The role of visual landmarks during homing

Melissa Bud Kearns & William H. Warren, Jr.

Cognitive and Linguistic Sciences, Brown University

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Path Integration Background

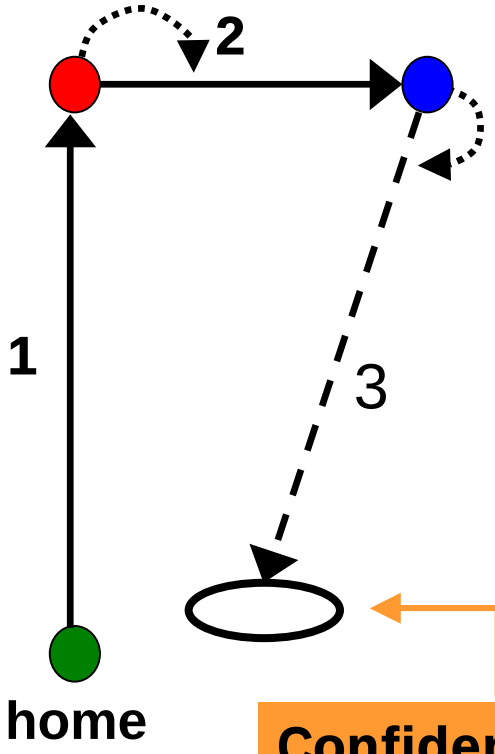
- When both body senses and optic flow are available, body senses dominate path integration (2000).
  - Body senses = info from proprioceptive, vestibular and efferent systems
- If optic flow is pitted against body senses, there is a small contribution of optic flow (2001)
  - ~15% optic flow + 85% body senses
- Will landmarks increase the visual contribution to homing?
  - Flow of salient features for path integration
  - Markers of orientation and position

Using landmarks for homing

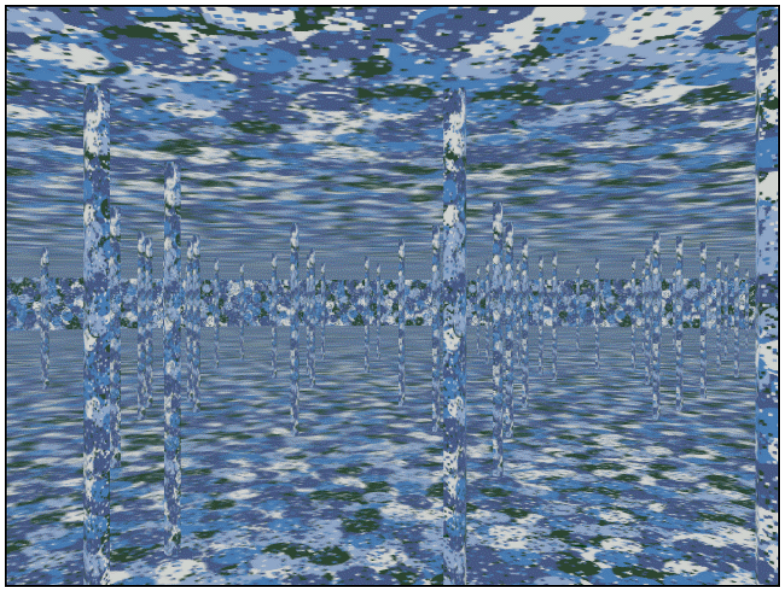
- Global landmarks = objects far away from our path, seen from one orientation
  - Flow information for rotation
  - Azimuth information for orientation

- Local landmarks = objects close our path that we can see from multiple views
  - Flow information for rotation and translation
  - Angular information about orientation and distance information about position

Triangle Completion Task

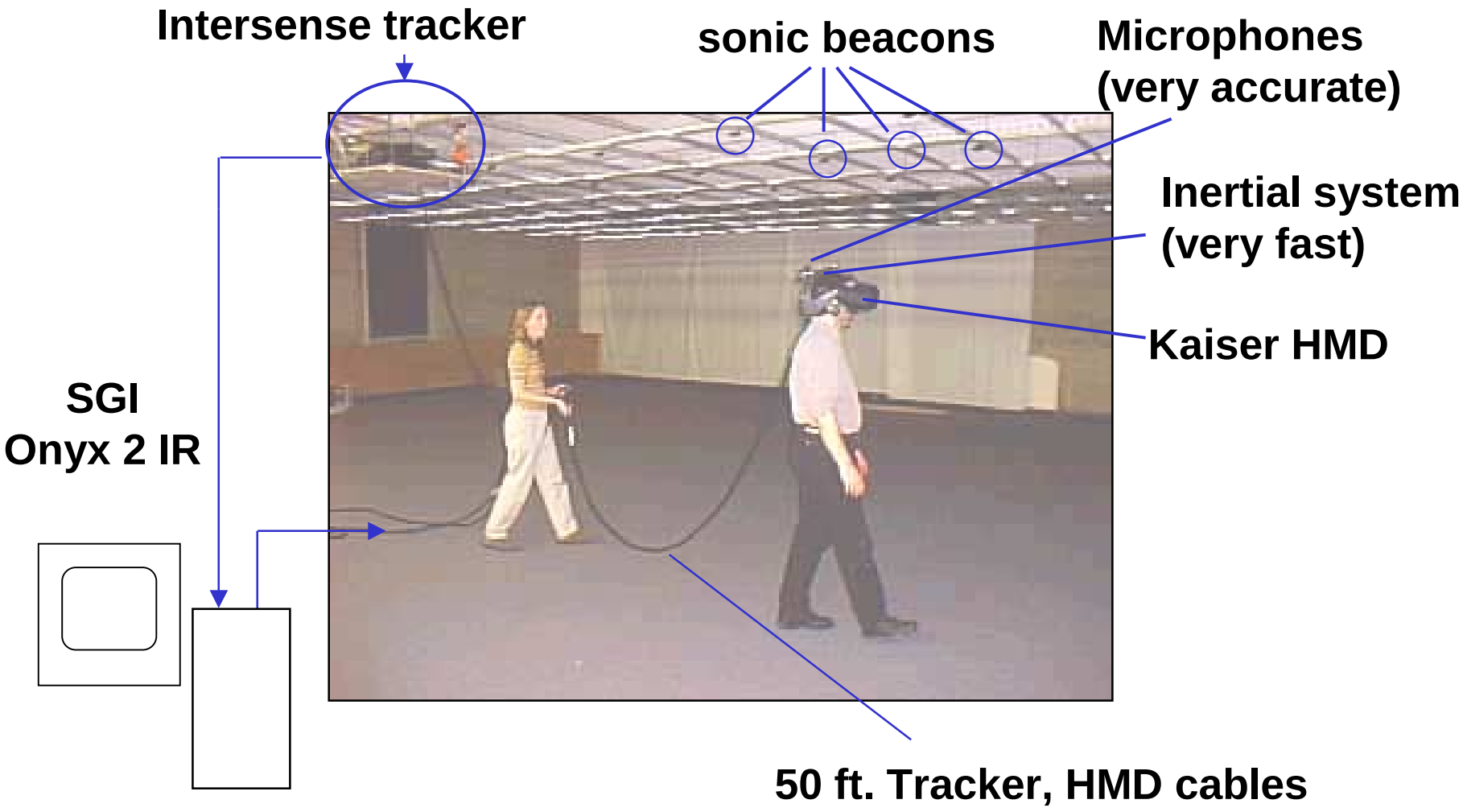


Confidence Ellipse: pop. mean is in ellipse with 95% probability



Virtual environment: Example w/no landmarks

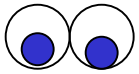
Virtual Environment Navigation Lab (VENLab)



Two Frames of Reference

PHYSICAL SPACE

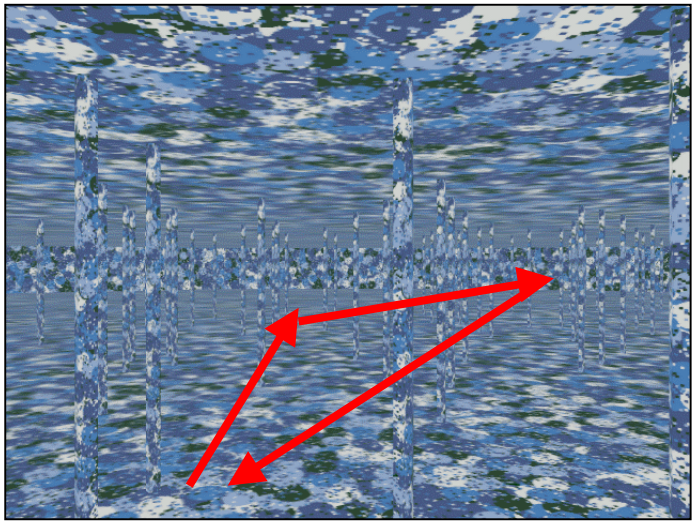
gain



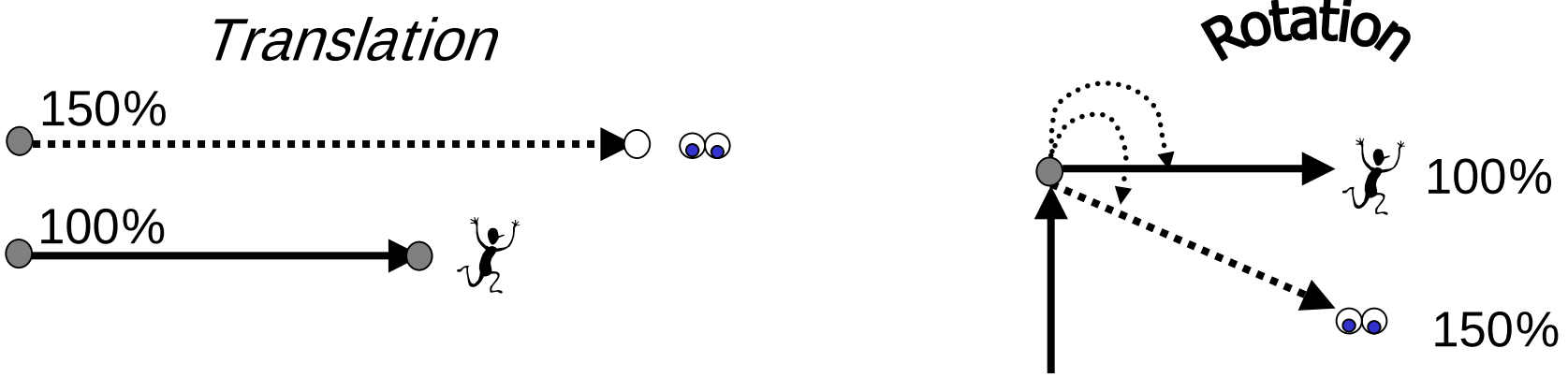
VISUAL SPACE

Movement in the physical room

Movement in the virtual environment



Gain Manipulations



High gain:

- Movement in physical space < Movement in visual space

Normal gain:

- Movement in physical space = Movement in visual space

Predictions:

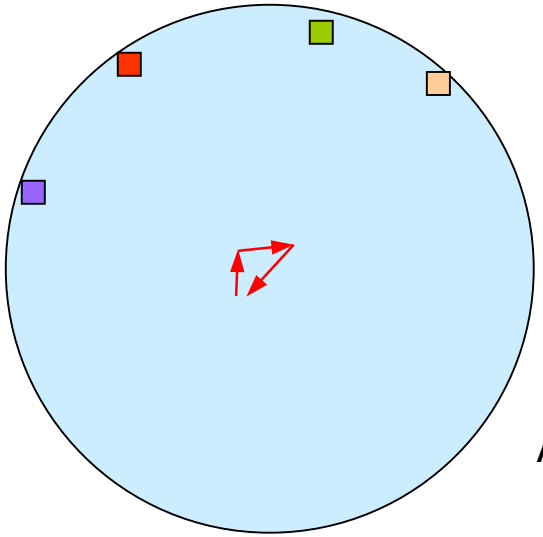
- If body senses dominate, no difference between gains in physical space
- If vision dominates, no difference between gains in visual space

Method

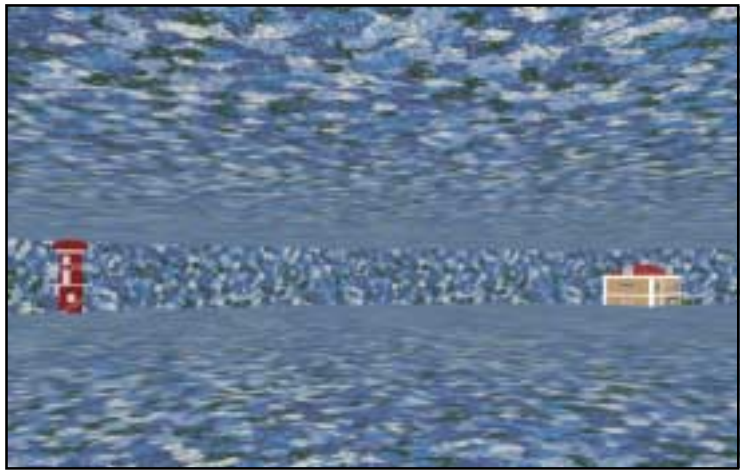
- Two sessions: Local and Global Landmarks
  - All objects could be seen from home by turning one's head
- Each session:
  - blocked by gain:
    - Local session: (normal, Rotation , and *translation*)
    - Global session: (normal and Rotation)
  - Within blocks, randomized presentations of 4 triangles, 4 trials each
  - Each trial: landmark locations randomly assigned within bounded regions
- For *translation* only, gain was reset to normal for return path

Environments

Global



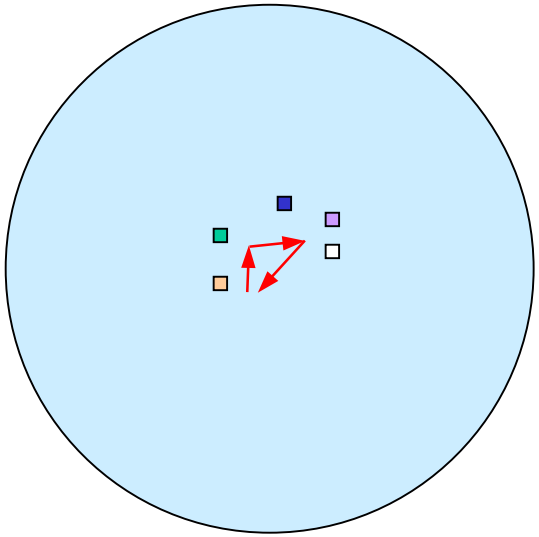
Bird's eye view



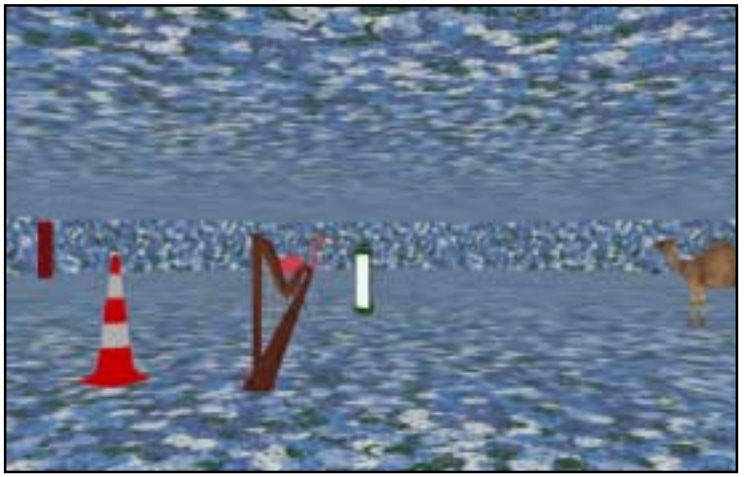
Participant's view

Arena scale: 30m radius

Local



Bird's eye view



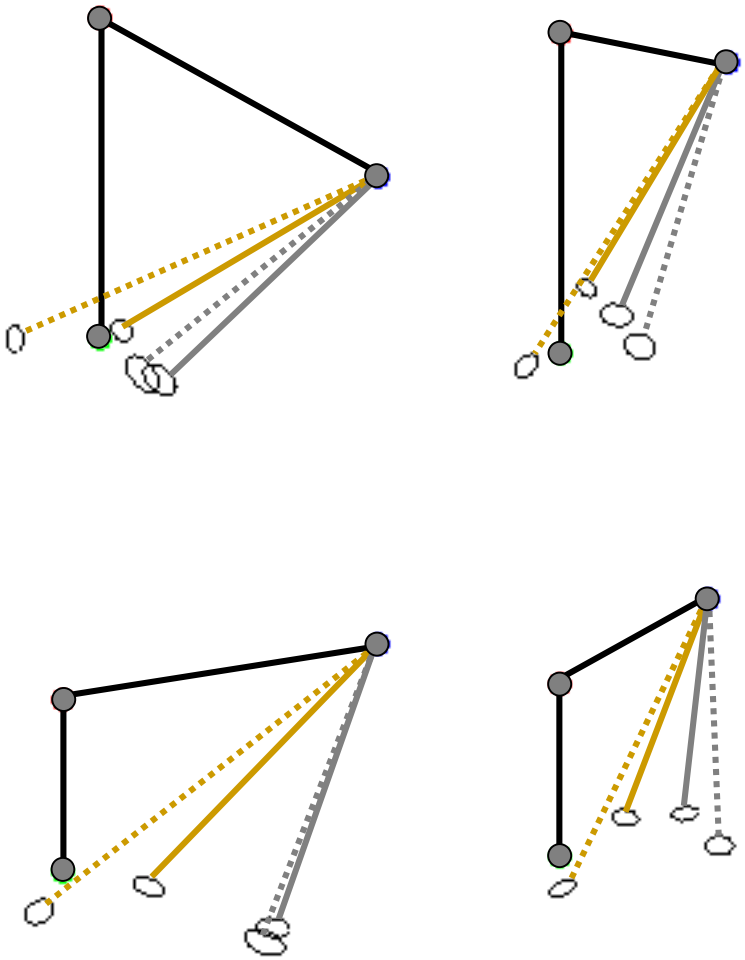
Participant's view

Local
No Landmarks

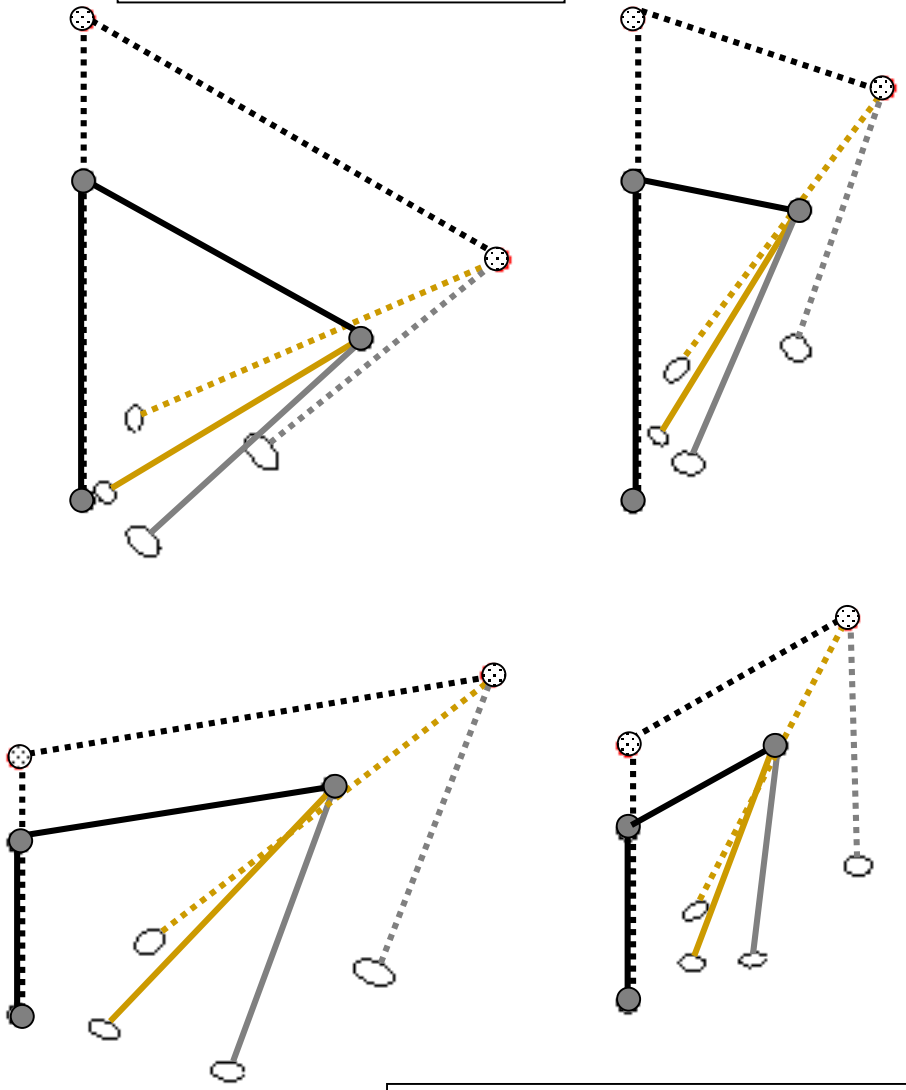
Translational Gain

150% = ·····
100% = ——

Physical Space



Visual Space



Scale: 1m = ——

Note: No Landmarks data
from previous gain exp. (2001)

No Landmarks: Significant differences between gains in both visual AND physical space for distance walked ($p < .01$)

Local Landmarks: Significant differences between gains in both visual AND physical space for distance walked ($p < .01$)

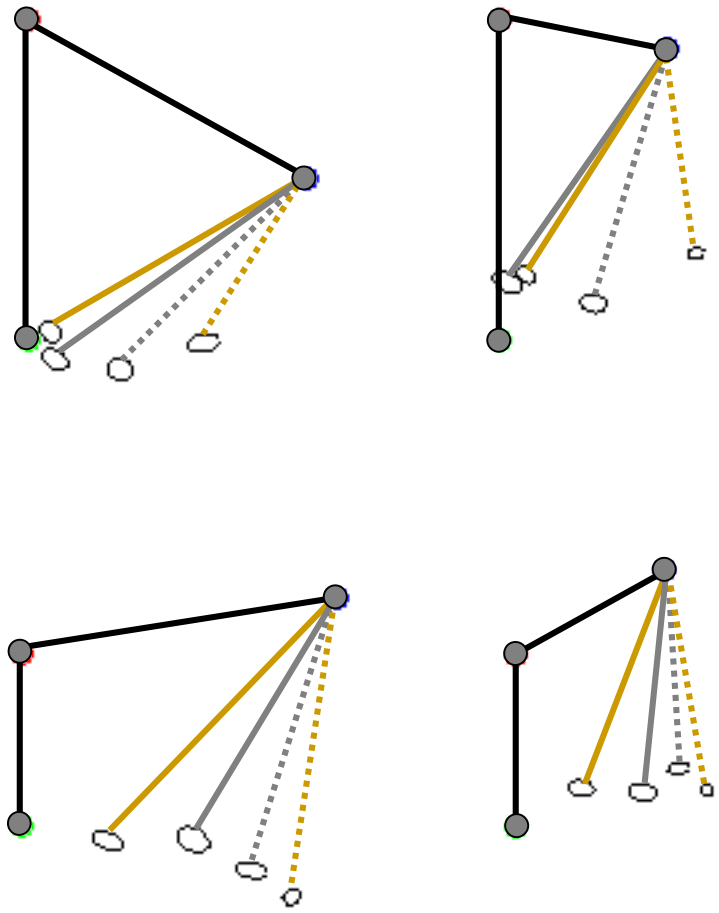
Comparison: Significantly more accurate with landmarks than without (distance from home, $p < .01$)

Local
No Landmarks

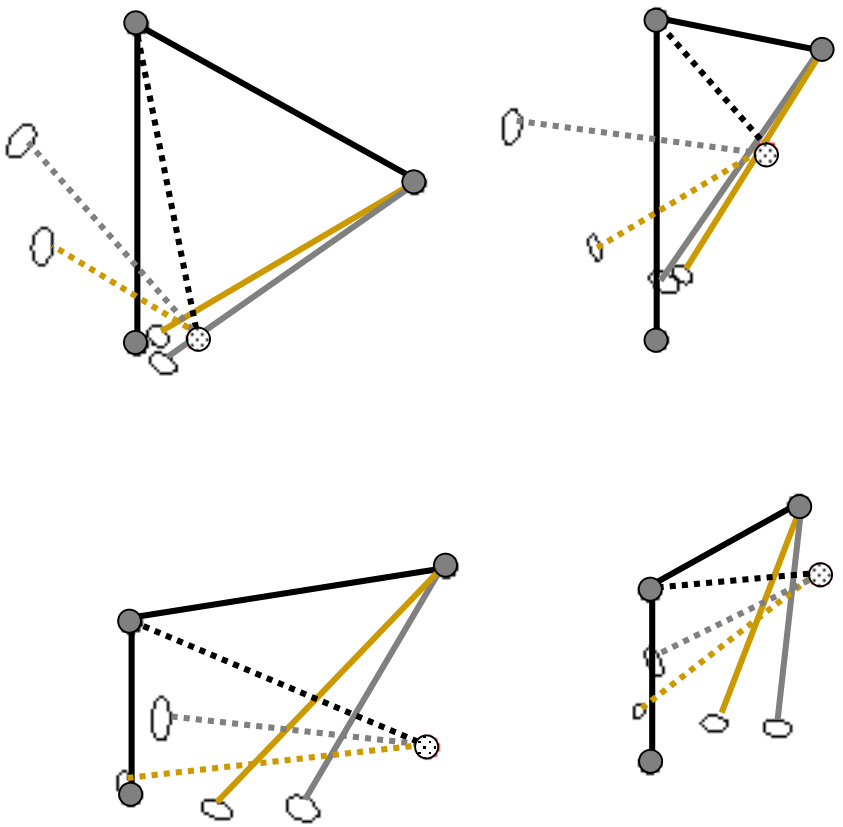
Local Rotational Gain

150% = ·····
100% = ——

Physical Space



Visual Space



Note: No Landmarks data from previous gain exp. (2001)

Scale: 1m = ——

No Landmarks: Significant differences between gains in both visual AND physical space for angle turned ($p < .01$)

Local Landmarks: Significant differences between gains in both visual AND physical space for angle turned ($p < .01$)

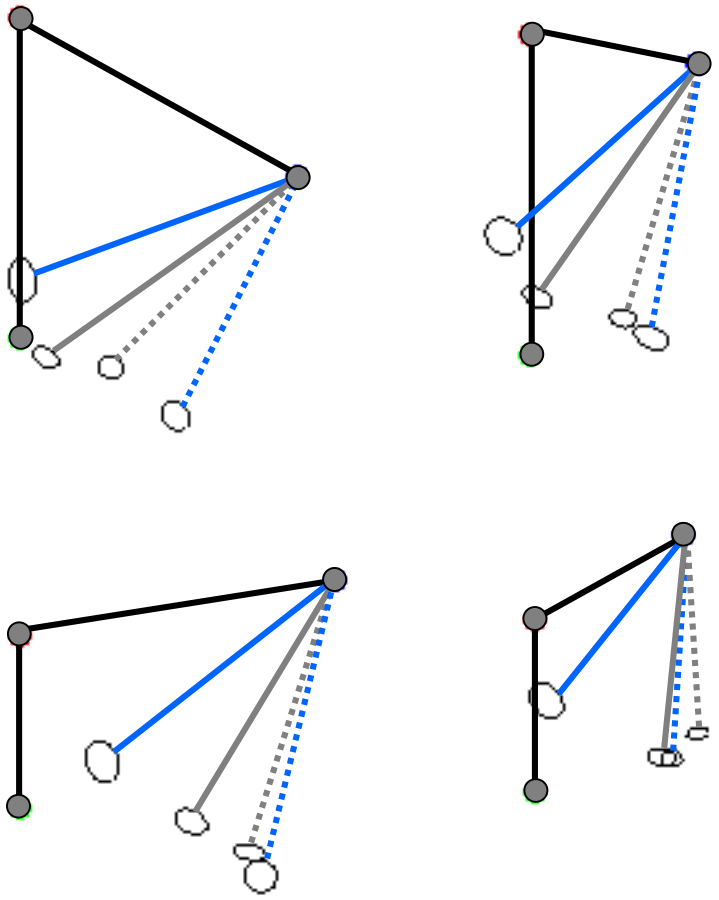
Comparison: Significantly more accurate with landmarks than without (normal gain - distance from home, $p < .01$)

Global
No Landmarks

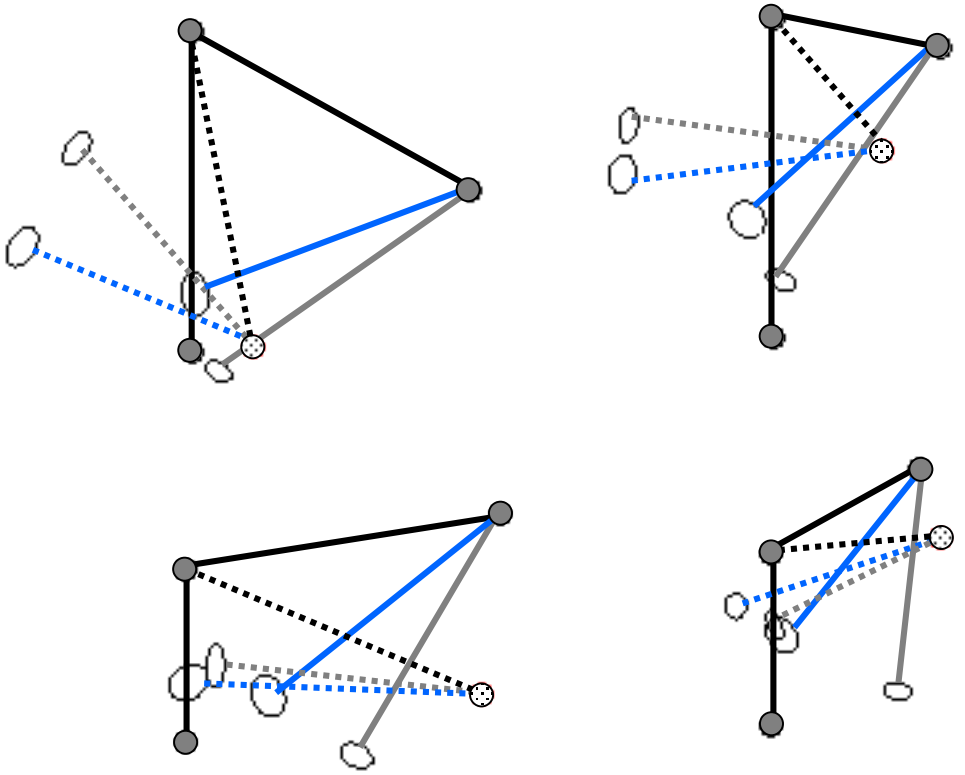
Global Rotational Gain

150% = ·····
100% = ——

Physical Space



Visual Space



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Scale: 1m = ——

No Landmarks: Significant differences between gains in both visual AND physical space for angle turned ($p < .01$)

Global Landmarks: Significant differences between gains in both visual AND physical space for angle turned ($p < .01$)

Comparison: More accurate with local landmarks than global landmarks (normal gain - distance from home, $p < .01$)

Relative Contributions of Vision and Body Senses

By comparing gain effects in PHYSICAL and VISUAL space, we can assess the relative contributions of visual information and body senses:

Distance = 46% vision + 54% body senses

Local Landmarks:

Angle = 59% vision + 41% body senses

Global Landmarks:

Angle = 60% vision + 40% body senses

Results

- Vision and body senses play roughly equal roles in homing: evidence comes from gain effects in both physical and visual space

- With normal gain, responses are more accurate with local landmarks than with global landmarks or no landmarks

- No subjects reported detecting gain changes

Conclusions

- The addition of landmarks contributed to a greater reliance on visual information
- Accuracy was greater with local than global landmarks, suggesting that they provide visual position information for navigation
- Currently examining whether landmarks that remain at constant positions throughout the experiment contribute to increased reliance on vision for navigation in a homing task

www.cog.brown.edu/Research/ven_lab

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