



Foldable Spaces

An Overt Redirection Approach for Natural Walking in
Virtual Reality

Authors: Jihae Han, Andrew Vande Moere, Adalberto L. Simeone

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Diogo Almeida nº 108902

Tomás Matos nº 108624

What are foldable spaces?

Foldable spaces are a way of dealing with the Virtual Environment in order to walk a space larger than the real-life tracking space.

Principle Research Questions

- To what extent do the foldable redirection techniques affect how users walk in a VE (walking speed and variation, idle time and frequency, walking trajectories)?
- To what extent do the foldable redirection techniques affect how users cognitively engage with a VE (memory recall, distance estimation, sketch maps)?
- Does the ‘overtness’ of the manipulation constitute a break in Presence too great to be ignored?

Subtle techniques

0 1 Change Blindness Redirection

Makes subtle changes to the environment while the user is distracted to influence their trajectory

0 3 Flexible Spaces

Expands the "Flexible Spaces" technique with the generation of corridors that connect several virtual rooms within the same physical space

0 2 Impossible Spaces

Compresses a large area into a smaller physical space, overlapping discrete parts of the VE

0 4 Scenography

Adapts these techniques to create a natural walking experience independent of tracking volume.

Overt techniques

0 1 Reset Vision

0 2 Teleport

0 3 Foldable Spaces

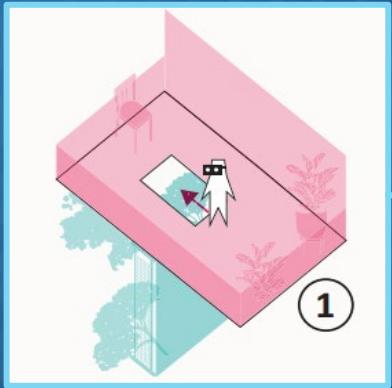
Subdivide the VE into spaces that dynamically fold
as the user moves

F o l d a b l e T e c h n i q u e s

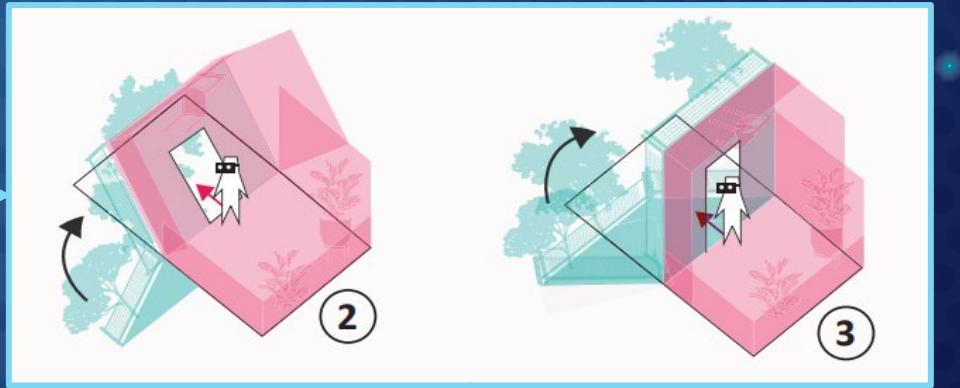


Horizontal

PHASE 01



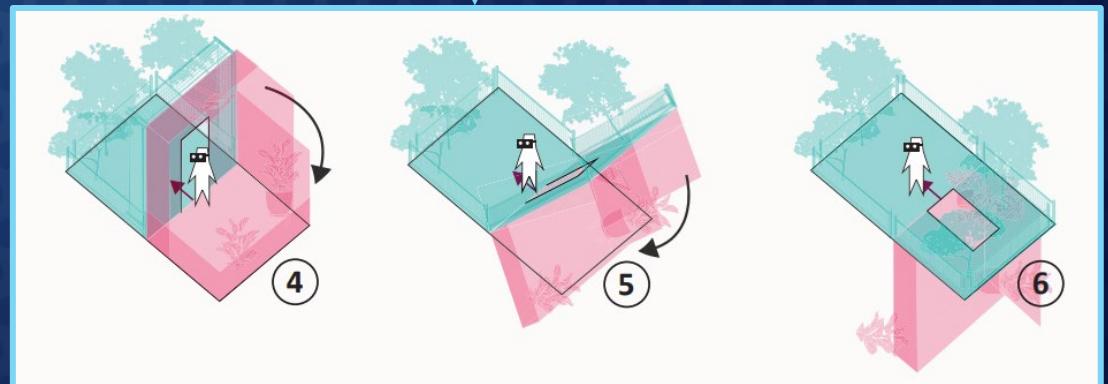
PHASE 02



07

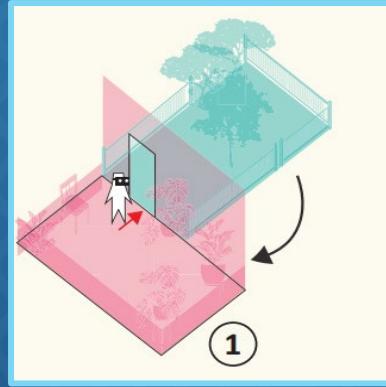
HOW TO ENABLE REAL WALK IN A 3D ENVIRONM

PHASE 03

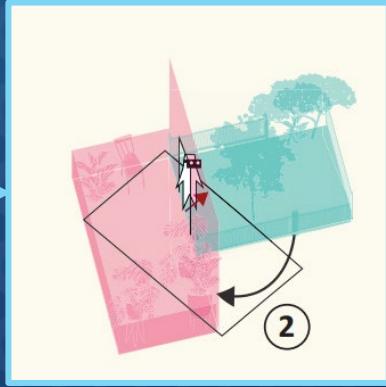


Vertical

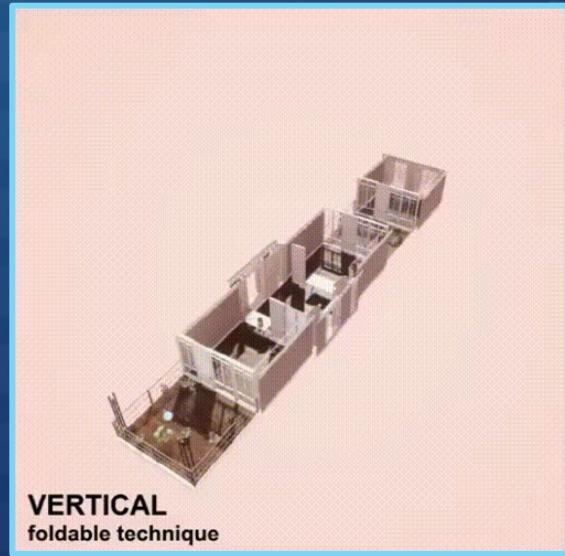
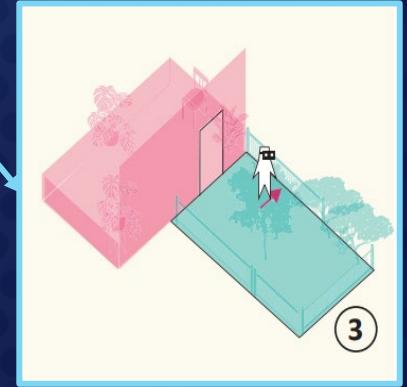
PHASE 01



PHASE 02



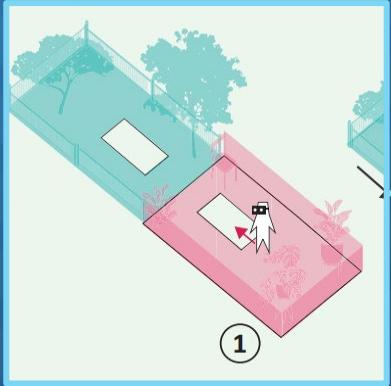
PHASE 03



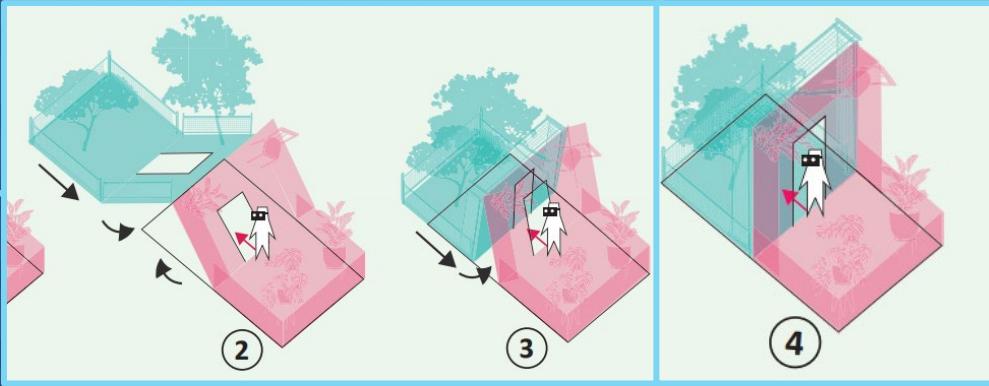
0.8

Acordeão

PHASE 01

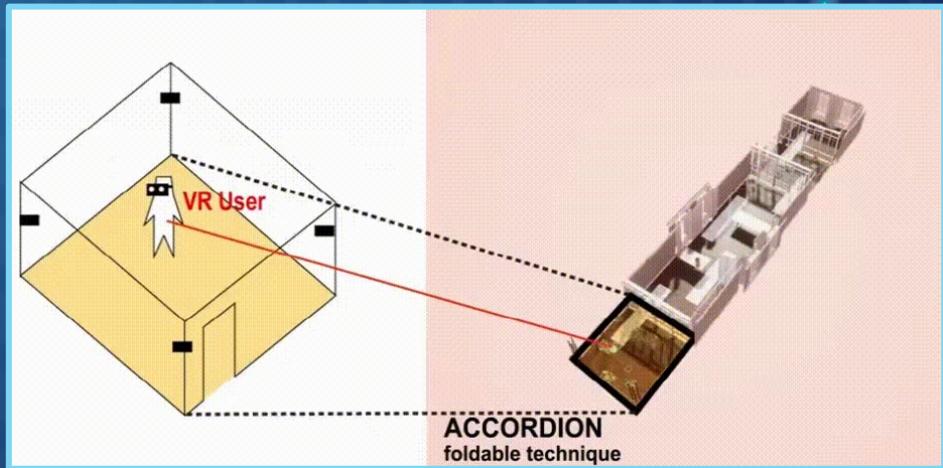
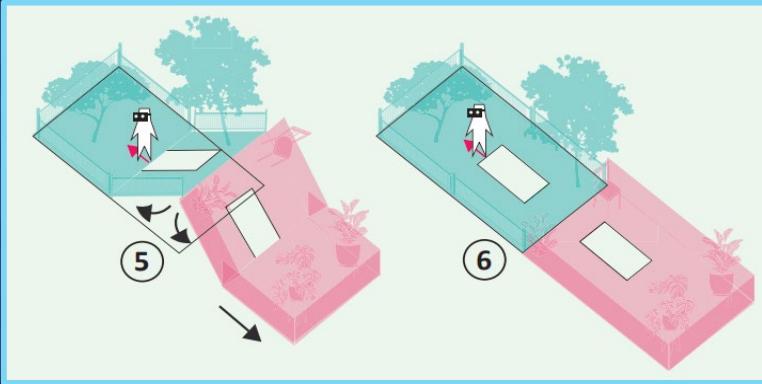


PHASE 02



0.9

PHASE 03



EXAMPLE



10

USER STUDY

For each Participant

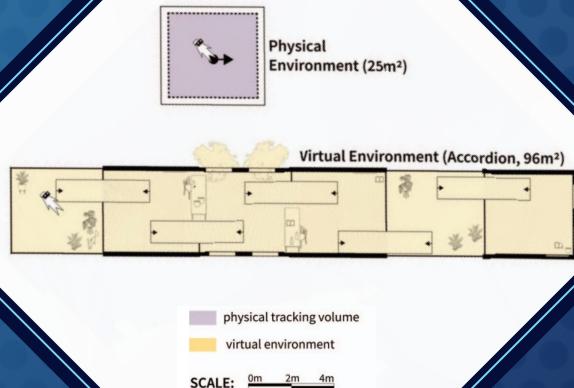
0 1 Quantitative evaluation

Performance on the walking and cognitive task

0 2 Qualitatively evaluation

Subjective classification, questionnaires, thematic analysis of interviews and sketch maps

Virtual Environment



Evaluation Rules



Participants had 3 minutes each tentative

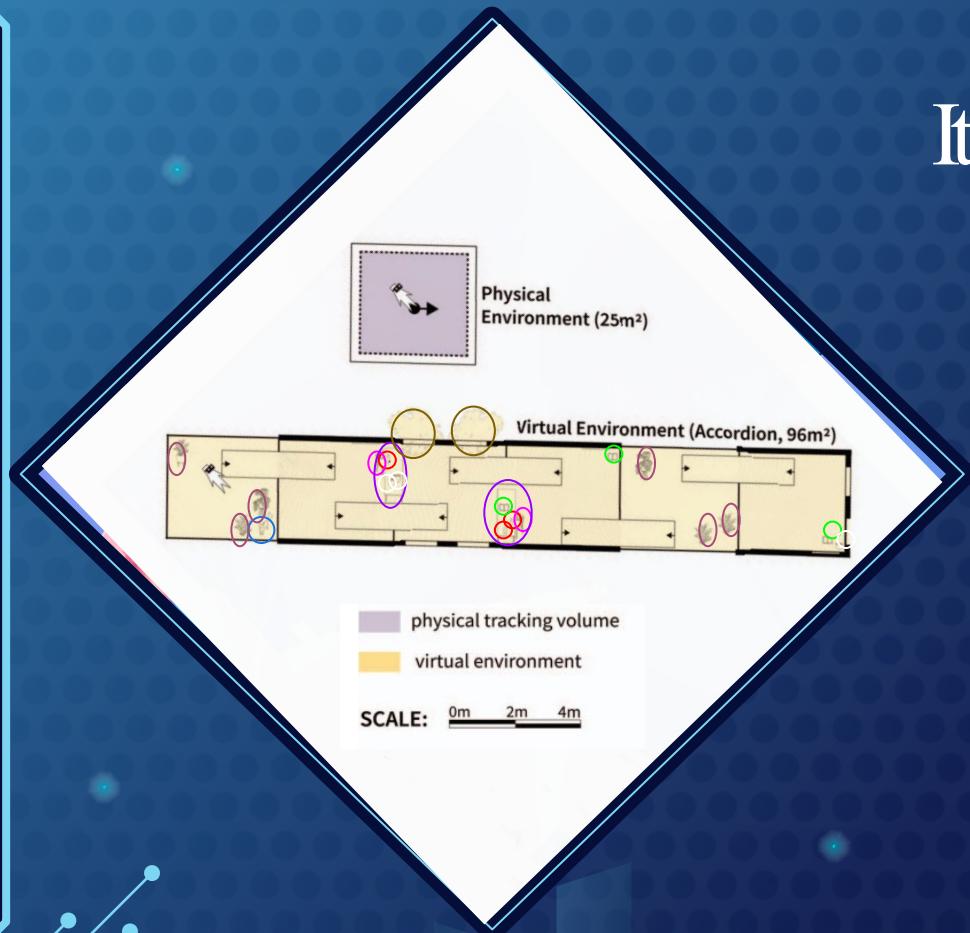


Each trial occurred in the same VE with the same number of virtual objects; however, the location of these virtual objects was different.



Each VE contained 3 bottles, 3 photos, 3 books, 2 chairs, 2 tables, 2 trees, 1 fox, 3 pots without plants and 6 indoor plants as shown in figure.

Items to search



- 3 Bottles - o
- 3 Photos (nor visible from above)
- 3 Books - o
- 2 Chairs - o
- 2 Tables - o
- 2 Trees - o
- 1 Fox - o
- 3 Pots - o
- 6 Plants - o

Post-Experiment

0 1

10 question memory test

0 2

Sketch map exercise

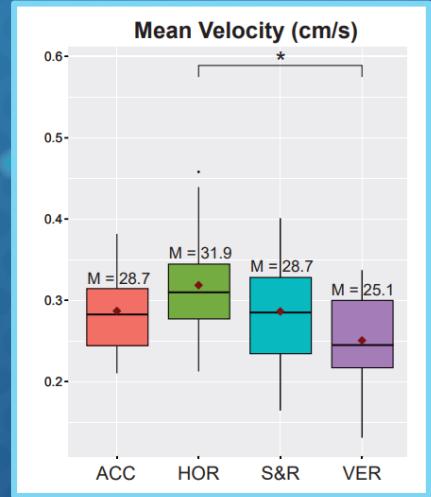
0 3

Short interview to get feedback

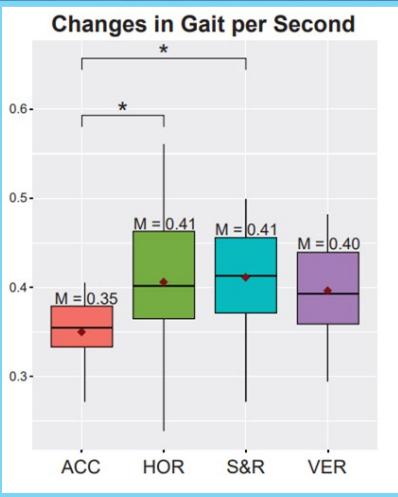
Table 1: Custom 10-question memory-recall test. True or False?

- 1 – One part of the roof was a different colour/material.
- 2 – If a deer was present in the VE, it was looking towards the building.
- 3 – If a fox was present in the VE, it was standing up.
- 4 – There are two different kinds of chairs in the environment.
- 5 – At least one glass bottle in the VE had a red label.
- 6 – All the plant pots were on stilts/stands.
- 7 – Trees could be seen outside both sides of the building.
- 8 – All the tables were made of the same material.
- 9 – All the windows were the same size.
- 10 – Not all the doors were white.

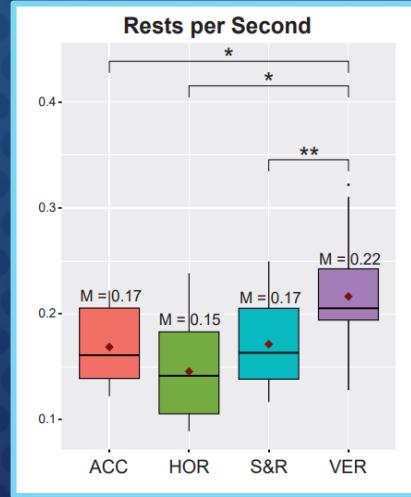
Results



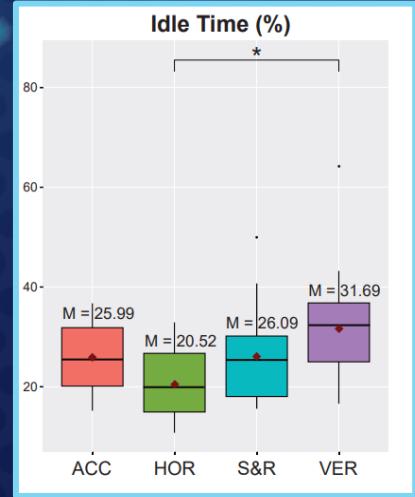
- 1º - Horizontal ($M=31.9 \text{ cm/s}$, $\text{Max}=45.8 \text{ cm/s}$)
 2º - Stop&Reset (28.7 cm/s , $\text{Max}=40.1 \text{ cm/s}$)
 2º - Accordion ($M=28.7 \text{ cm/s}$, $\text{Max}=38.2 \text{ cm/s}$)
 3º - Vertical ($M=25.1 \text{ cm/s}$, $\text{Max}=33.8 \text{ cm/s}$)



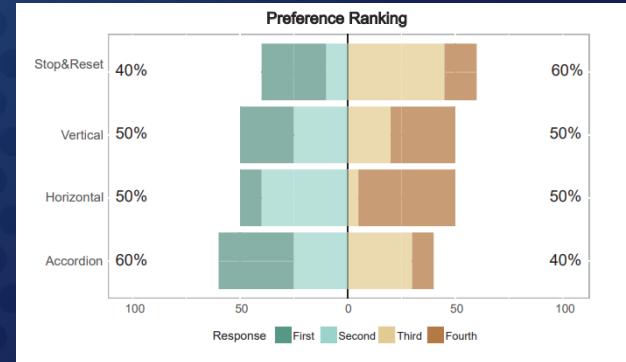
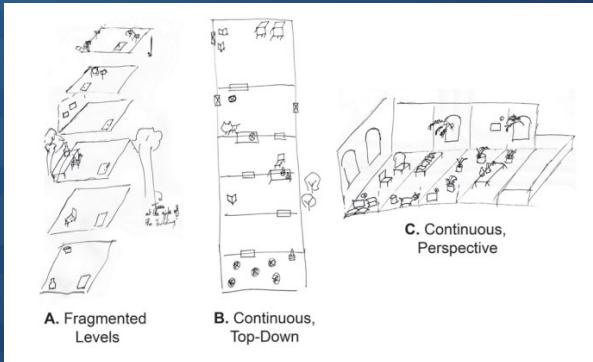
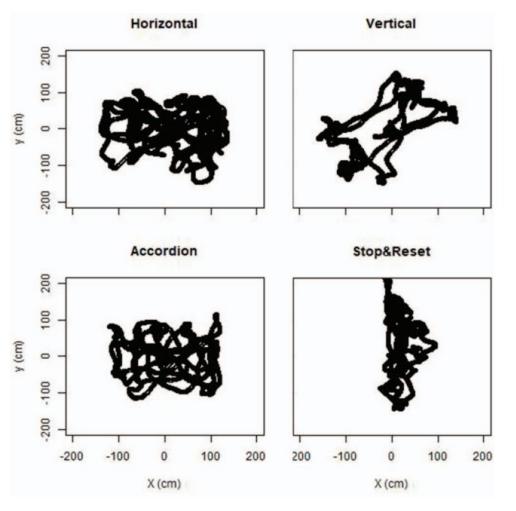
- 1º - Accordion ($M=0.35 \Delta/\text{s}$)
 2º - Vertical ($M=0.40 \Delta/\text{s}$)
 3º - Stop&Reset ($M=0.41 \Delta/\text{s}$)
 3º - Horizontal ($M=0.41 \Delta/\text{s}$)



- 1º - Horizontal ($M=0.15$)
 2º - Stop&Reset ($M=0.17$)
 2º - Accordion ($M=0.17$)
 3º - Vertical ($M=0.22$)



More Results



Security

Sketch Map

Preference Ranking

Dis c u s s i o n

Q 1

Affect how users walk in a VE on Foldable
redirection techniques

Q 2

How users cognitively engage with a VE with
Foldable redirection techniques

Q 3

Does the ‘overtness’ of the manipulation
constitute a break in Presence too great to
be ignored?

Future Work

THANKS !

Do you have any questions?

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