

Critical region detection for non-road^(*) navigation

(*) open space, sidewalk, and shopping street scenes, etc.

■ Goal and background

- Modeling an attention mechanism to critical region for non-road (e.g., street scenes) navigation.
- Research on drivers' attention exist for the road scenes (e.g., <https://deepdrive.berkeley.edu/node/395>), but we don't have enough examples and data (datasets) for non-road scenes.



■ Approach

- Collect gaze data using a wheelchair and an eye tracker.
- Construct and analyze an attention model with making the eye-tracking data as ground truth (or proposal).

■ Steps

- Collecting data with controlling an electric wheelchair with various sensors including an eye-tracker.
- Design, train, and evaluate an attention model with the data.
- Discriminate attention from eye movements (critical or not)

■ Future directions / Extensions

- Application to autonomous navigation.
- Comparison with neural attention module trained in an end-to-end manner.



Tobii eye-tracker



WHILL CR

End-to-end recognition of alert level / end-to-end control for non-road^(*) navigation

(*) open space, sidewalk, and shopping street scenes, etc.

■ Goal and background

- Realize a robot that can move safely and efficiently in the sidewalk and/or shopping street scenes.
- Most of recent navigation research focus on autonomous driving vehicles on the road scenes, thus we don't have enough examples and data (datasets).

■ Approach

- Alert-level recognition for autonomous driving
 - Example situations and actions: level 0: move (wide area, no moving objects), level 1: move with care (collision avoidance, mobile objects), level 2: stop (fast moving objects, too crowded)
- End-to-end imitation learning
- Dataset generation using real data

■ Steps

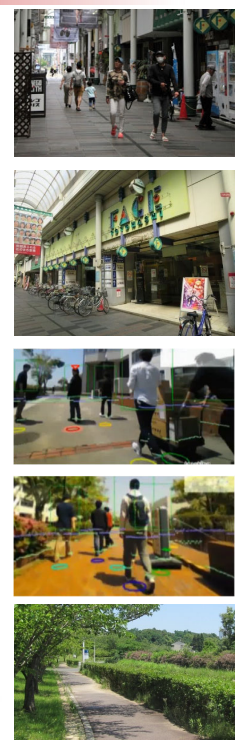
- Collecting data with controlling an electric wheelchair with various sensors.
- Dataset generation: manually assigning alert-levels or alert-level estimation from control signal sequence.
 - Semantic segmentation and depth estimation (optional).
- Train and evaluate the models.

■ Future directions / Extensions

- Autonomous navigation of the wheelchair.



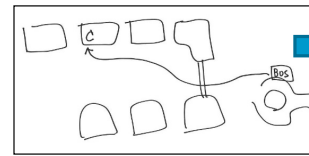
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Outdoor navigation using a hand-drawn map

■ Goal and background

- Navigate a robot with a hand-drawn map (like human).
- We previously developed a SLAM method with FastSLAM and PSO (particle swarm optimization)-based map refinement. The method assumes that the hand-drawn map is qualitatively correct and uses a simple object classifier. No autonomous navigation.



Example hand-drawn map: large buildings and a route (from bus stop to Building C)



A part of TUT campus.

■ Approach

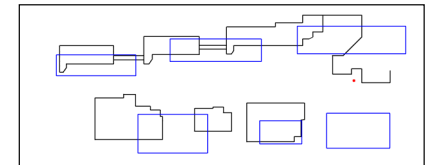
- A unified formulation using particle filter (covers multiple hypotheses on map-observation correspondence)
- A more accurate object classifier (e.g., semantic segmentation)
- Waypoint selection (motion planning) based on the current map.

■ Steps

- Formulate the SLAM problem and develop observation functions.
- Test in simulation and a real world.
- Autonomous navigation with waypoint selection.

■ Further directions / Extensions

- Multiple hypotheses extraction and query generation for interactive navigation.



Initial map (blue) superimposed on the true one (black).



Final map and the estimated path.

[Matsuo and Miura, 2012]

Motion skill-based scene categorization

■ Goal and background

- A new categorization of outdoor environments based on the robot motion skills (how the robot moves). The categorization is used for choosing appropriate skills for autonomous navigation.
- Most of scene recognition focus on what each object is, not on how the robot moves at each scene.

■ Approach

- Designing a motion skill set for a variety of scenes (e.g., the whole TUT campus).
- Categorize an input scene in terms of skills needed for maneuver.

■ Steps

- Analyze lots of scenes and list necessary motion skills. A skill is a sensory-motor function (e.g., road following).
 - Different scene may use the same skill, while similar scenes may use different skills.
 - Construct a taxonomy of motion skills.
- Designing a network for skill-based scene categorization (from an image to a category).
 - Semantic segmentation subtask may be useful.

■ Further directions / Extensions

- Route planning with recommended skills.
- Navigation of a real robot.



Follow the left-side step



Follow the center of the road



Move down the street with person avoidance



Move towards next subgoal with person avoidance

Scene-skill examples

Person re-identification for collaborative guide robots



■ Goal and background

- Describing and transferring person's information (mainly appearance) for collaboration between human and robot or robots.
- Most identification methods are image-based, not text-based. Relationship to image captioning.

■ Approach

- Image-to-text transfer and text-based matching.
- Comparison with image-based methods.

■ Steps

- Define a set of attributes for describing a person (male/female, height, clothing, etc.) and the dataset generation.
- Construct an image-to-text transfer model.
- Evaluate the model, with comparison with existing image-based methods.
- A POC (Proof-of-concept) guiding scenario.

■ Future directions / Extensions

- Campus-wide guiding with autonomous guide robots.

Personal Service Robot with Verbal Human-Robot Interaction

■ Goal and Background

- We have developed an ontology-based knowledge management system for personal service robots.
- Can interact with the user in a predefined manner.

■ Approach (Two extensions)

- (1) interact with the user only when needed
- (2) learn new objects interactively.

■ Steps

- (1) Develop a planning algorithm for choosing actions (ask the user, search by itself, etc.) which increase the efficiency and the usability.
- (2) Develop a method of extracting information of a new object and memorizing it with relationships with existing objects.

■ Future directions / Extensions

- Extensive experiments using real robots.
- The robot that can recognize a new home with occasional interaction with the user.

