What is the relevance of ecological optics, especially optic flow to interface design and development?

Assessing effects of optic flow deterioration in individuals with Parkinson’s Disease using virtual reality

Young, D.E., Wagenaar, R.C., Lin, C.C., Chou, Y.H., Davidsdottir, S., Saltzman, E. and Cronin-Golomb, A., 2010. Visuospatial perception and navigation in Parkinson’s disease. Vision research, 50(23), pp.2495-2504.

Parkinson’s Disease (PD): Movement related symptoms, also visual disorders - -> could alter optic flow, and affect walking.

Asymmetries in perception of optic flow between individuals with PD whose left side was initially affected (LPD) compared with individuals with PD whose right side was initially affected (RPD).

Assessing effects of optic flow deterioration in individuals with Parkinson's Disease using virtual reality

Expt: Effects of manipulation of optic flow on veering and coordination of walking in individuals with PD.

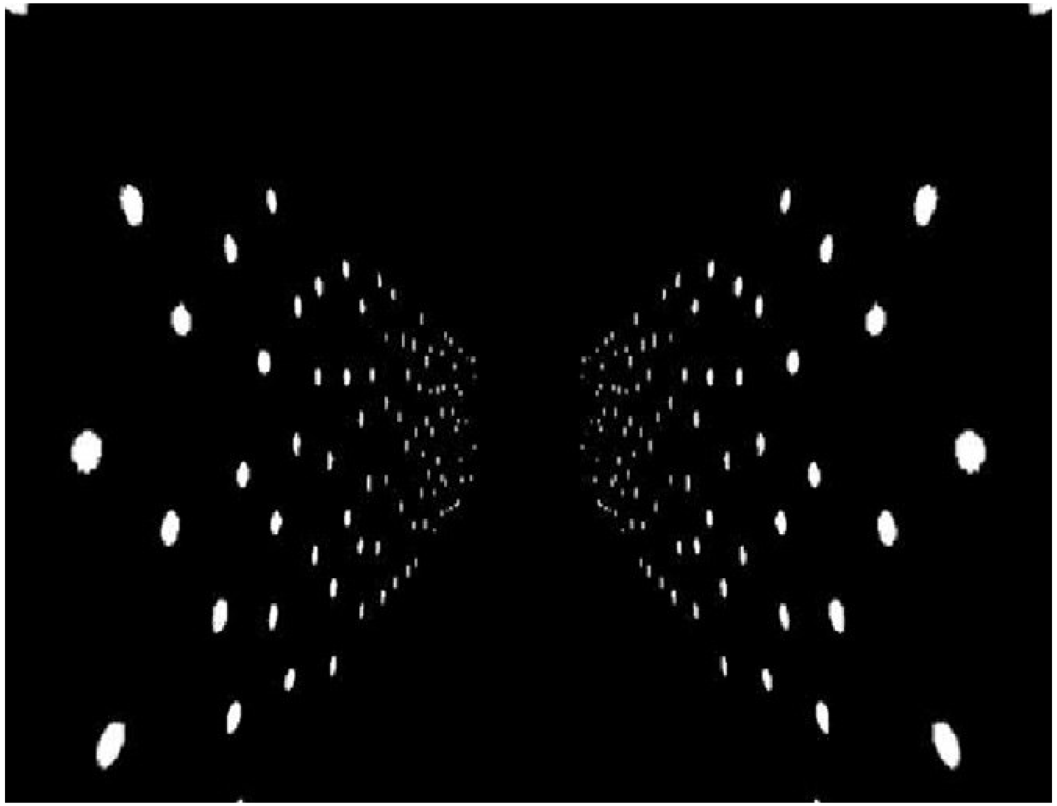
It was anticipated that individuals with PD would veer towards their initially affected body side.

Assessed individuals with eyes open, blindfolded, and in a virtual reality environment.

Manipulated symmetric and asymmetric optic flow speed manipulations

Measured walking speed, stride frequency, stride length.

Assessing effects of optic flow deterioration in individuals with Parkinson's Disease using Virtual reality

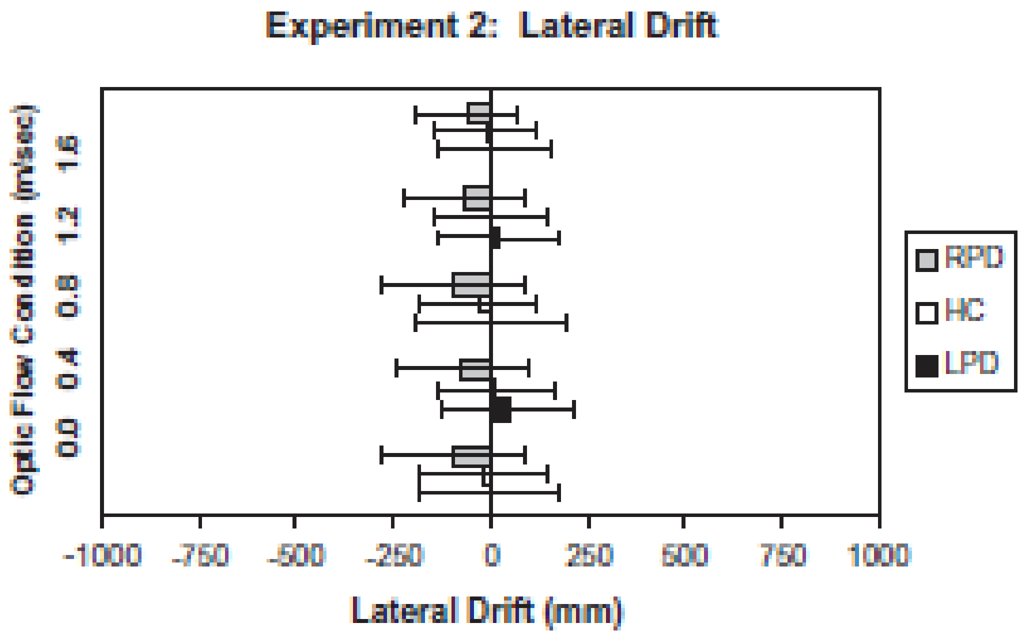


Shown a virtual hallway (wore HMDs)
Two sidewalls were textured with randomly placed white dots.
Simulated depth perception

Pre-test: Walking parameters tracked (overground)

Testing:
Walking overground with eyes open, blindfolded, then wearing a head-mounted display (HMD) for the virtual hallway.

Assessing effects of optic flow deterioration in individuals with Parkinson's Disease using Virtual reality



Virtual Reality: Presented symmetric & asymmetric optic flow speeds.
By changing the optic flow characteristics can measure the amount of veering in both RPD and LPD individuals.

Fig 2: lateral drift values (average between left and right hip position data) for RPD individuals tended towards the left (i.e., a shift in the field of view).

Overall, altered perception of optic flow can lead to changes in gait (e.g., decreased walking speed, increased stride frequency, and veering whilst walking).

Method can be used to assess shifted field of view.

How do we recalibrate visually directed actions to changing circumstances in the environment

Mohler, B.J., Thompson, W.B., Creem-Regehr, S.H., Willemsen, P., Pick, Jr, H.L. and Rieser, J.J., 2007. Calibration of locomotion resulting from visual motion in a treadmill-based virtual environment. ACM Transactions on Applied Perception (TAP), 4(1), pp.4-es.

Describes the use of a treadmill-based virtual environment (VE) to investigate the influence of visual motion on locomotion.

How do we recalibrate visually directed actions to changing circumstances in the environment

The role of “visual flow” in the control of locomotion.

A person’s perceived self-motion depends on:

a) pattern and magnitude of optic flow
b) perceived distance between observer and environmental locations generating visual flow.

Method:
Visual information presented to participants in different conditions specified different velocities of self-motion, while maintaining similar magnitudes and patterns of optic flow.

How do we recalibrate visually directed actions to changing circumstances in the environment.

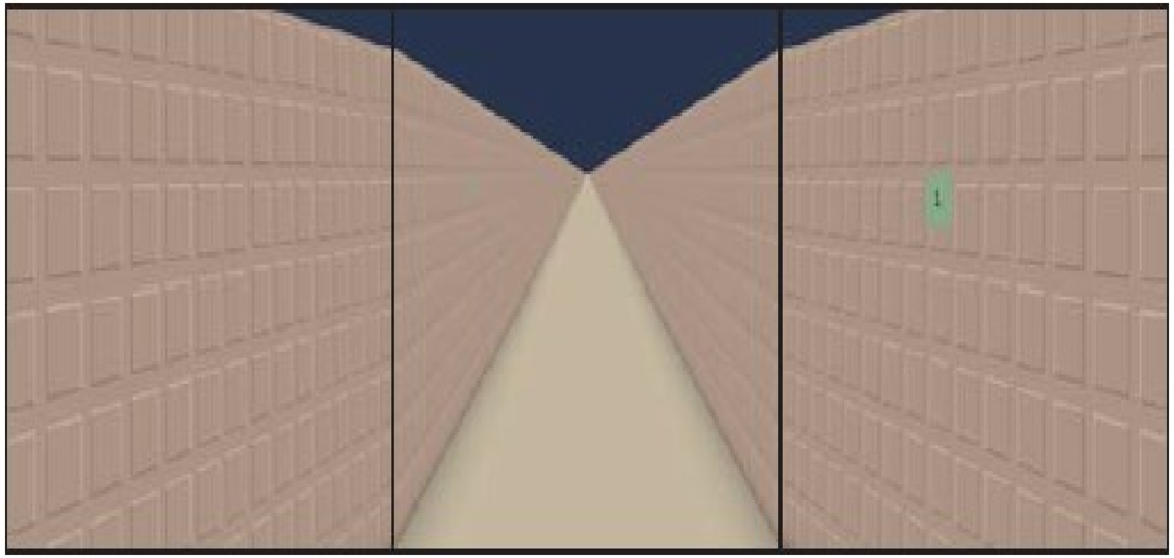
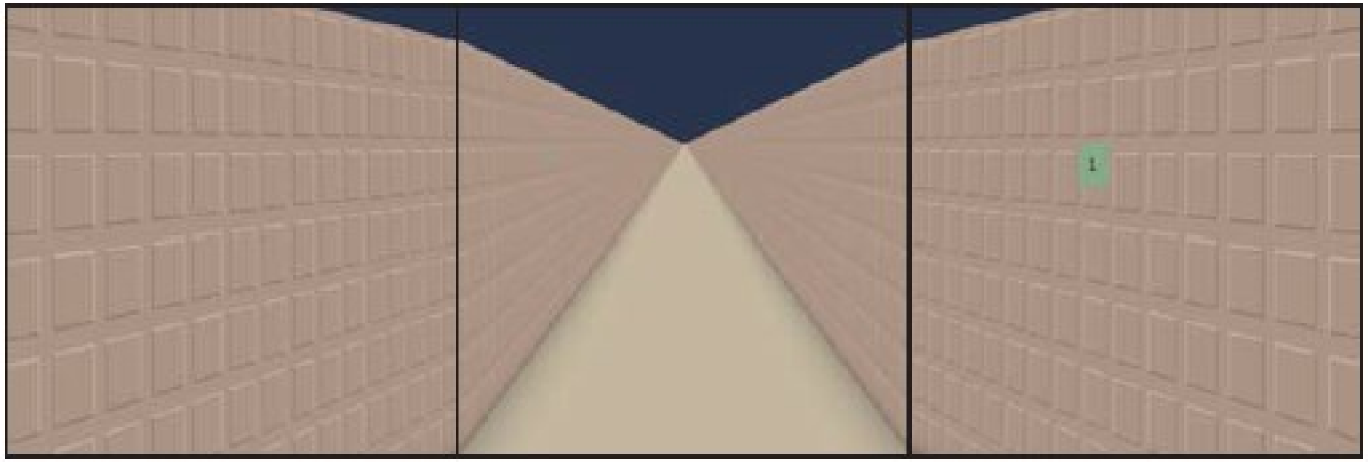


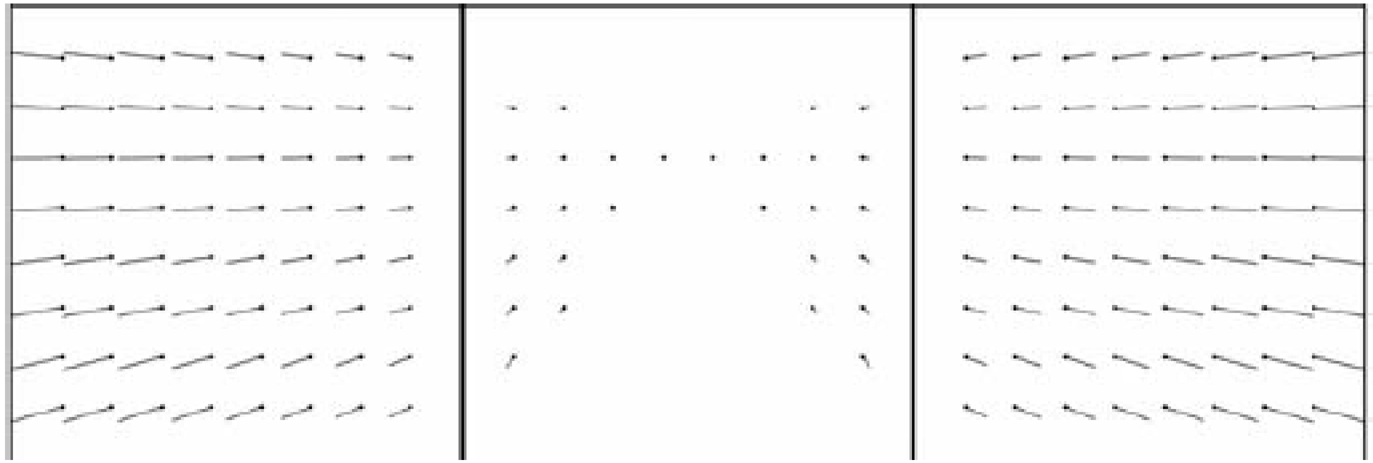
Fig. 4. View of small hallway, with distance cues sufficient to indicate a speed of self-motion slower than biomechanical walking speed. The images displayed on all three Treadport screens are shown. One of the visual attention posters is apparent on the right screen.

Presented with hallway moving at visual speed less, greater, or the same than their biomechanical rate of walking

How do we recalibrate visually directed actions to changing circumstances in the environment.



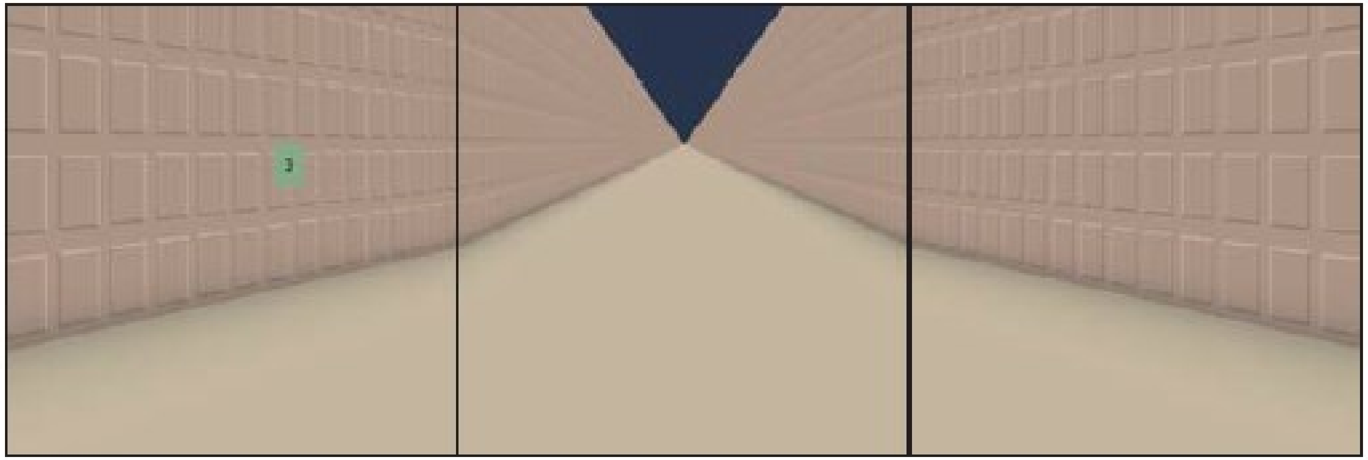
Cues indicate speed of self-motion <u>slower</u> than biomechanical walking speed.



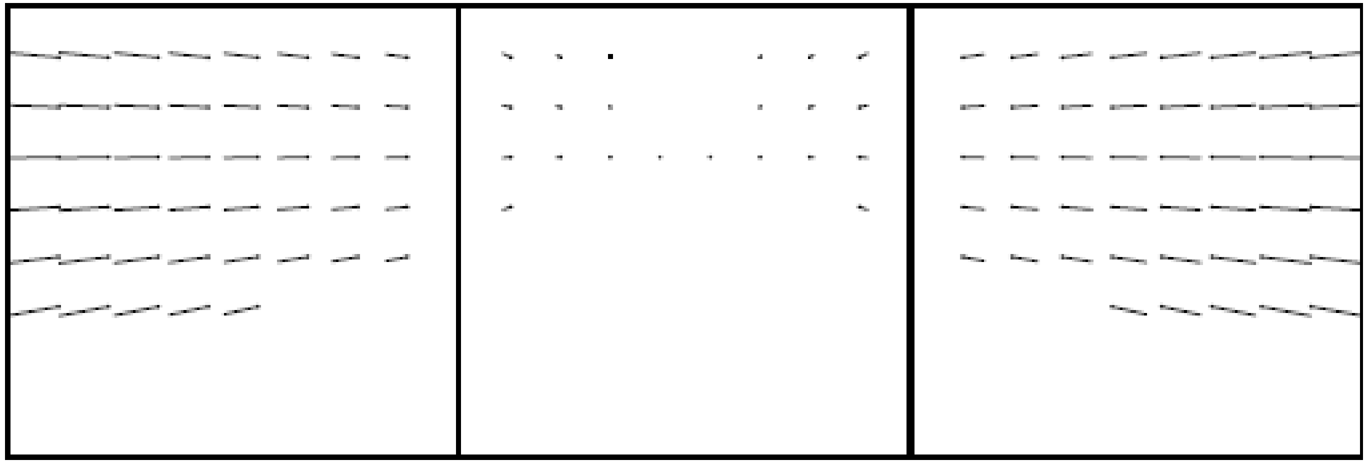
Associated optic flow field

Results- participants increased distance walked by ~ 10%

How do we recalibrate visually directed actions to changing circumstances in the environment.



Cues indicate speed of self-motion <u>faster </u>than biomechanical walking speed.



Associated optic flow field

<u>Results</u>- participants decreased distance walked by ~ 3%

Age-related differences in using optical flow and landmark information when steering during driving

Ni, R., Bian, Z. and Andersen, G.J., 2009, June. Age-related differences in using optical flow and landmark information for steering control. In 2009 IEEE Intelligent Vehicles Symposium (pp. 691-694). IEEE.

Ability to use visual information to steer is important- use optical flow information, but this may not provide reference information for steering control.

So, drivers may rely on landmarks to provide reference information regarding the path of motion.

There may be age-related differences in perception of motion and in the use of optic flow information.

This study- examined age-related differences in the use of optical flow and scene-based information for steering control:

Proposed that: Older drivers may show decreased sensitivity to spatially integrate velocity information for steering control from the optic flow

Older drivers may have difficulty encoding and using spatial location of landmark position information (so may not be able to use this positional information as reference information to maintain the intended path of motion).

Age-related differences in using optical flow and landmark information when steering during driving

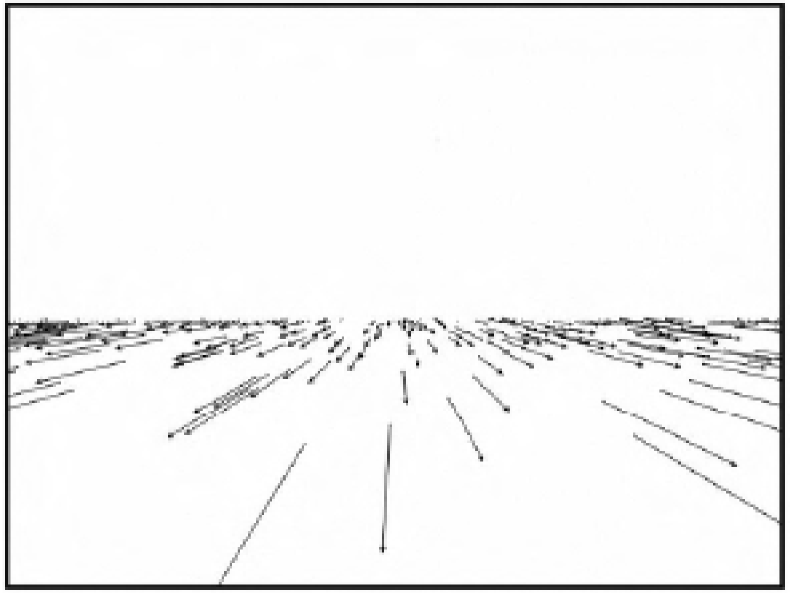


Figure 1. Optic flow field used in the experiments in reversed contrast. In the experiment, drivers were driving through a white dots field on a black background.

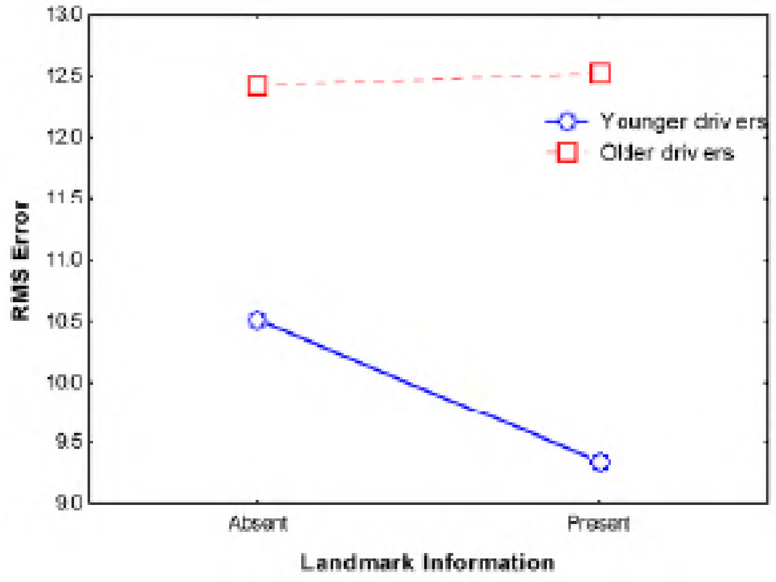
Participants- younger and older partcipants

Displays simulated driving through a 3D array of dots located on a ground plane.

Perturbed dot pattern

Also presented display with or without landmark (landmark- 1 dot coloured in the flow field in half the presented trials).

Age-related differences in using optical flow and landmark information when steering during driving



RMS tracking error calculated.

1- Landmark information was useful for younger drivers when optical flow information was reduced.

2. Older drivers showed reduced performance under the less optical flow information condition, even when the landmark information was available.

Computer-mediated optic flow can make a user perceive self-motion as faster or slower than it actually is.

Bruder, G., Wieland, P., Bolte, B., Lappe, M. and Steinicke, F., 2013, October. Going with the flow: Modifying self-motion perception with computer-mediated optic flow. In 2013 IEEE International Symposium on Mixed and Augmented Reality (ISMAR) (pp. 67-74). IEEE.

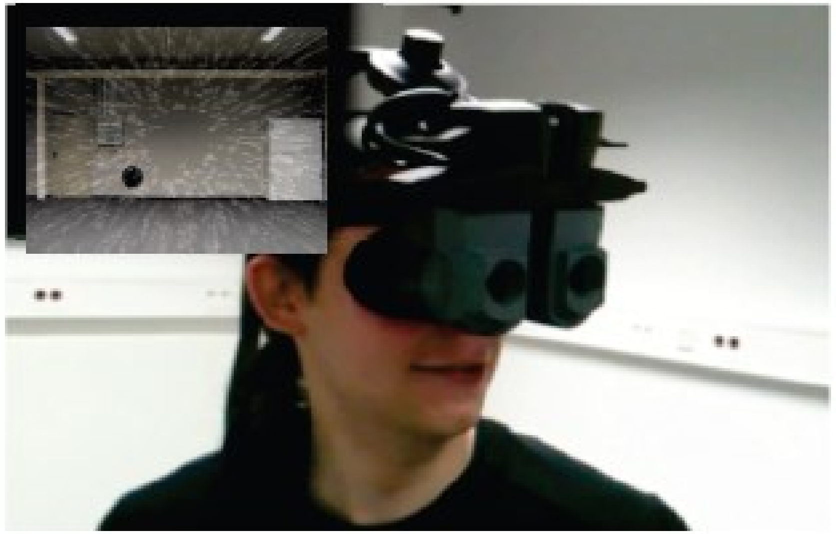


Figure 1: Photo of a user wearing a tracked NVIS nVisor MH-60V video see-through HMD. The inset shows an illustration of the resulting expansional optic flow field during forward movements.

Visual self-motion feedback can be changed with video see-through displays using techniques based on optic flow manipulations.

This study:

Participants wore a video see-through HMD which was tracked whilst person is free to walk.
Used different approaches to introduce optic flow patterns that differed from the visual fields naturally experienced when moving in augmented reality environments.

Tested 3 types of transformations- Temporal transformations, screen space transformations, pixel motion transformations

Computer-mediated optic flow can make a user perceive self-motion as faster or slower than it actually is

Temporal transformations

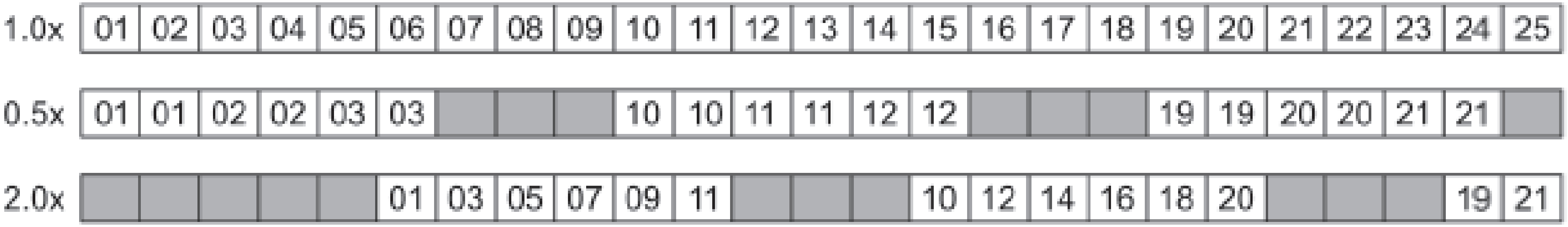


Figure 2: Illustration of different temporal transformations: The top row shows camera images captured at each frame and displayed to the user on the video see-through display, which results in a natural visual velocity. The center row illustrates temporal expansion by displaying each camera image for twice its natural time span resulting in half the visual velocity. The bottom row illustrates temporal compression by skipping each second camera image resulting in twice the visual velocity. The blank screens denote inter-stimulus intervals.

Computer-mediated optic flow can make a user perceive self-motion as faster or slower than it actually is

Screen space transformations

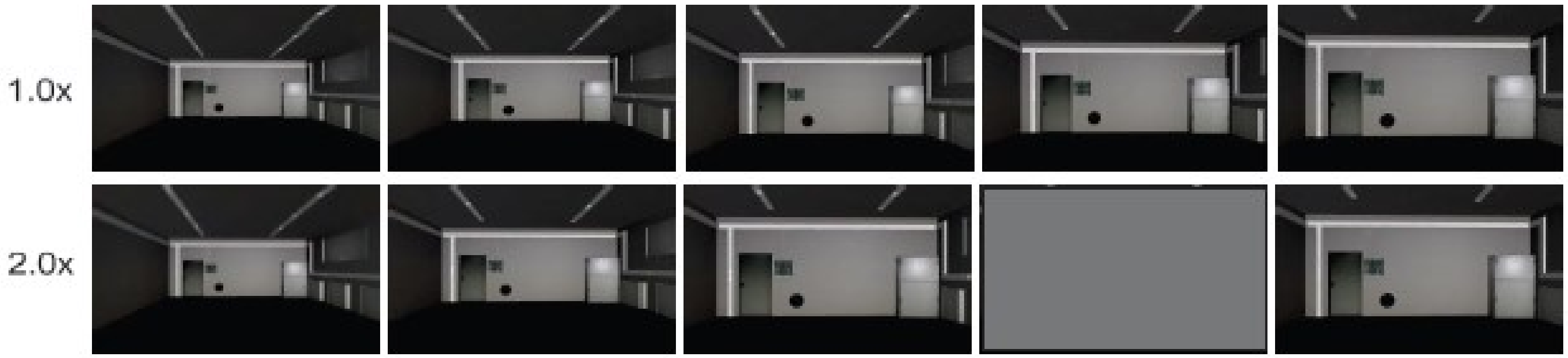


Figure 3: Illustration of screen space transformations: The top row shows camera images captured while the observer is moving forward. The bottom row shows an increased visual velocity with magnification and change blindness. The blank screen denotes an inter-stimulus interval.

Computer-mediated optic flow can make a user perceive self-motion as faster or slower than it actually is

Figure 4: Example of pixel motion transformation with a faster or slower flow field introduced in the periphery of the observer's eyes.

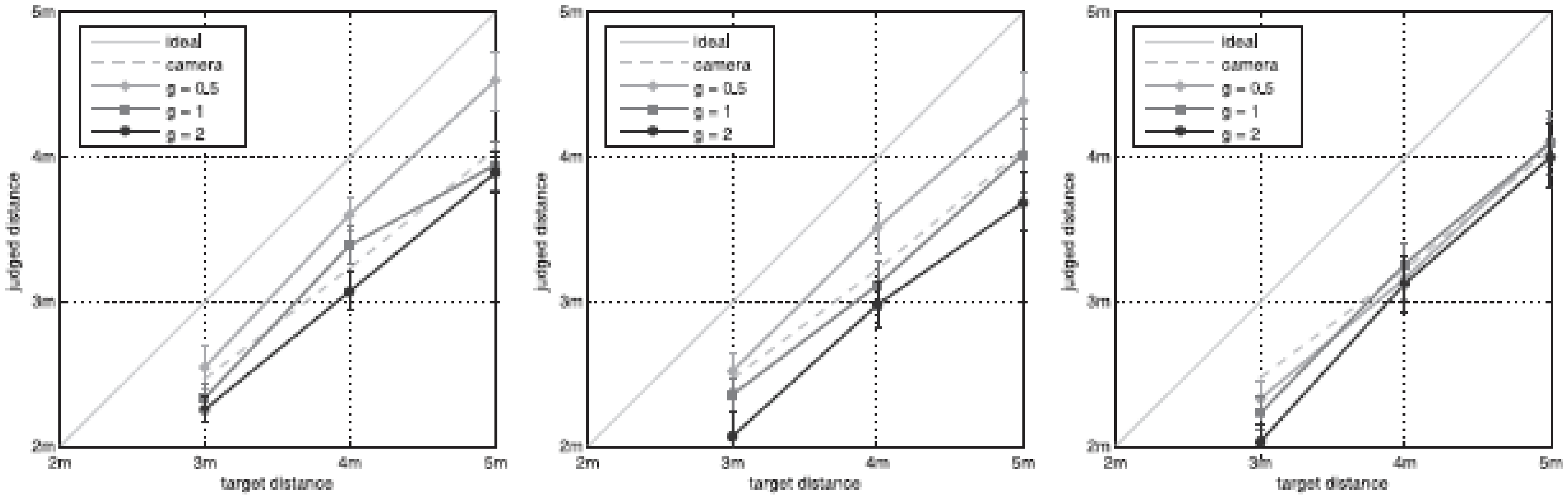
Pixel motion transformations

Figure 5: Experiment setup: subject walking in the direction of a target displayed at eye height for a distance indicated by the center of two vertical poles.

Overall, participants walked shorter distance with the augmented reality HMD than in the real world.

Different walked distances for temporal and screen space transformations.

Underestimate of target distance and/or overestimation of self motion velocities while wearing the augmented reality HMD.



(a) temporal (b) screen space (c) pixel motion

Figure 7: Results of the judged walk distances for (a) temporal, (b) screen space, and (c) pixel motion transformations. The vertical bars show the standard error.

Computer-mediated optic flow can potentially be used to make users perceive self-motion as faster or slower than it actually is- with applications to augmented reality.

Is the concept of optic flow adequate?

Even if optic flow information is available, how much, if any, of this information do they make use of?

Experiments already mentioned- e.g, driving.

Experiments have been designed to look at this using walking or driving tasks.
An early experiment by Lee (1974; 1980) showed that keeping the FOE centred on the destination may not work for a curved road, because the destination keeps shifting as the car negotiates the curve.
Drivers may be using other information in addition to FOE to help them stay on course.

Another consideration-Do the senses work in isolation?

In other words is only optic flow sufficient?

Let’s look at some examples where both visual information and information from balance organs in the body are important.

We will next cover some basics about the balance system in Part 02 in order to answer this question.

Overall Summary

Covered a general introduction to perception and action and its relevance to interface design and evaluation

Studied the role of perceptual information (visual) from the environment
Introduced ecological optics (and relevant studies) and idea of size constancy
Covered the optic array and optic flow.

Also looked at the role of self-produced information, and its relevance

Studied optic flow in more detail with motion studies

Asked if optic flow is sufficient to explain perceptual behaviour

Resources

Essential: Sensation and Perception, E. Bruce Goldstein- “Taking Action” Chapter 7

Supplementary:

Young, D.E., Wagenaar, R.C., Lin, C.C., Chou, Y.H., Davidsdottir, S., Saltzman, E. and Cronin-Golomb, A., 2010. Visuospatial perception and navigation in Parkinson’s disease. Vision research, 50(23), pp.2495-2504.

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Bruder, G., Steinicke, F., Wieland, P. and Lappe, M., 2011. Tuning self-motion perception in virtual reality with visual illusions. IEEE Transactions on Visualization and Computer Graphics, 18(7), pp.1068-1078.