「安全・安心なロボティックス」

Towards Comfortable Autonomous Vehicles

環境理解グループ
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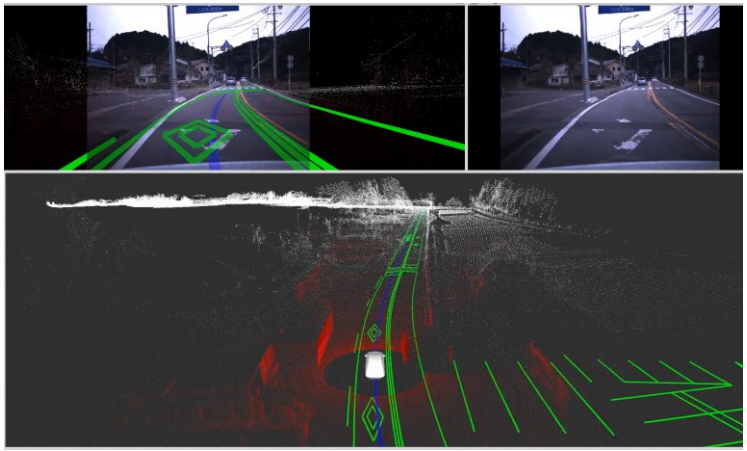
Presentation Contents

- State of the art of Autonomous Vehicles
- What is missing in Autonomous Vehicles
- Towards Comfortable ride in autonomy
- Experimentation with Personal Mobility Vehicles

State of the Art in Autonomous Navigation

Necessary Technical Elements

- Map Building
- Localization
- Path Planning (Global, Local)
- Autonomous Navigation



Development and Experimentation in Small Sized Passenger Vehicles in

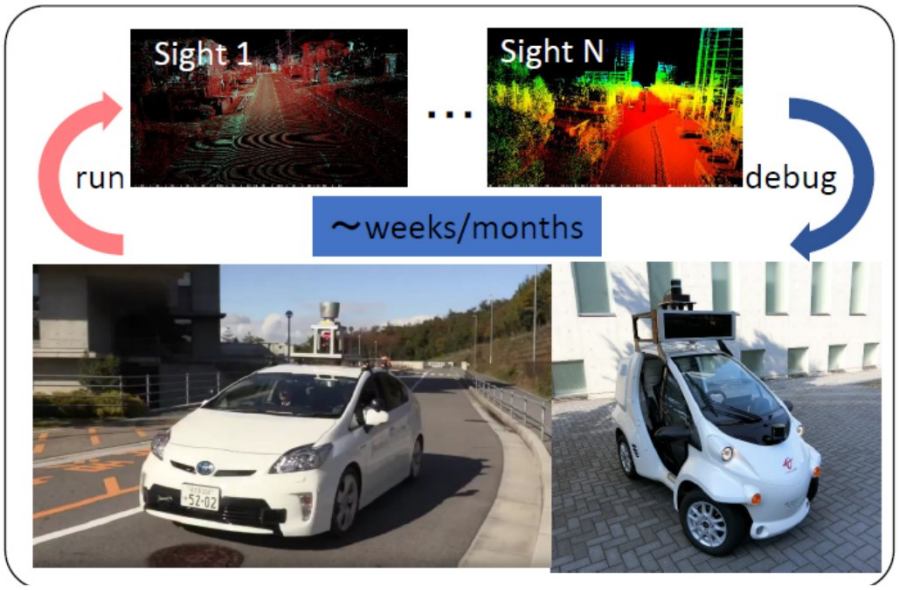
規範ドライバの運転データに基づく安全かつ快適な自動運転

自動運転車両

- レベル4に向けた自動運転
- 滑らかな軌道生成技術による安全かつ快適な自動走行
- 死角などでの飛び出しを予測した走行

小型パーソナルモビリティロボット

- 自動運転モジュールの検証プラットフォーム
- 学内での実験および学生でも使用可能
- 実装した認識モジュールは自動運転車両と共有可能
- 試乗による感性評価＋安全かつ高速なテスト環境



issues

module

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What is Missing in Passenger Vehicles?

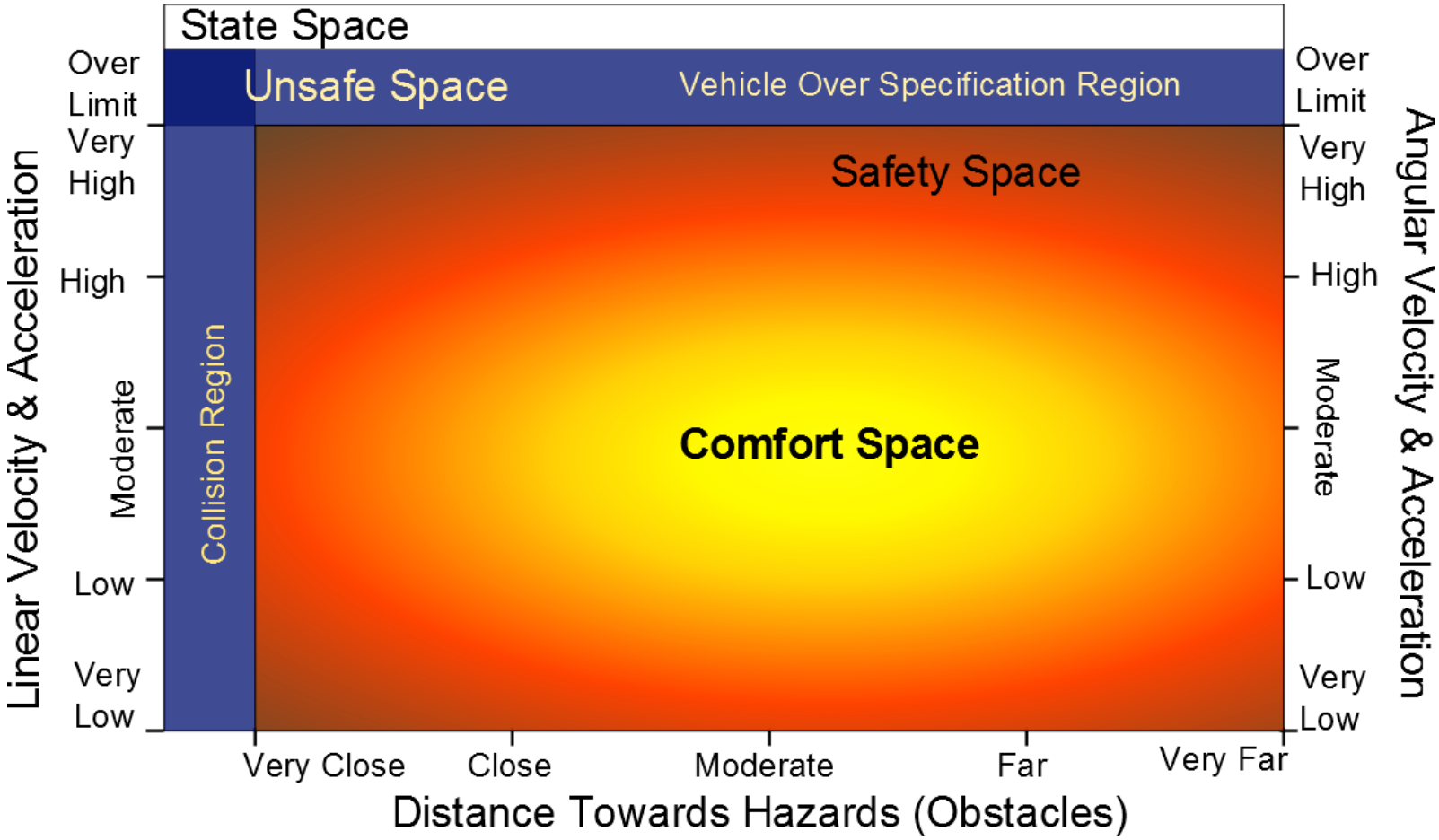
- Autonomous navigation in dynamic environments is feasible
- The navigation is safe: “Obstacle collision free”
- However,

  How comfortable is it ?



- Safe & Reliable ≠ Comfortable (sense of ease, relief)

Safe vs Comfortable



Comfortable Navigation Locations

- Straight segments:
  - Visible Areas (Non Occluded)

Human-Comfortable Navigation for an Autonomous Robotic Wheelchair
Morales et. al., (**IROS 2013**)

Comfortable Navigation Locations

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Discomfort Comfort

Comfortable Navigation Locations

- Straight segments:
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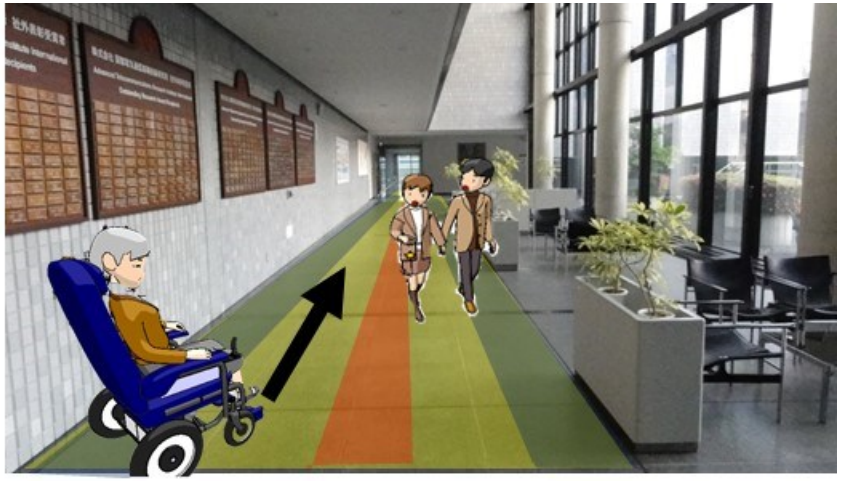

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Discomfort Comfort

Comfortable Navigation Locations

$$U(y) = \frac{a}{y} + \frac{a}{1-y} + \left(\frac{y-c}{b}\right)^2$$

$$p(y) = e^{-U(y)}$$

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Discomfort — Comfort

Modeling Turns and Corners: 3D Environmental Visibility Map

Non-blind corner

Blind corner

Visibility Analysis for Autonomous Vehicle Comfortable Navigation
Morales et. al., (**ICRA 2014**)

Modeling Turns and Corners: 3D Environmental Visibility Map

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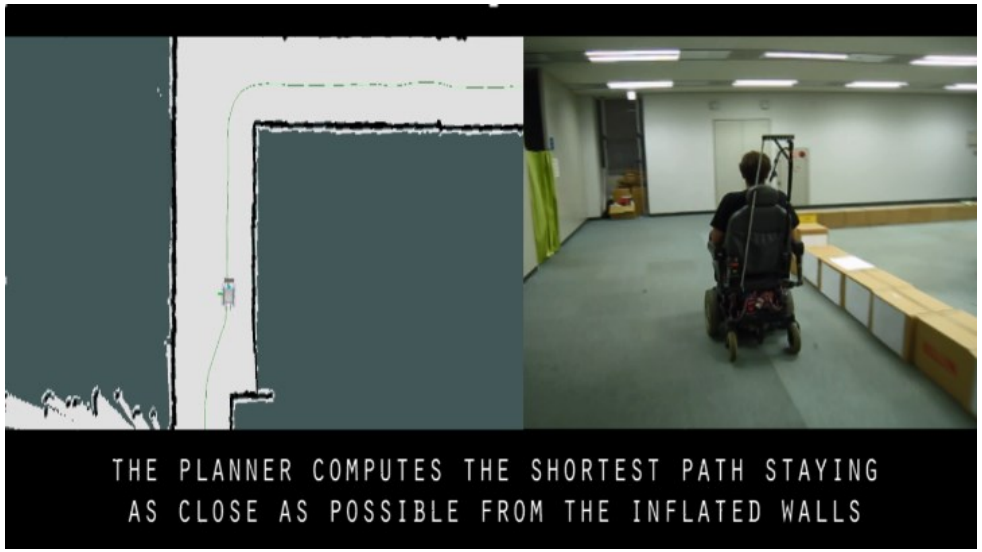
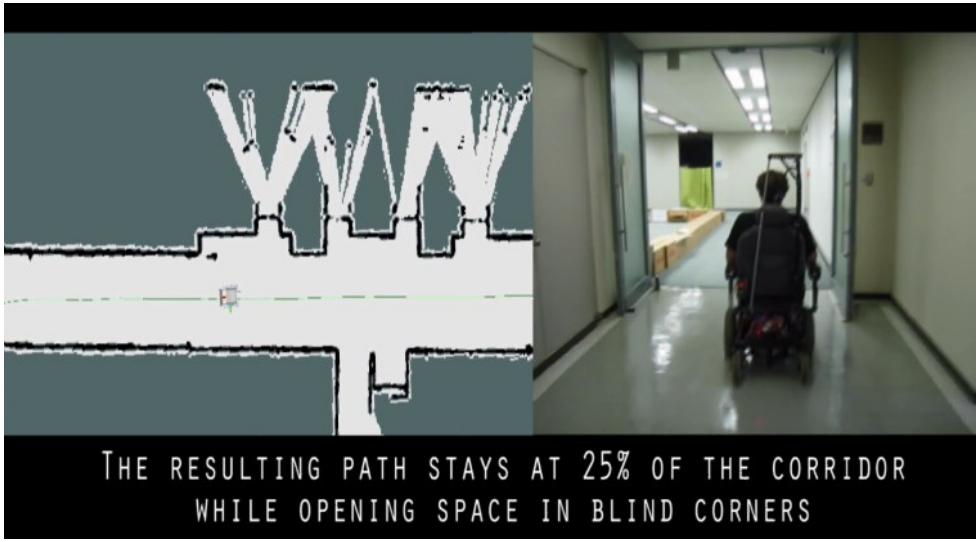
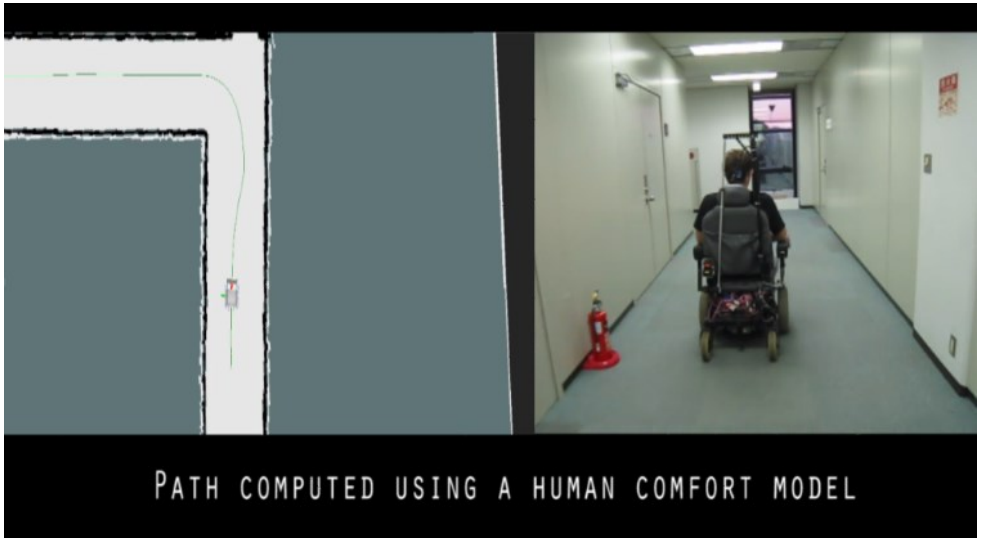
Discomfort

Comfort



Including Human Factors for Planning Comfortable Paths
Morales et. al., (**ICRA 2015**)





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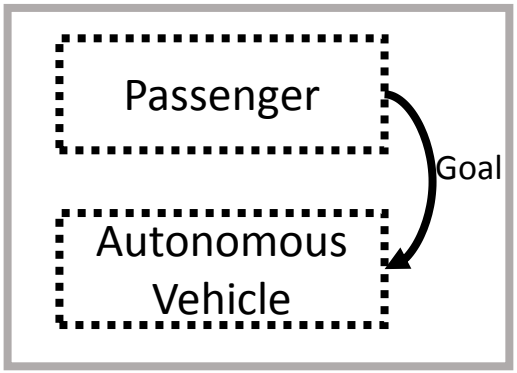
Communicating Navigation Intentions



Watanabe & Morales et. al., (**IROS 2015**)
Communicating Robotic Navigational Intentions

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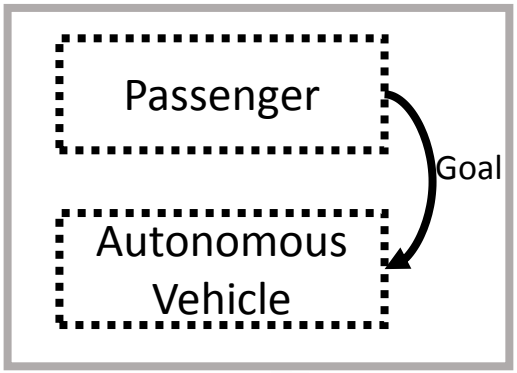

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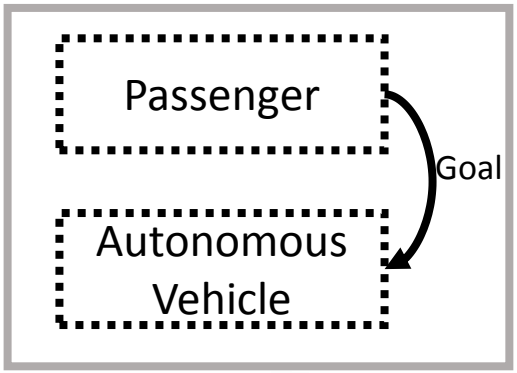

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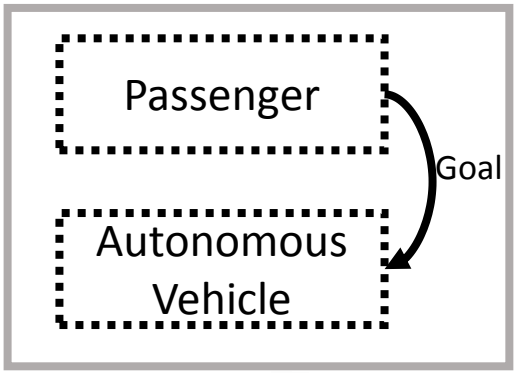

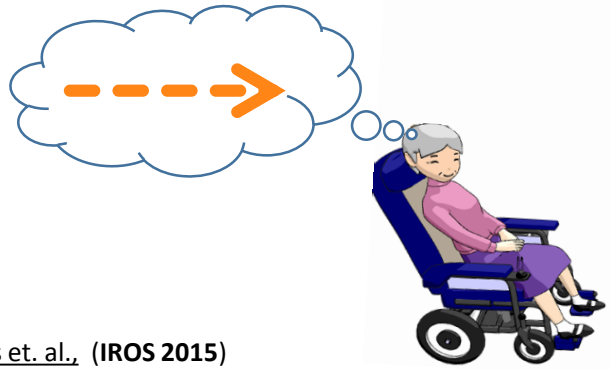

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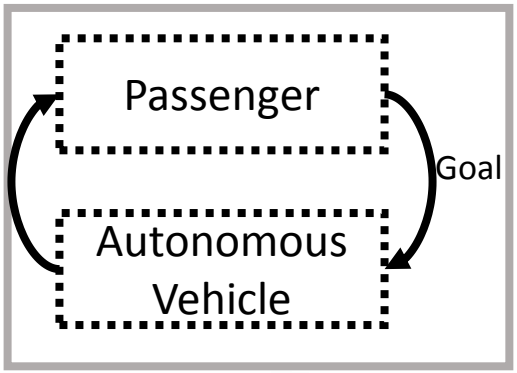
Communicating Navigation Intentions

Navigational
Intention cue



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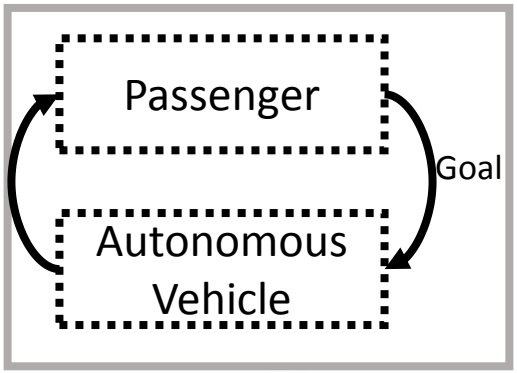
Navigational Intention cue



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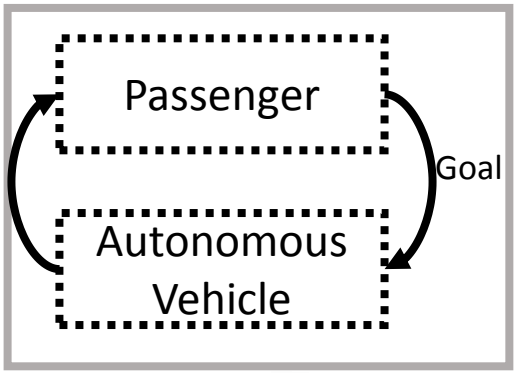
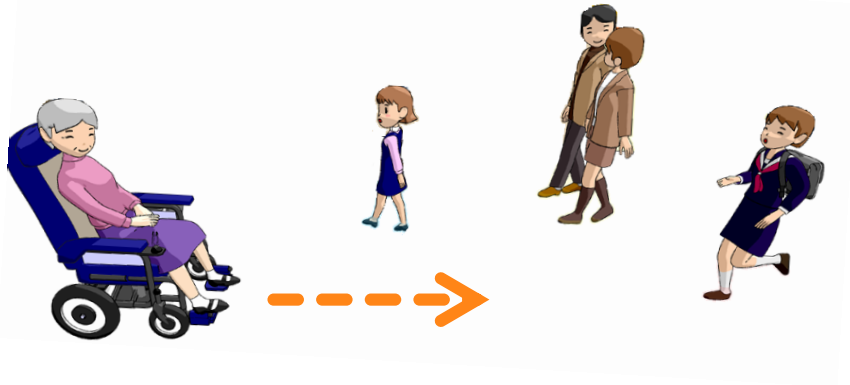
Navigational Intention cue



Pedestrians



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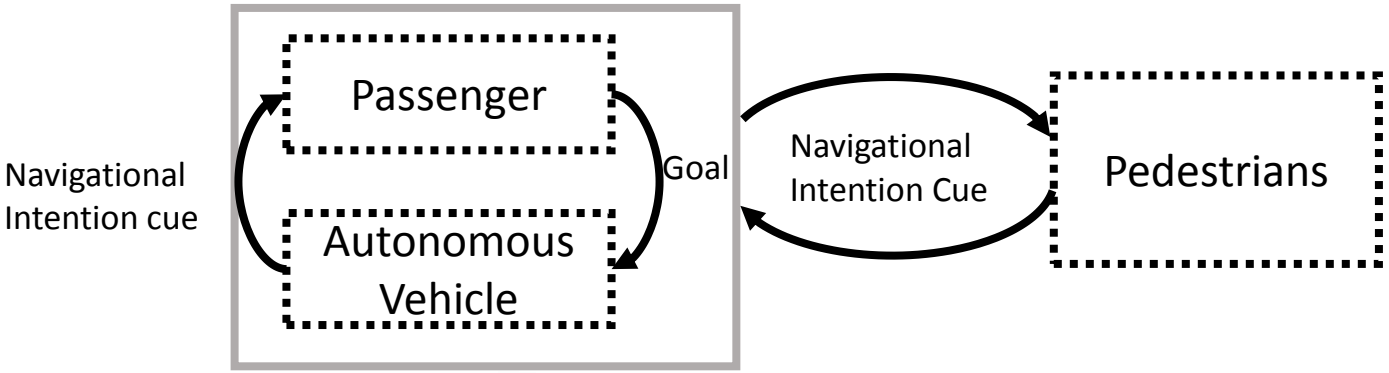

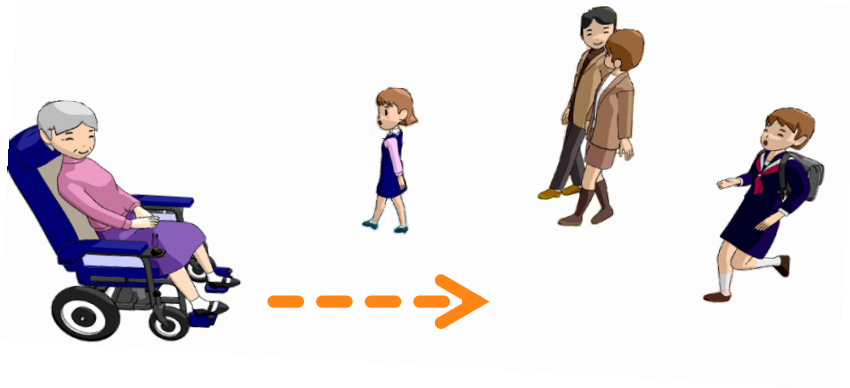

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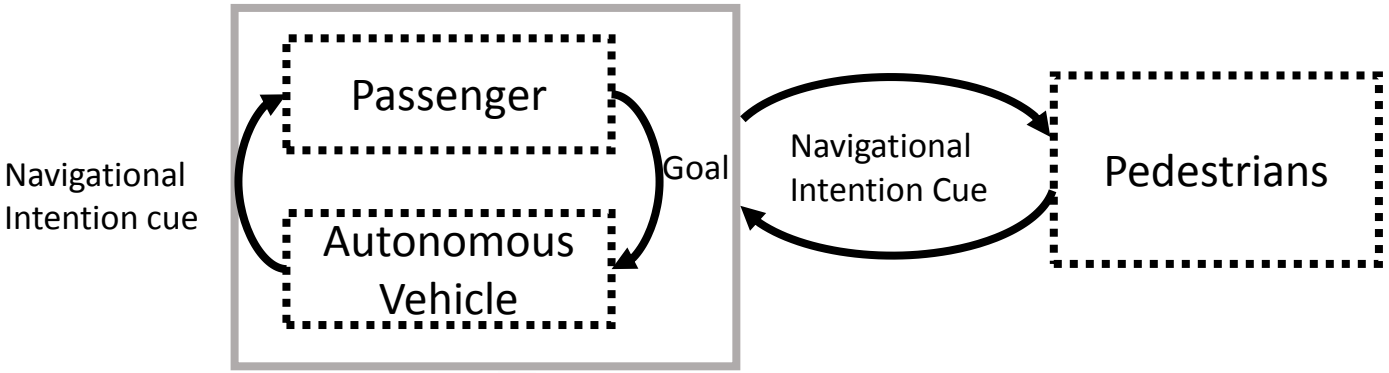

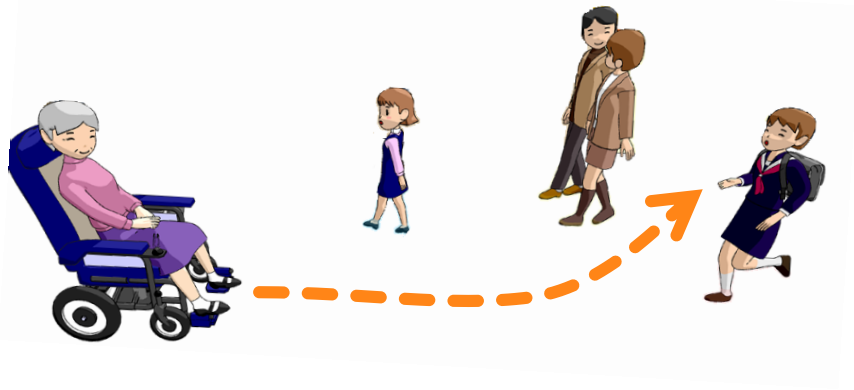

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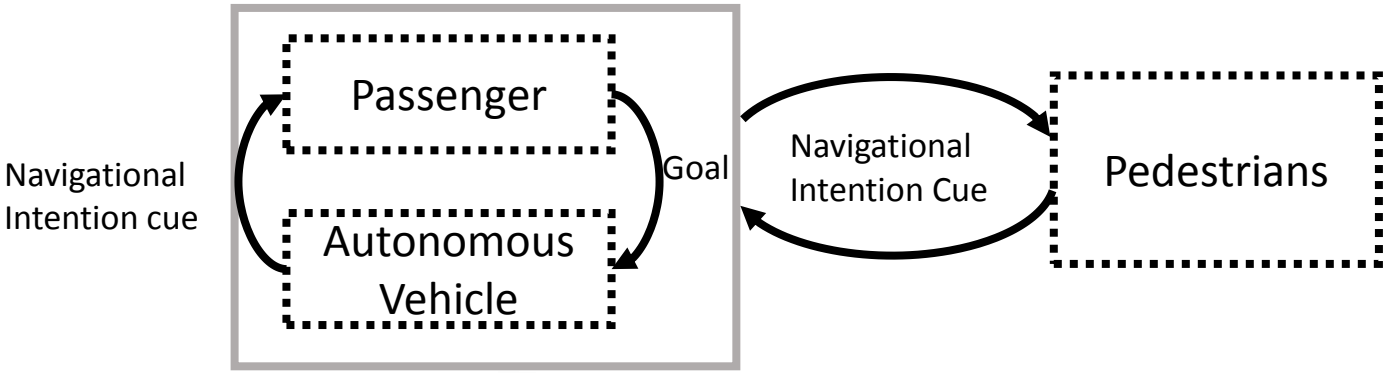

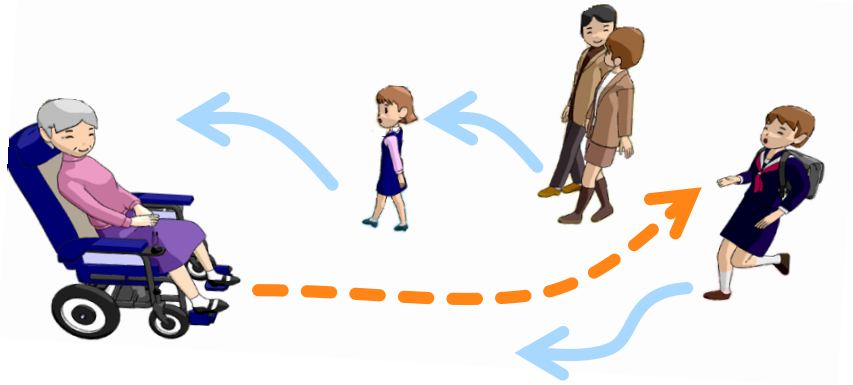

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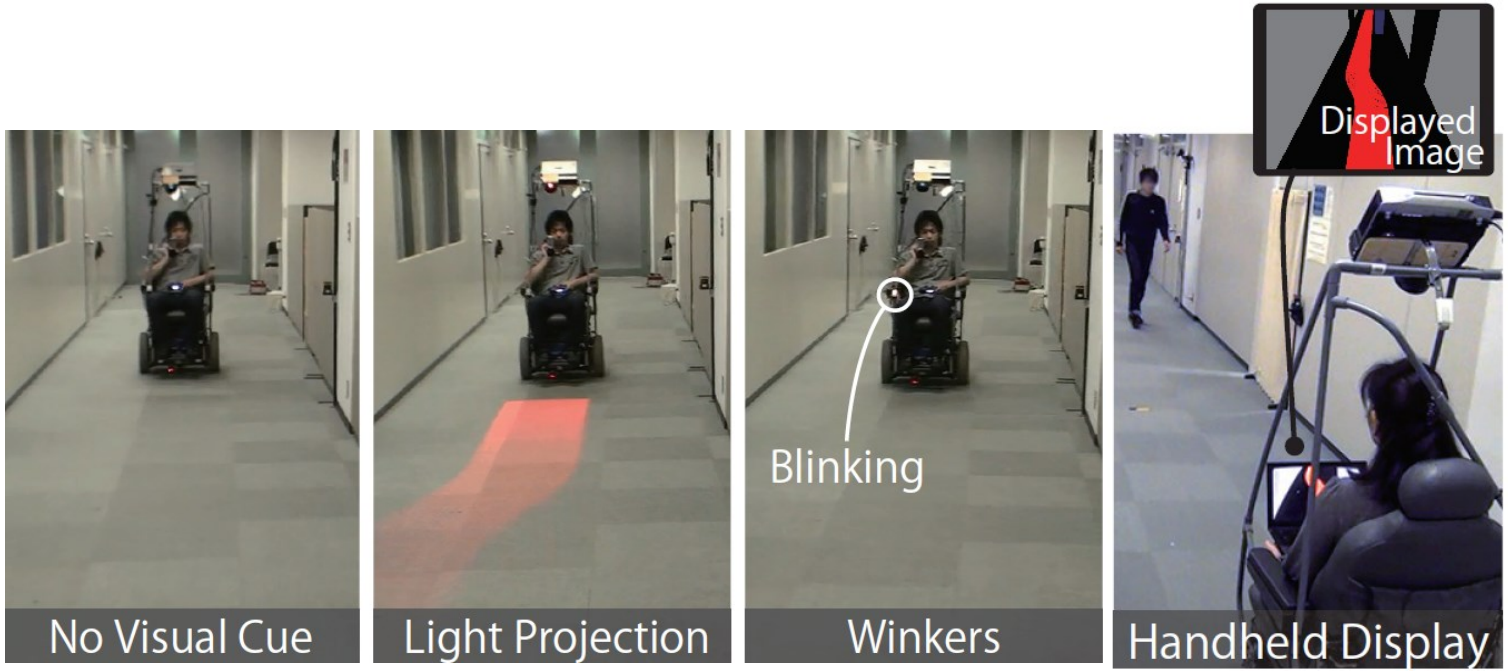
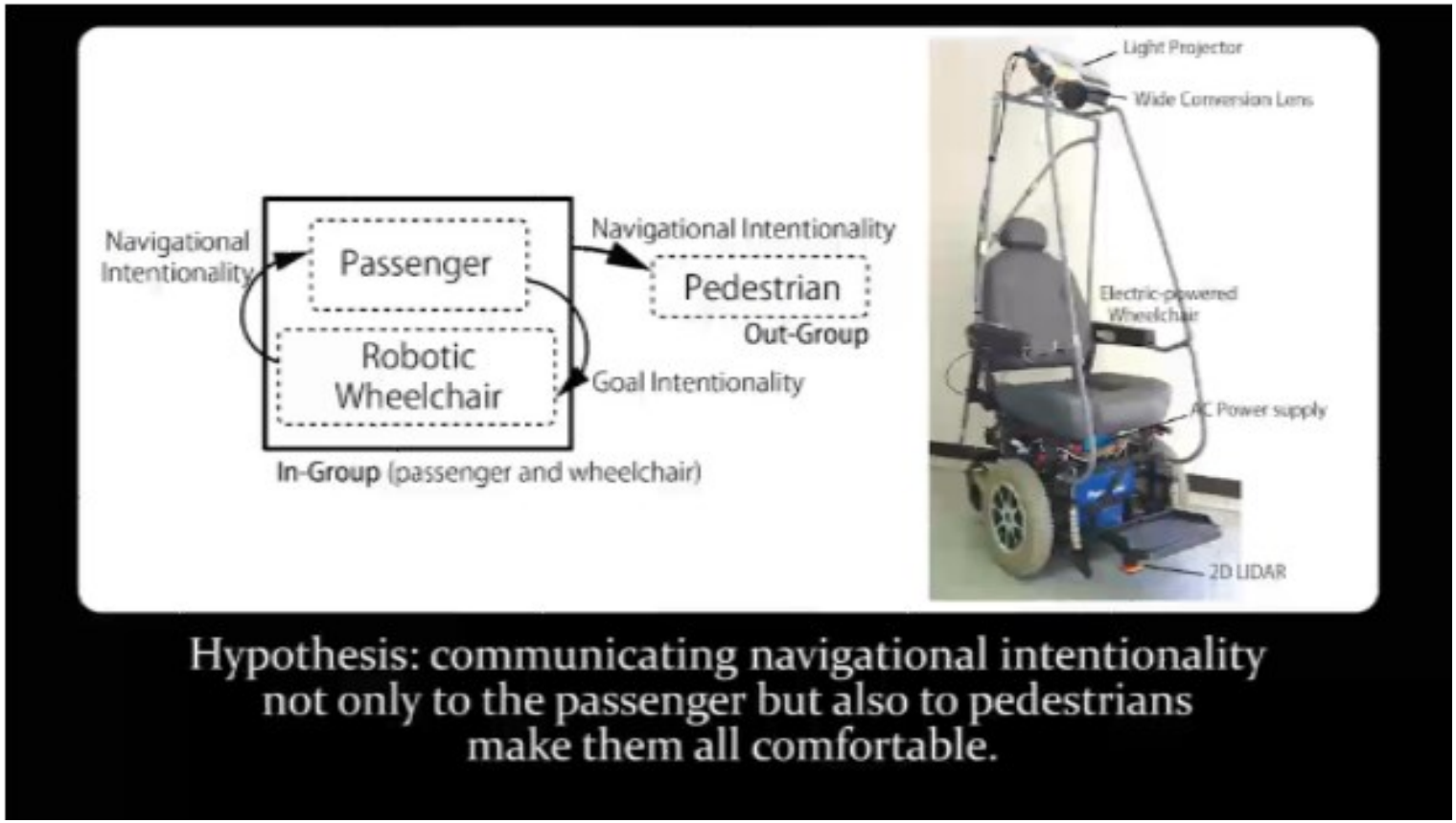
Autonomous Vehicle Facing Pedestrians



Communicating Navigational Intentions



Watanabe et., al., "Communicating Robotic Navigational Intentions"
IROS 2015


No motion cue.


Light projector shows wheelchair's future path.
Pause
Change of the planned path immediately projected
and navigational intentionality shared.


Hand-held display shows wheelchair's future path.


Hand-held display shows wheelchair's future path.
They go to the same side
due to lack of navigational intentionality communication.

Conclusions

- Self driving vehicles are for humans
- We have to consider the humans in the control loop
- We have to keep developing
  “Human Centered Autonomous Driving Vehicles”