Research on the recognition technology required for automated driving technology (Lv. 3 and 4)

Leader: Naoki Suganuma, Kanazawa University

SIP

Cabinet Office

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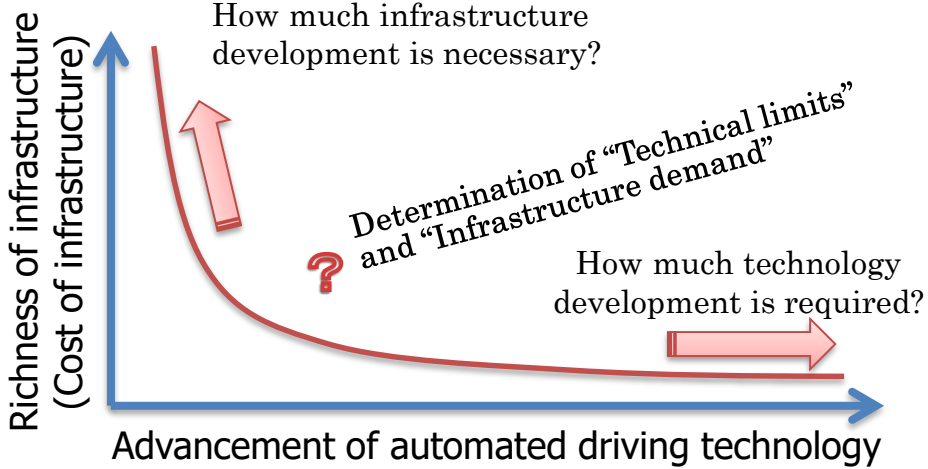
6. Assessment of traffic signal recognition
7. Utilization of remained traffic light time
8. Conclusion

Background

- Level 4 equivalent autonomous driving at urban area
  - Advanced perception and decision making system by onboard AI
  - Infrastructure such as road facilities and communication facilities to support it
- State-of-the-art autonomous vehicle technology
  - Competition area in the industry
  - Knowledge of academia is essential



Kanazawa Univ., Chubu Univ., Meijo Univ.

Open research at universities

Demonstration experiment at Tokyo waterfront area

Outcome

Determination of minimum required of infrastructure and recognition technology

Members

Cabinet Office SIP
METI

NEDO

Cooperation

Expertise from outside

Leader: Kanazawa Univ.
Naoki Suganuma

Direction

Kanazawa Univ.
（Autonomous driving）


Naoki Suganuma, Keisuke Yoneda
Theme: a, b, c, d, e, f

Chubu Univ.
（AI）


Takayoshi Yamashita, Hironobu Fujiyoshi
Theme: a, b, d, e

Meijo Univ.
（GNSS）

Junichi Meguro
Theme: c

Experiment-vehicle and safety management

Data analysis

Demonstration experiment (Kanazawa Univ.)
- Kanazawa city, Tokyo waterfront area, etc.

Cooperation

Cooperative research org.
(OEM, Tier1, Camera, Traffic light, Map, Insurance, Neutral research center etc.)

Coordination with external org.

Frontier Science and Social Co-creation Initiative, Kanazawa Univ.

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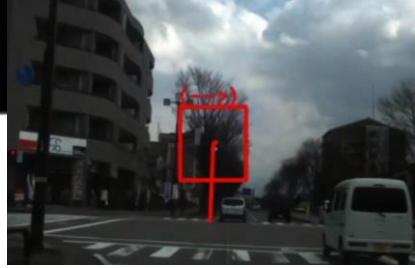
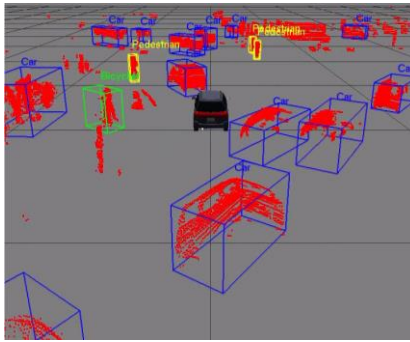
Themes

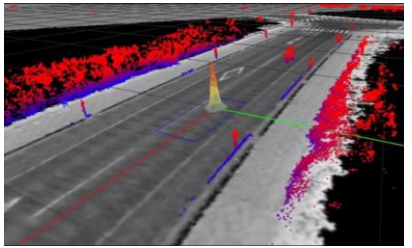
- a. “Development of traffic signal recognition technology and investigation of difficult condition”
  - Verification of effects by using infrastructure-supported traffic lights
- b. “Development of AI technology required to detect distant object”
  - Recognition of traffic participants required when entering an intersection
- c. “Development of high precision self-localization technology”
  - Development of low-cost GNSS/INS system using QZSS
  - Determine road marking maintenance demand for stable map matching
- d. “Development of behavior prediction technology of traffic participants and path planning algorithm”
  - Safety driving among many traffic participants in urban area
- e. “Investigation of problem in the situation where multiple autonomous vehicle exist”
  - *Deadlock* problem where two or more autonomous vehicles are stuck
- f. “Demonstration experiment”
  - At Kanazawa city and Tokyo waterfront area



Traffic signal recognition



Object detection



Localization

Summary of demonstration experiment

- Objective
  - Proof of concepts of theme a. ~ e.
    - Acceleration of research by real experiment-vehicle experiment
  - Investigation regarding infrastructure
    - Places where need installation of infrastructure-supported traffic lights
    - Road marking maintenance demand for stable map matching
    - Others (Situation where needs V2X, etc.)

- Experiment-vehicle
  - Built two experiment-vehicles
    - Public road experiment at center of Kanazawa city
    - Public road experiment at Tokyo waterfront area (60+ days per year)
  - LiDAR, Mill Wave Radar, Camera, GNSS/INS, ITS receiver, etc.

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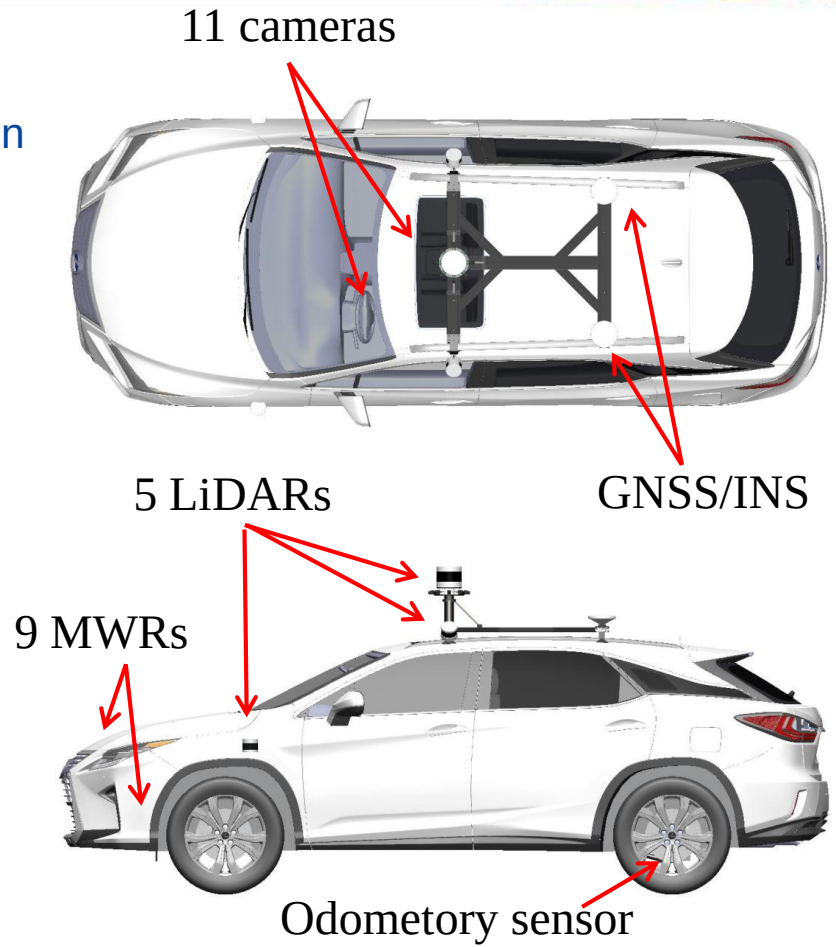
Progress of demonstration experiment

- Public road experiment (Tokyo, Kanazawa)
  - Evaluation of localization and object recognition
    - Utilization of simulation technology
  - Cooperative driving with ITS traffic lights (Tokyo waterfront area)

Receiving remained traffic light time



Demonstration experiments at Tokyo waterfront area

- Experiment record in 2019：Driving day：67[day], Autonomous mileage：850.6[km]

Evaluation of traffic light recognition

- Evaluated by each traffic light
  - 96.2% accuracy of traffic lights within 120 m

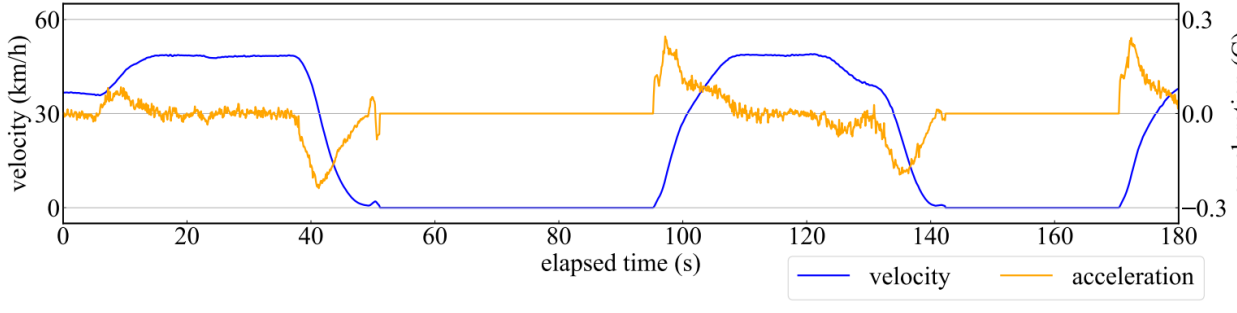
- Found problems
  - False positive
    - Occlusion by other cars, trees, etc.
    - Misperception between red and yellow light
  - False negative
    - Sun backlight
      - Able to mitigate by HDR
    - Looking up from very close to traffic lights
      - Due to the directional characteristic of LED traffic lights

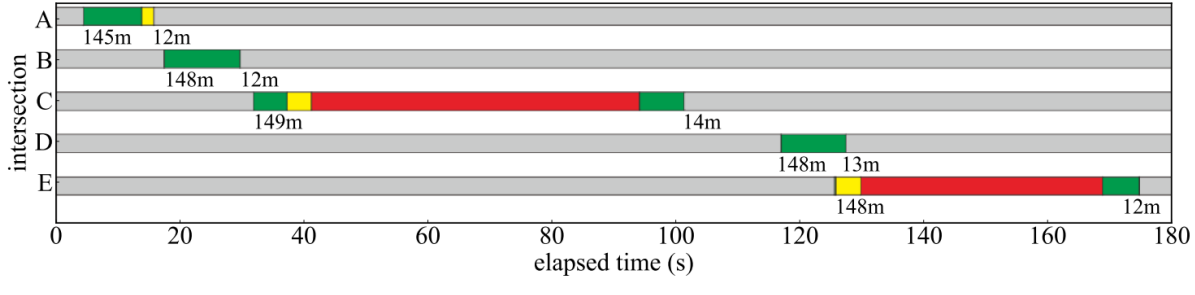
	Light	Arrow	Ave.
F-score (within 120m)	0.981	0.942	0.962

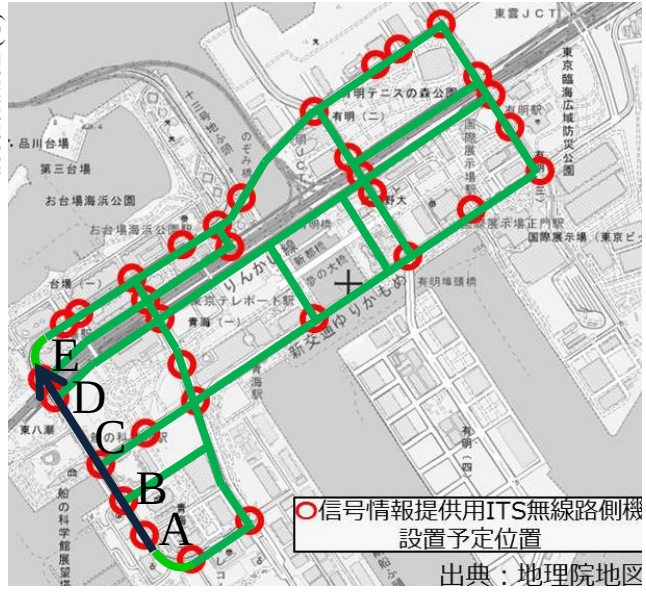
(※Evaluated by each traffic light)

Evaluation of traffic light recognition

- Decision making of entering intersection
  - No big problems where multiple traffic lights installed
    - FY2020's Goal: 99+% accuracy of decision making of entering intersection
  - Continue to investigate situations that would cause problems for entering intersection

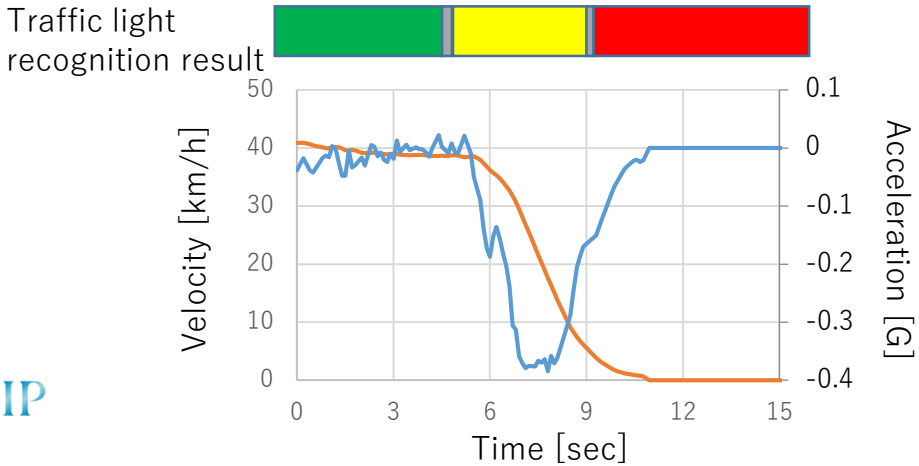


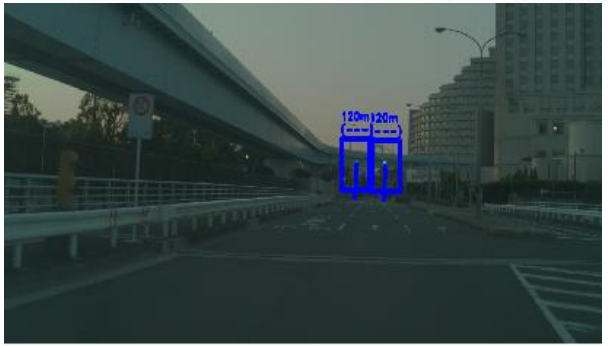




Example of dilemma zone

- Traffic light recognition by on-board camera and decision making of entering intersection
  - Urgent deceleration would occur when the light changes right before entering intersection
  - Ex: driving at 40[km/h]
    - Starts decelerating 40[m] before stop line
    - Max deceleration 0.38[G]



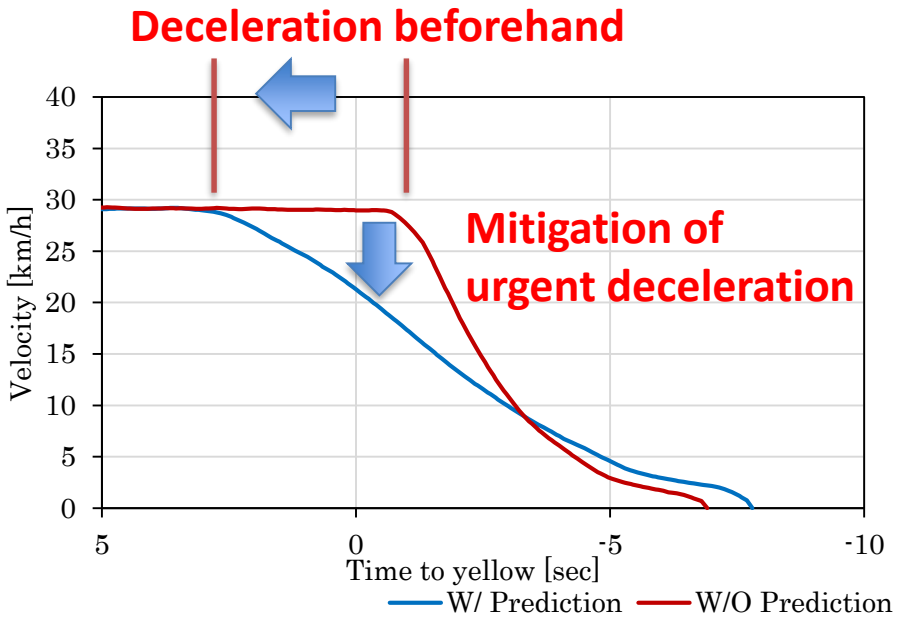


Approaching intersection as recognized “blue”
(Distance to traffic light: 120[m])

Recognize “yellow” 40[m] before stop line
(Distance to traffic light : 69m)

Cooperative driving with remained traffic light time

- Effective of infrastructure-supported traffic light
  - Radio receiver of traffic light information
  - Utilization of remained traffic light time
- Evaluation using test traffic light
  - Deceleration using remained traffic light time
    - Enters intersection at dilemma zone purposely
    - Adjusts the timing of start moving
  - Largely mitigated the urgent deceleration
- Current
  - Experimenting at Tokyo waterfront area



Conclusion

- Demonstration experiment
  - Built two experiment-vehicles
  - Executed at Tokyo waterfront area
    - Experiment record in 2019：Driving day：67[day], Autonomous mileage：850.6[km]

- Evaluation of traffic light recognition by on-board camera
  - 96.2% accuracy of traffic light (evaluated by each traffic light)
  - 99+% accuracy of decision making of entering intersection
    - Continue to investigate situations that would cause problems for entering intersection

- Cooperative driving with remained traffic light time
  - Urgent deceleration would occur when using only on-board camera for recognition
  - Mitigated the deceleration at dilemma zone by utilizing remained traffic light time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2020
Thank you