Lecture 5: Perception and Action

Part 3 of 4

Navigation

Relevance

Oprea, S., Martinez-Gonzalez, P., Garcia-Garcia, A., Castro-Vargas, J.A., Orts-Escolano, S. and Garcia-Rodriguez, J., 2019. A visually realistic grasping system for object manipulation and interaction in virtual reality environments. Computers & Graphics, 83, pp.77-86.

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Bergström, J., Mottelson, A. and Knibbe, J., 2019, October. Resized grasping in VR: Estimating thresholds for object discrimination. In Proceedings of the 32nd Annual ACM Symposium on User Interface Software and Technology (pp. 1175-1183).

Han, D.T., Suhail, M. and Ragan, E.D., 2018. Evaluating remapped physical reach for hand interactions with passive haptics in virtual reality. IEEE transactions on visualization and computer graphics, 24(4), pp.1467-1476.

Subramanian, M., Park, S., Orlov, P., Shafti, A. and Faisal, A.A., 2021, May. Gaze-contingent decoding of human navigation intention on an autonomous wheelchair platform. In 2021 10th International IEEE/EMBS Conference on Neural Engineering (NER) (pp. 335-338). IEEE.

Learning Objectives

To understand the information processing involved in navigating

To understand why human brain information processing has been key to understanding navigation and intention

To have an understanding of the applications of the perceptual cues for intention in the design of interfaces

Learning Outcomes

To be able to describe key experiments investigating human navigation

To be able to describe key experiments investigating human intention processing

To be able to describe how human perception experiments of intention can be used to design user interfaces

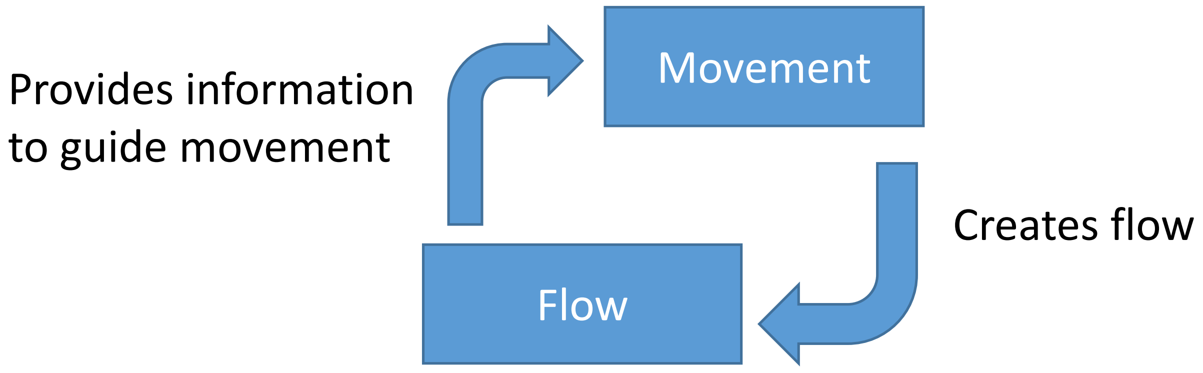
Recap

Ecological approach.

Self-produced information form a person's movement within an environment provides self-produced information to guide further movement.

I.e.., movement is useful for perception.

In particular, optic flow

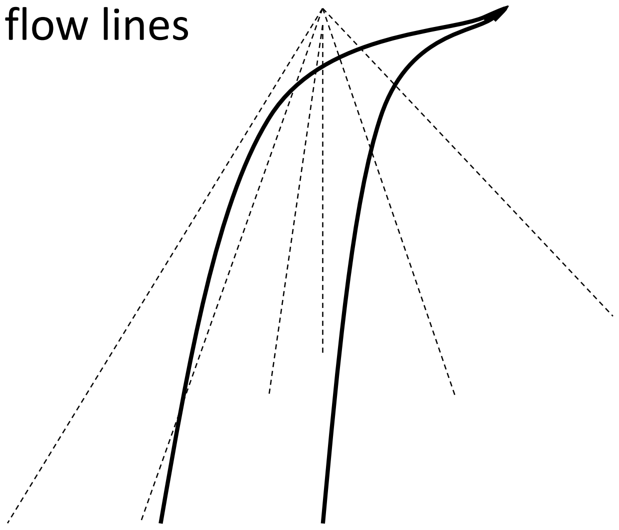


Optic Flow: Self-produced information for perception

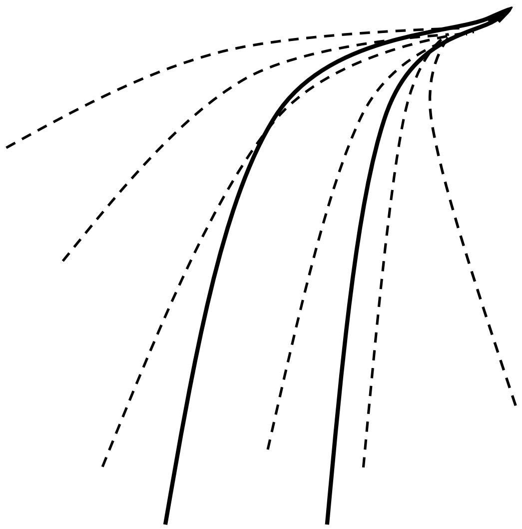
RECAP: Driving Experiments

Information other than FOE is used such as locomotor flow lines (Lee 1980)

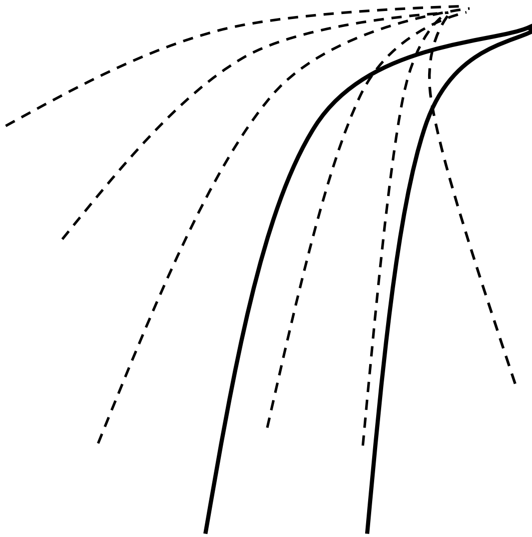
Optic flow lines



a) Movement along a straight stretch of road



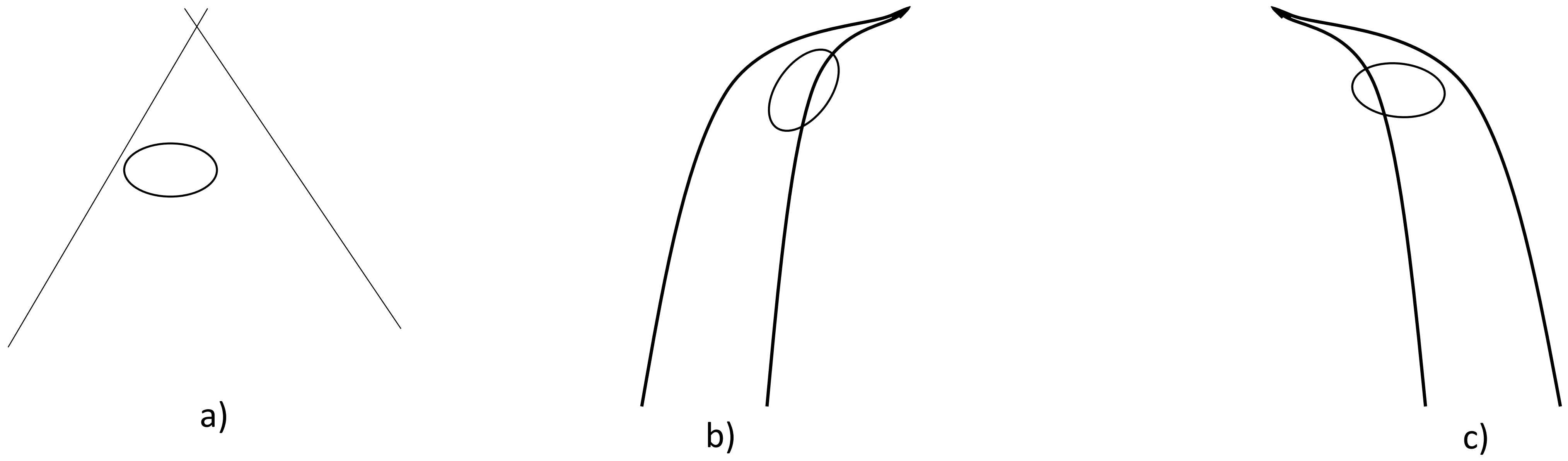
b) Correct negotiation of a curved stretch of road



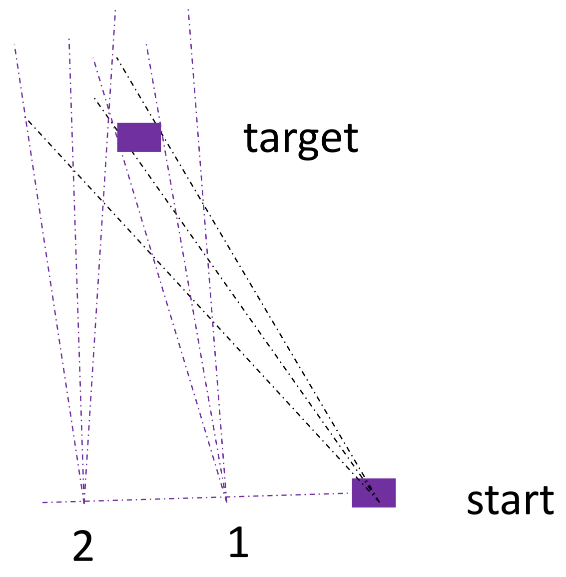
c) Incorrect negotiation of a curved stretch of road

Information used to determine heading

Other driving Experiments (E.g., Land and Lee 1994). Fitted a Jaguar with instruments to record angle of steering wheel and speed and also measured driver's gaze. Schematic shown below. In a) when driving straight ahead, driver looks straight ahead but not directly at the focus of expansion (FOE).
b) and c): When negotiating a curve drivers tend to look at the tangent point of the curve.
Drivers use information in addition to optic flow to determine their heading.
[Other experiments too, e.g., Rushton et al., 2001]



Information used to determine heading



Results of the eyes-closed experiment. Schematic shows paths taken

Philbeck et al., 1997)

Walking Experiments.

Visual direction strategy (does not involve flow): walkers keep body pointed at target.

Optic flow is not available in some circumstances, and not necessary, e.g., navigating at night or in snow.

Eyes-Closed Experiment (no optic flow information available): Individuals looked at target (6m from starting point), then closed eyes and begin walking to the left from the start position, and are asked to make a turn and walk to the target. They turned either at point 1 or point 2, keeping their eyes closed throughout, and kept walking until they believed they had reached the target.

Information used in navigation

2 important Questions:

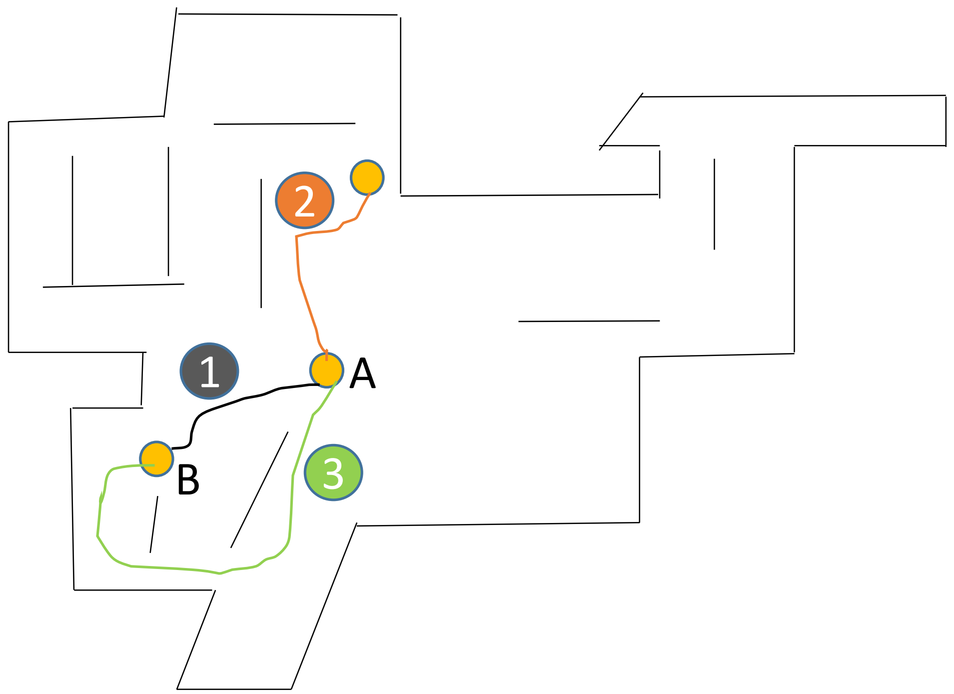
What information is available?

What information is actually used?

Ecological optics and ideas of optic flow: This is one type of information that is available, but individuals can use a combination of available information to aid navigation.

E.g., individuals can also use a visual direction strategy when navigating on foot- in which individuals keep their body pointed towards the intended target. If they move off course, the target will also drift right or left, provides cues to the individuals -can be used to correct their course.
Also, use landmarks etc.

Knowing Which Path to Take



Reduced schematic adapted from Maguire et al (1998)

Maguire et al (1998): tour through a “virtual town” viewed by participants on a computer screen.

Participants learnt town’s layout.
PET scan whilst given the task of navigating one point to another in the town.

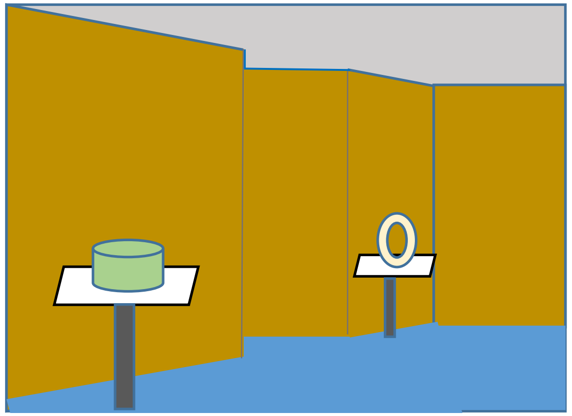
Results:
Brain areas activated by navigation: Right hippocampus & part of parietal cortex.

Activation was greater when navigation between A and B was accurate (path 1), than when it was inaccurate (paths 2 and 3).

- - > these brain areas possibly form a navigation network

Remembering Landmarks

Using Landmarks that people use to find their way around an environment.



Schematic
demonstrating the task

Janzen and Turennout (2004)

Participants- watched film sequence that moved through "virtual museum".
Participants- required to learn their way around the museum.
Objects positioned in the museum hallway.
Decision-point objects- marked place where necessary to turn.
Non-decision point objects -located at a place where decision not required.

Remembering Landmarks

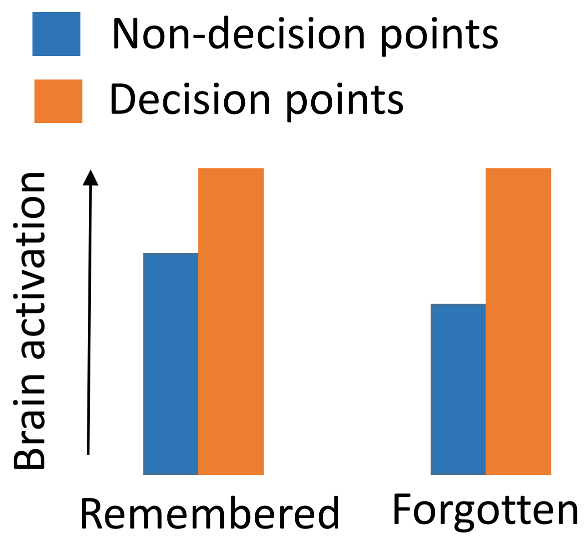
After studying the museum layout in the film, individuals were given a recognition task while in an fMRI scanner.
They were shown objects that had been in the hallway and some objects they had never seen.

Brain activation was measured as they indicated whether they remembered seeing each object.

Remembered objects: Brain activation was greater for decision point objects than non-decision point objects.

Forgotten objects: Brain activation for decision point objects occurs at the same level as for remembered.

One idea is that brain automatically distinguishes objects that are used as landmarks to guide navigation.
The brain is responding not just to the object but also how relevant that object is for guiding navigation.



Reaching and Grasping

Information in the environment that provides information for perception.

One type of such environmental information is called affordances – information that indicates what an object is used for and can guide our actions towards it.

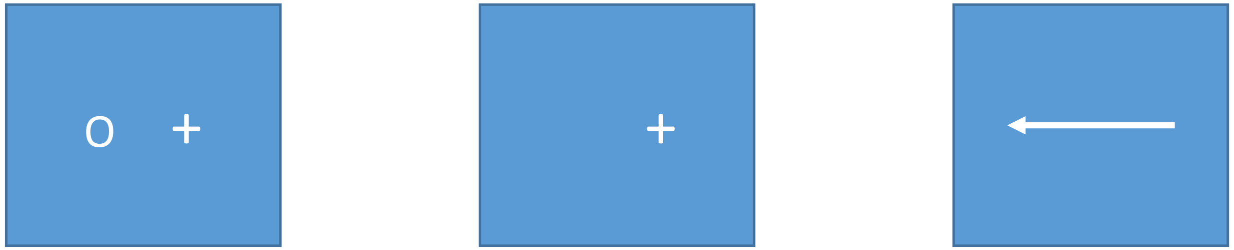
E.G a cup; has visual characteristics as well as indicators that suggest that it can be picked up in a particular way.

Intending to move

Connolly et al 2003:

Study in which participants are presented with a visual localisation task on screen. Recorded activity from the brain using fMRI.

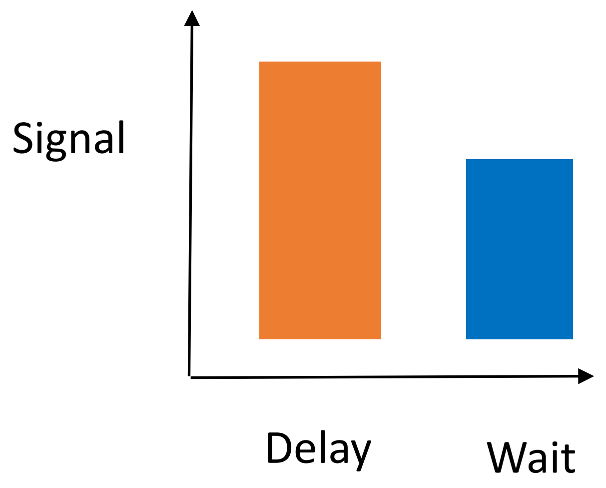
look at a fixation point (+), provided with a cue (O) to the left of the fixation point, indicating the target location. Then there is a 9s delay in which time the individual has to hold the target location in their mind. After 9s, the fixation point disappears and the individual has to point in the direction of the target.



Cue — 9 s delay — Participant points

In the control or comparison condition, the 9s waiting period occurred first, followed by the cue and the participant's pointing movement.

Intending to move



Activity in an area of the brain (parietal reach region) that responds to planning for reaching was higher when individuals were holding a location in their mind during the 9s, than when they were just waiting.

Concluded that human brain region encodes information relating to an observer's intention to make a movement to a specific location.

Grasping System for Object Manipulation and Interaction in Virtual Reality Environments

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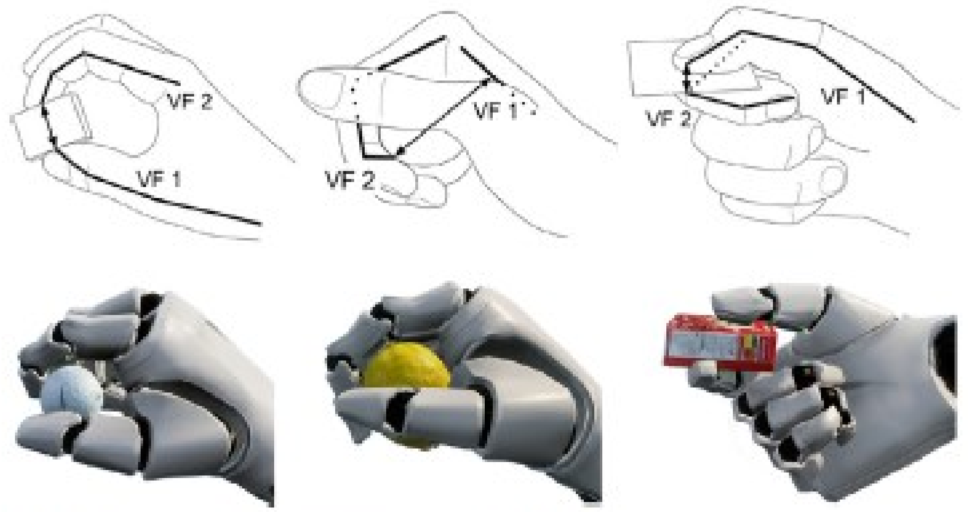


Fig. 2. Represented from left to right the three different opposition types of the grasping hand: pad opposition, palm opposition, side opposition. The abbreviation VF refers to Virtual Finger. Figure adapted from [19].

Interaction in virtual reality (VR) environments (e.g. grasping and manipulating virtual objects) important for an immersive experience.

Devised a visually realistic, flexible grasping system that enables real-time interactions in virtual environments.

Grasping System for Object Manipulation and Interaction in Virtual Reality Environments

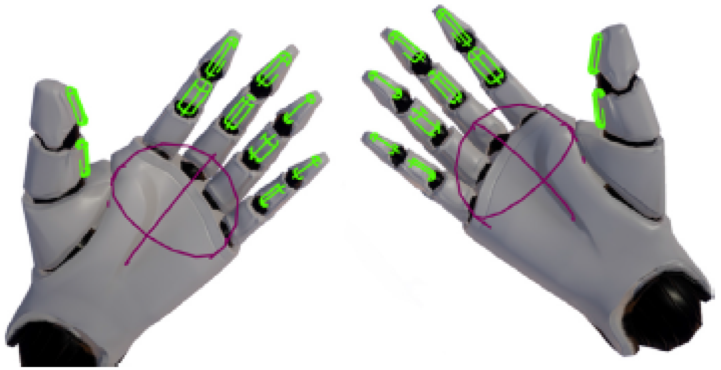


Fig. 3. Represented in green, the capsule triggers of the middle and distal phalanges. In purple, sphere trigger of the palm used to detect the nearest object to be grasped.

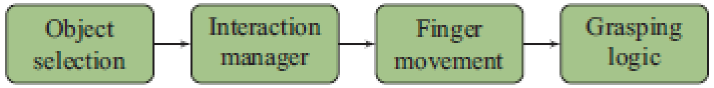
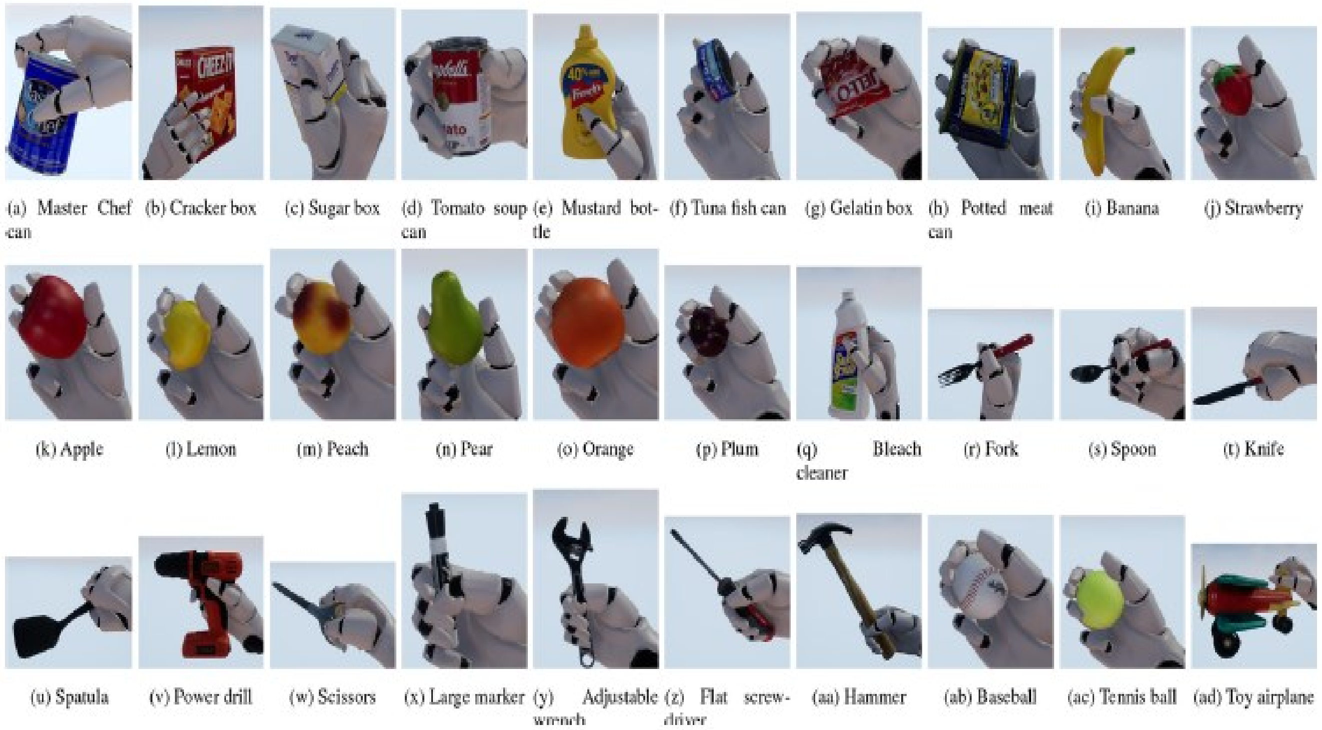


Fig. 4. Pipeline with the components of our grasping system.



(a) Master Chef can (b) Cracker box (c) Sugar box (d) Tomato soup can (e) Mustard bottle (f) Tuna fish can (g) Gelatin box (h) Potted meat can (i) Banana (j) Strawberry

(k) Apple (l) Lemon (m) Peach (n) Pear (o) Orange (p) Plum (q) Bleach cleaner (r) Fork (s) Spoon (t) Knife

(u) Spatula (v) Power drill (w) Scissors (x) Large marker (y) Adjustable wrench (z) Flat screwdriver (aa) Hammer (ab) Baseball (ac) Tennis ball (ad) Toy airplane

Fig. 5. Grasping performed on objects from the YCB dataset.

Grasping System for Object Manipulation and Interaction in Virtual Reality Environments

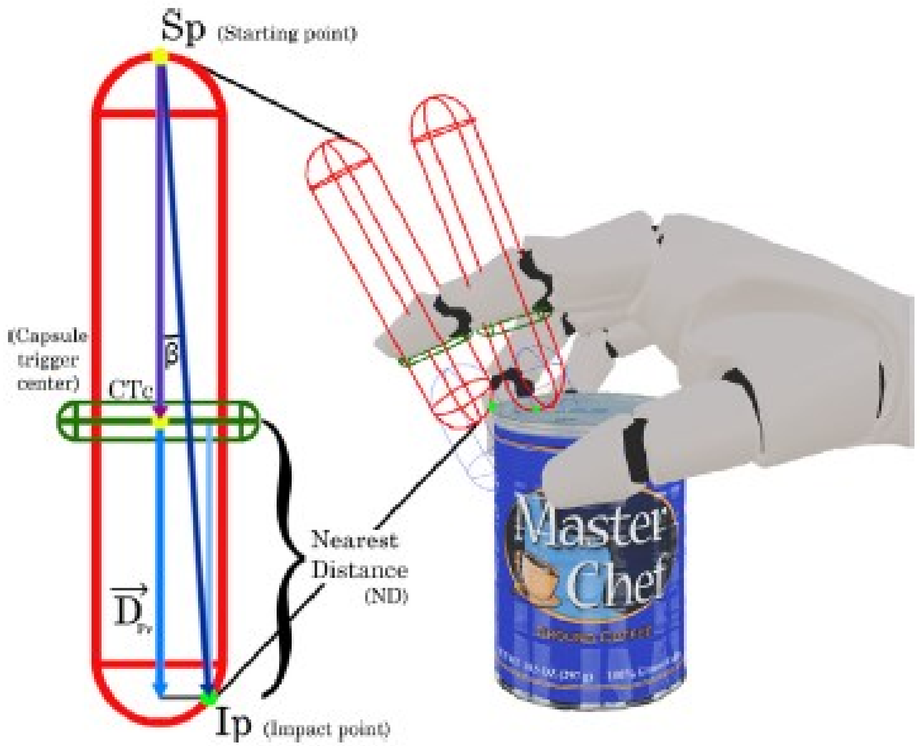


Fig. 6. Distance computation for index finger.

Qualitative: Questionnaire

Quantitative: To quantify each grasp, analysed each finger position.

Also differences between experienced and inexperienced users.

Possible uses: robotics, rehabilitation, interactions using augmented reality

Navigation Intent Communication

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Eye gaze can convey information about intentions.

Proposed eye-tracking glasses shared by humans and robots.

Investigated possibility of human-to-robot implicit intention transference from eye gaze data.

Also looked at how measured eye gaze patterns of the participants relate to their navigation decisions.

Navigation Intent Communication

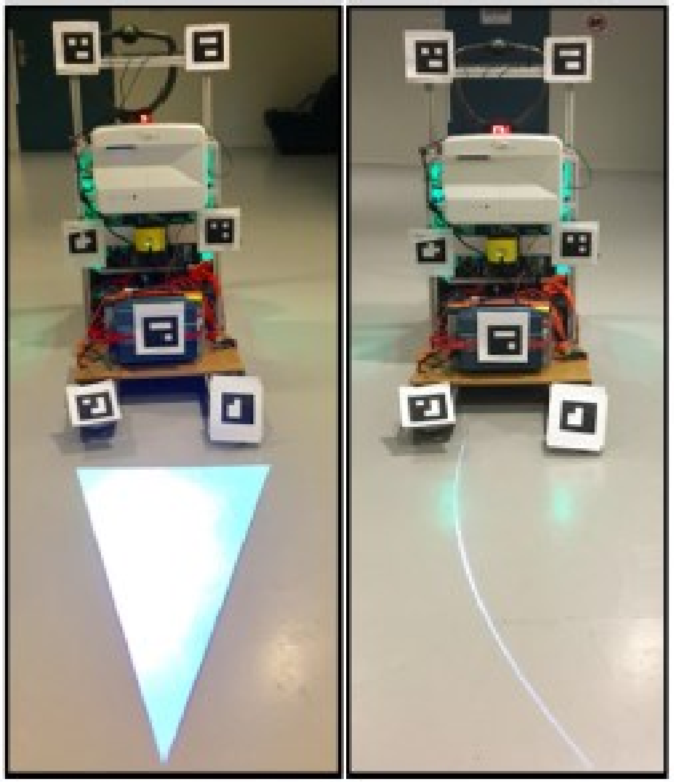
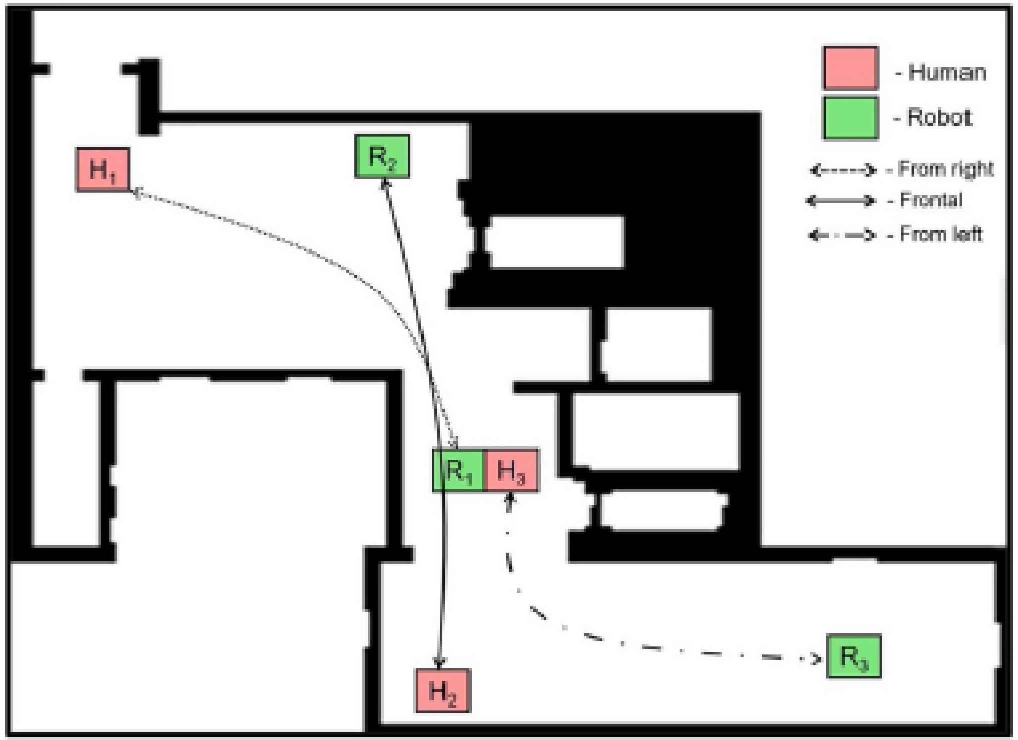


Fig. 2. AGV communicating its future trajectory intentions. Four patterns were defined to be used in the experiments - 1. Line (Right), 2. Arrow (Left), 3. Blinking Arrow (Arrow that blinks at 1 Hz) and 4. Nothing.

Results

Gaze information could allow autonomous vehicles to take intentions of a human into account and improve safety in human–robot encounters.



Overall Summary

Key information used in navigation – not only optic flow.

Information used in heading, knowing which path to take, using landmarks

Reaching and grasping, and intention to move.

Recent research into grasping and navigation intent

Resources

Essential:

Sensation and Perception- E. Bruce Goldstein: Chapter “Taking action”. [Chapter 7 in 8th Edition]

Supplementary:

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