

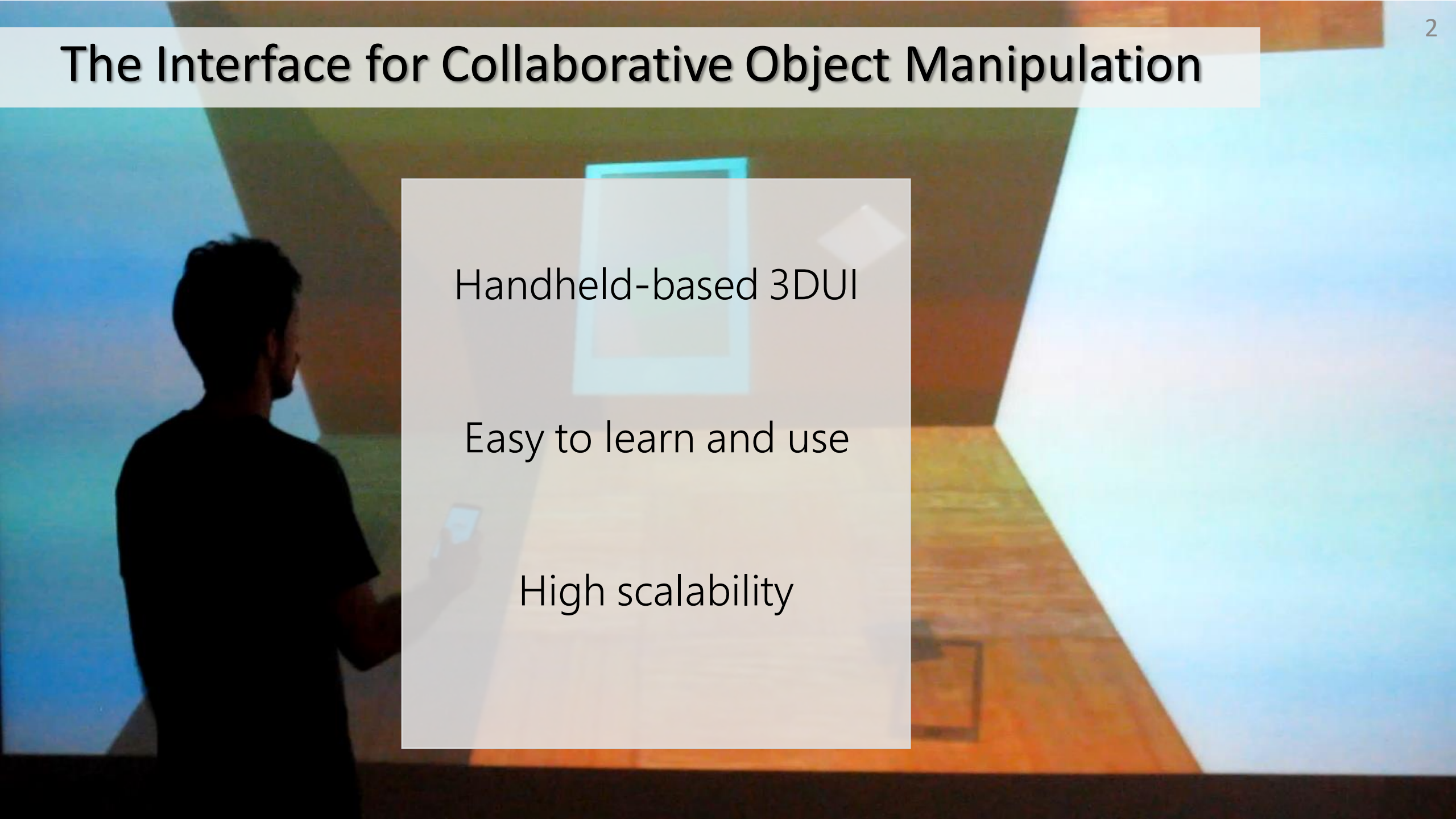
Design and Evaluation of a Handheld-based 3D User Interface for Collaborative Object Manipulation

Jerônimo G. Grandi, Henrique G. Debarba, Luciana Nedel, Anderson Maciel

Federal University of Rio Grande do Sul – Brazil
Graphics, Visualization and Interaction LAB

The Interface for Collaborative Object Manipulation

2

A person is shown in silhouette, standing in a room with large-scale projections on the walls and floor. The person is holding a small device, likely a smartphone, and appears to be interacting with the projected interface. The projections include a large blue square on the wall and a large orange rectangle on the floor. The overall scene suggests a collaborative environment for object manipulation.

Handheld-based 3DUI

Easy to learn and use

High scalability

Research Questions

3

Is our technique suitable for collaborative tasks in VEs?

Does the performance increase accordingly to the number of members in the group?

Applications

Assembly tasks

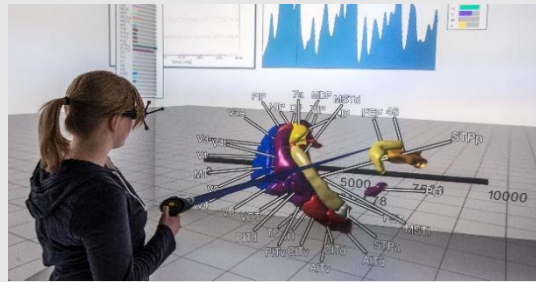


Ford



ESI Group

Data Exploration

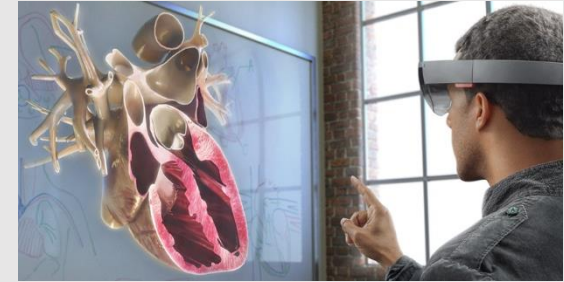


VisNEST



CAVE2™

Serious Games



Medtech Boston



CNN Tech

Collaboration for 3D Spatial Manipulations

Divide and Conquer



Join and Solve



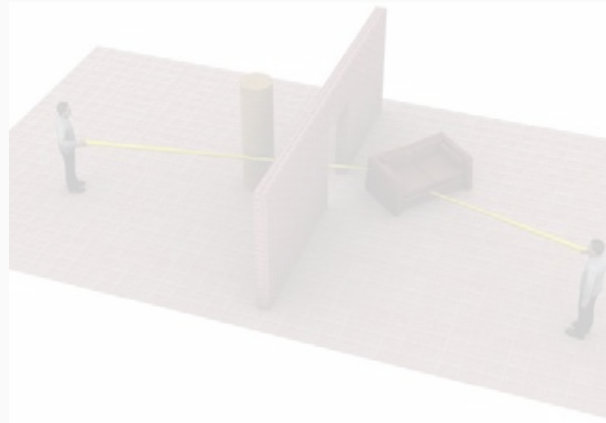
Simultaneous Manipulations of 3D Objects

TUI



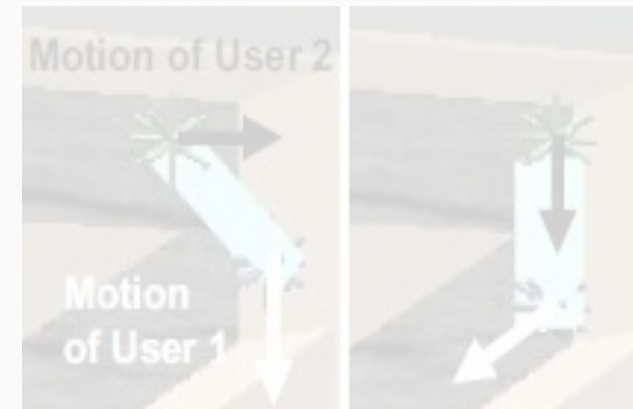
Aguerreche et al. 2010

DOF Separation



Pinho et al. 2008

Mean Average



Duval et al. 2006

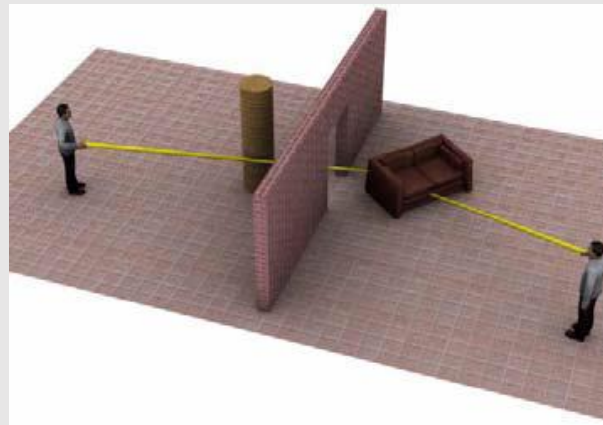
Simultaneous Manipulations of 3D Objects

TUI



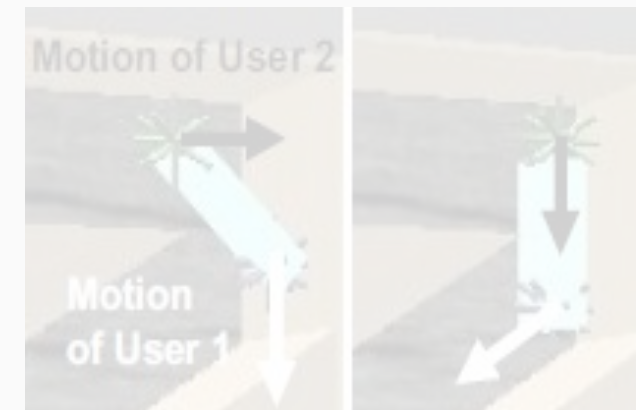
Aguerreche et al. 2010

DOF Separation



Pinho et al. 2008

Mean Average



Duval et al. 2006

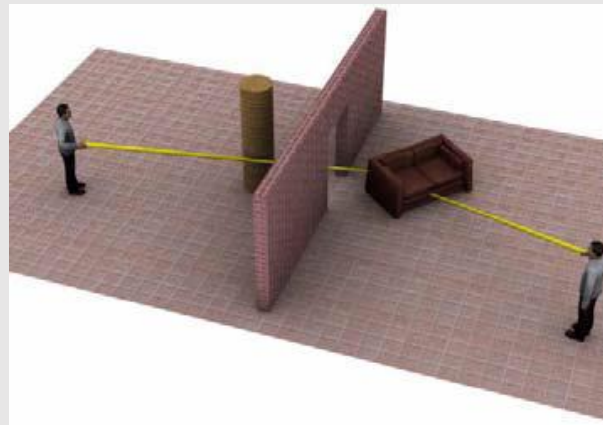
Simultaneous Manipulations of 3D Objects

TUI



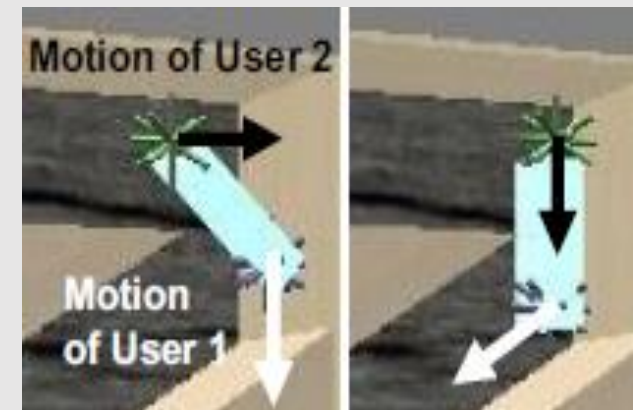
Aguerreche et al. 2010

DOF Separation



Pinho et al. 2008

Mean Average



Duval et al. 2006

Mobile phones as 3D user interface

3DUIs



Mobile phones as 3D user interface

3DUIs



Mobile Device

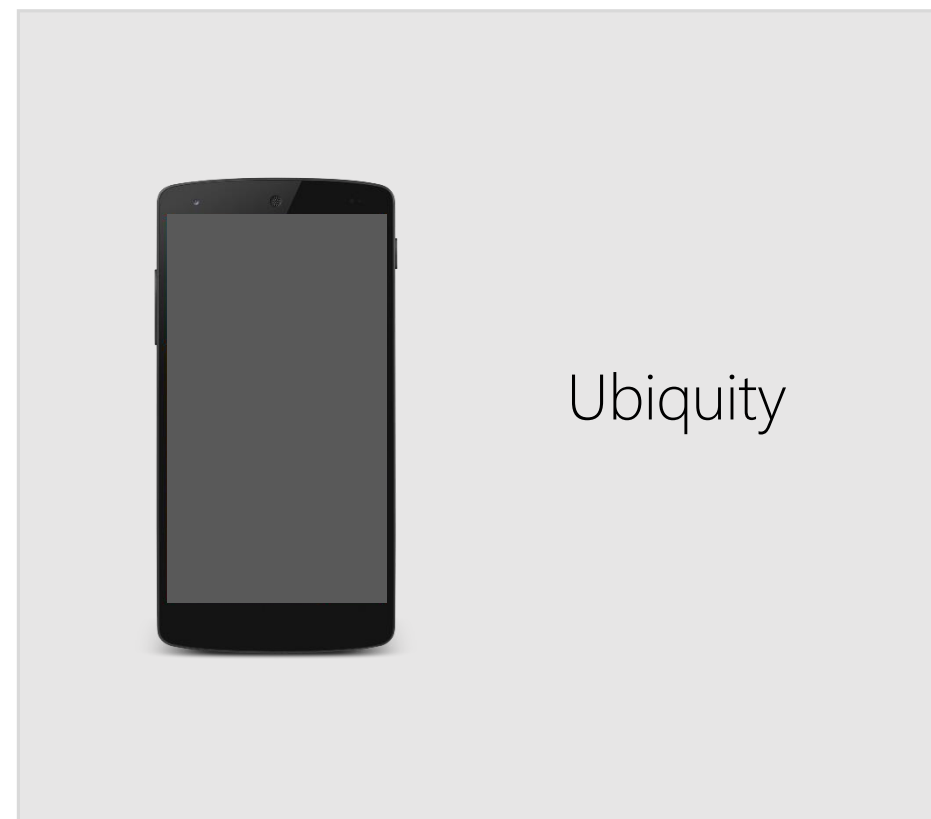


Mobile phones as 3D user interface

3DUIs

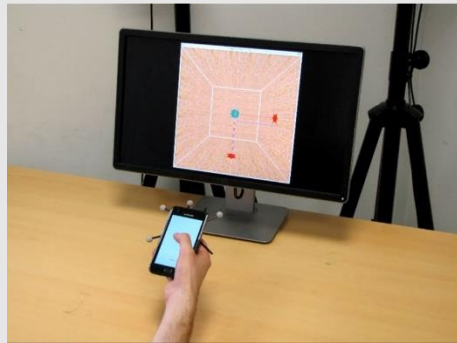


Mobile Device

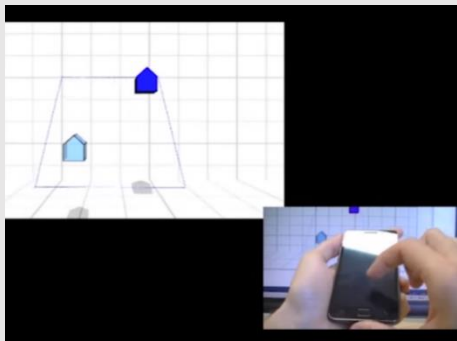


Mobile Phones as 3D User Interface

Manipulation



Bergé et al., 2015



Katzakis et al., 2015

Selection

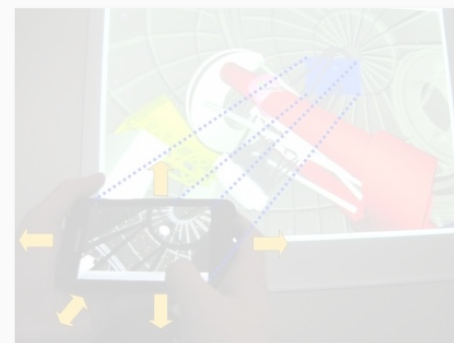


Pietroszek et al., 2015

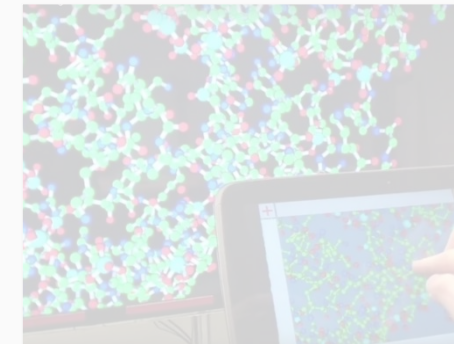


Debarba et al., 2012

Overview + Detail

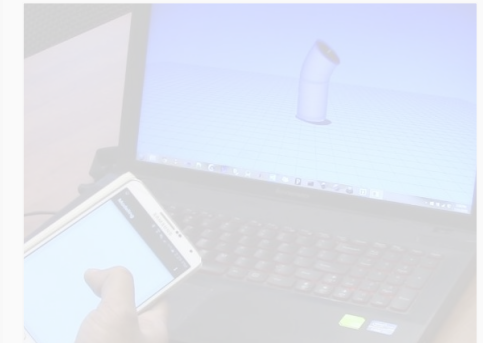


Bergé et al. 2014



López et al., 2016

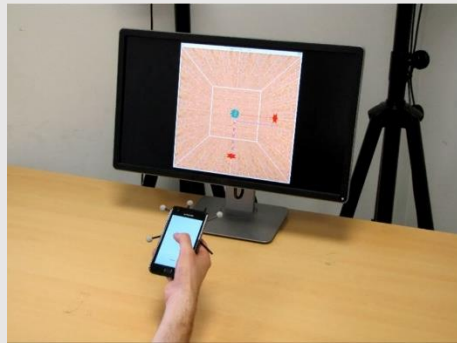
Object Creation



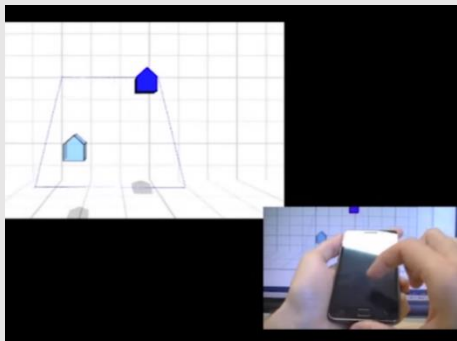
Vinayak et al. 2016

Mobile Phones as 3D User Interface

Manipulation

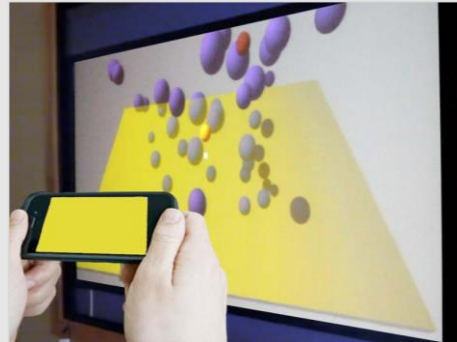


Bergé et al., 2015

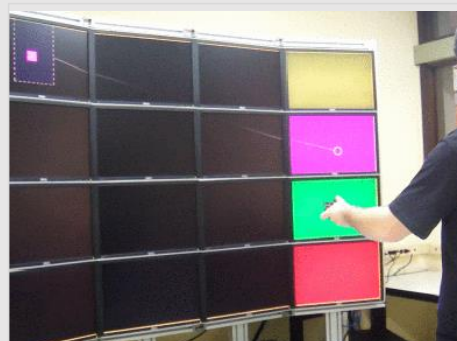


Katzakis et al., 2015

Selection

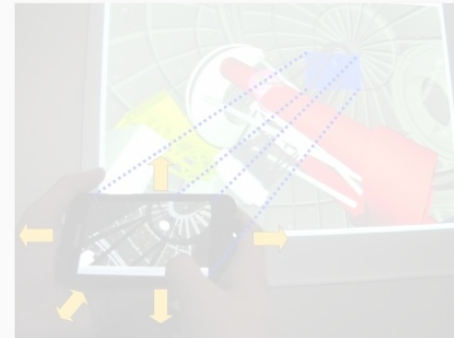


Pietroszek et al., 2015

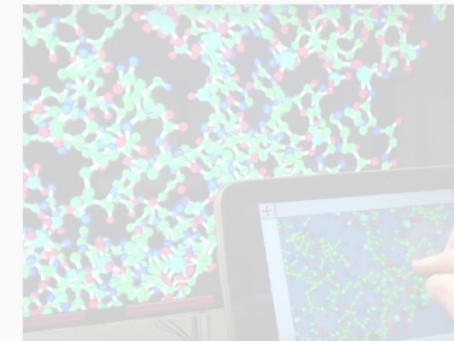


Debarba et al., 2012

Overview + Detail

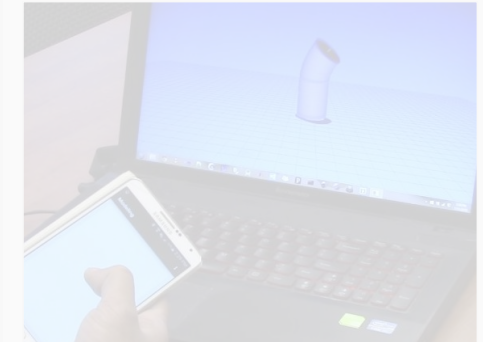


Bergé et al. 2014



López et al., 2016

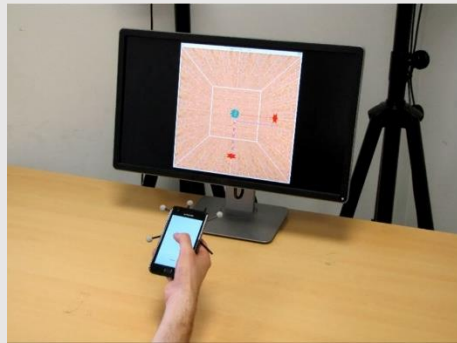
Object Creation



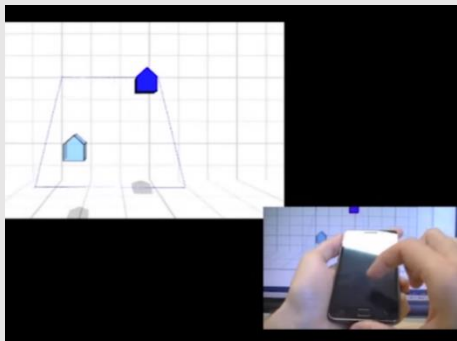
Vinayak et al. 2016

Mobile Phones as 3D User Interface

Manipulation

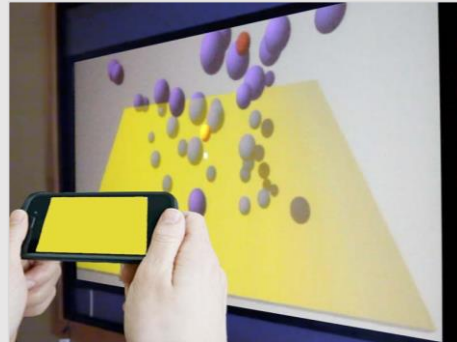


Bergé et al., 2015

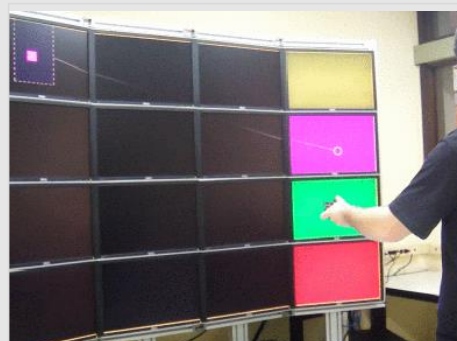


Katzakis et al., 2015

Selection

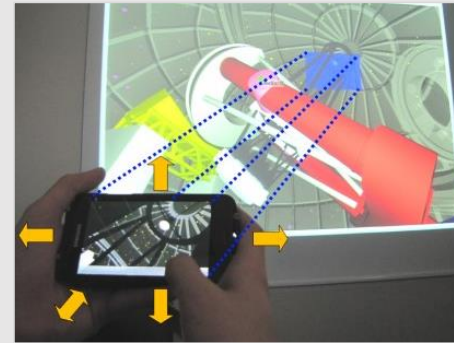


Pietroszek et al., 2015

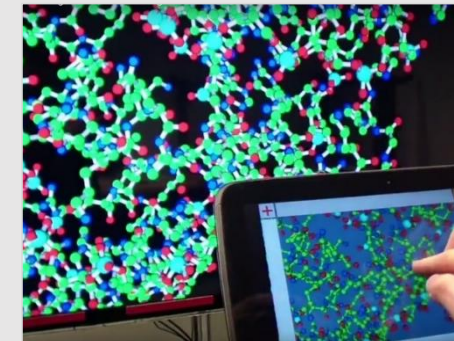


Debarba et al., 2012

Overview + Detail

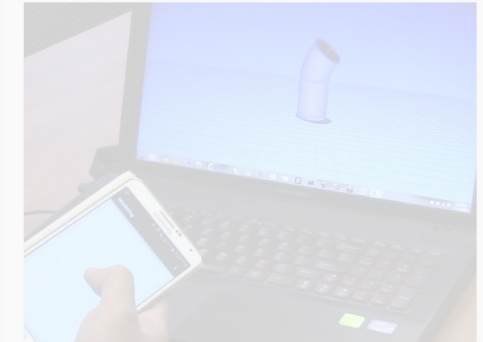


Bergé et al. 2014



López et al., 2016

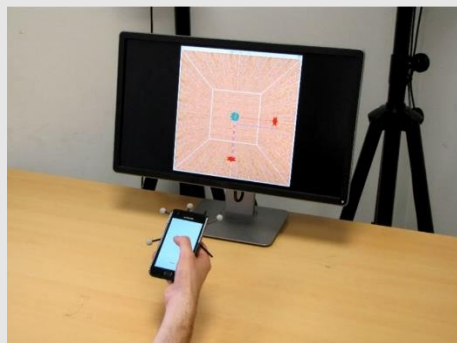
Object Creation



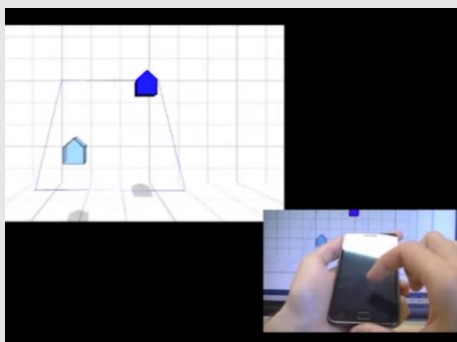
Vinayak et al. 2016

Mobile Phones as 3D User Interface

Manipulation

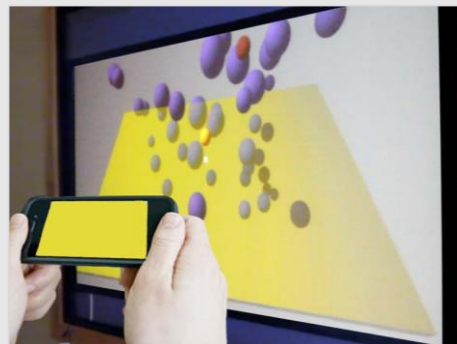


Bergé et al., 2015



Katzakis et al., 2015

Selection

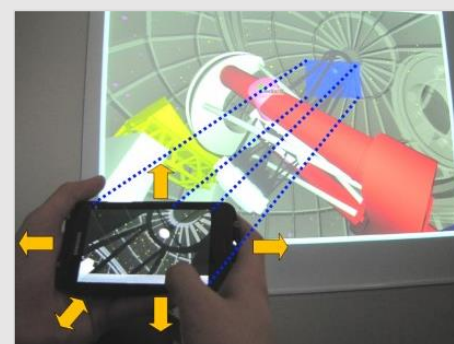


Pietroszek et al., 2015

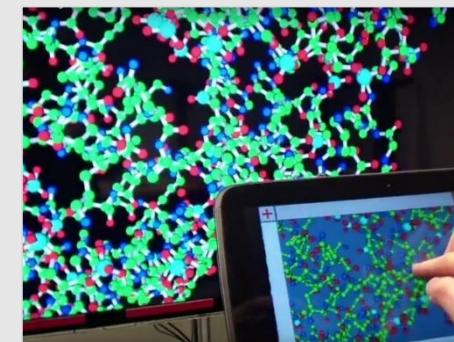


Debarba et al., 2012

Overview + Detail



Bergé et al. 2014



López et al., 2016

Object Creation

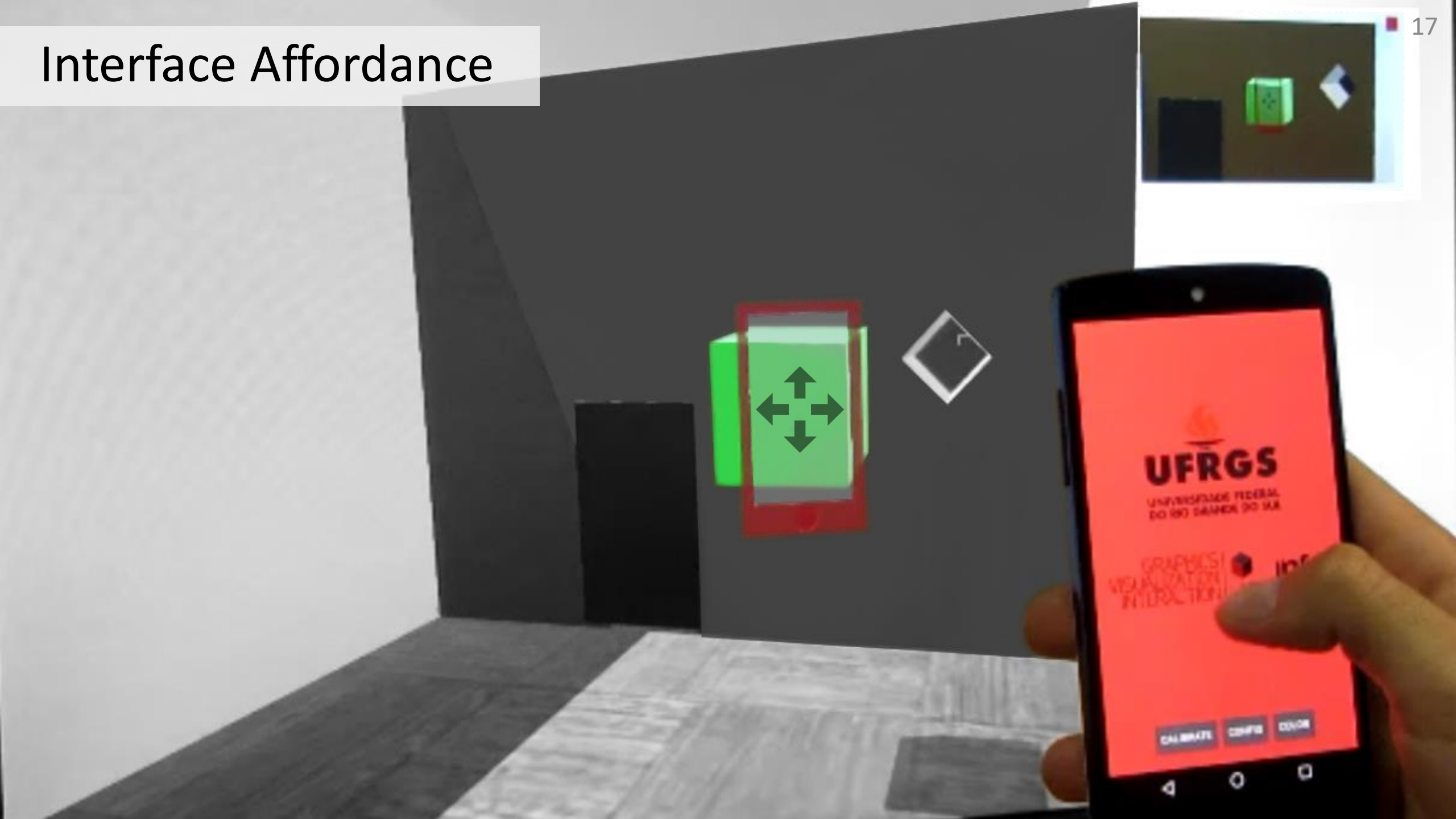


Vinayak et al. 2016

3D Manipulation Using Mobile Phones

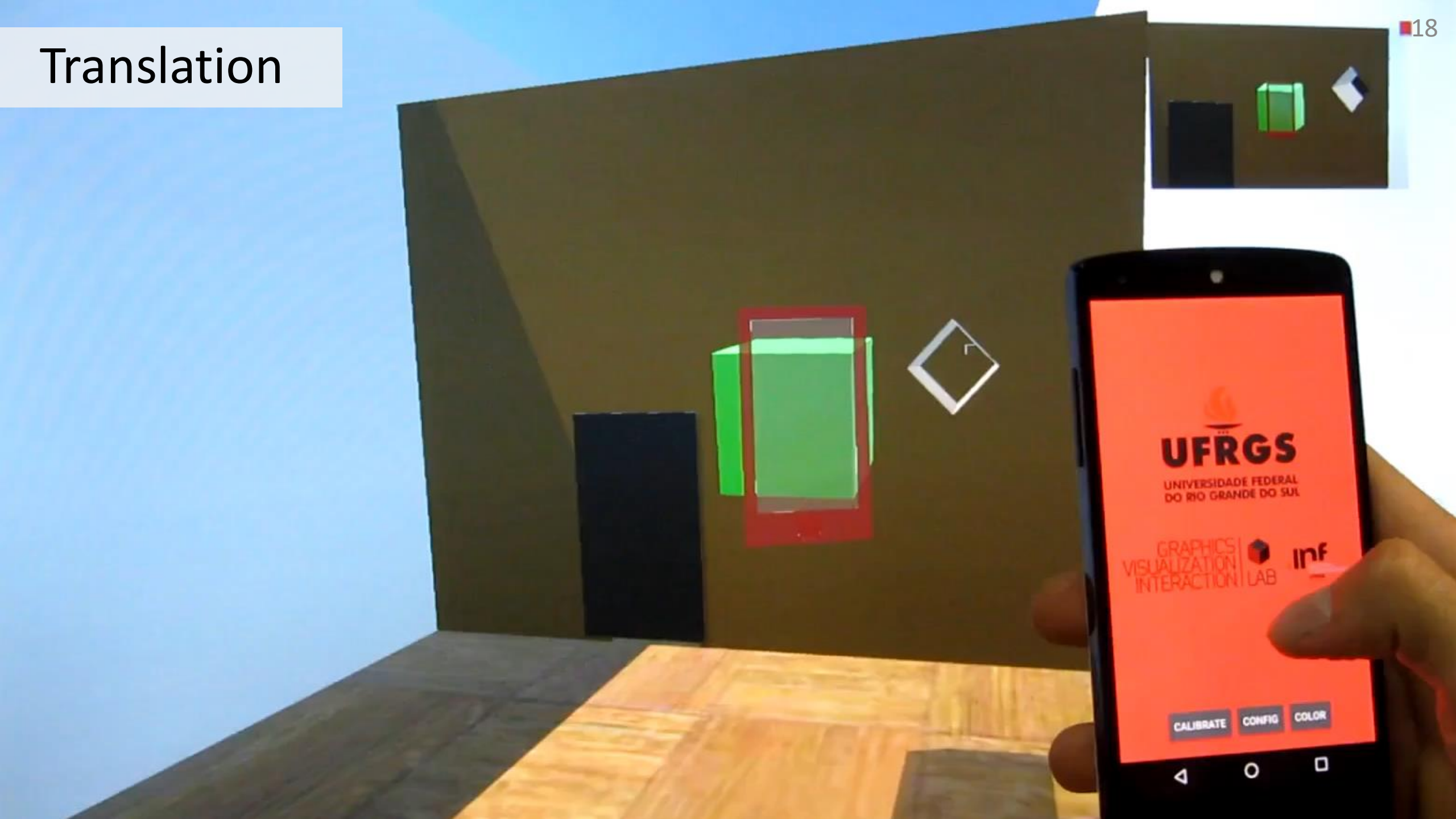


Interface Affordance

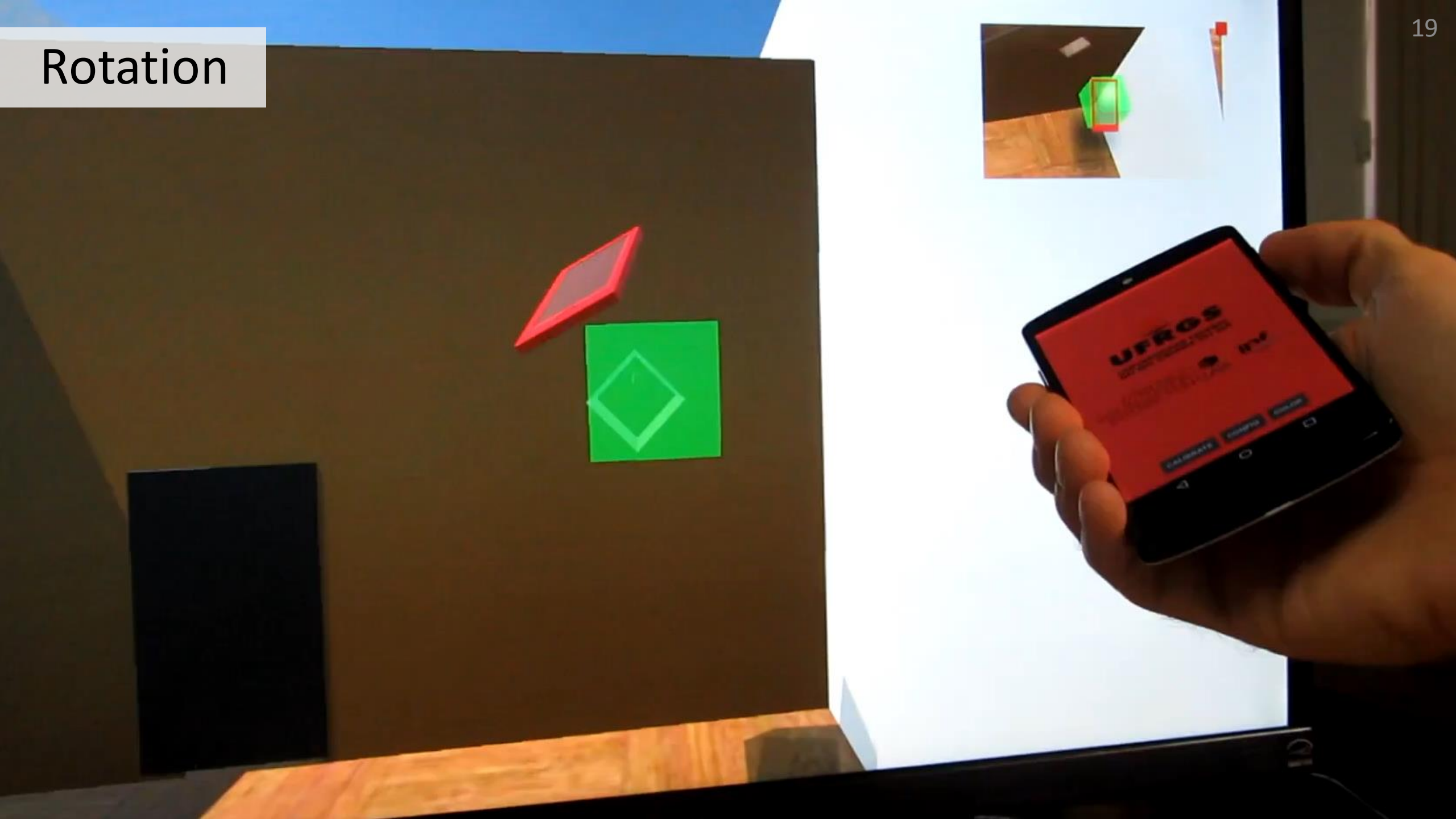


Translation

18

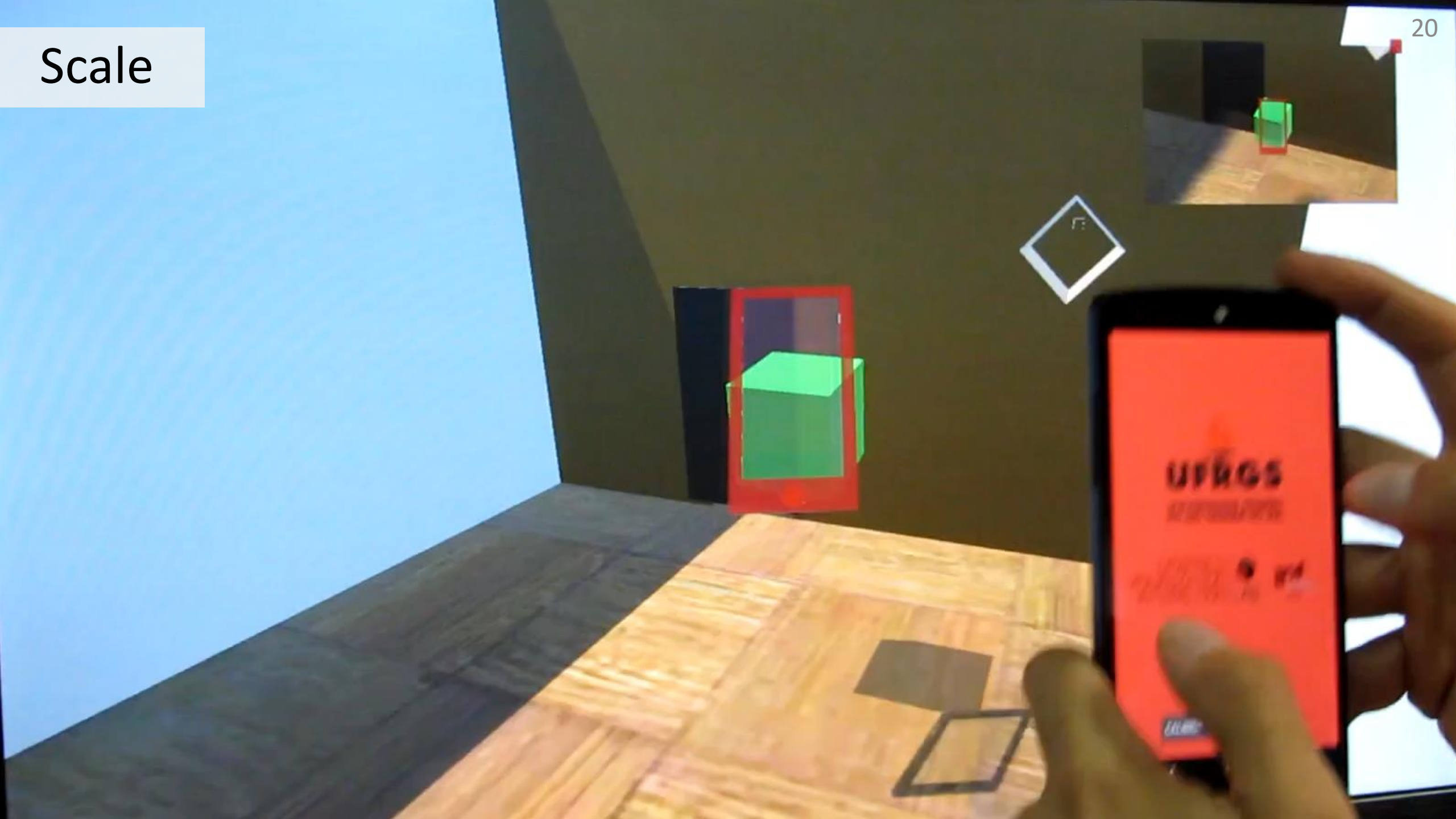


Rotation

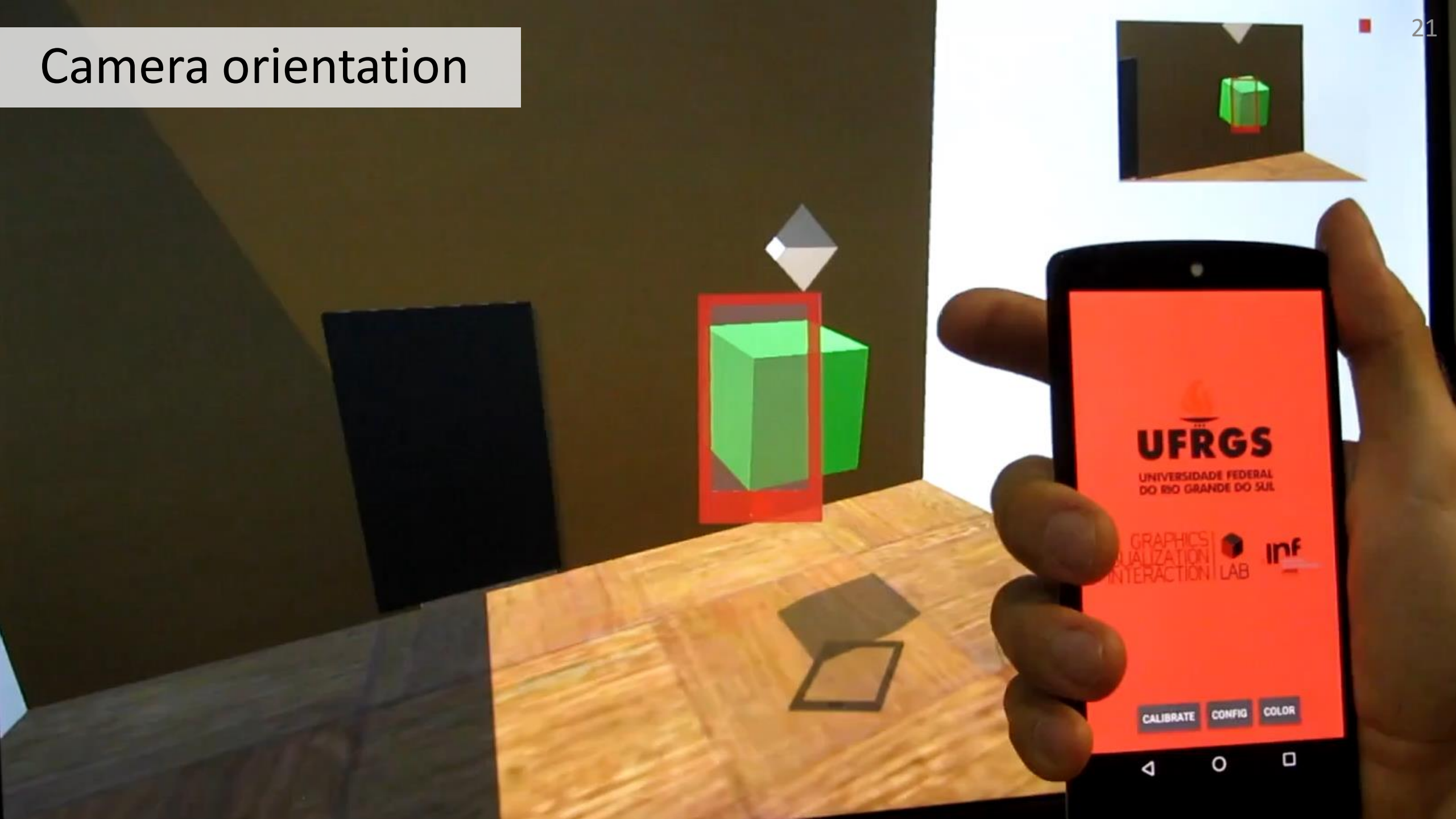


Scale

20

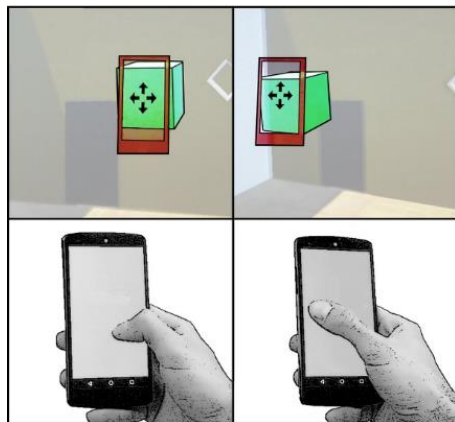


Camera orientation



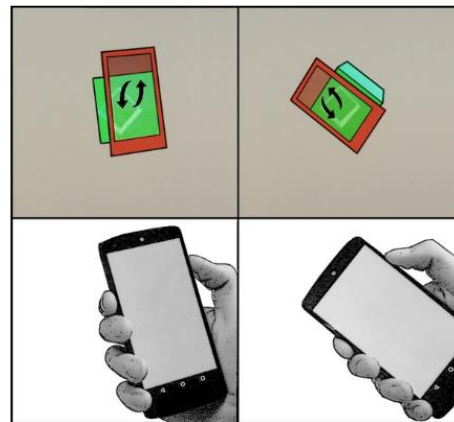
Transformations

Translation



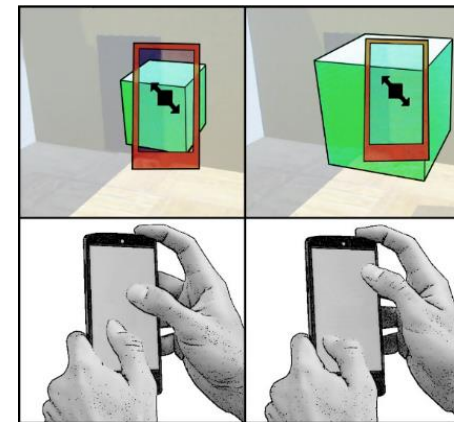
validated in *Katzakis et al., 2015*

Rotation



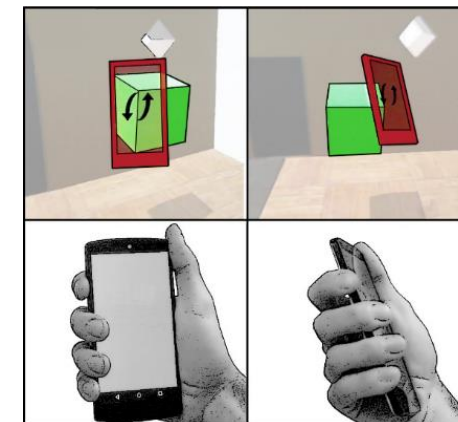
validated in *Bergé et al., 2015*

Scale



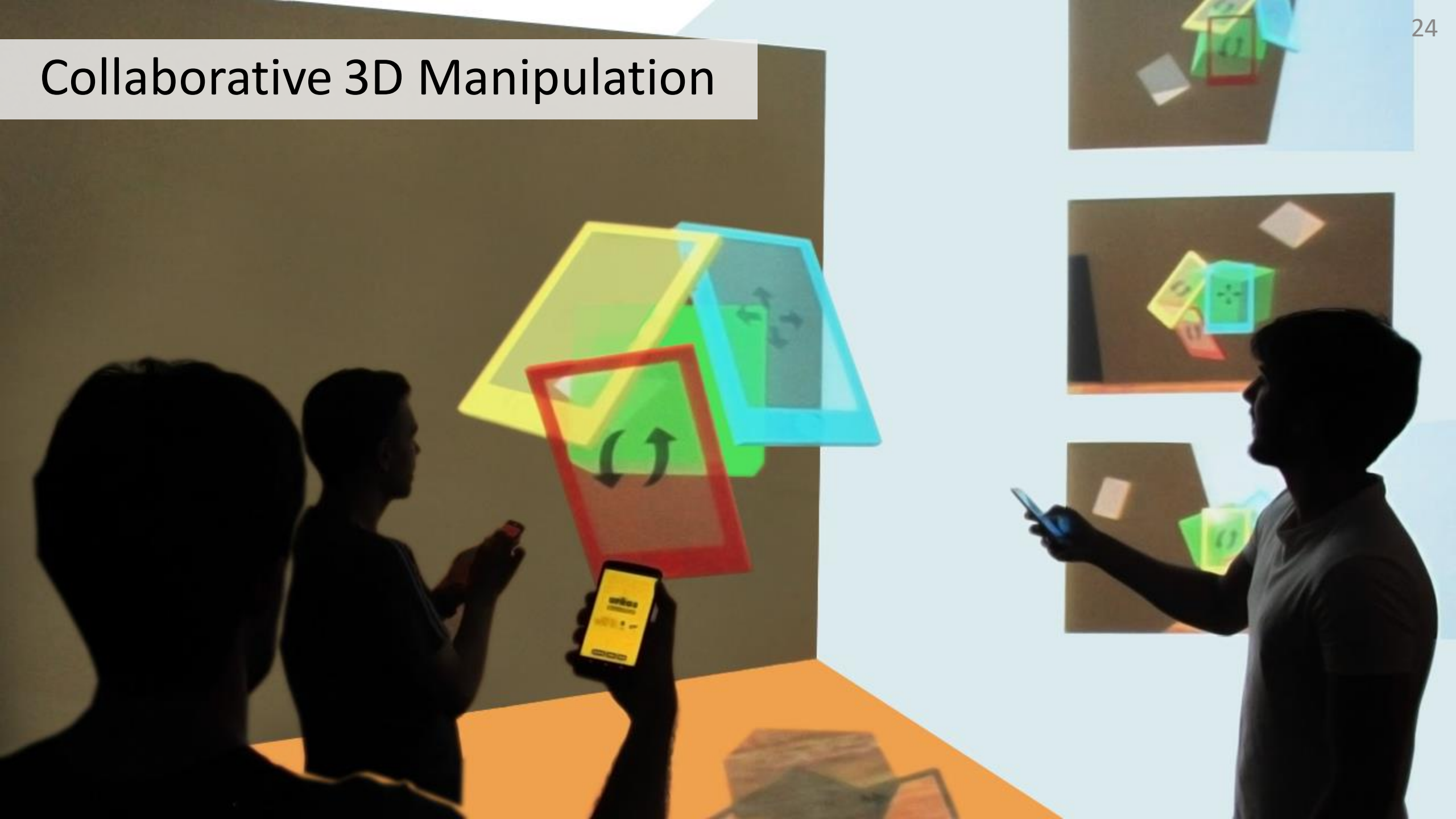
well known gesture

Camera Rotation

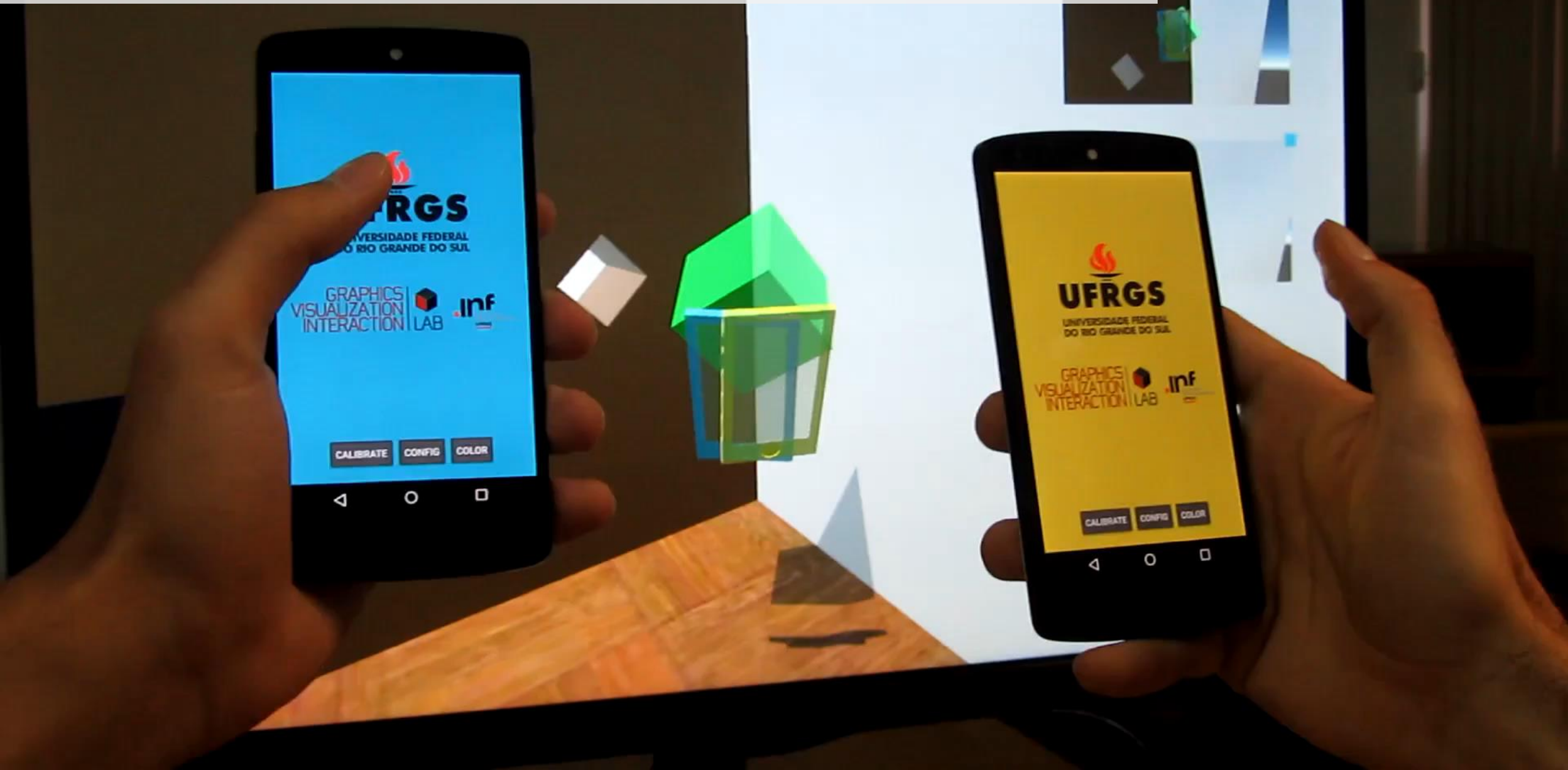


Collaborative 3D Manipulation

Collaborative 3D Manipulation



Collaborative actions negotiation



Collaborative actions negotiation



Is our technique suitable for collaborative tasks in VEs?

Collaborative 3D Manipulation Assessment

Public Demonstration



4 Demos

Over 100 people

Pair Work

Collaborative 3D Manipulation Assessment

Public Demonstration

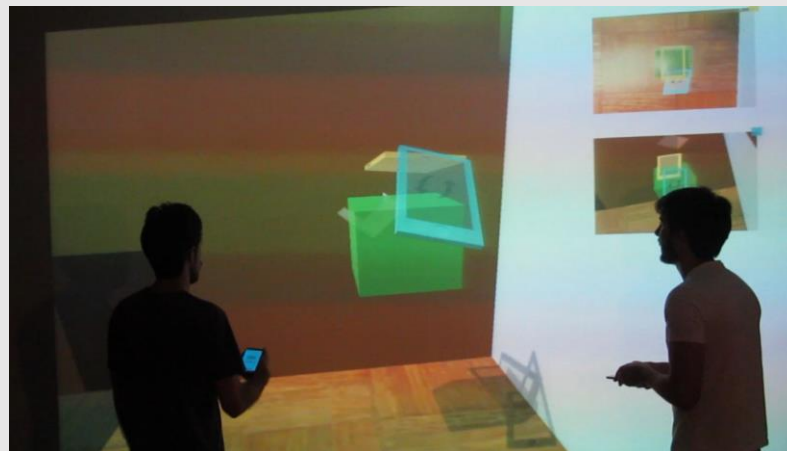


4 Demos

Over 100 people

Pair Work

Tunnel crossing



Docking



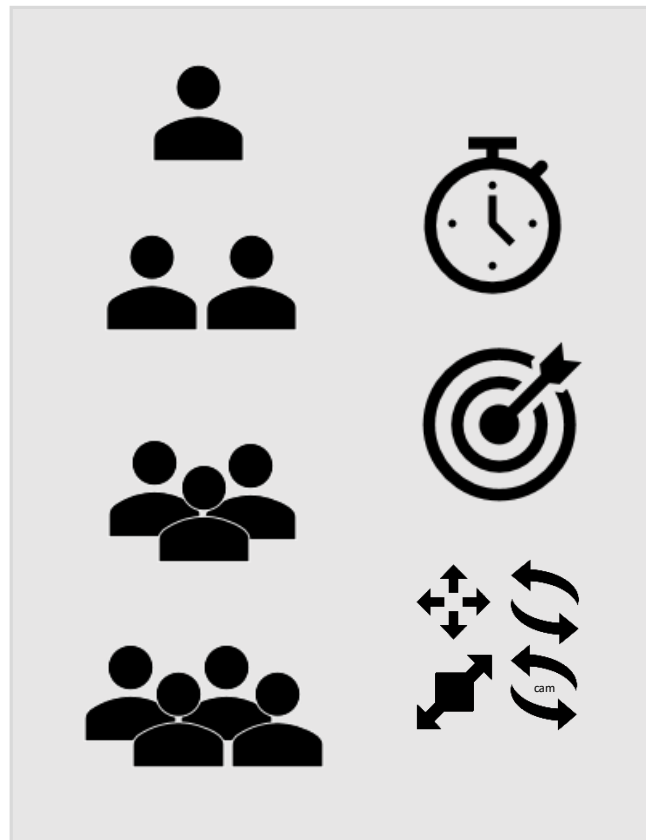
Is our technique suitable for collaborative tasks in VEs?



Does the performance increases accordingly to the number of members in the group?

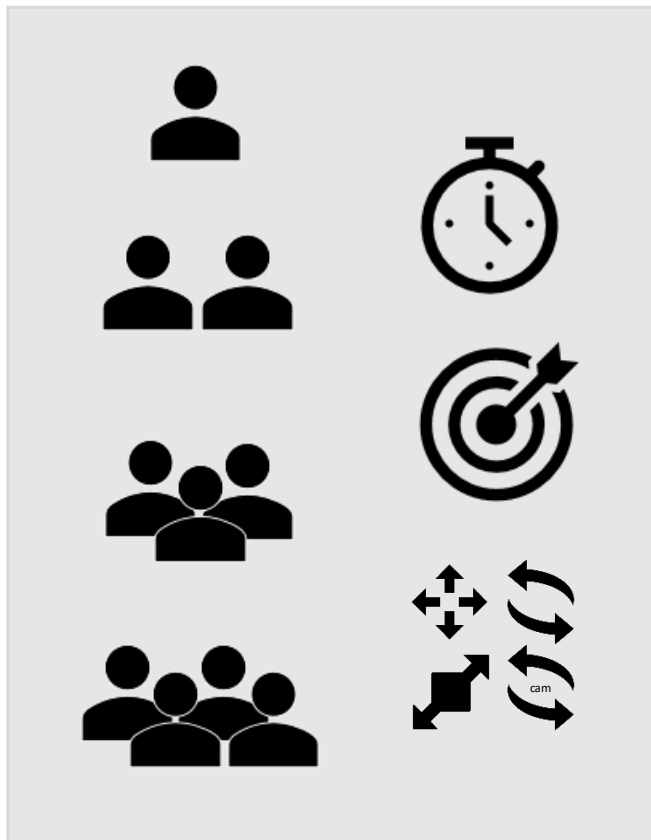
User Study – Design and Procedure

Group Size vs. Time and Accuracy

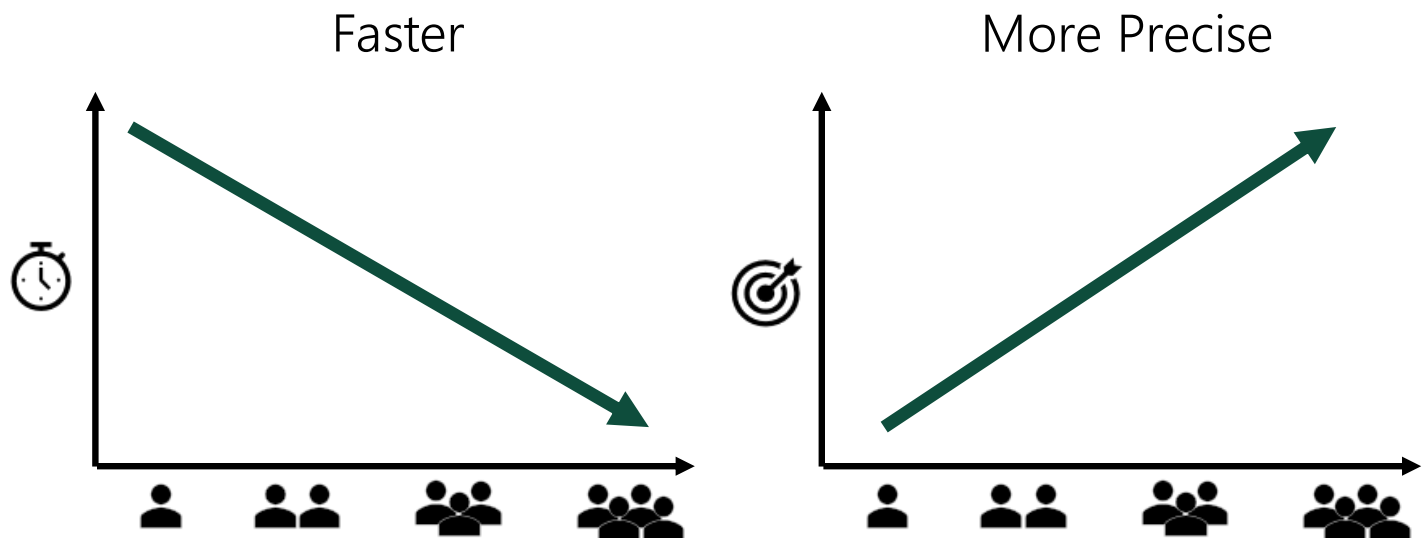


User Study – Main Hypothesis

Group Size vs. Time and Accuracy

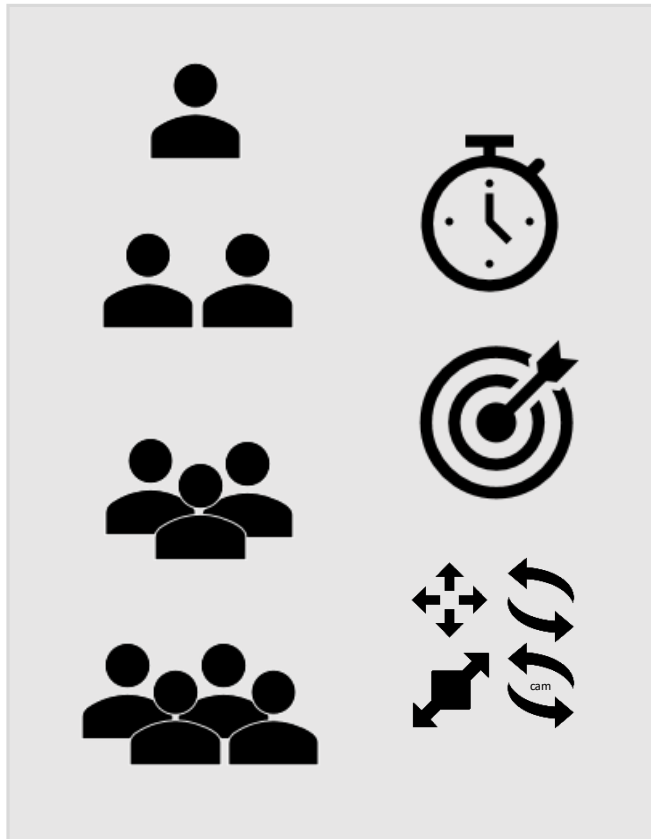


The overall **performance** of a team **increases** accordingly to the **number of members** in the group.

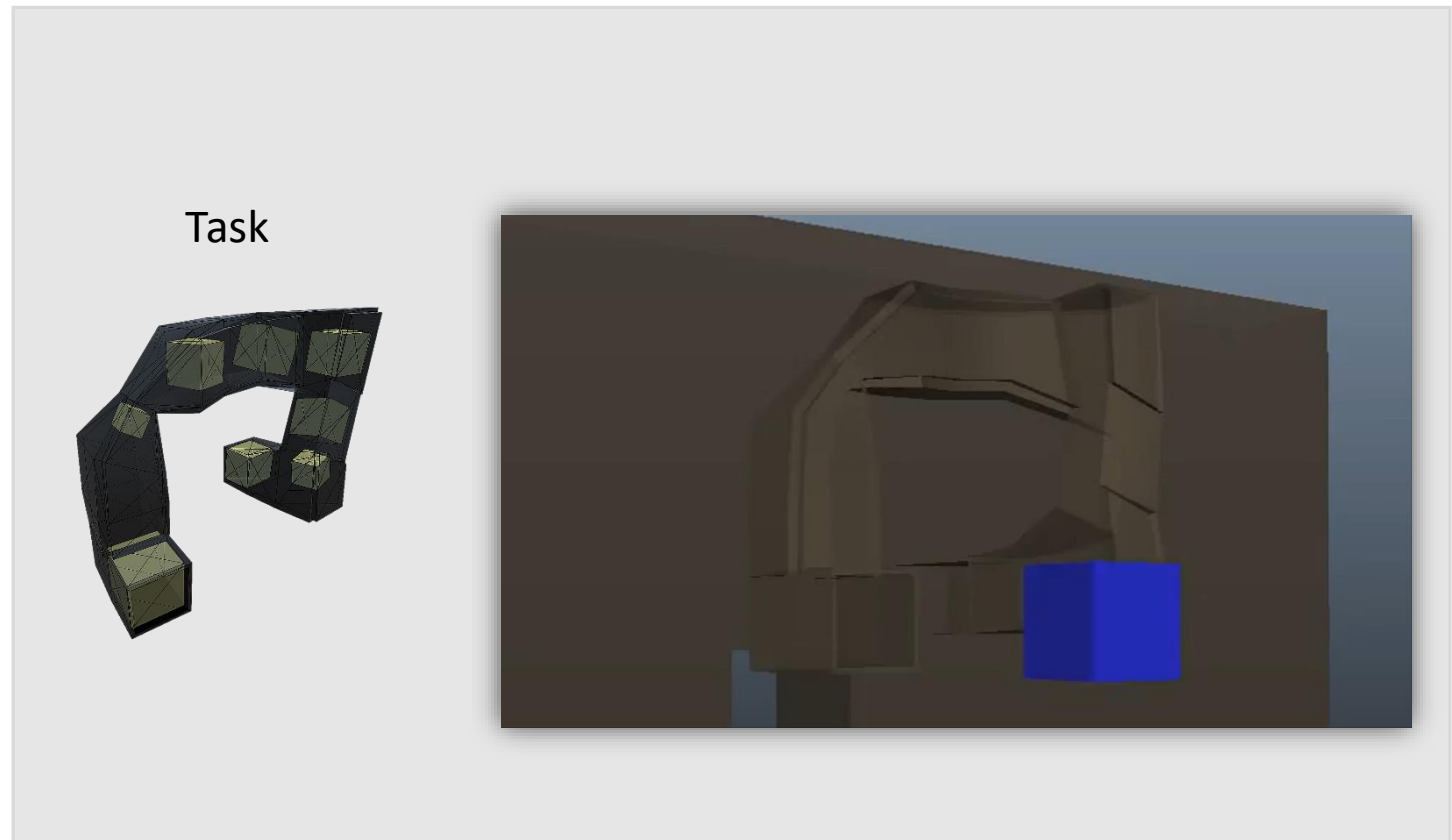


User Study – Design and Procedure

Group Size vs. Time and Accuracy

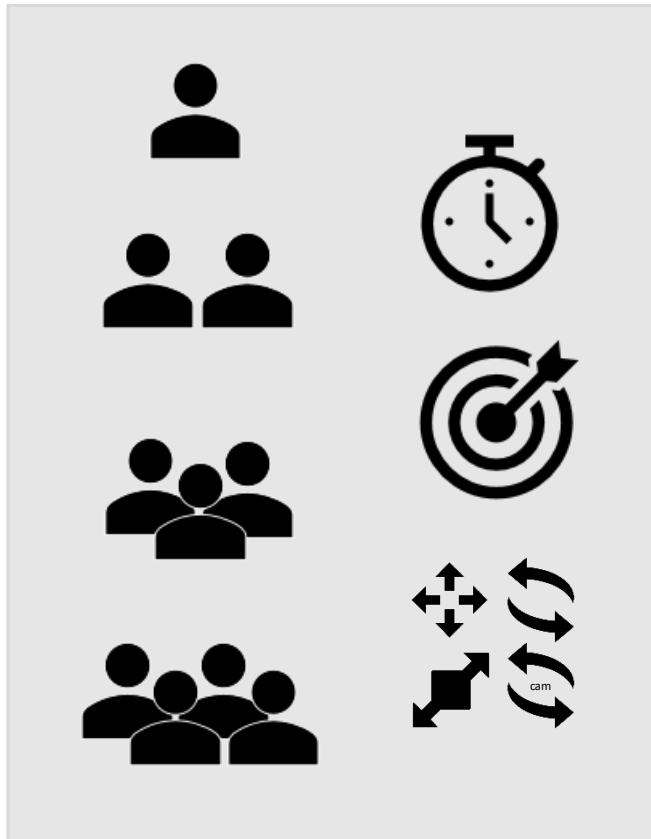


Evaluation Details



User Study – Design and Procedure

Group Size vs. Time and Accuracy

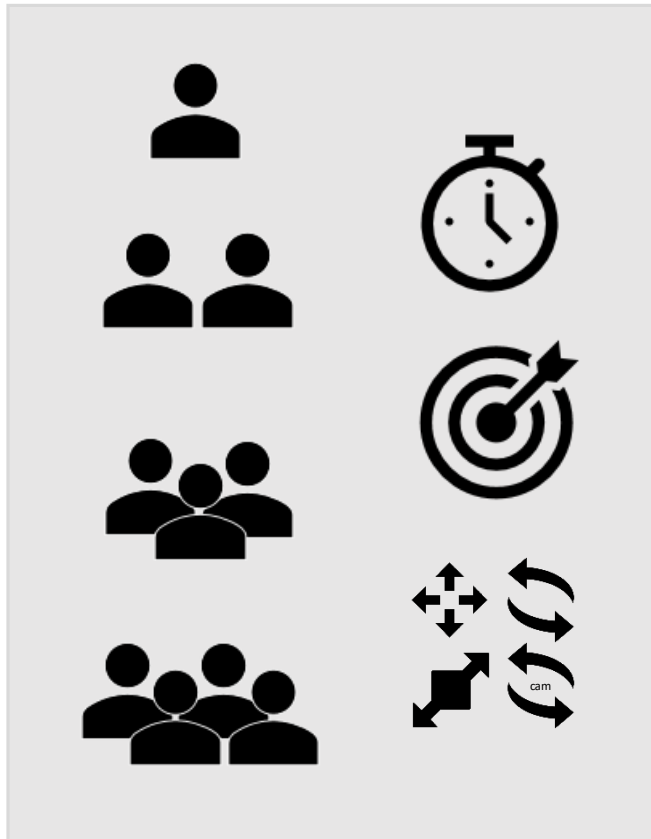


Evaluation Details

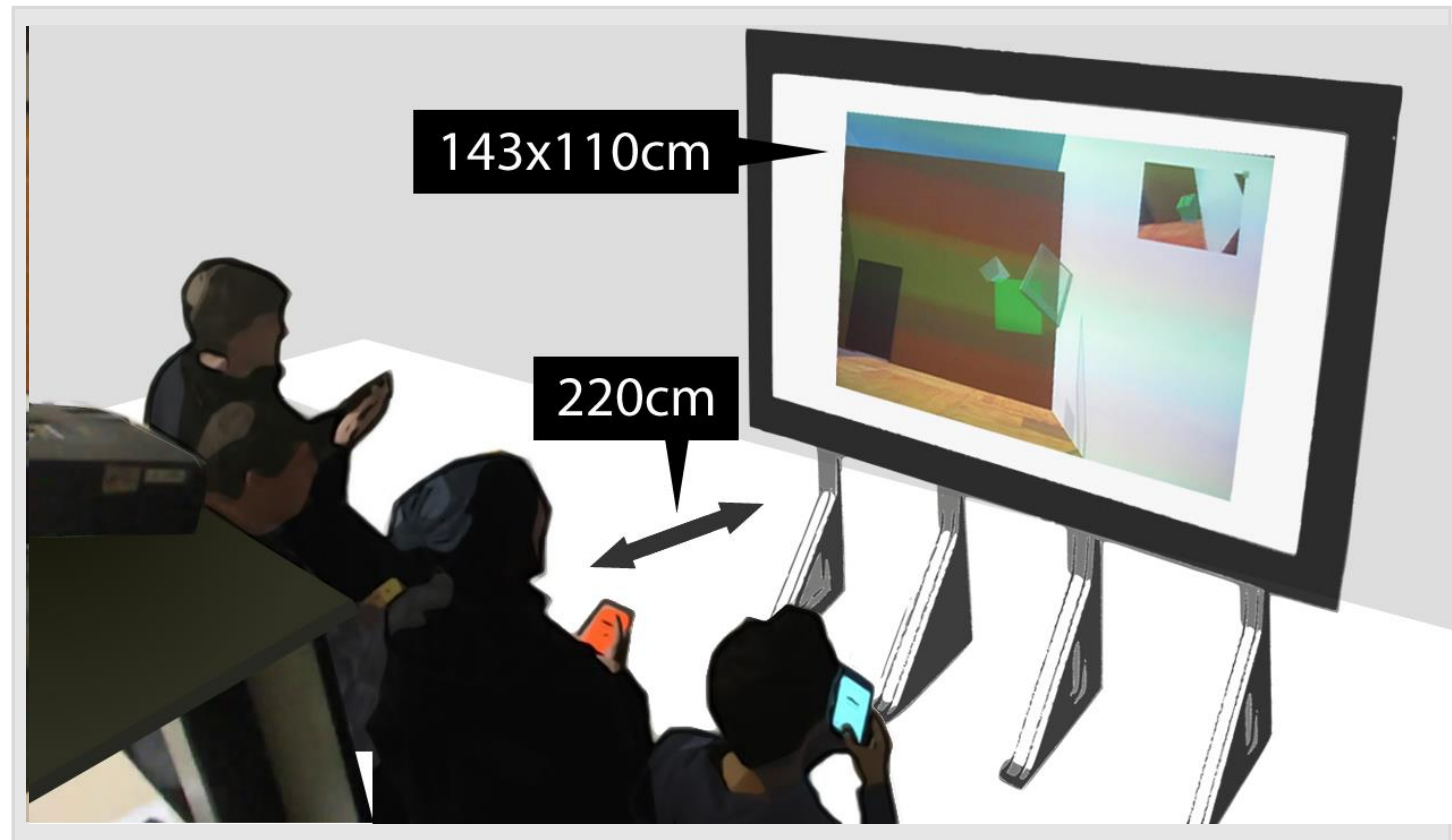


User Study – Design and Procedure

Group Size vs. Time and Accuracy

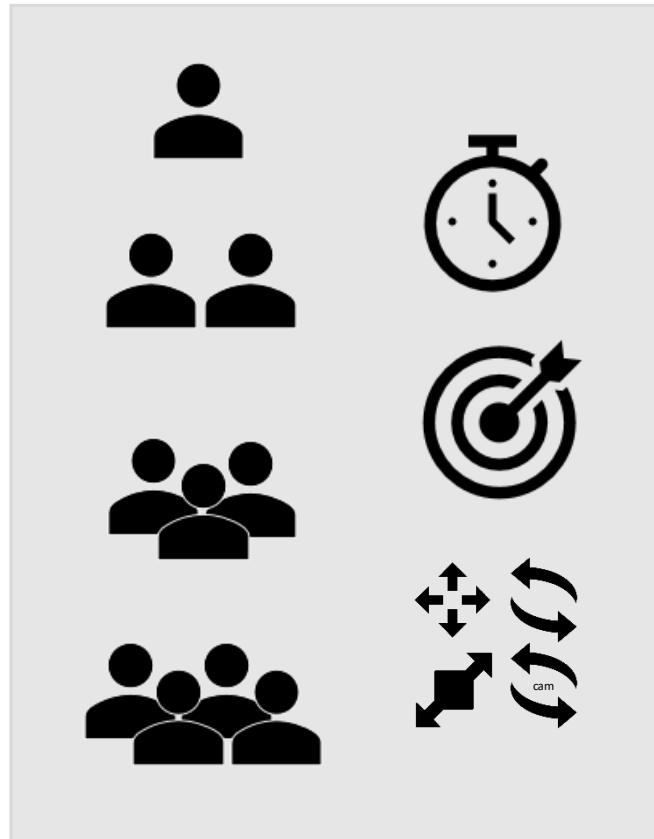


Evaluation Details

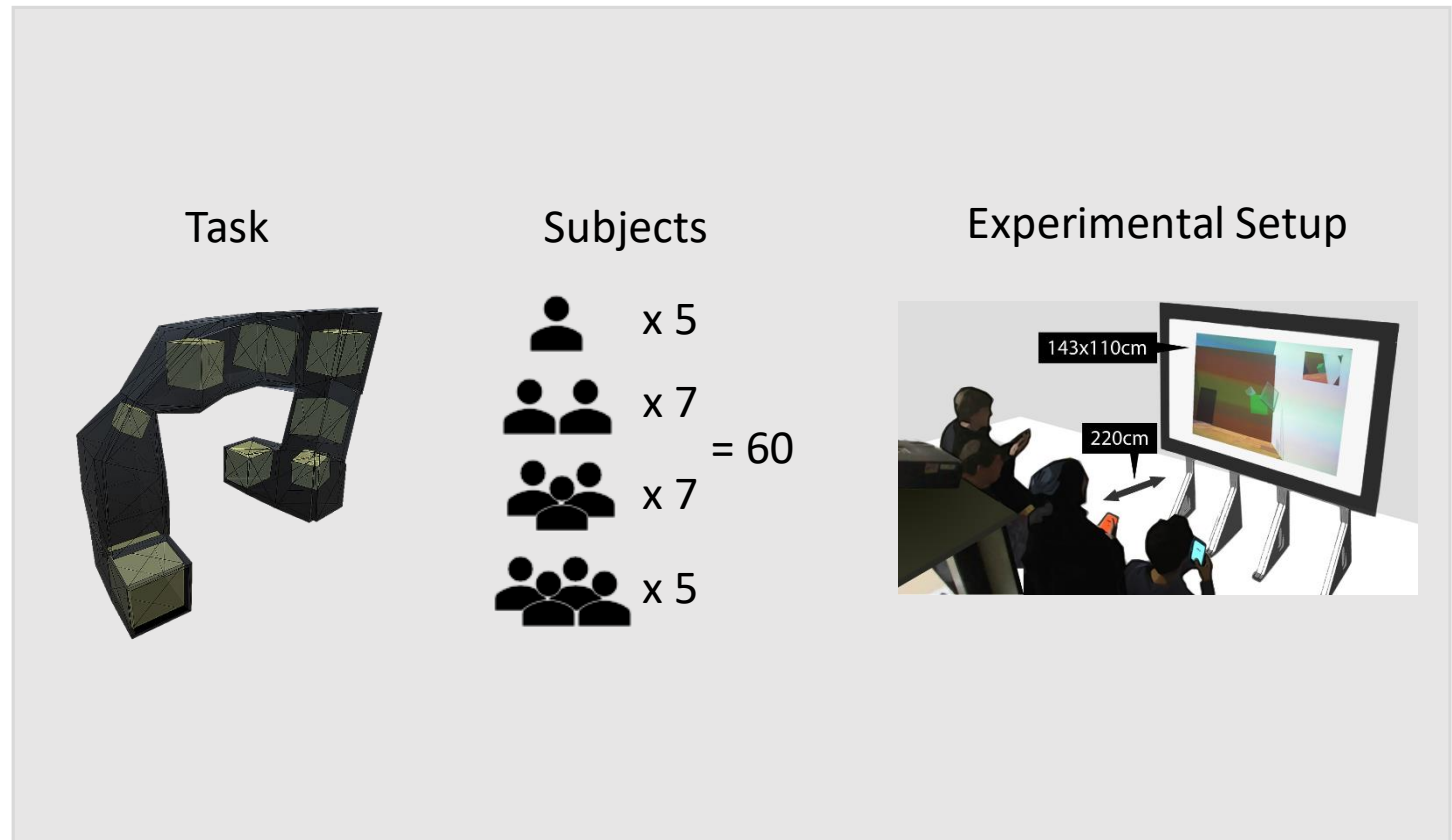


User Study – Design and Procedure

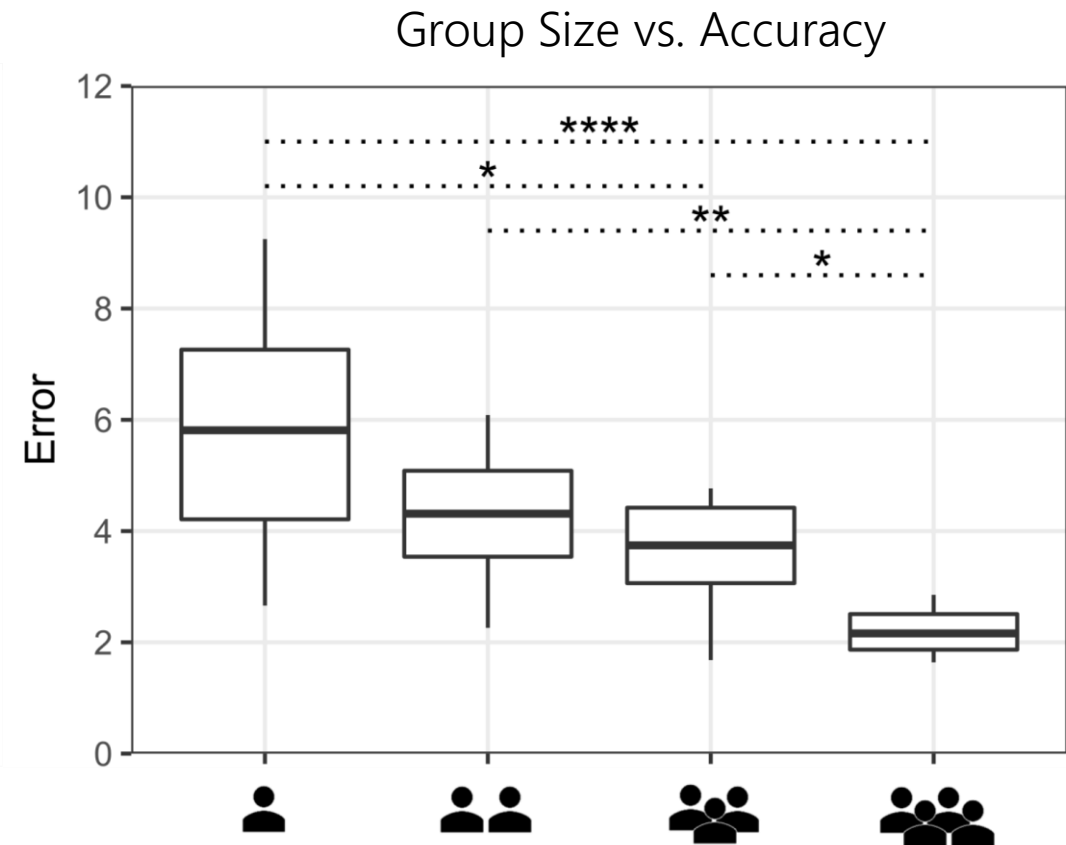
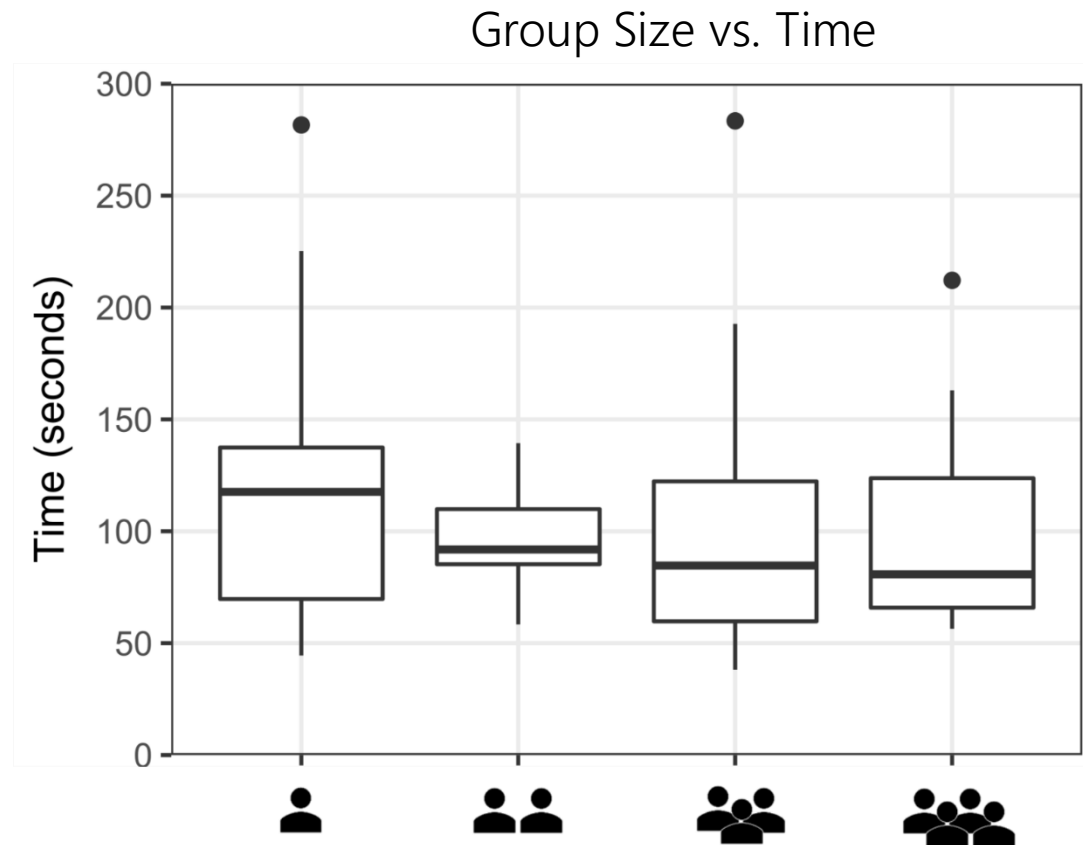
Group Size vs. Time and Accuracy



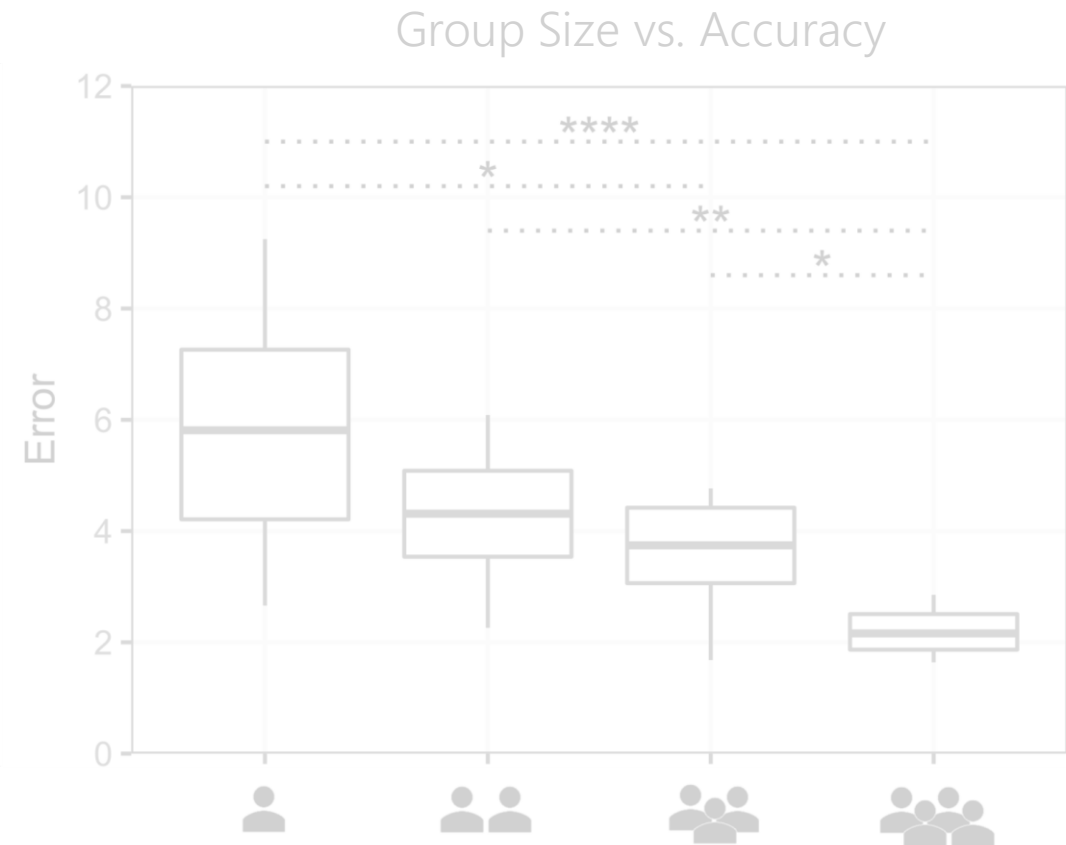
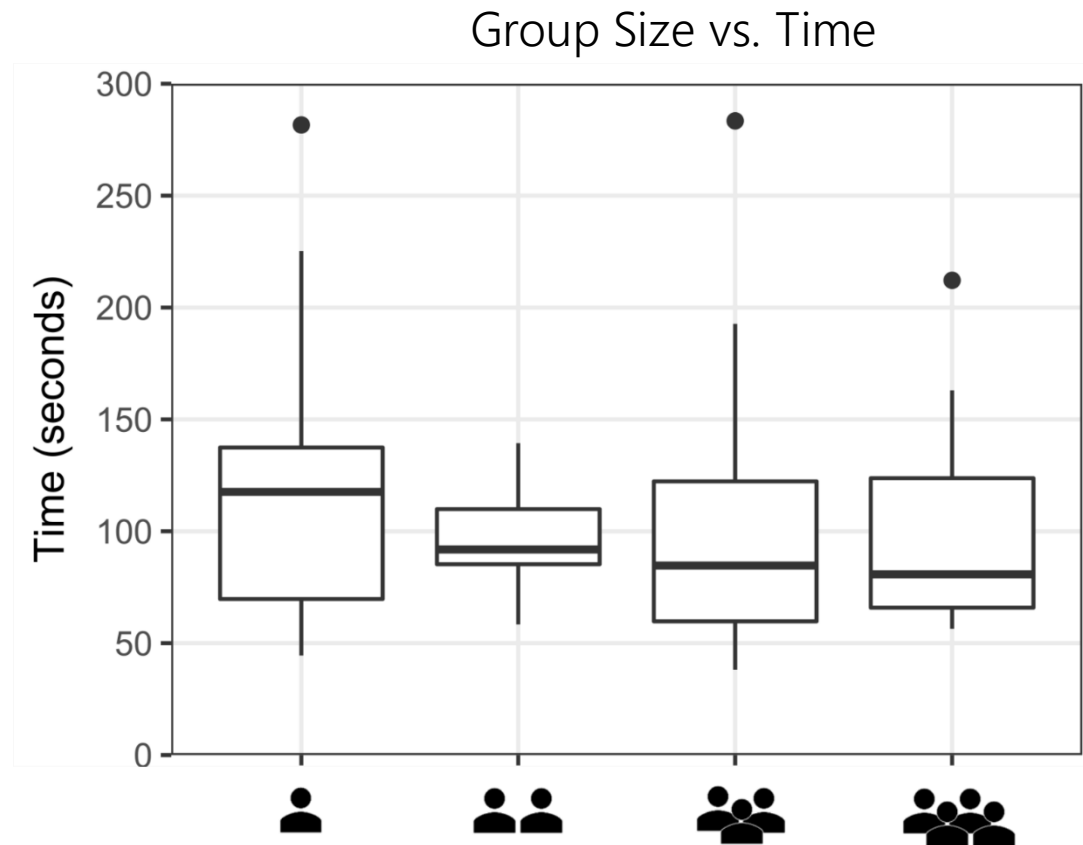
Evaluation Details



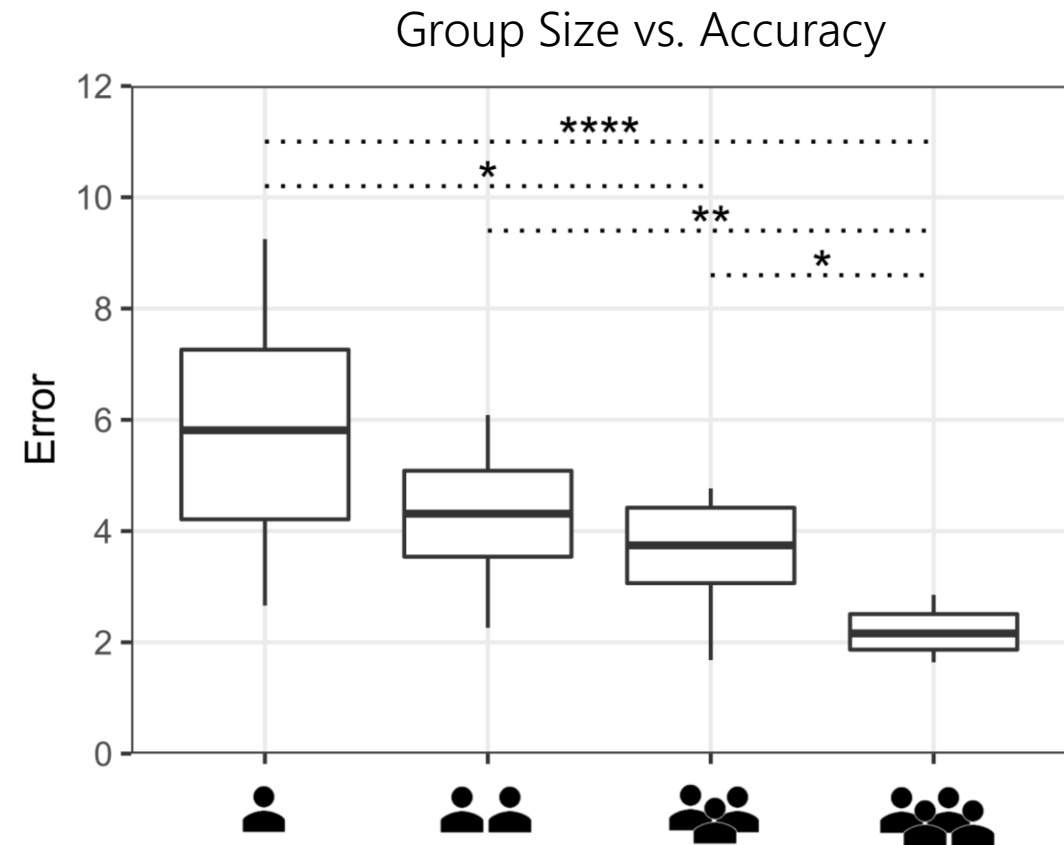
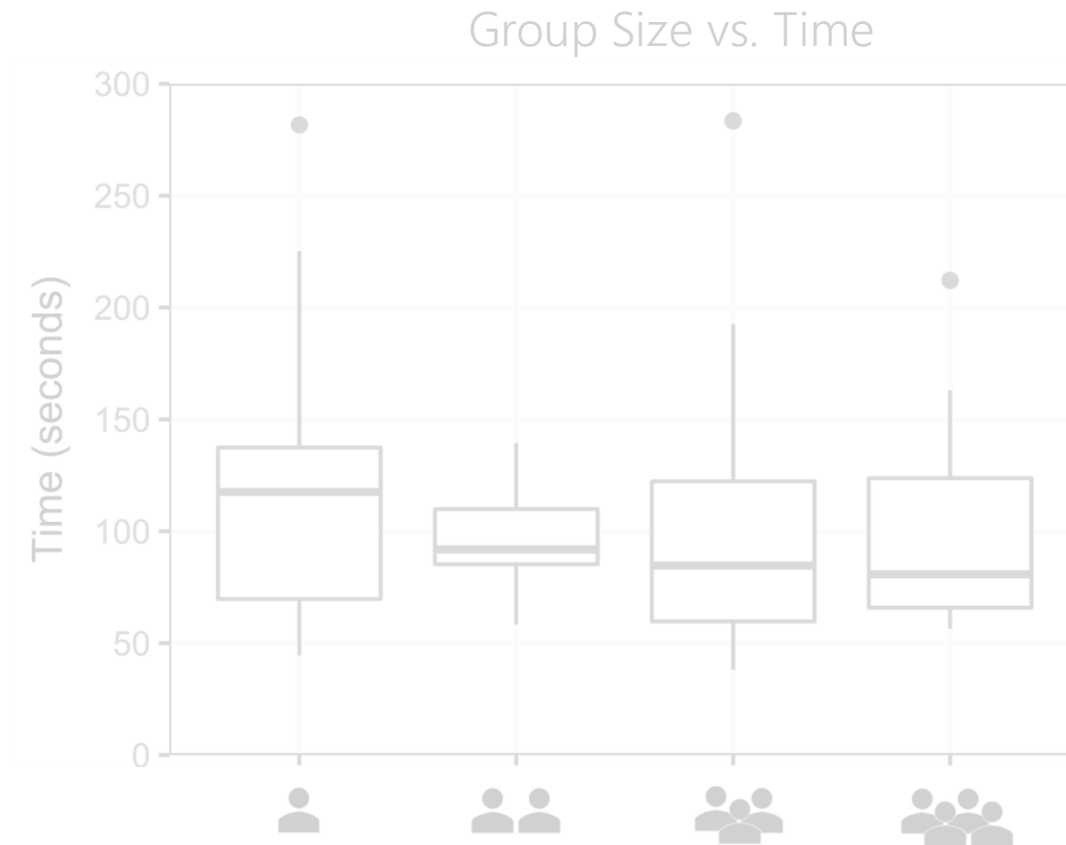
User Study – Group Size vs. Time and Accuracy



User Study – Group Size vs. Time

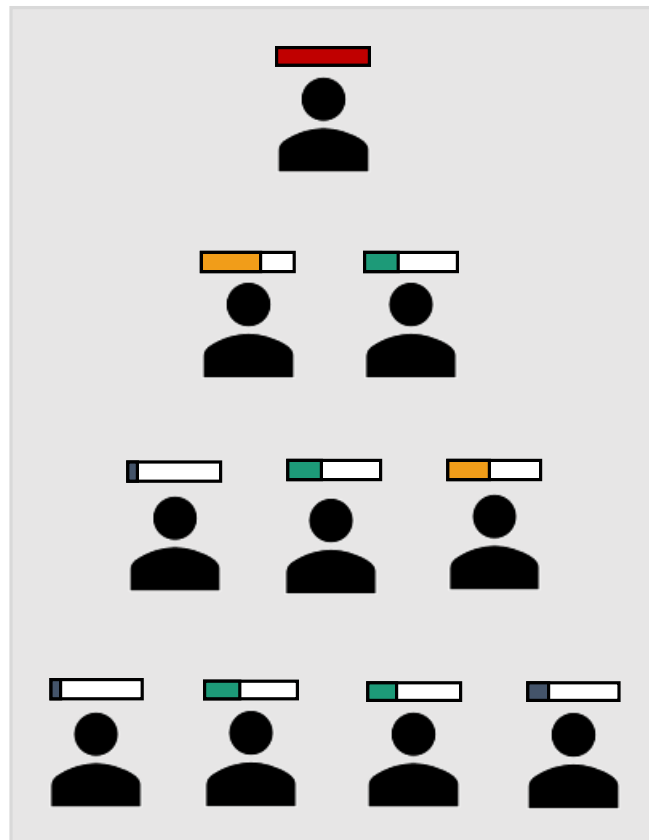


User Study – Group Size vs. Accuracy

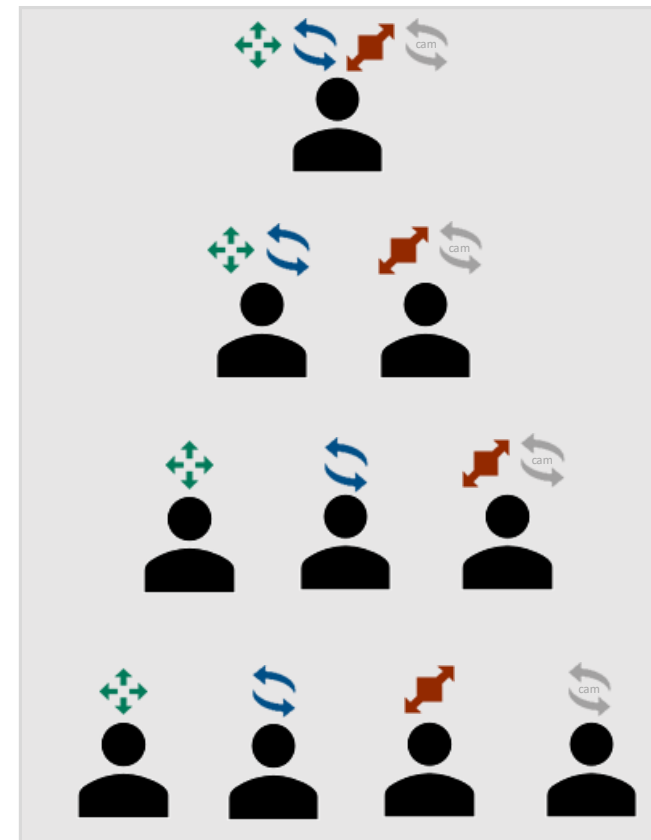


User Study – Accuracy vs. Work Strategies

Work distribution balance

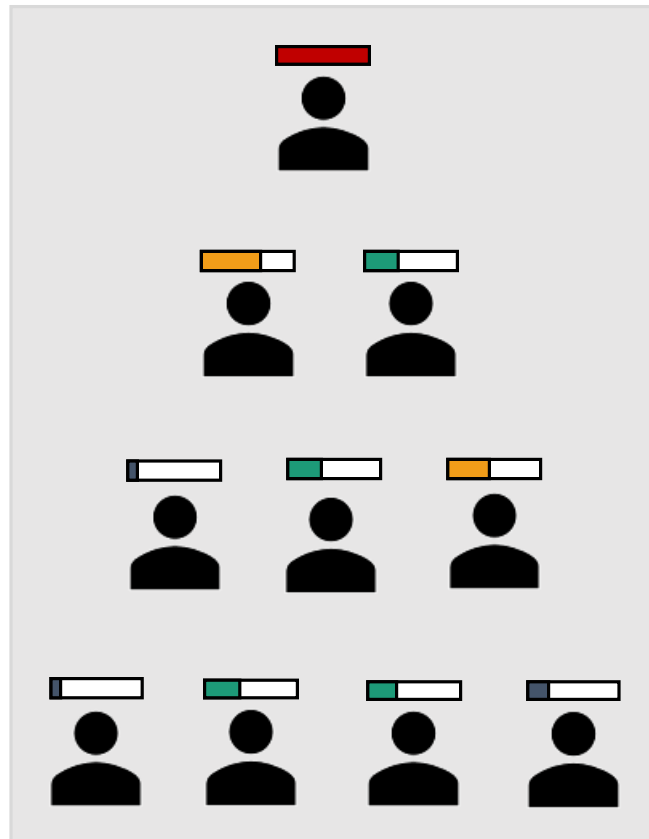


Work division

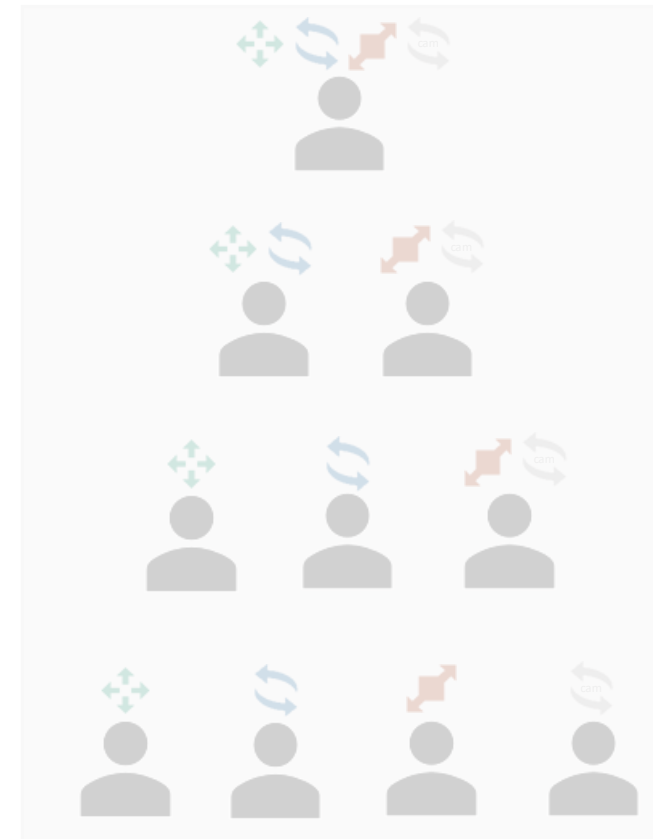


User Study – Accuracy vs. Work Strategies

Work distribution balance

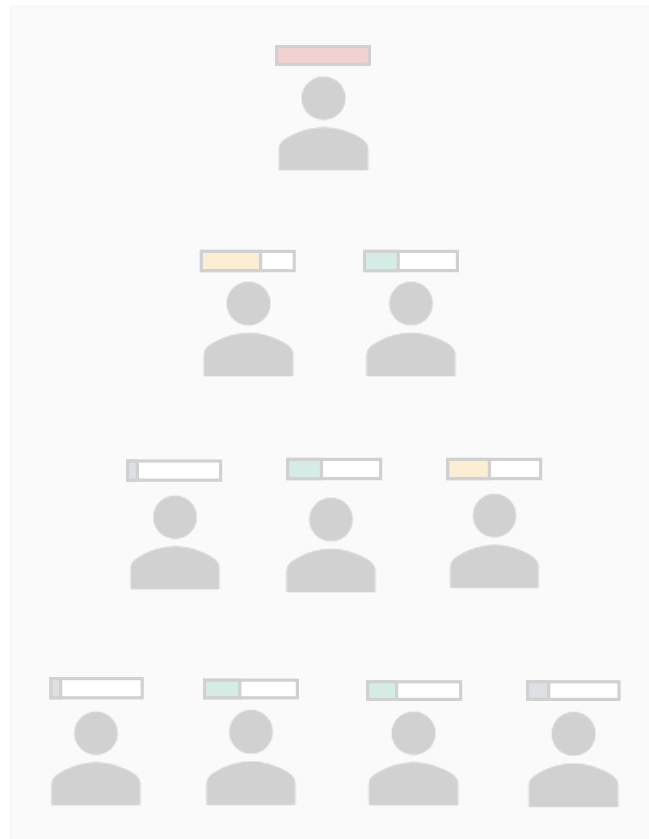


Work division

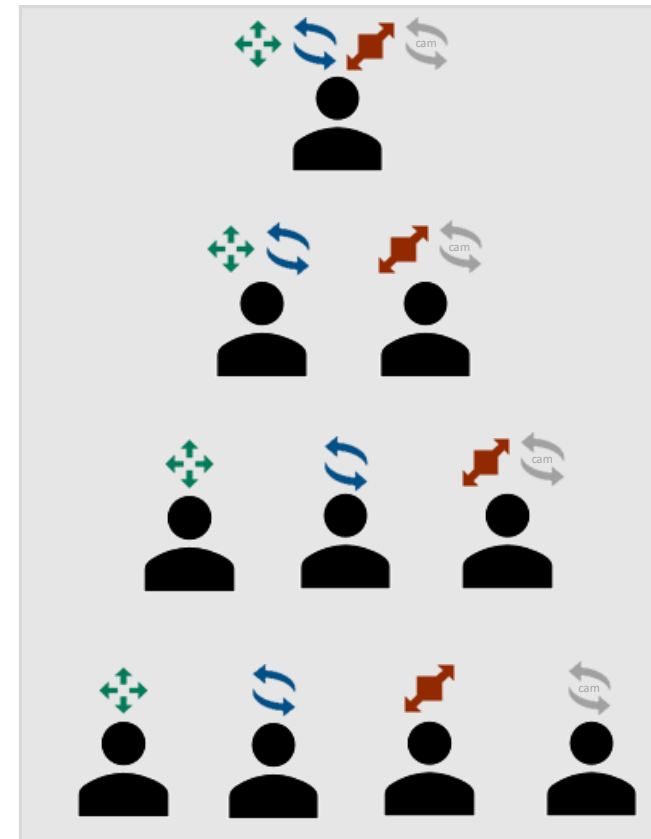


User Study – Accuracy vs. Work Strategies

Work distribution balance

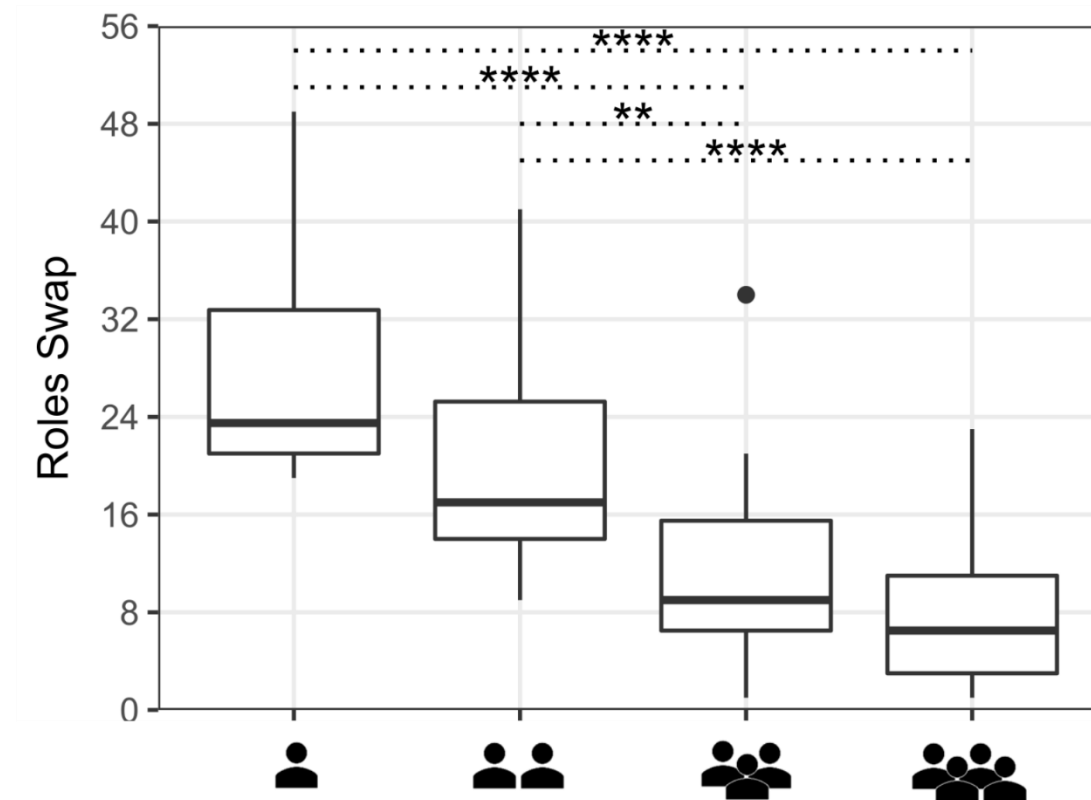
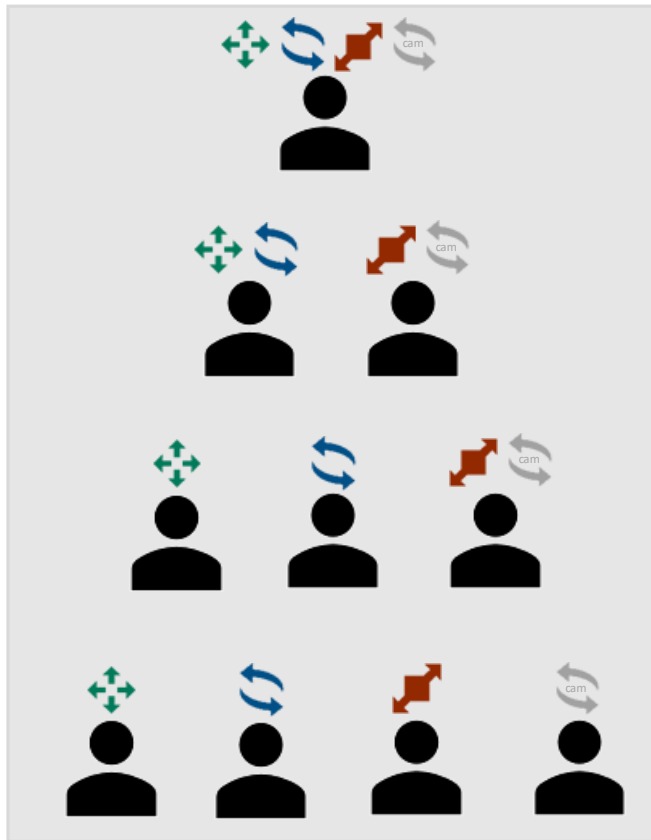


Work division



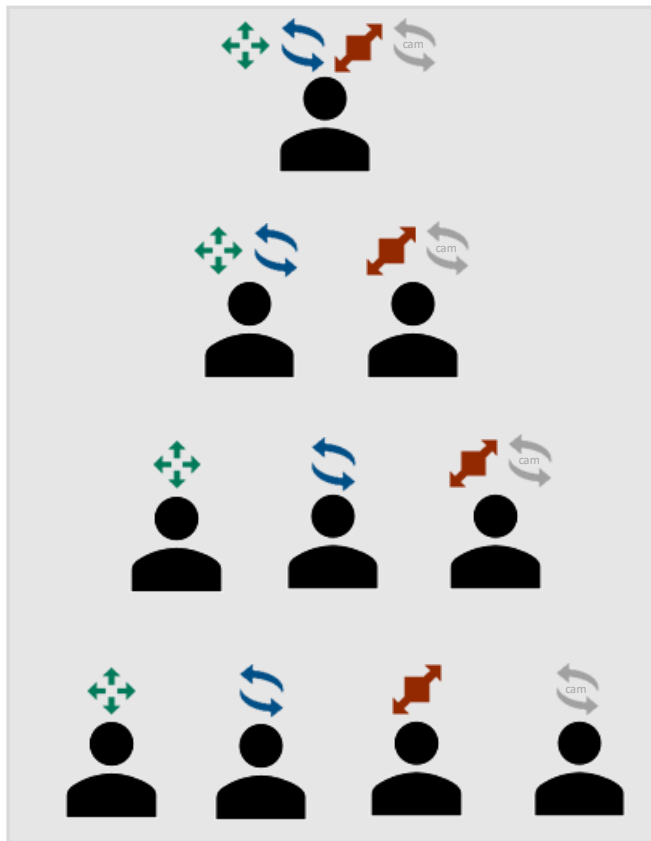
User Study – Work Division

Work division

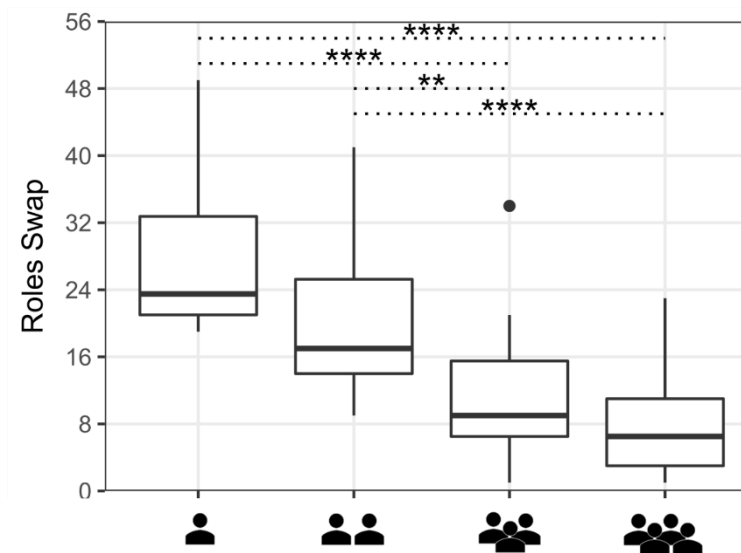


User Study – Work Division

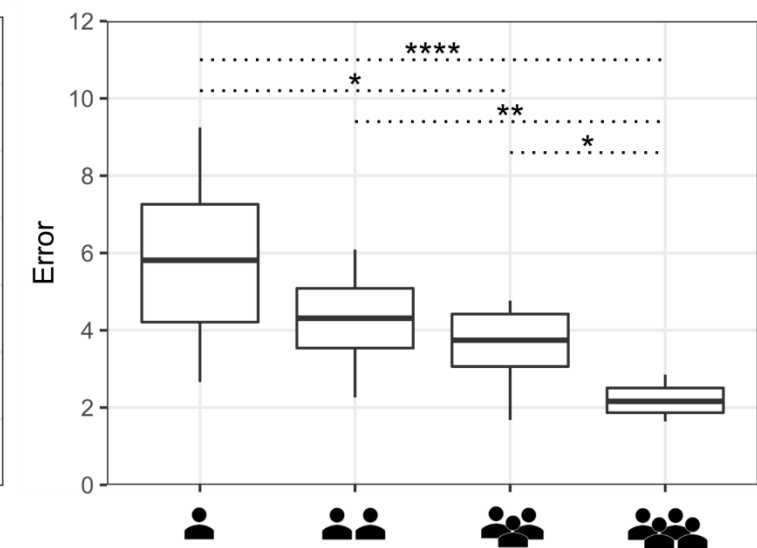
Work division



Work Division

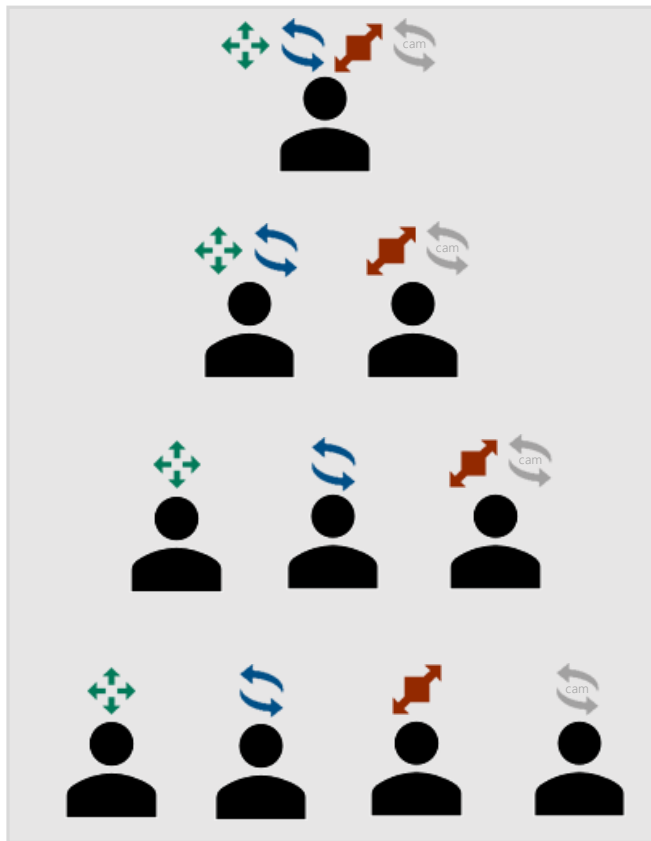


Accuracy

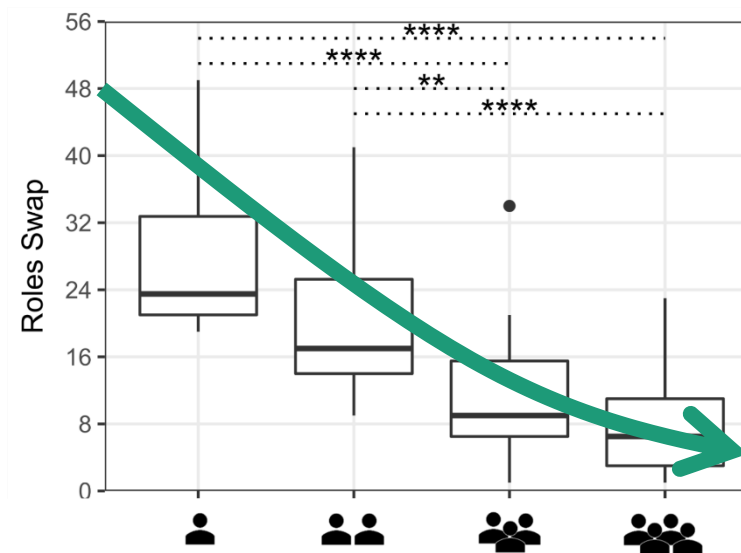


User Study – Work Division

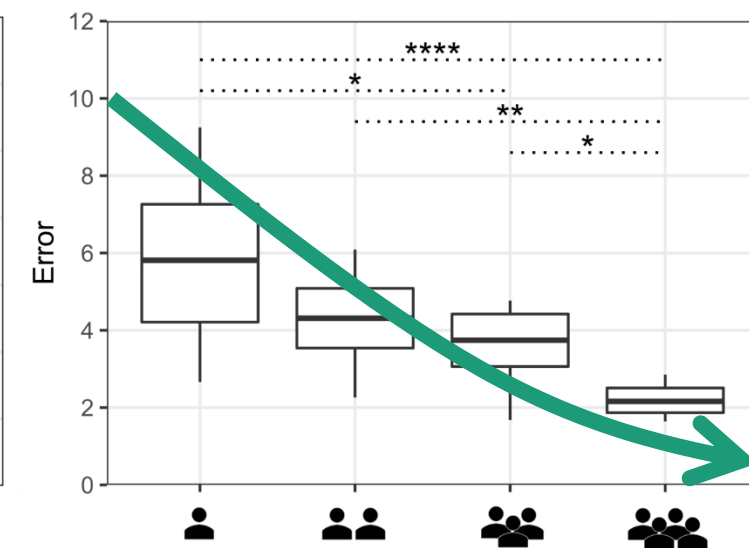
Work division



Work Division



Accuracy

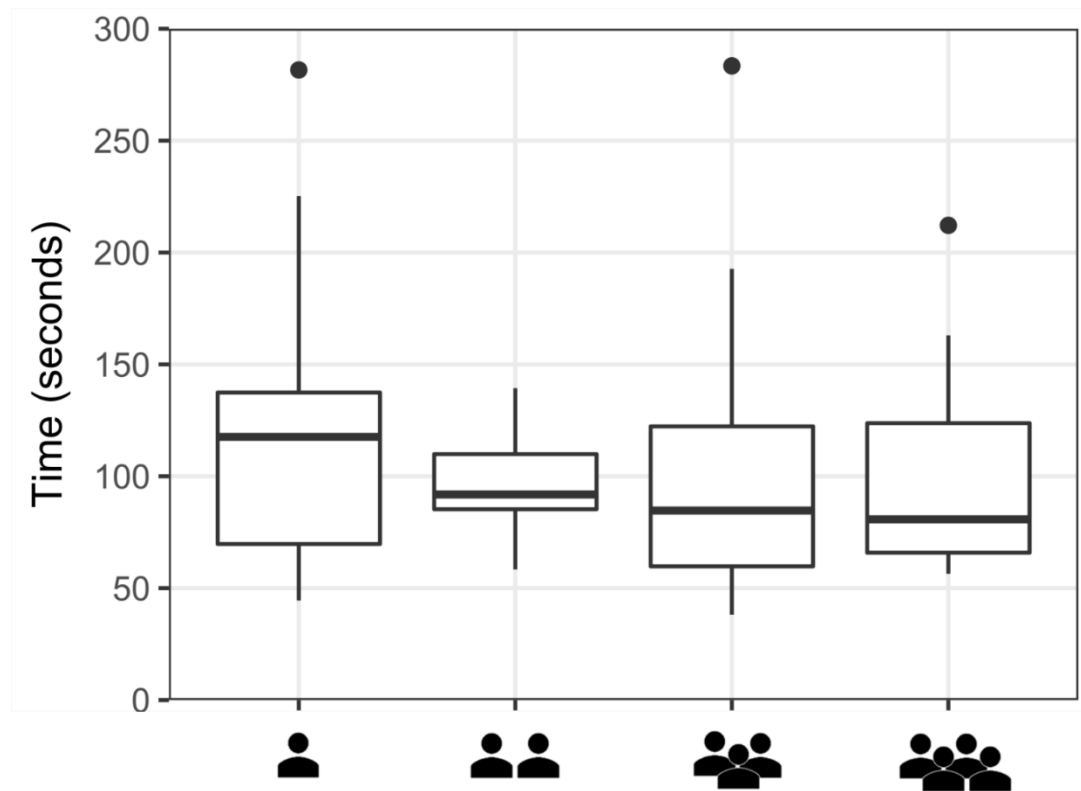


User Study – Work Division Strategies

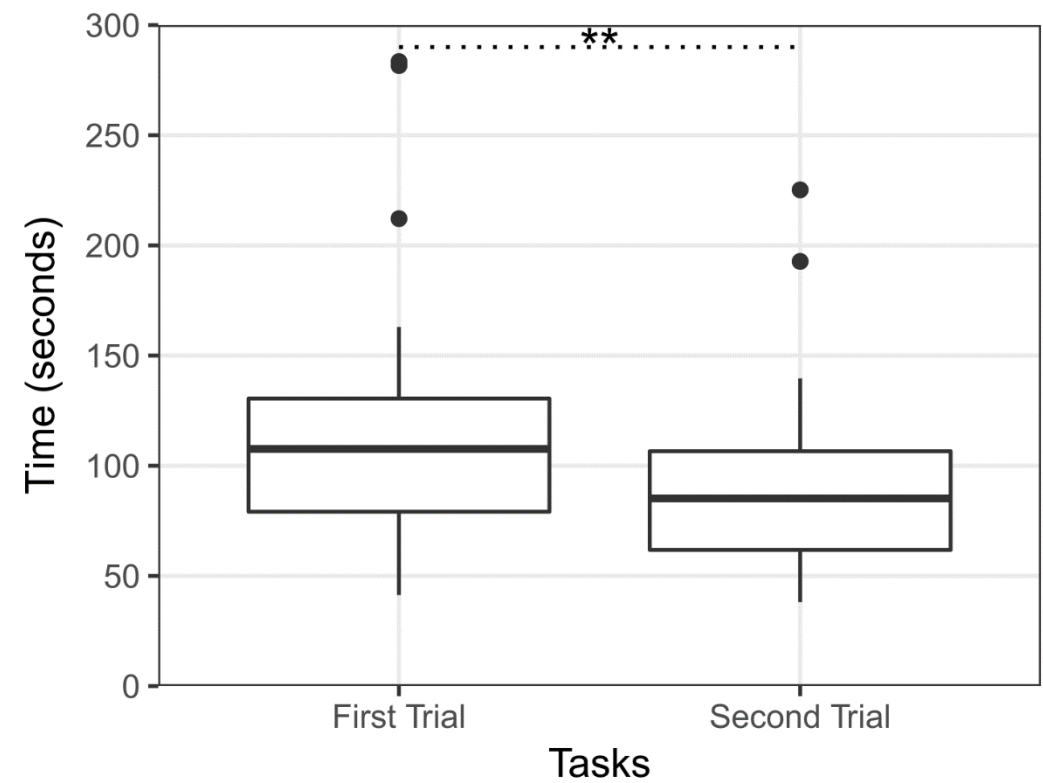


User Study – Learning Effect

Group Size vs. Time

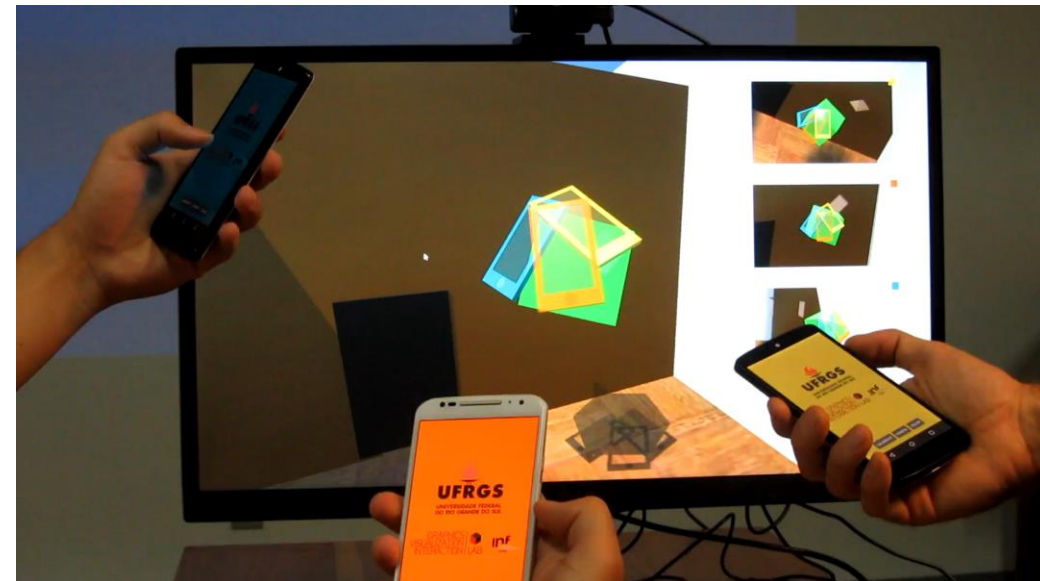


Learning between Trials



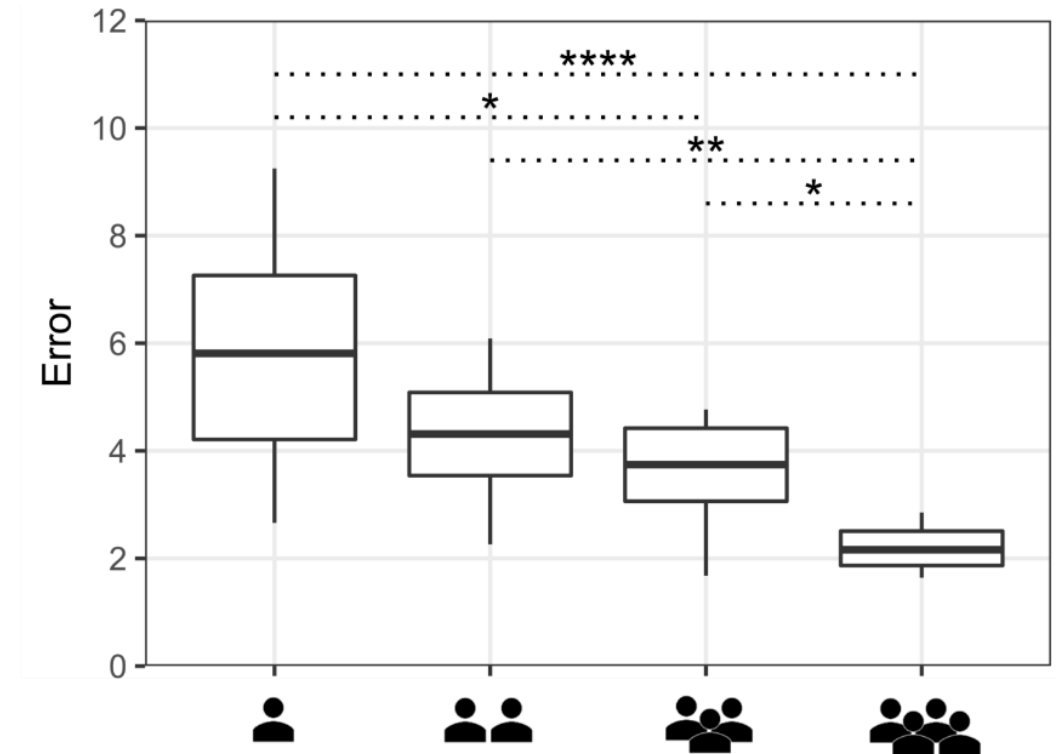
Results Summary

- Handheld devices are powerful tools for 3D collaborative tasks



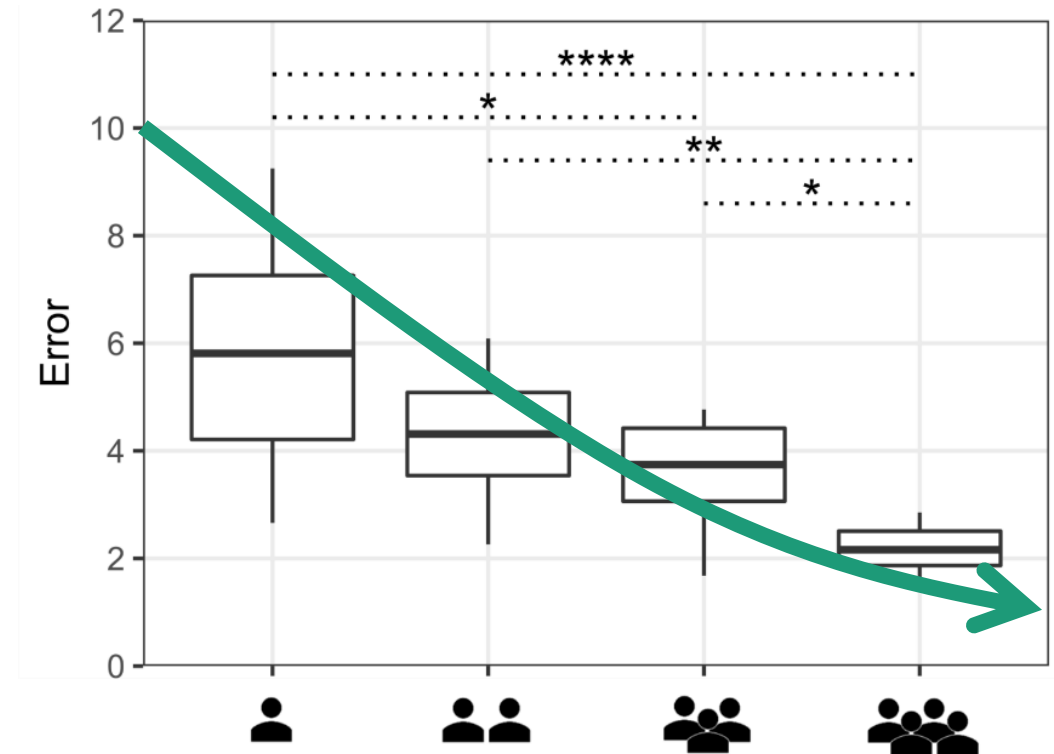
Results Summary

- Handheld devices are powerful tools for 3D collaborative tasks
- Teams are significantly more accurate than individuals



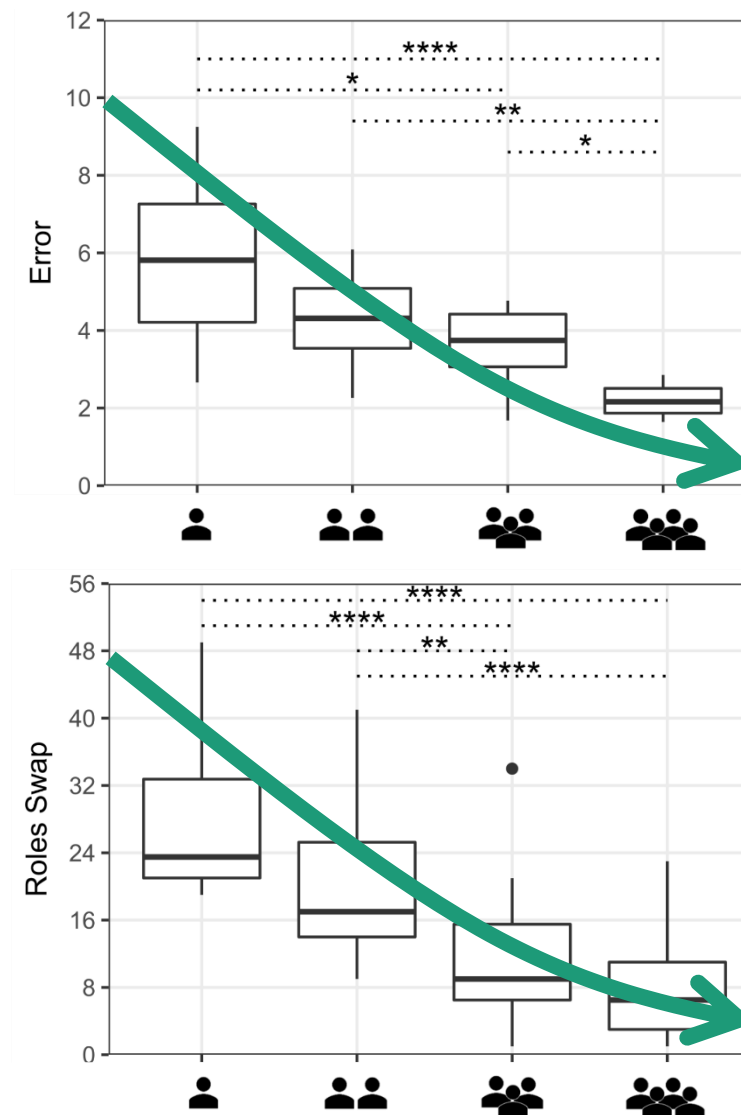
Results Summary

- Handheld devices are powerful tools for 3D collaborative tasks
- Teams are significantly more accurate than individuals
- Accuracy increases with larger group sizes (up to 4)



Results Summary

- Handheld devices are powerful tools for 3D collaborative tasks
- Teams are significantly more accurate than individuals
- Accuracy increases with larger group sizes (up to 4)
- Teams are accurate because they divide the tasks



Future Work

- Controlled labor division

Future Work

- Controlled labor division
- Explore other immersion scenarios



Future Work

- Controlled labor division
- Explore other immersion scenarios
- Collaboration in augmented reality



Design and Evaluation of a Handheld-based 3D User Interface for Collaborative Object Manipulation

Jerônimo G. Grandi, Henrique G. Debarba, Luciana Nedel, Anderson Maciel

jggrandi@inf.ufrgs.br

Handheld devices are powerful tools for 3D collaborative tasks

Teams are significantly more accurately than individuals

Accuracy increases with larger group sizes

Teams are accurate because they divide the tasks