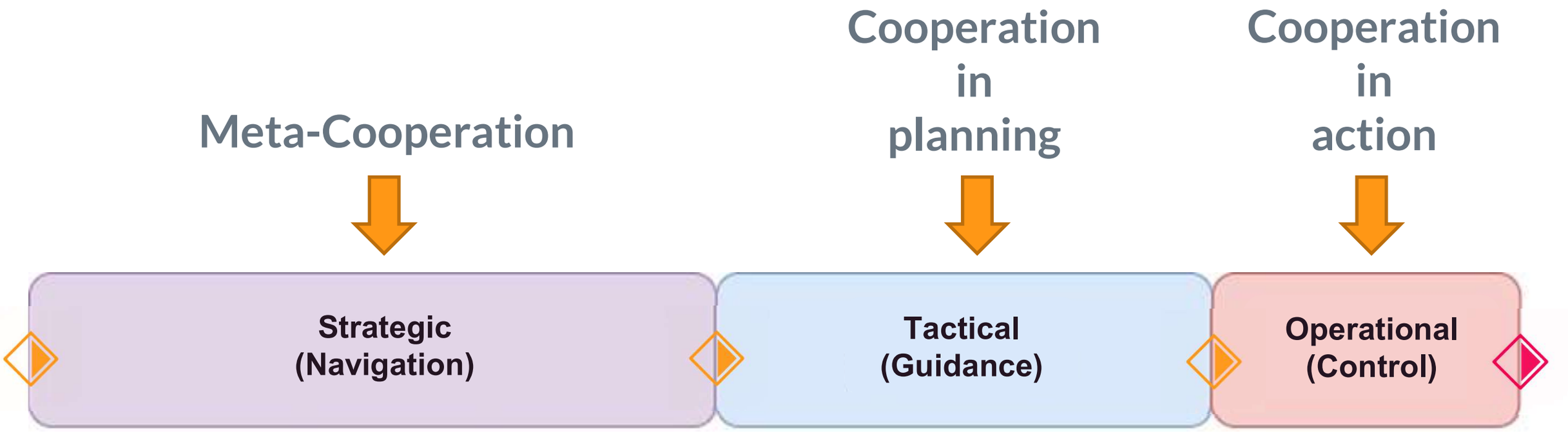
Human-machine cooperation

Know-how:

- Get information
- Make decisions
- Act
- Solve a problem



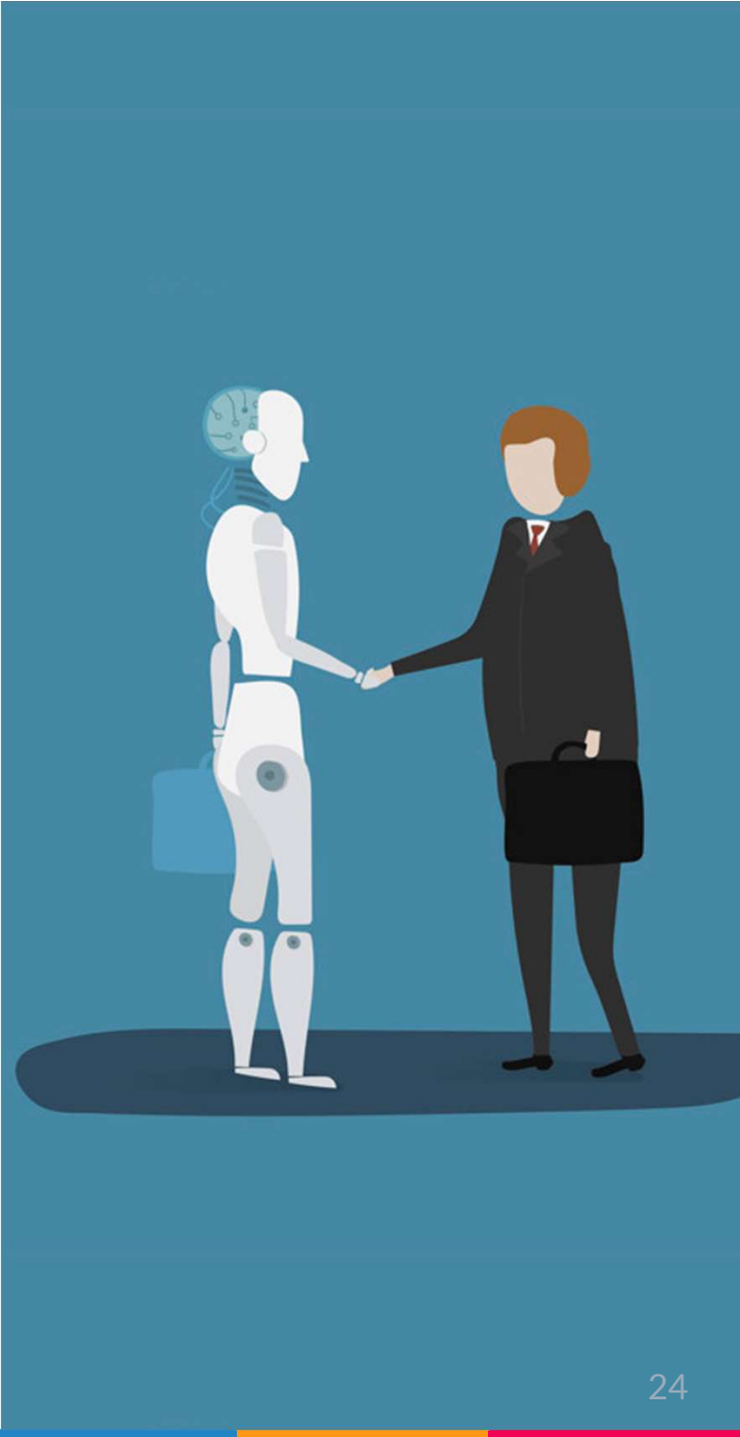
Know-how-to-cooperate



Human-machine cooperation

Know-how-to-cooperate:

- Deduce others' intentions
- Understanding other agents' actions
- Produce common plan
- Provide information to other agents



To ***successfully*** *achieve* ***cooperation*** *and communication in* ***human-machine*** *relationships, it is needed to* ***introduce more aspects of human-human interaction models.***

(Hoc, 2000)

(Google images)

Human-human cooperation

Joint activity

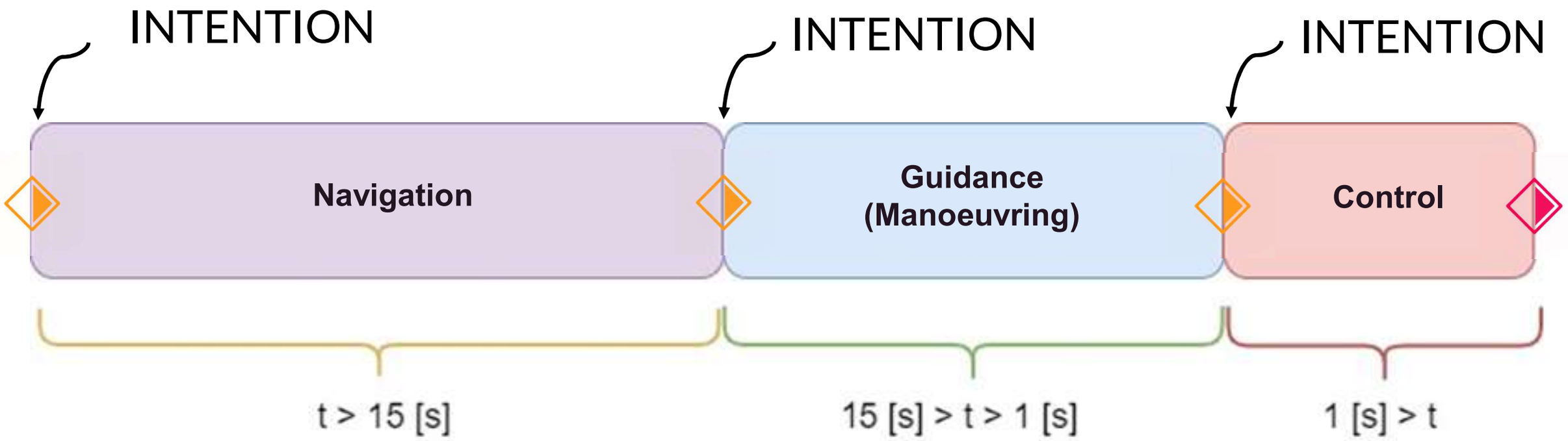
Human-human cooperation

Joint activity

- Ability to create shared representations
- Ability to predict intentions and actions
- Ability to integrate predicted effects on own and others' actions

Cooperative Driving

Driving intentions



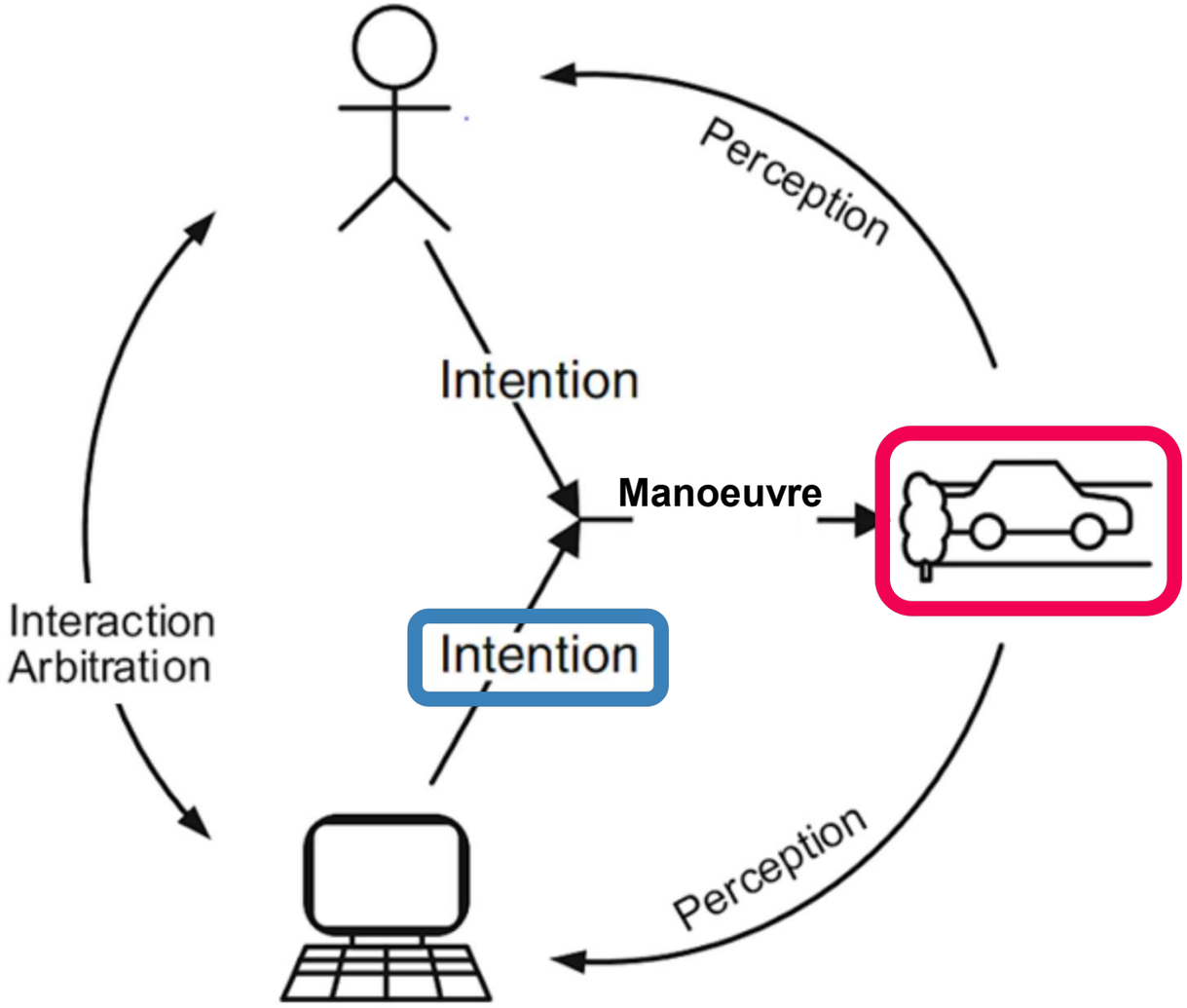
- High uncertainty level

- Enough time for conveying and processing intention.

- Not enough time to share intention.

- Prone to errors

Sharing intention



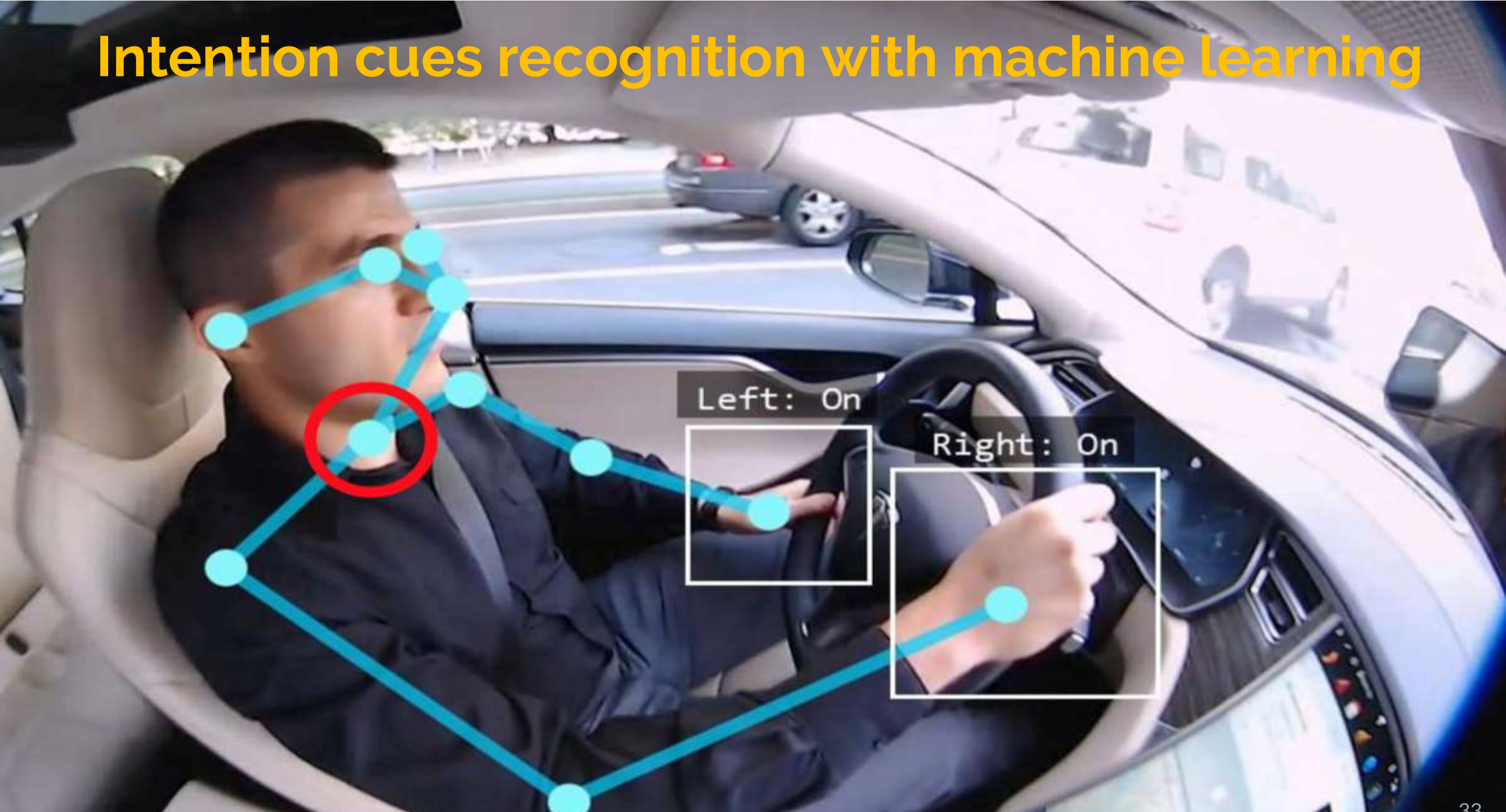
Human-machine cooperative driving (Flemisch et al. 2016)

Intention embedded in body movements

(Google images)

Body movements as a form of non-verbal communication (kinesics)

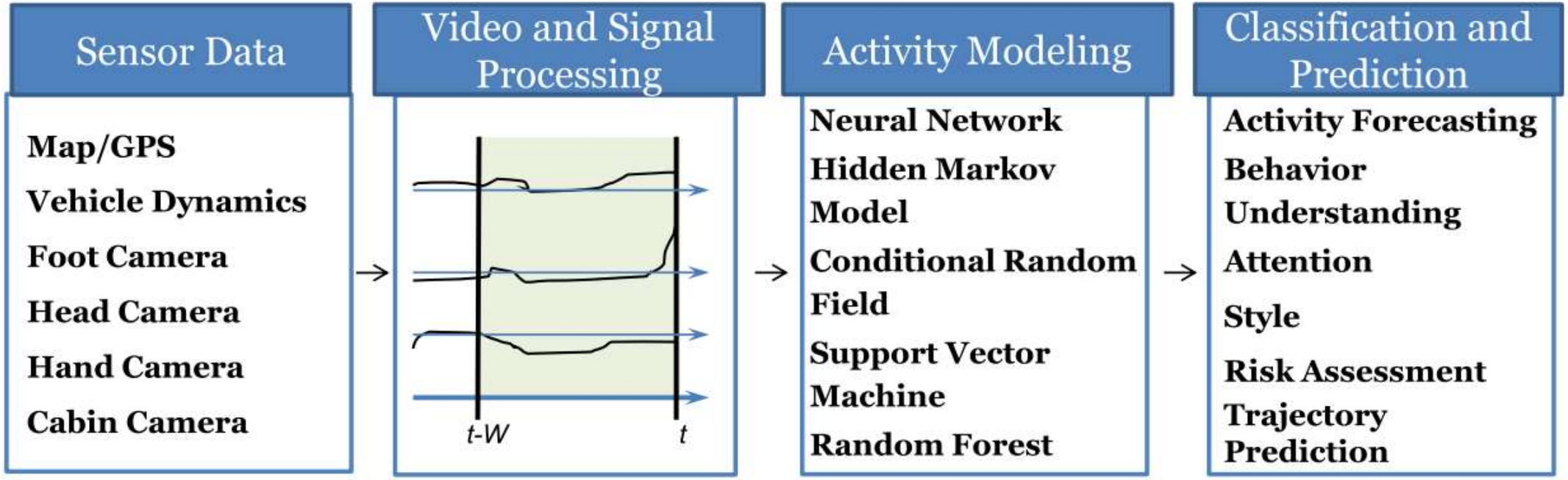
Intention cues recognition with machine learning



MIT Advanced Vehicle Technology Study (Fridman et al., 2019)

Intention embedded in body movements

Machine Learning Algorithms



Overview of the sensing and learning pipeline commonly used to study humans in the cabin (Ohn-Bar & Trivedi, 2016)

Human-Centred Intention-Aware Machine learning model

- **When** intention was needed
- **When** intention was perceived
- **What** was the driving context

Learning from humans

Objectives

Research objectives

1. Discover, analyse and provide an understanding regarding how **intention cues** are **intuitively shared** between **human driver** and **co-driver/passenger** pairs.

2. **Explore** and deploy **machine learning algorithms** that are able to **extract** high-level and interpretable features (**human driver's intention cues**) from human's driving behaviour during the driving task.

Research objectives

3. Development of novel **human intention recognition** mechanisms in a quantitative way. In other words, explore and deploy **machine learning** models to **recognise** the **human driver's intention**.

4. Create a **dataset**, focused on **human-centric cues**, that may allow the development of more detailed research regarding **intention awareness** in the context of automation more broadly.

Research Questions

This PhD research aims to answer the fundamental question:

"How can a human-centred context-dependent intention-aware recognition system be modelled and work accurately in a dynamic driving task?"

1. *How are the **intention cues** being **intuitively shared** between **human driver** and **passenger**?*

    a) *How do passengers **perceive** and **classify** human driver's **intention cues** during the dynamic driving task?*

    b) *What is the **impact** of **passenger's** **interaction** with the drivers?*

    c) *To what extent do the **passenger's** **awareness** cues **influence** the **driver's** **behaviour** and the process of **sharing intention cues**?*

1. *How are the **intention cues** being **intuitively shared** between **human driver** and **passenger**?*

    d) *How to **foresee** human drivers' **intentions** during the driving task?*

    e) *Which **factors influence** the manifestation of **intention cues** during the driving task?*

2. *To what extent the human driver's **intention cues** could be used by a **machine learning** model to effectively **recognise/classify** driving **intentions**?*

    a) *What are the **usability challenges** of the **intention-aware machine learning** model?*

Methodology

Methodology

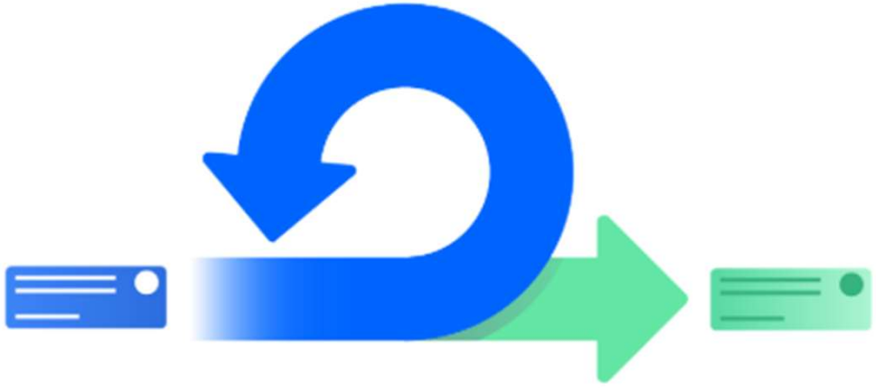
Fail fast → Learn faster → Succeed faster

(Google images)

Methodology

Sprints:

- 2 data sprints
- 3 evaluation sprints



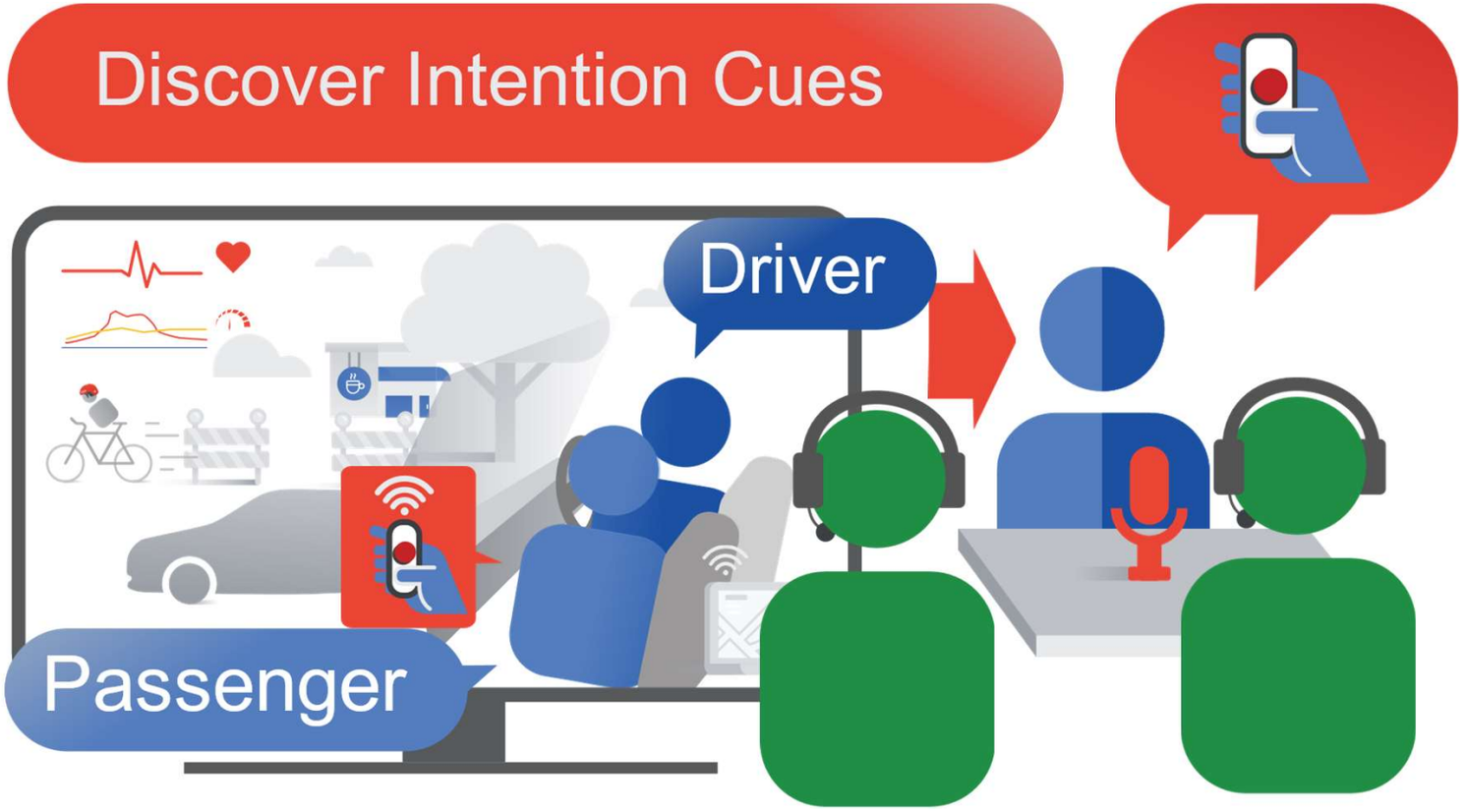
"Sprints make projects more manageable, allow teams to ship high-quality work faster and more frequently, and gives them more flexibility to adapt to change."

(Attlasian)

Study 1 Design

Study 1: Field Observation

Understand how human-human intention cues are shared during the driving task



Study 1 overview: Field observation

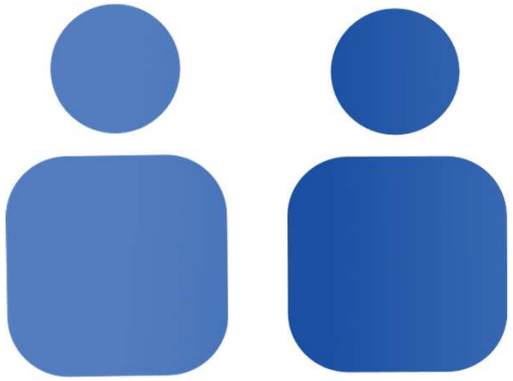
Participants

Group 1

Partner Passenger

Regular Driver

Group 2



Stranger Passenger

Unfamiliar Driver

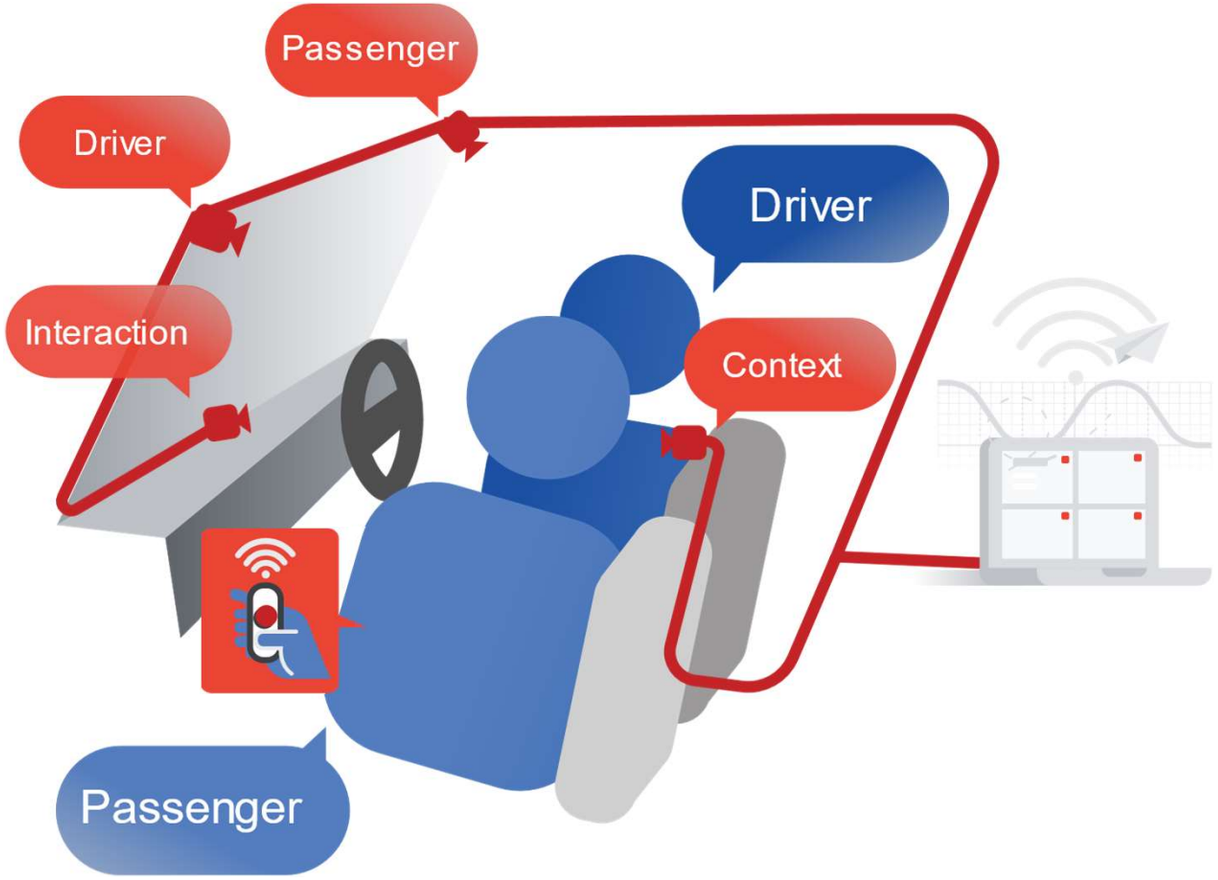
Group 3

Professional Passenger

Novice Driver

Varying degrees of trust, familiarity, comfort, among others …

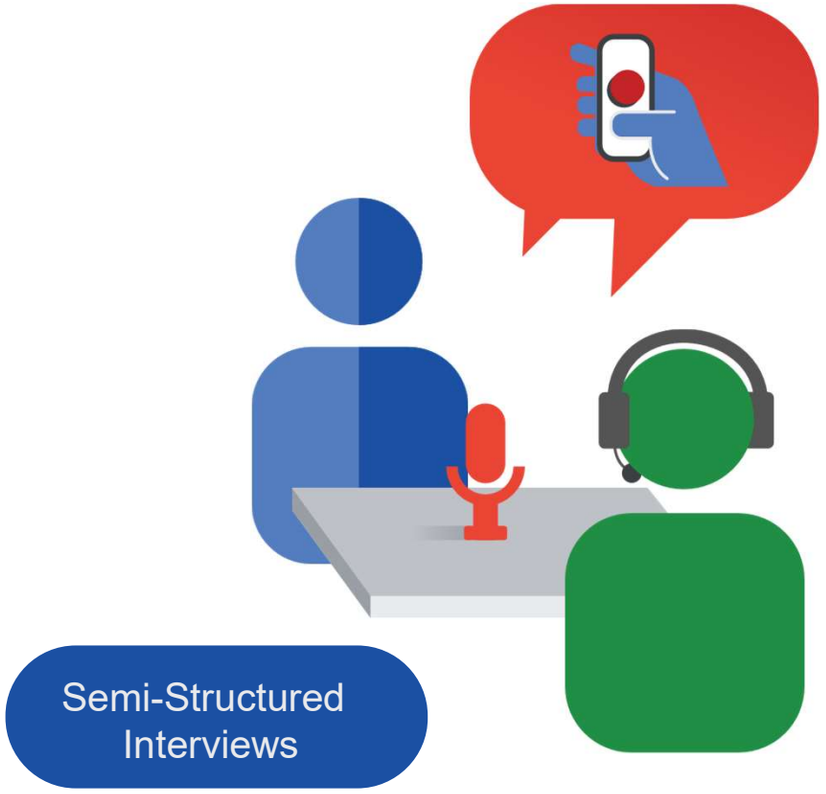
Apparatus – 1st Iteration



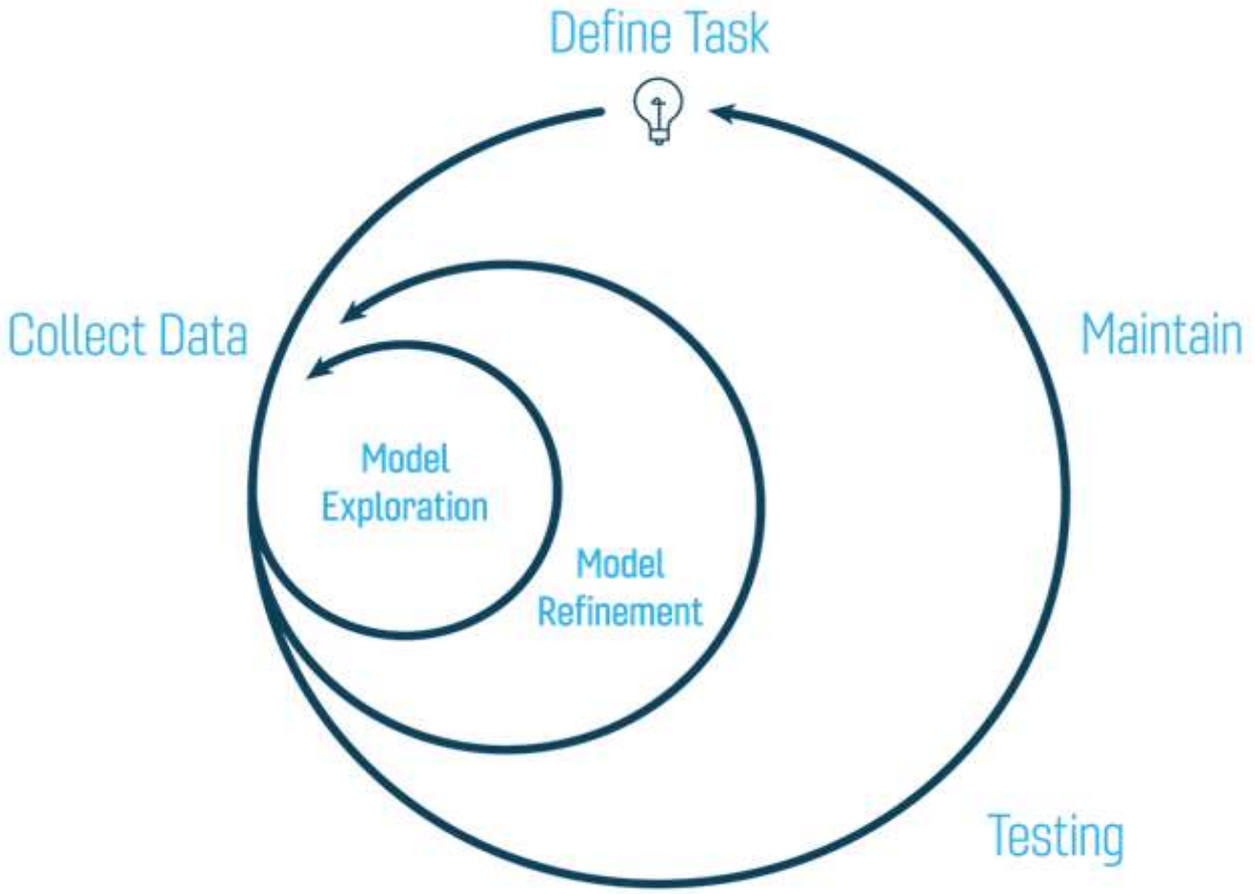
First proposal for the data acquisition system from a variation of “WoZ Way” (Martelaro & Ju, 2017)

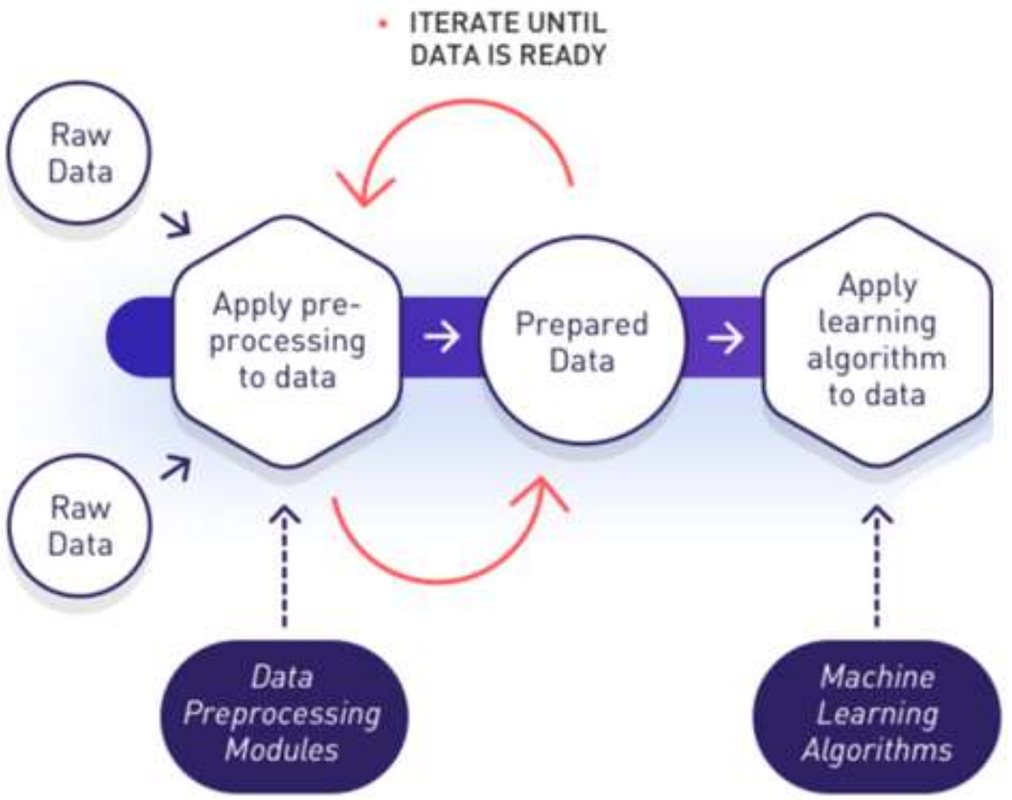
HUMAN CENTRIC

Post-drive interview



Methodology

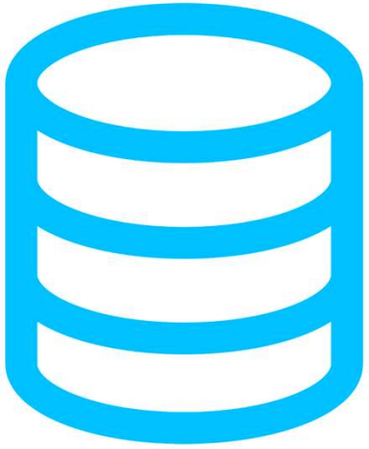




(Google images)

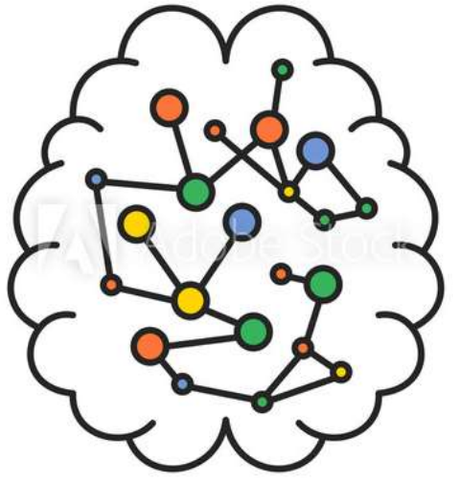
Development plan for "data" sprints (Study 1 and Study 2)

Expected outcomes – 1st Iteration



1st dataset iteration

Thematic labels



1st ML model exploration

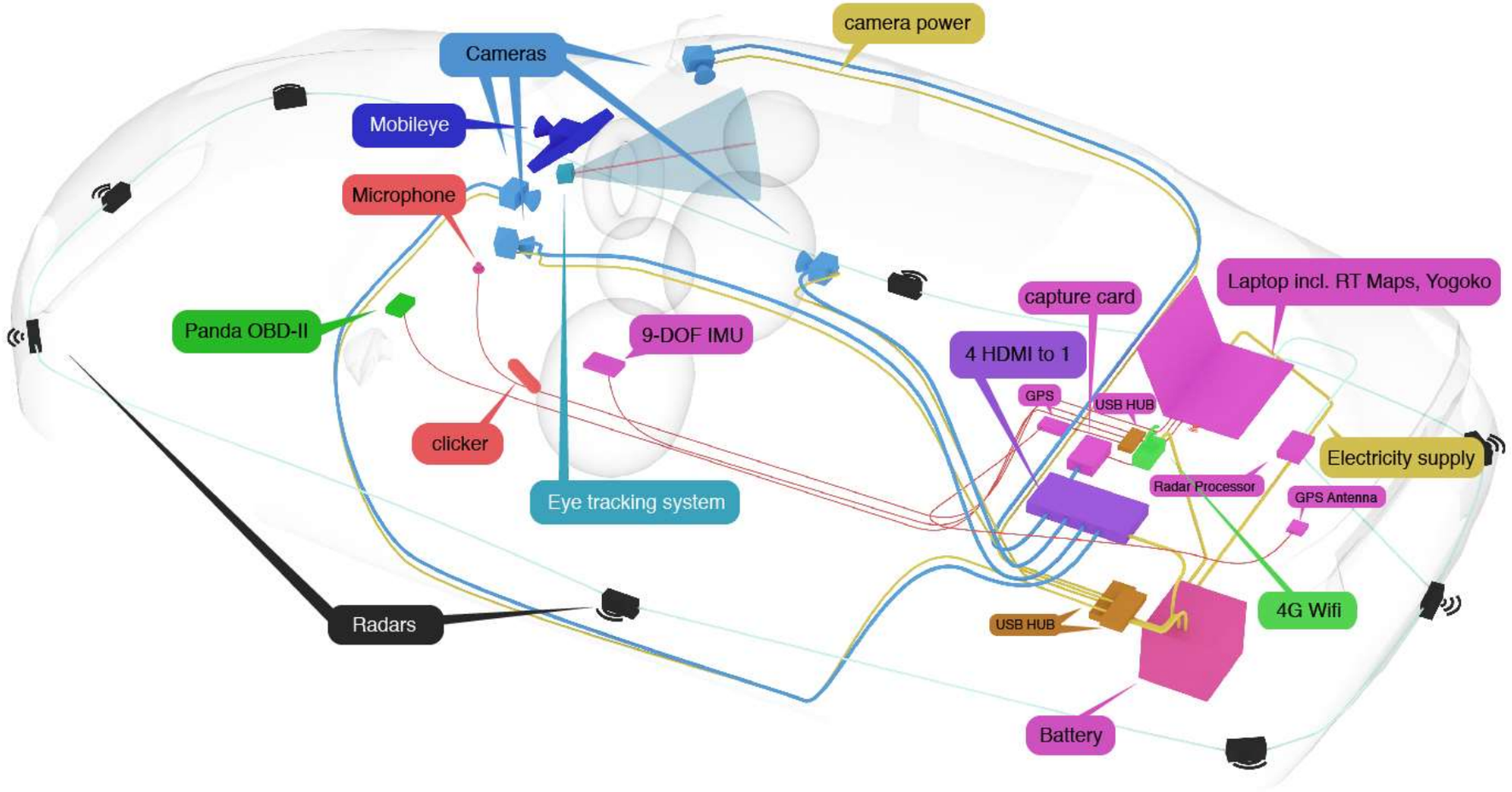
Insights

LESSONS LEARNED

Study 2

“*Fail fast, learn faster, succeed faster*”. Towards a human-centric intention-aware dataset.

Apparatus – 2nd Iteration

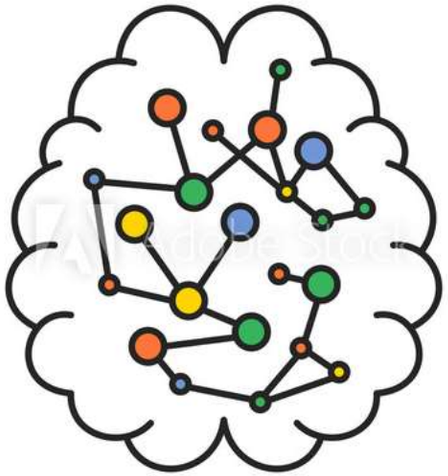


Proposal for the enhanced data acquisition system from a variation of "WoZ Way" (Martelaro & Ju, 2017)

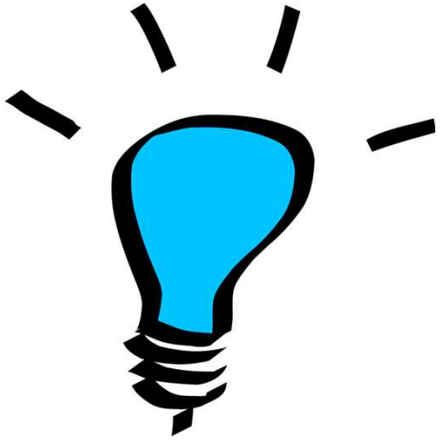
Expected outcomes – 2nd Iteration

Enhanced dataset

Enhanced thematic labels



2nd ML model exploration

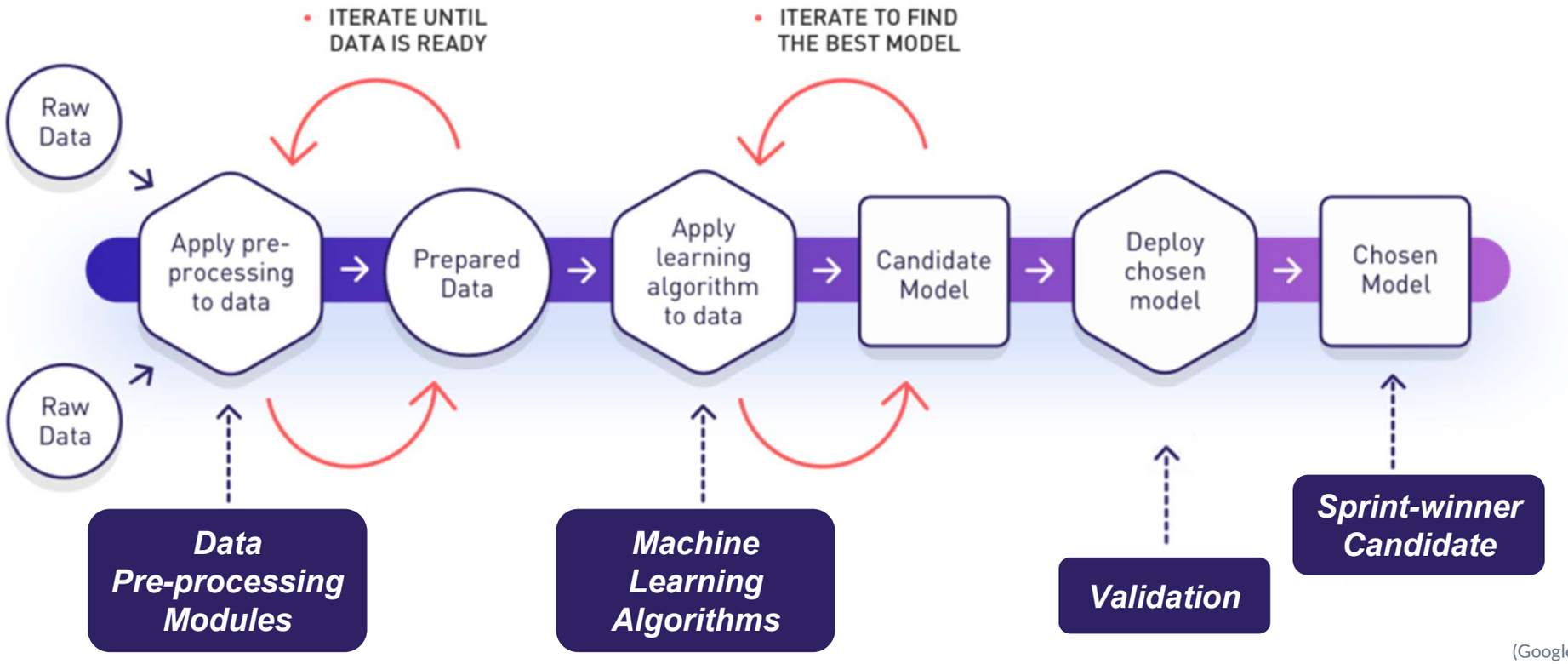


Insights

LESSONS LEARNED

Study 3

Test and validation of the machine learning model

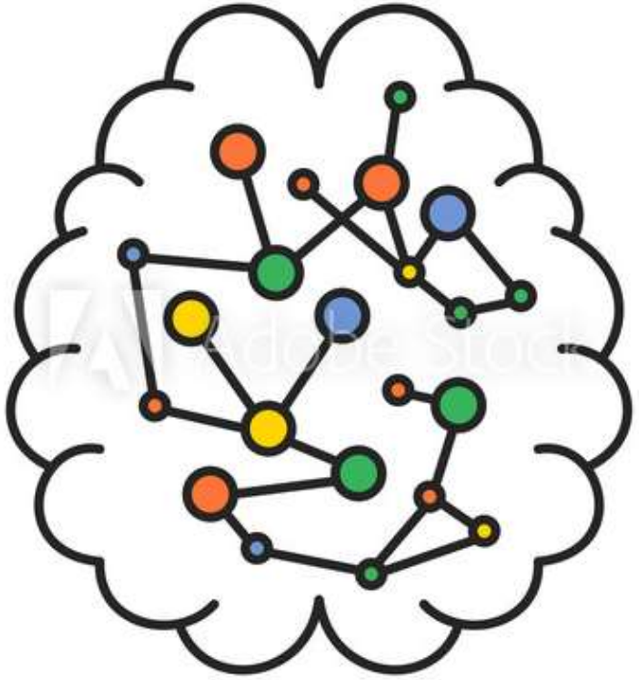


(Google images)

Pipeline for Study 3

Expected outcomes – 3rd Iteration

Final dataset



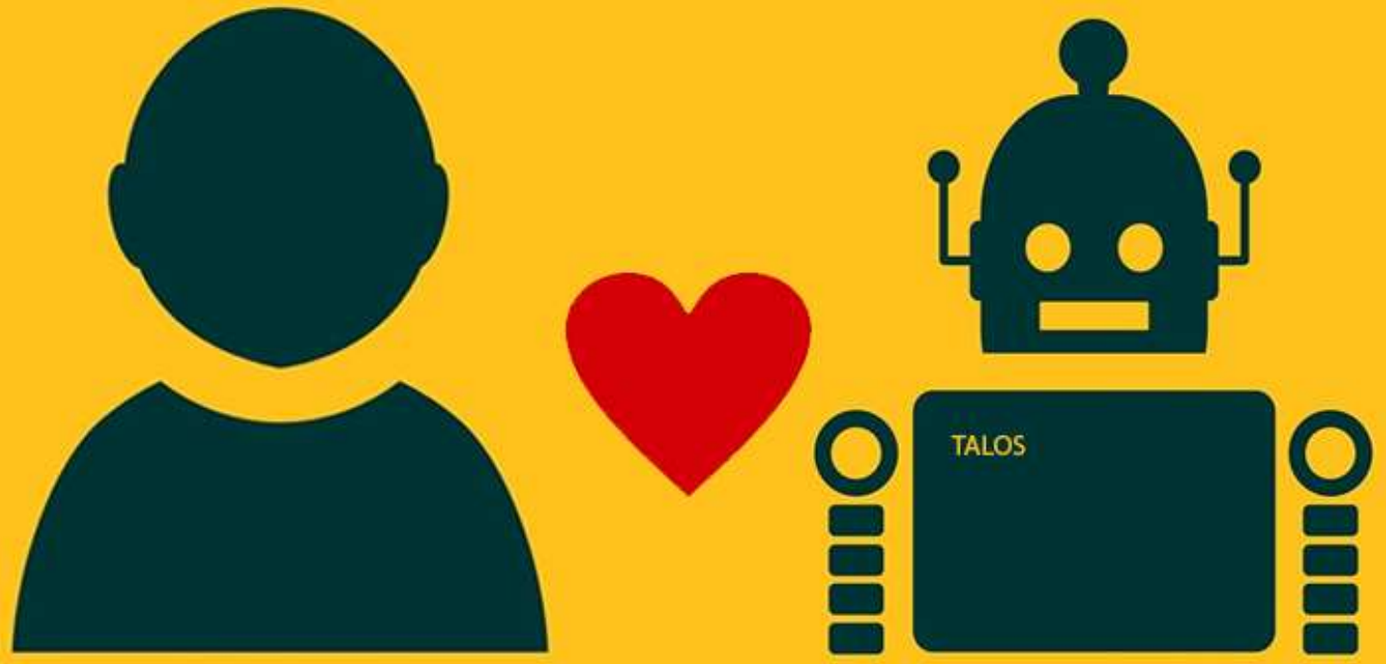
Final ML model

Results validation

Outlook

“Alone we can do so little; together we can do so much”

– Helen Keller



At the very least, it will help to decrease the number of times people say “stupid computer that does not share its driving intentions”

Thank you!

- Working on intention awareness towards cooperation is fun!

- I hope more of you “intend” to join the game

You can find me at:

jorgeluis.pardogaytan@hdr.qut.edu.au

Centre for Accident Research and Road Safety – Queensland (CARRS-Q),

Queensland University of Technology (QUT)

This research is supported by an Australian Government Research Training Program (RTP) Scholarship and the ARC Discovery DP180103491.

https://research.qut.edu.au/carrsq/

References

Jack Weast. Chief Systems Architect for Automated Driving, Intel.

Hoc, J. M. (2000). From human-machine interaction to human-machine cooperation. *Ergonomics*, *43*(7), 833–843.

Flemisch, F., Winner, H., Bruder, R., & Bengler, K. (2016). Cooperative Guidance, Control, and Automation. In H. Winner, S. Hakuli, F. Lotz, & C. Singer (Eds.), *Handbook of Driver Assistance Systems: Basic Information, Components and Systems for Active Safety and Comfort* (pp. 1471–1481). Springer International Publishing.

Ju, W. (2015). The Design of Implicit Interactions. *Synthesis Lectures on Human-Centered Informatics*, *8*(2), 1–93.

Howard, N., & Cambria, E. (2013). Intention awareness: improving upon situation awareness in human-centric environments. *Human-Centric Computing and Information Sciences*, *3*(1), *9*.

Howard, N. (2013). Intention-based automated conflict prediction and notification system (USPTO Patent No. 8407281). In *US Patent* (No. 8407281). https://patentimages.storage.googleapis.com/7a/7f/f6/3ab178cef7624c/US8407281.pdf

Fridman, L., Brown, D. E., Glazer, M., Angell, W., Dodd, S., Jenik, B., … Reimer, B. (2019). MIT Advanced Vehicle Technology Study: Large-Scale Naturalistic Driving Study of Driver Behavior and Interaction With Automation. *IEEE Access*, *7*, 102021–102038.

Ohn-Bar, E., & Trivedi, M. M. (2016). Looking at Humans in the Age of Self-Driving and Highly Automated Vehicles. *IEEE Transactions on Intelligent Vehicles*, *1*(1), 90–104.

Martelaro, N., & Ju, W. (2017). WoZ Way: Enabling Real-time Remote Interaction Prototyping & Observation in On-road Vehicles. *Companion of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing*, 21–24.

Credits

Special thanks to all the people who made and released these awesome resources for free: Presentation template by SlidesCarnival

Photographs by:

- Google images
- Getty images