EyeScope: A 3D Interaction Technique for Accurate Object Selection in Immersive Environments

Cleber Ughini, Fausto Blanco, Francisco Pinto,
Carla M.D.S. Freitas, Luciana P. Nedel
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Motivation: object selection in VEs

- Metaphors
  - Exocentric
  - Egocentric
    - Virtual hand
    - Virtual pointer
- Immersive environments
  - HMD
  - Data glove

Motivation: object selection in VEs

- Requirements
  - Accuracy
  - Reachability
  - Time saving
  - Comfort
  - Simplicity
  - Immersion sense
  - Error and tolerance
- Virtual hand
  - User's hand is explicitly represented in the virtual environment
  - To select an object the user intercept the object with the virtual hand
  - Selection is confirmed by:
    - pressing a button on the input device
    - performing a specific gesture with the fingers or the whole hand
- More physical hand movement
  - Lack of comfort

Motivation: object selection in VEs

- Requirements
  - Accuracy
  - Reachability
  - Time saving
  - Comfort
  - Simplicity
  - Immersion sense
  - Error and tolerance
- Ray casting
  - Bolt (1990)
  - An infinite and semi-transparent ray from the user's hand towards the point indicated by the hand orientation
  - The object pointed at by the ray is selected through a specific command using the input device
  - Powerful technique but
- Fails in dense environments or with faraway objects
  - Lack of accuracy

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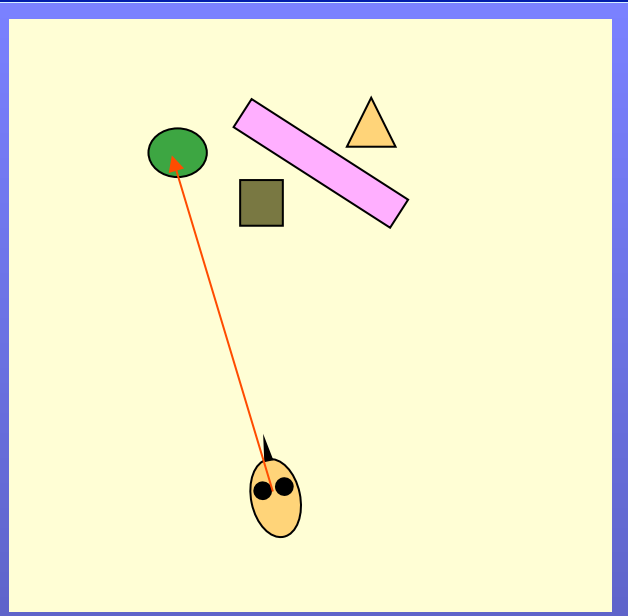
Motivation: object selection in VEs

- Requirements
  - Accuracy
  - Reachability
  - Time saving
  - Comfort
  - Simplicity
  - Immersion sense
  - Error and tolerance
- Gaze-directed technique
  - Jacob (1990)
  - Tracking the user's eye movement and determining to where the user is looking at
  - Selection of the object the user pointed by the viewing direction
- Fails in dense environments or with faraway objects
  - Lacks accuracy

Gaze-directed selection technique

- Used by other authors
  - Bleser and Sibert (1990)
  - Tanaka (1999)
  - Yamato et al. (2000)
- Appropriate for use with HMD
- Lacks accuracy in dense environments or with faraway objects due to the low precision of pointing with the eye's or head movement



Goal

- Improving selection in immersive environments using virtual hand
  - Looking at objects and zooming in their direction for selection
  - Provide a finer control over the viewing direction during zoom in to improve precision of object selection
    - HMD controls the viewing direction
    - Data glove gestures control zoom in/out and selection

Eyescope

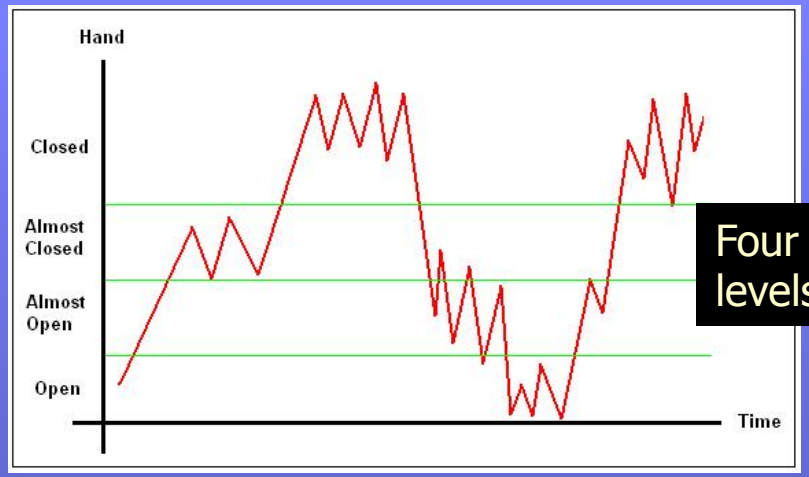
- HMD movement
  - used to control the position of the cursor (red cross)
- Hand (using a data glove) closing gestures
  - control zoom in/out and selection

Opening/closing
Zooming in or out

Closed
Selection

Eyescope: hand gestures to zooming factor

- Zooming in occurs between *almost open* and *almost closed* hands
- *Open* hand means no zoom through a smooth zoom out
- *Closed* hand means selection of the object under the cursor



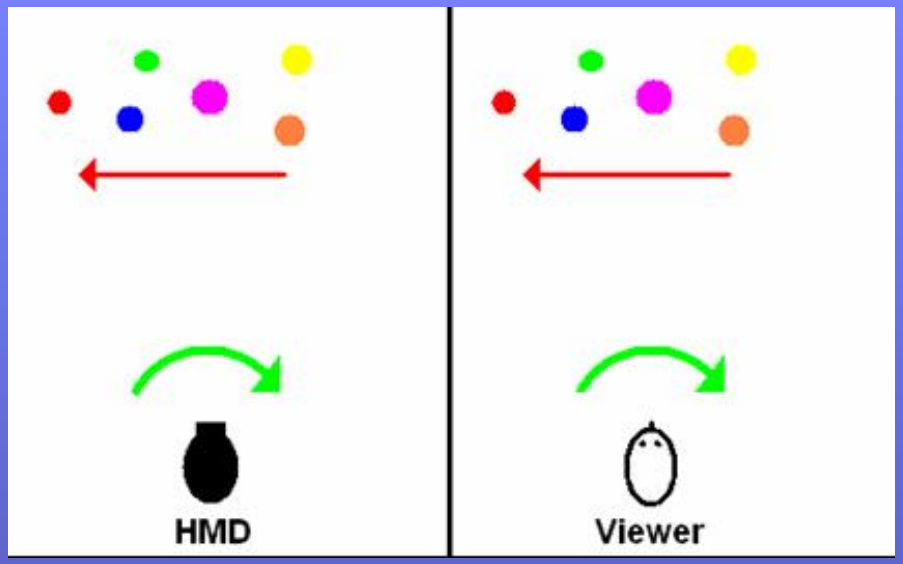
Open
No zoom

Almost open
Zooming out

Almost closed
Zooming in

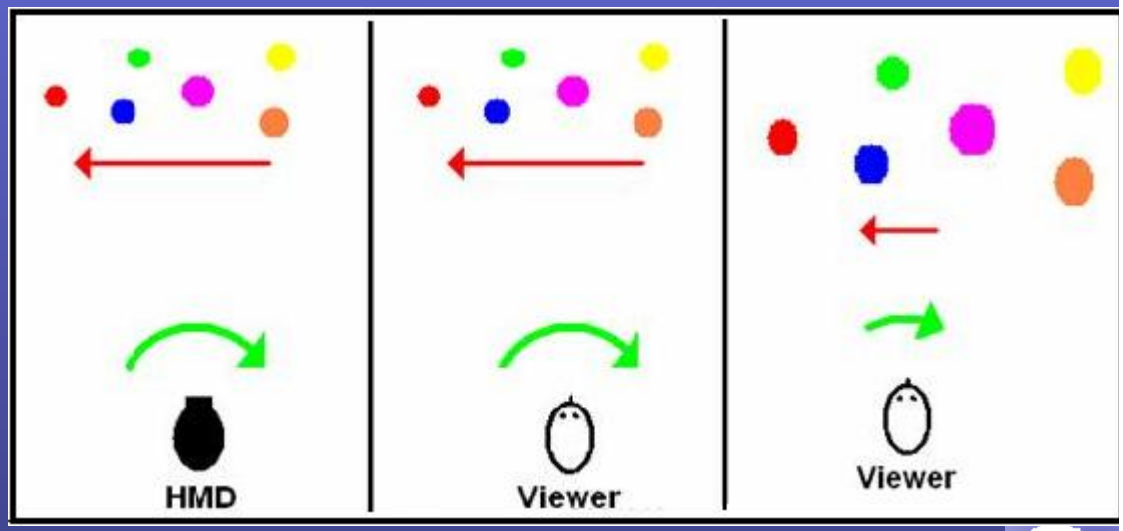
Closed
Selection

Eyescope: head movements



- Gaze-directed selection
  - Angles are mapped 1:1 from the HMD to the virtual observer in the VRE
  - Lack of stability

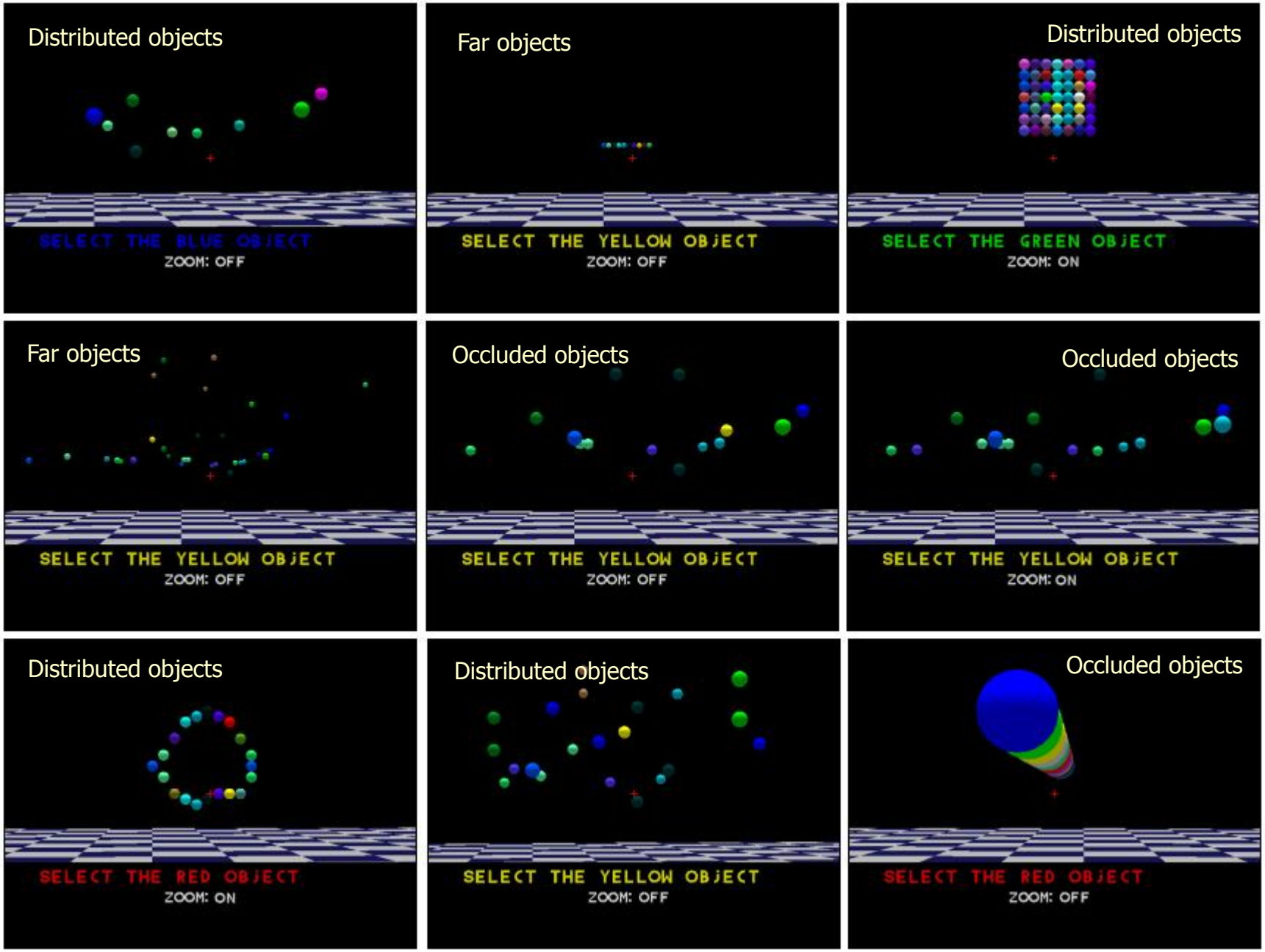
- Eyescope
  - Larger zooming levels imply smaller angular variations in the viewing direction for the same variation in the HMD orientation



Application

- Spheres populate the VRE
- Apparatus
  - VFX3D head-mounted display with yaw, pitch and roll orientation sensors; maximum screen resolution of 640 by 480 pixels, and 60^{o} frustum
  - 5DT data glove
  - Background music (Super Mario Bros)

1-usertests.avi


Distributed objects
SELECT THE BLUE OBJECT
ZOOM: OFF
Far objects
SELECT THE YELLOW OBJECT
ZOOM: OFF
Distributed objects
SELECT THE GREEN OBJECT
ZOOM: ON
Far objects
SELECT THE YELLOW OBJECT
ZOOM: OFF
Occluded objects
SELECT THE YELLOW OBJECT
ZOOM: OFF
Occluded objects
SELECT THE YELLOW OBJECT
ZOOM: ON
Distributed objects
SELECT THE RED OBJECT
ZOOM: ON
Distributed objects
SELECT THE YELLOW OBJECT
ZOOM: OFF
Occluded objects
SELECT THE RED OBJECT
ZOOM: OFF

Experiment: task and hypotheses

- Task: Selection of the target object
- Hypotheses
  - H1. Eyescope is more efficient in the cases of far, small or partially occluded objects
  - H2. Eyescope is always more accurate, avoiding wrong selections
  - H3. Eyescope will be chosen as better than gaze-directed selection, and the users will feel more confident with it

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Experiment: variables and sample

Independent

- Age
- Gender
- Previous use of virtual reality devices
- Previous use of 3D applications, like games, CAD, etc.
- Previous participation in experimental studies
- The technique being used (eyescope=with zoom/ gaze directed=without zoom)
- The scenario

Dependent

- Time to select the target
- Number of errors until task completion

Subjects

- 24 subjects
- 9 women and 15 men aging from 19 to 37 years old.

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Experiment: procedure

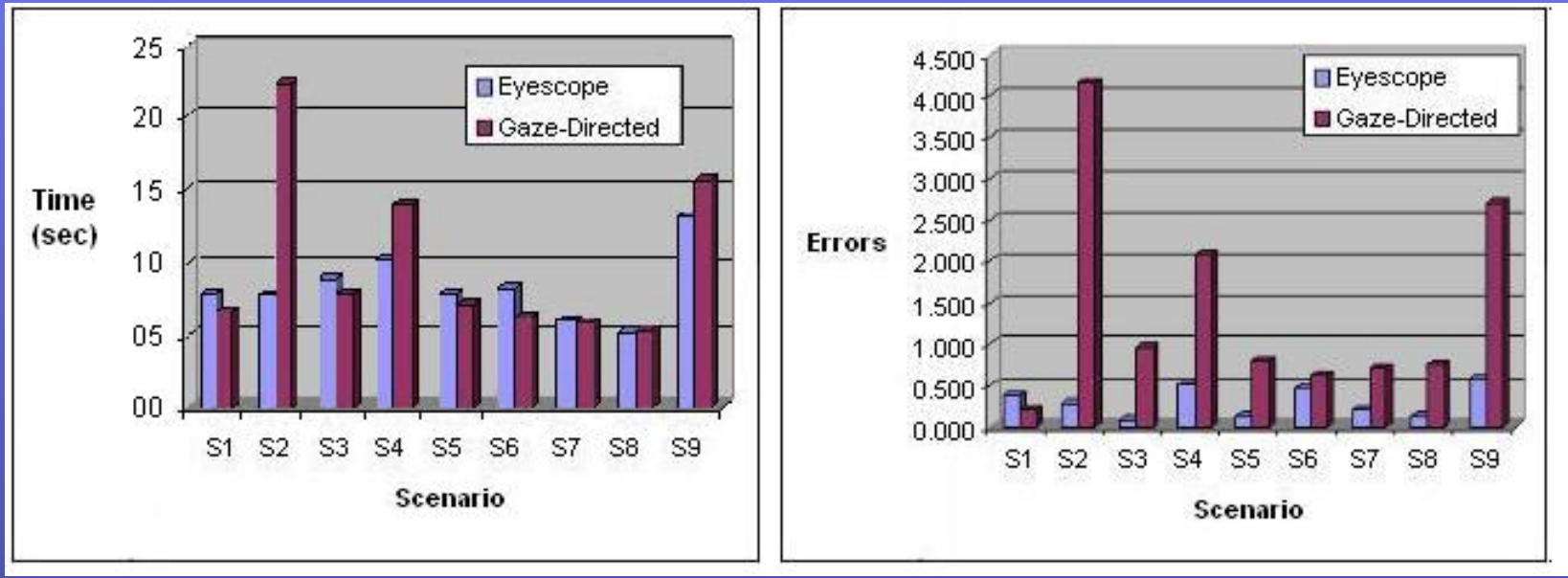
- Users trained until feeling confident
- Tasks executed in an interleavead way
  - 12 no zoom / 12 zooming on and vice-versa
- Post-questionnaire
- Log of results

- First result
  - There is no correlation between any variables and time completion/errors
  - Time and number of errors are correlated to each other and to zoom

	Gdr	Age	Dev	Env	Rsr	Scn	Time	Zm	Ers
Gender	×	61	30	45	20	0	5	2	7
Age	-51	×	14	35	9	0	2	1	1
Device	-37	2	×	24	91	0	9	1	7
Envrmn:	-37	-11	33	×	34	0	1	2	4
Rosoarch	-31	-1	92	41	×	0	5	0	3
Scene	0	0	0	0	0	×	5	0	2
Time	8	-5	-8	-7	-7	-5	×	11	67
Zoom	0	0	0	0	0	0	-10	×	27
Errors	-4	1	5	-3	4	-2	66	-27	×

Results

- H1. *Eyescope is more efficient in the cases of far, small or partially occluded objects*



- H1 holds for all scenarios taken altogether: eyescope is better, mean time of 8.369±6.47 x 10.09±10.19

Results (H1)

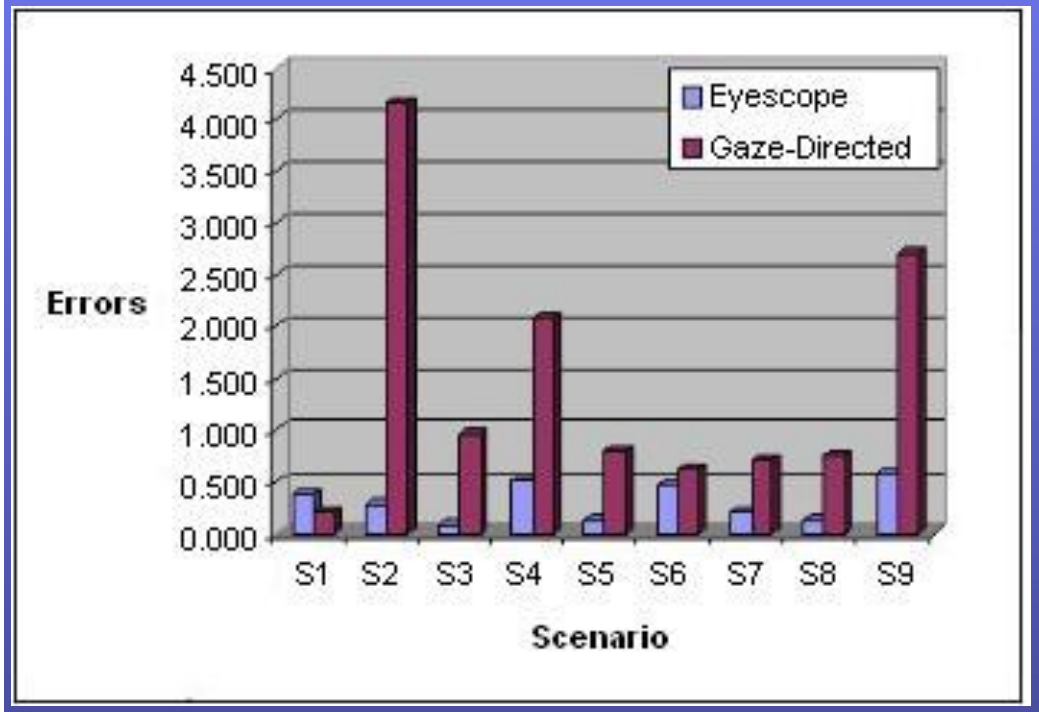
2

6

- ANOVA applied to data from each scenario
- Eyescope is better in scenario 2
  - $F = 17.159$; $p < 0.000146$
- Gaze-directed is better in scenario 6
  - $F = 6.754$; $p < 0.0125$
- No significant difference in the other scenes

Results

- H2: *Eyescope is always more accurate, avoiding wrong selections*



- Except scenarios 1 and 6, all showed significant differences, eyescope being better

  $F = 38.291$

  $p < 1.46605E{-}09$

Results (H2)

2

4

9

- Eyescope avoids wrong selection

Results

- H3. *Eyescope will be chosen as better than gaze-directed selection, and the users will feel more confident with it*

- From the post-test questionnaires:
  - Only 2 of the 24 users preferred the gaze-directed
  - 29.71% said the zoom sometimes confused them
  - 92% preferred the eyescope technique

Conclusions

- Eyescope demonstrated to be better for selecting objects due to the fine control
  - Taking into account all the scenes, the total time to accomplish the tasks dropped from 90.81 seconds with the gaze-directed selection to 75.31 seconds with eyescope
  - The mean number of errors until task completion was reduced from 13.79 to 2.75
- Future work
  - Use data glove's other degrees of freedom to allow navigation in the VRE

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- http://www.inf.ufrgs.br/~ughini/EyeScope/index.html