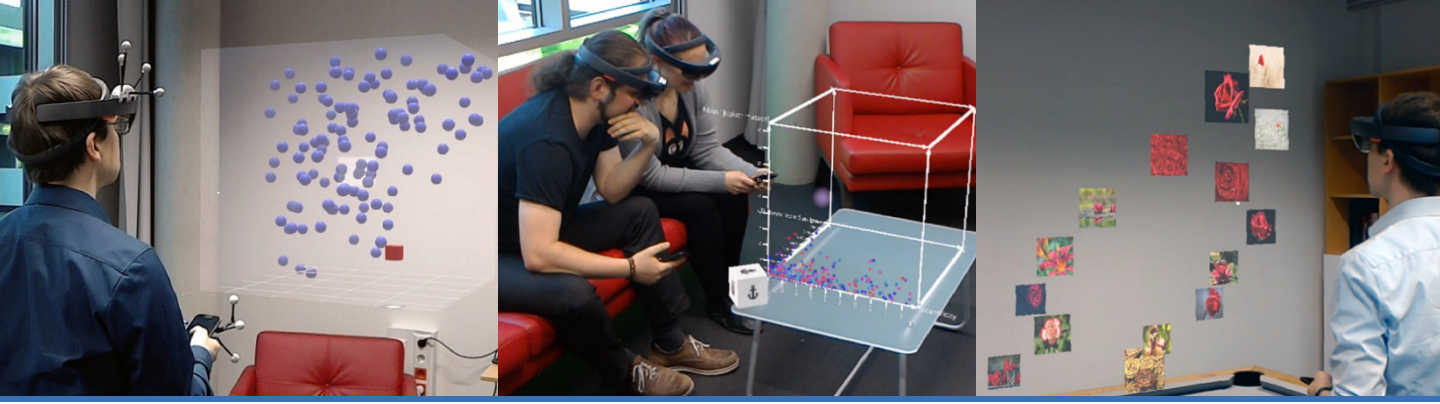


Investigating Smartphone-based Pan and Zoom in 3D Data Spaces in Augmented Reality

Wolfgang Büschel, Annett Mitschick, Thomas Meyer, Raimund Dachselt

MobileHCI 2019 • Taipei, Taiwan

TECHNISCHE UNIVERSITÄT DRESDEN

INTERACTIVE MEDIA LAB DRESDEN

Introduction

Current trends

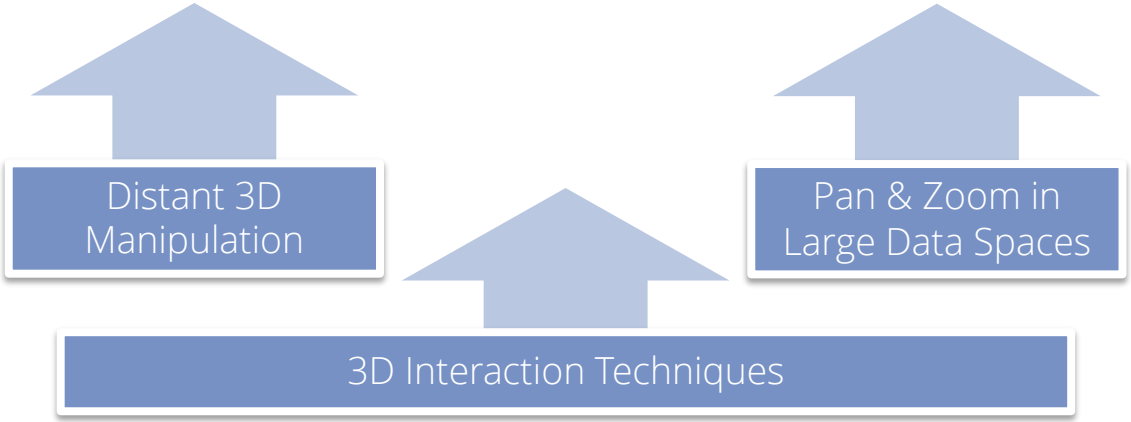
- More diverse and complex use cases for Augmented Reality
- Data space exploration shifts focus to interaction

- Current interaction modalities are limited
- Smartphones widely available in mobile contexts
- Can we use these devices as controllers for AR?

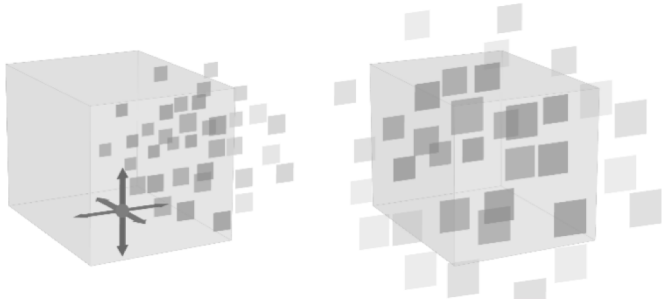
Research Contributions

Mobile devices as controllers for AR data space exploration

1. Set of techniques for 3D pan & zoom, combining touch input and spatial interaction
2. Study comparing these techniques to the baseline AirTap gesture of the HoloLens



Design Space



Data space definition

- 3D AR data space fixed in physical environment
- Explorable by 3D Pan & Zoom
- 3 DoF translation
- 1 DoF uniform scaling

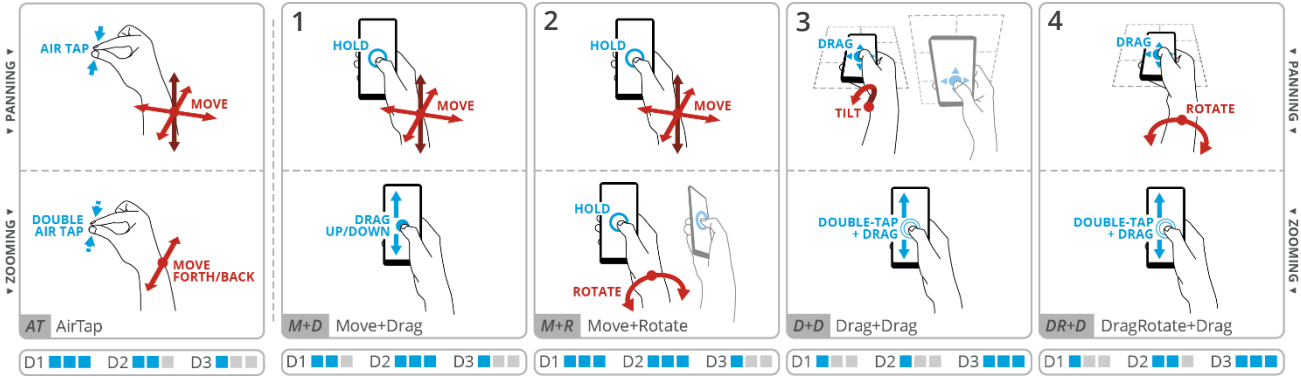
Design goals

- Unimanual, smartphone-only
- Eyes-free Interaction
- High Degree of Compatibility
- Robustness and Conciseness

Design dimensions

- Degree of spatiality (D1)
- Degree of simultaneity (D2)
- Degree of guidance (D3)

Interaction Techniques – Overview

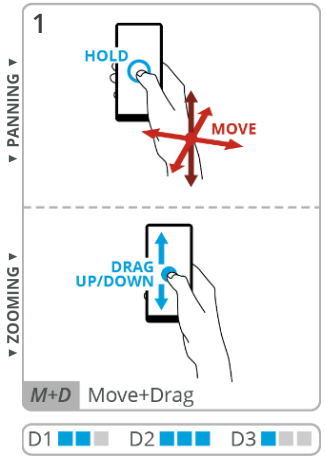


Four techniques for 3D pan & zoom + AirTap as baseline

Combination of Spatial Interaction and Touch Interaction

Different degrees of spatiality (D1), simultaneity (D2), and guidance (D3)

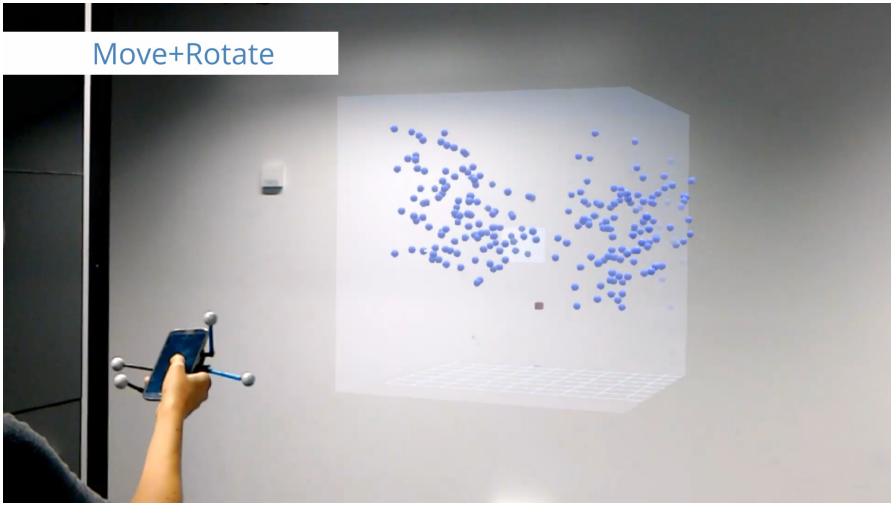
Interaction Techniques – Move+Drag (1)

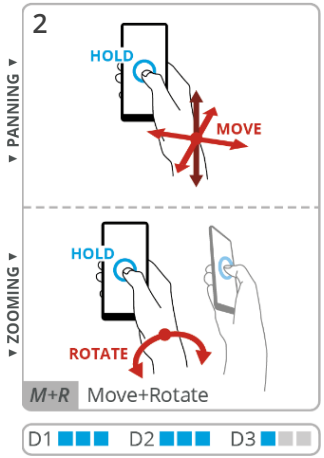


Free device movement for 3D pan, touch-based drag gestures for zoom

Moderate spatiality, high simultaneity, and low guidance

Interaction Techniques – Move+Rotate (2)

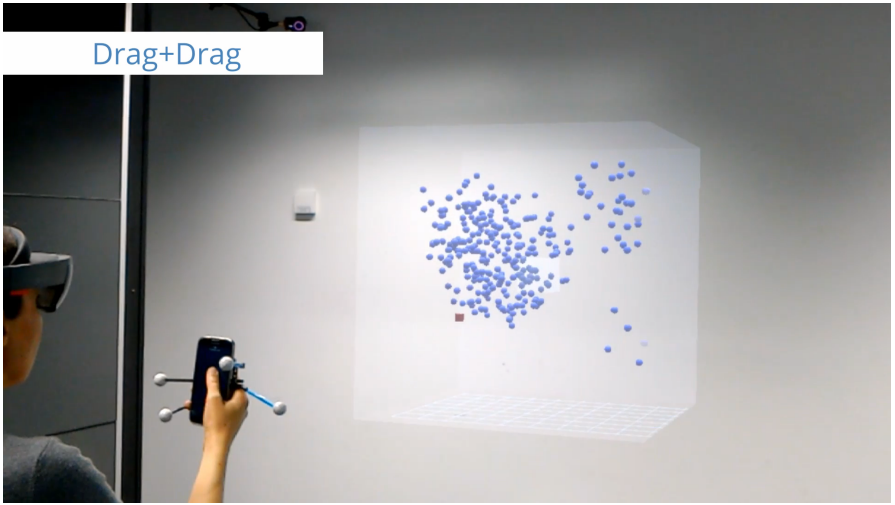


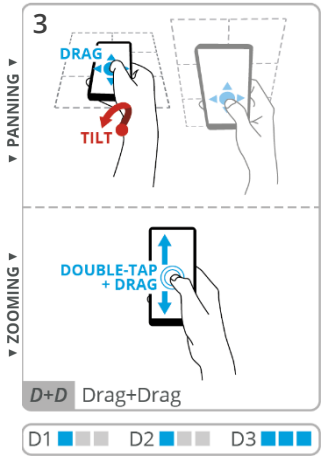


Pan as in Move+Drag, zoom by device rotation

Resulting higher spatiality, similar high simultaneity and low guidance

Interaction Techniques – Drag+Drag (3)



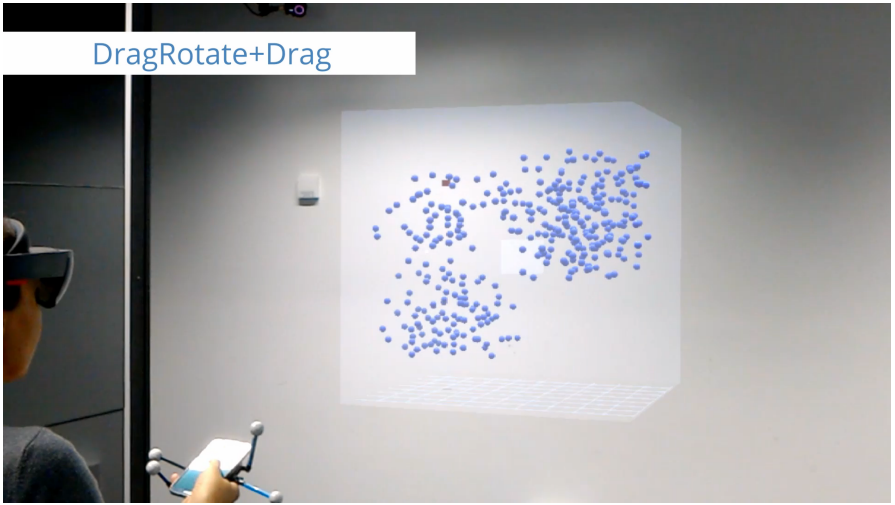


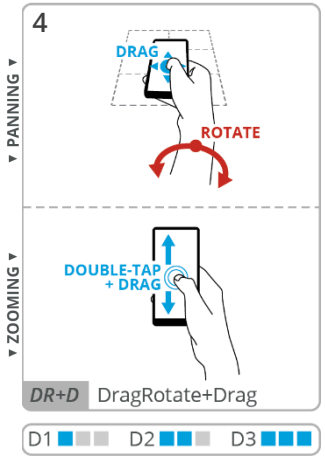
2D drag on coordinate planes (XZ, YZ, XY), phone orientation to chose plane

Double tap to activate zooming

Low spatiality and simultaneity, high guidance

Interaction Techniques – DragRotate+Drag (4)





2D drag for horizontal (XZ) panning, phone rotation for up-/down movement

Zoom activated by double tap as in Drag+Drag

Low spatiality, moderate simultaneity, high guidance

Study Design – Overview

Controlled lab study, within-subject design

25 participants, 15 male, 10 female, avg. age 25

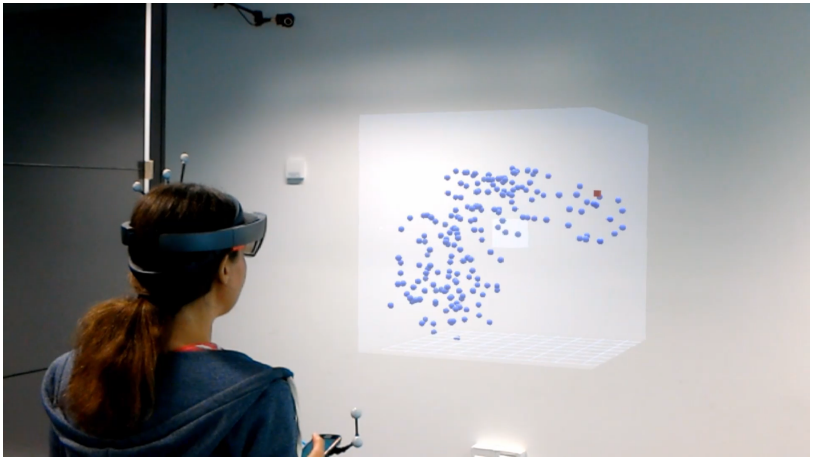
IV: interaction technique (5) x target zoom level (3)

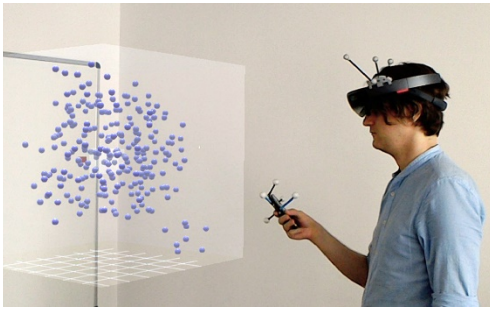
Techniques counterbalanced, task order randomized

Logging of task completion times & position data

Questionnaires on task load & performance

Study Design – Apparatus & Task



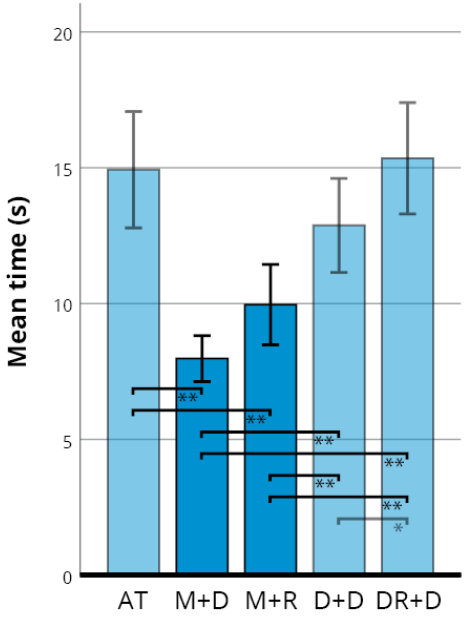


Setup Phone + HoloLens tracked for precision & logging, tracking volume 4m x 3.2m x 1.7m

Task Find, center, and zoom into a target object

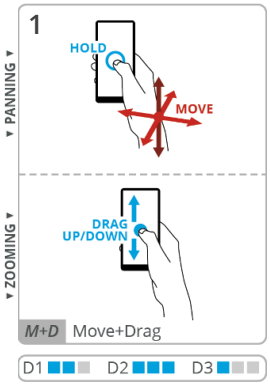
36 tasks per technique, 12 with target placed on coordinate planes, 24 with targets distributed in 3D

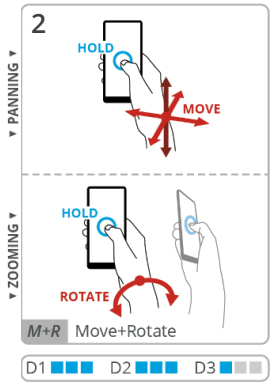
Study Results – Task Completion Times



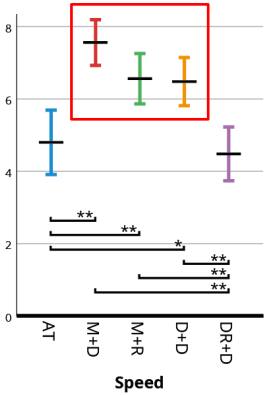
Move+Drag and Move+Rotate significantly faster

Similar results for all task types & zoom levels

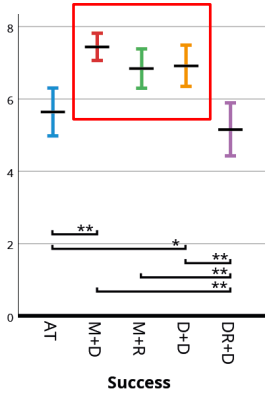




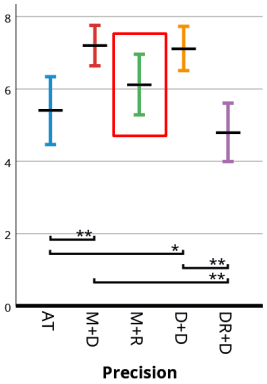
Study Results – Perceived Performance



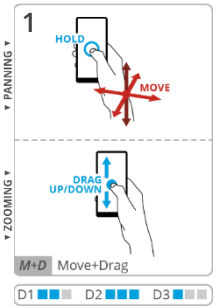
Speed

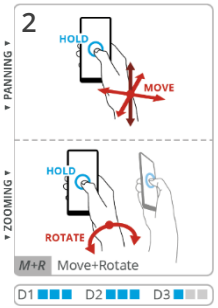


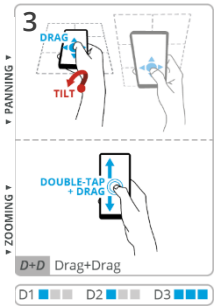
Success



Precision



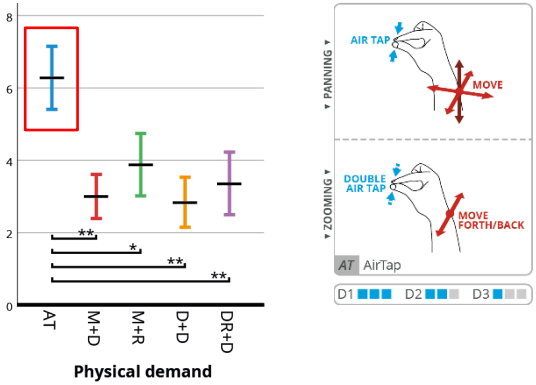




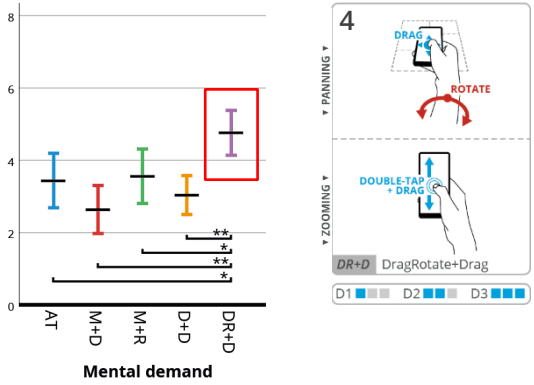
Perceived speed & success were best for Move+Drag, Move+Rotate, & Drag+Drag

Precision slightly lower for Drag+Drag

Study Results – Task Load



Physical demand was highest for the AirTap gesture



Mental demand was highest for DragRotate+Drag

Insights & Recommendations

- **Spatiality matters**

  Spatial interaction outperforms touch-based techniques

- **Ergonomics before weight**

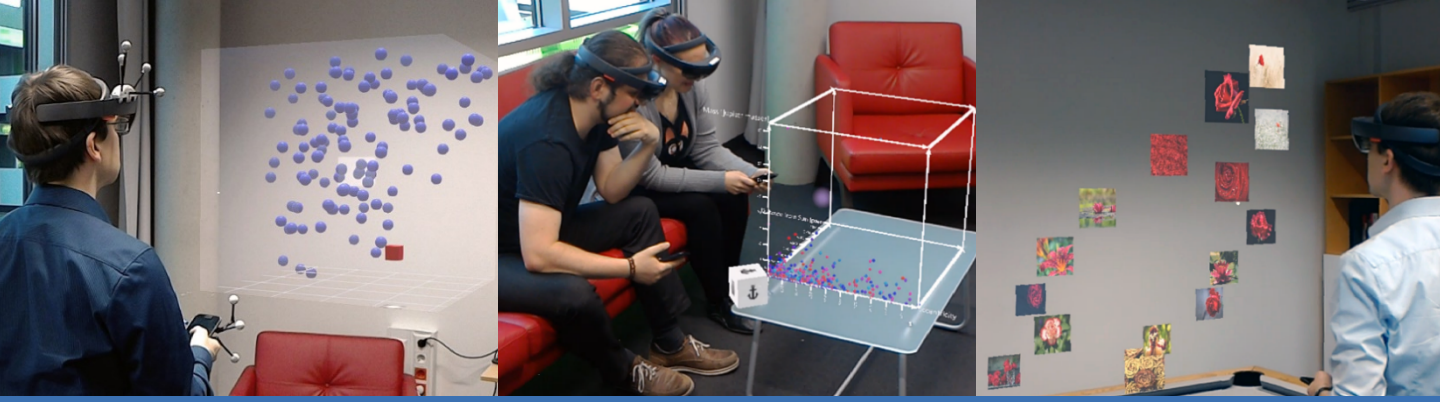
  AirTap is more demanding than even spatial phone gestures

- **Simultaneity before guidance**

  For free 3D zoom & pan, separation of DoF is slower

- **Limited space is fine**

  Though possible, participants rarely moved during our study



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› **imld.de/ar-pan-zoom**

Project website, data, study logs, slides

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