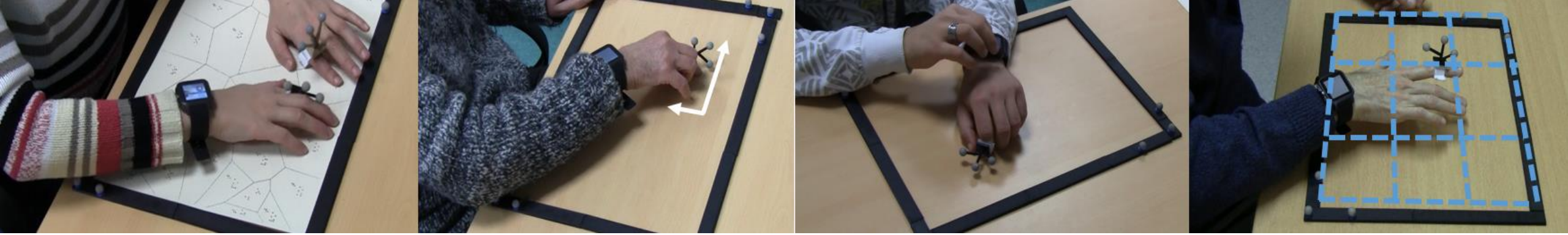

From Tactile to Virtual: Using a Smartwatch to Improve Spatial Map Exploration for Visually Impaired Users

Sandra Bardot, Marcos Serrano, Christophe Jouffrais
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UNIVERSITÉ TOULOUSE III PAUL SABATIER Université de Toulouse

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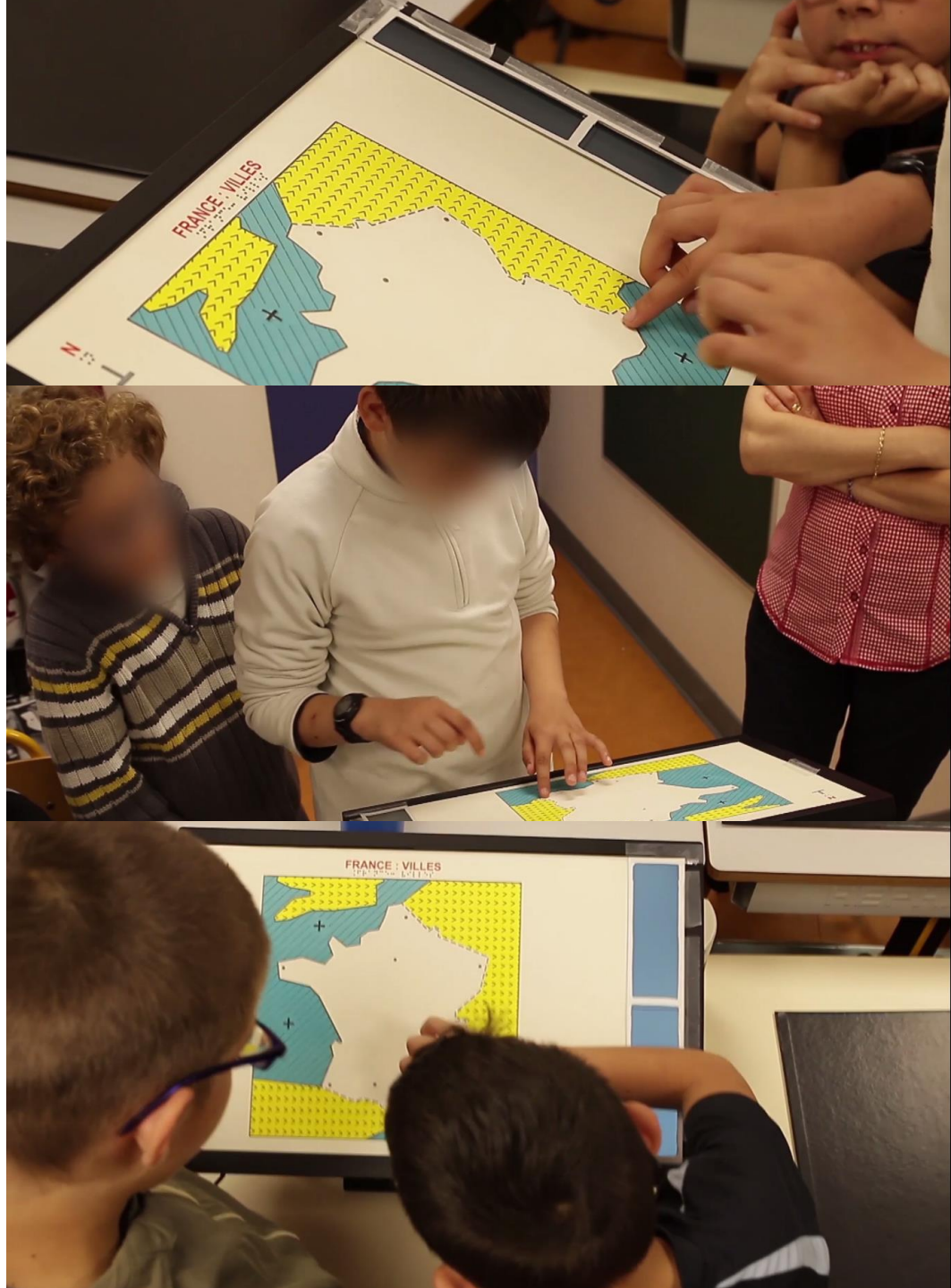
Context

Maps for visually impaired people:

- Education
- Mobility
- Autonomy

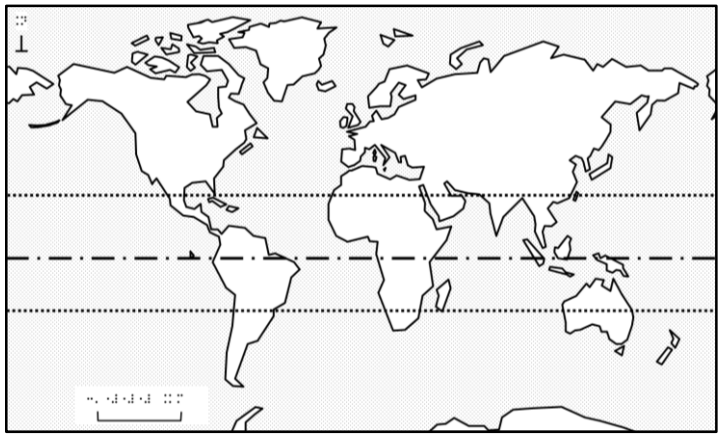
Raised-line map: common tool

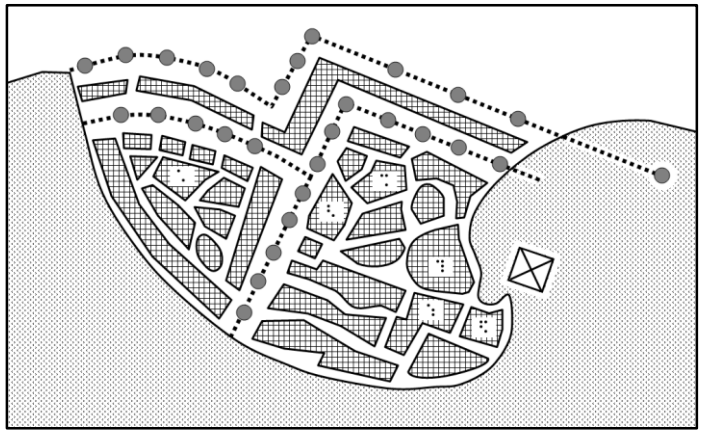


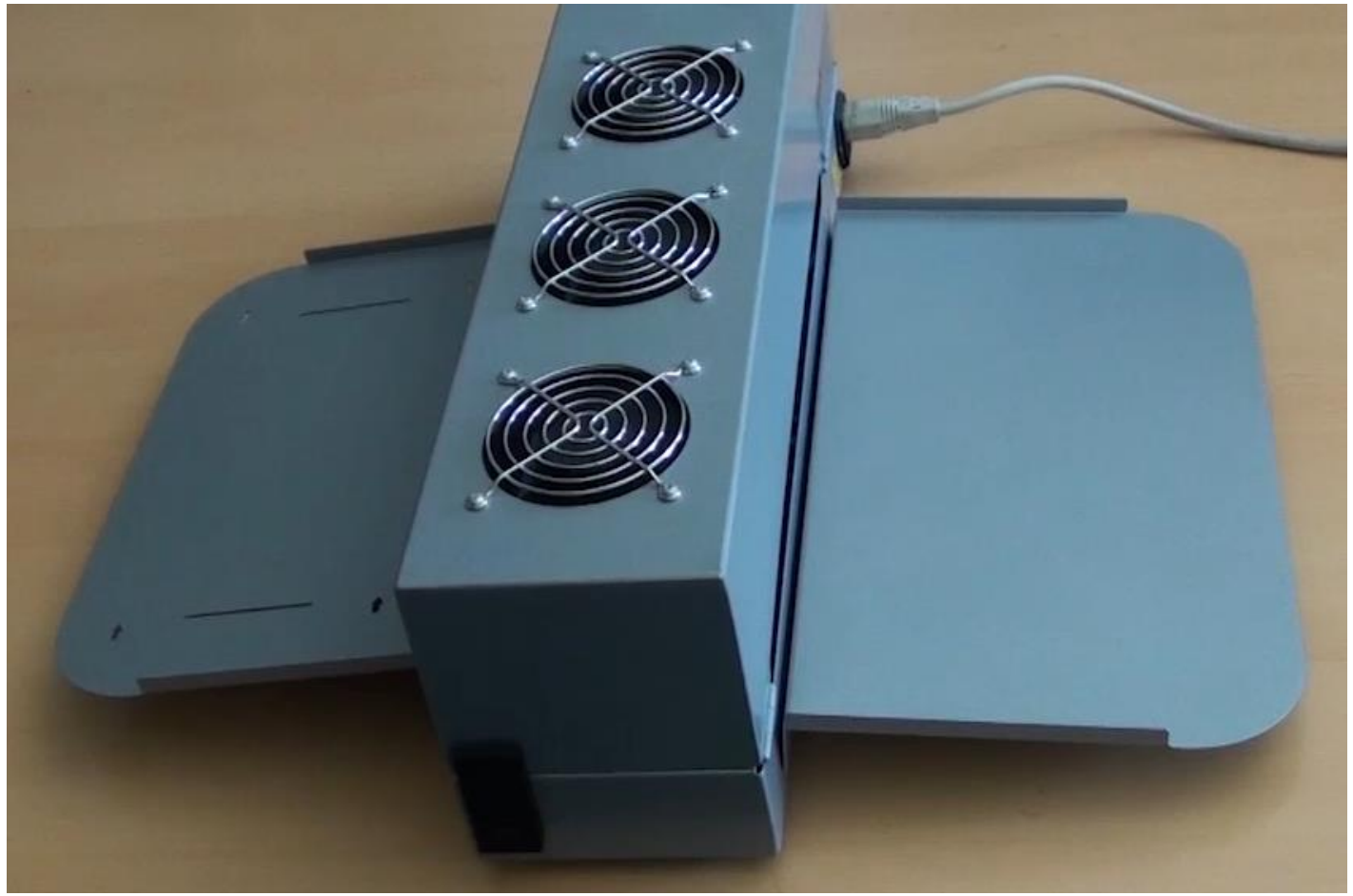
Context

Raised-line maps:

- Content simplified
- Content cannot be modified



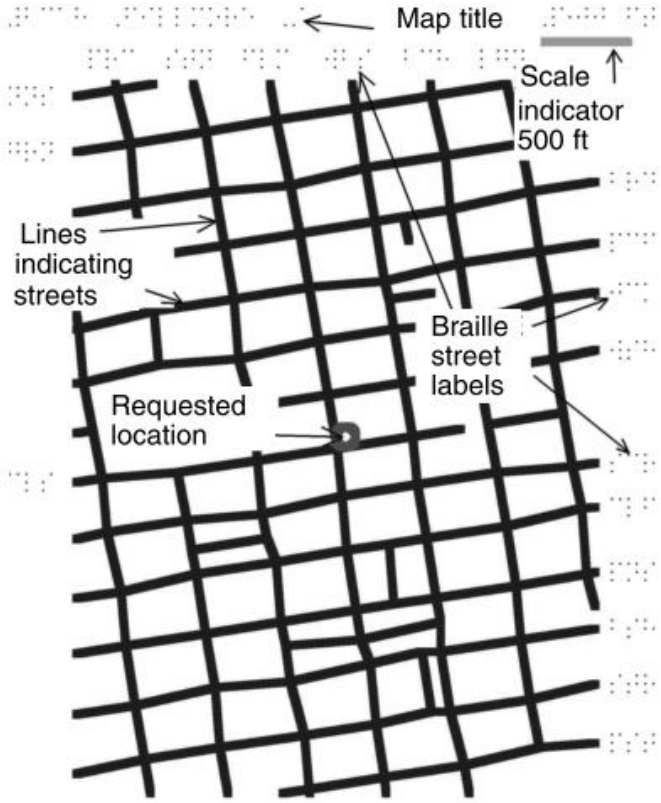




Need interactive maps

Related work

Interactive maps



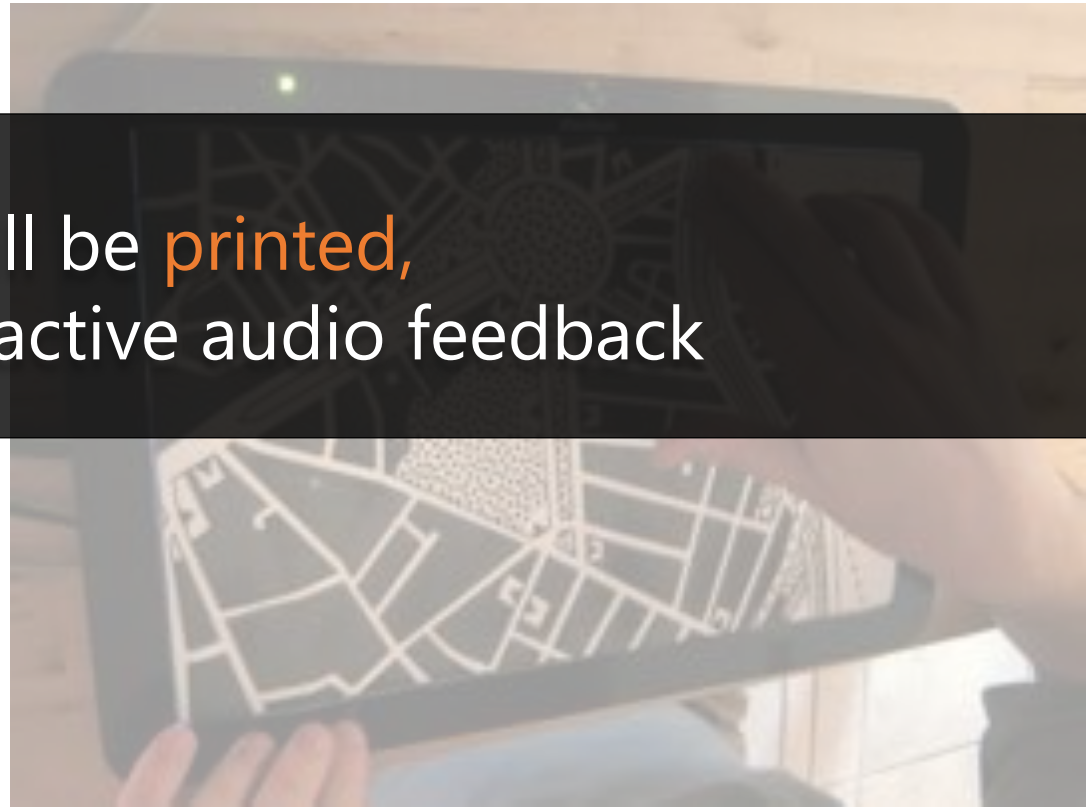
[Miele et al., 2006]

[Brock et al., 2014]

Related work

Interactive maps

Raised line map must still be printed,
thus limiting the benefits of interactive audio feedback



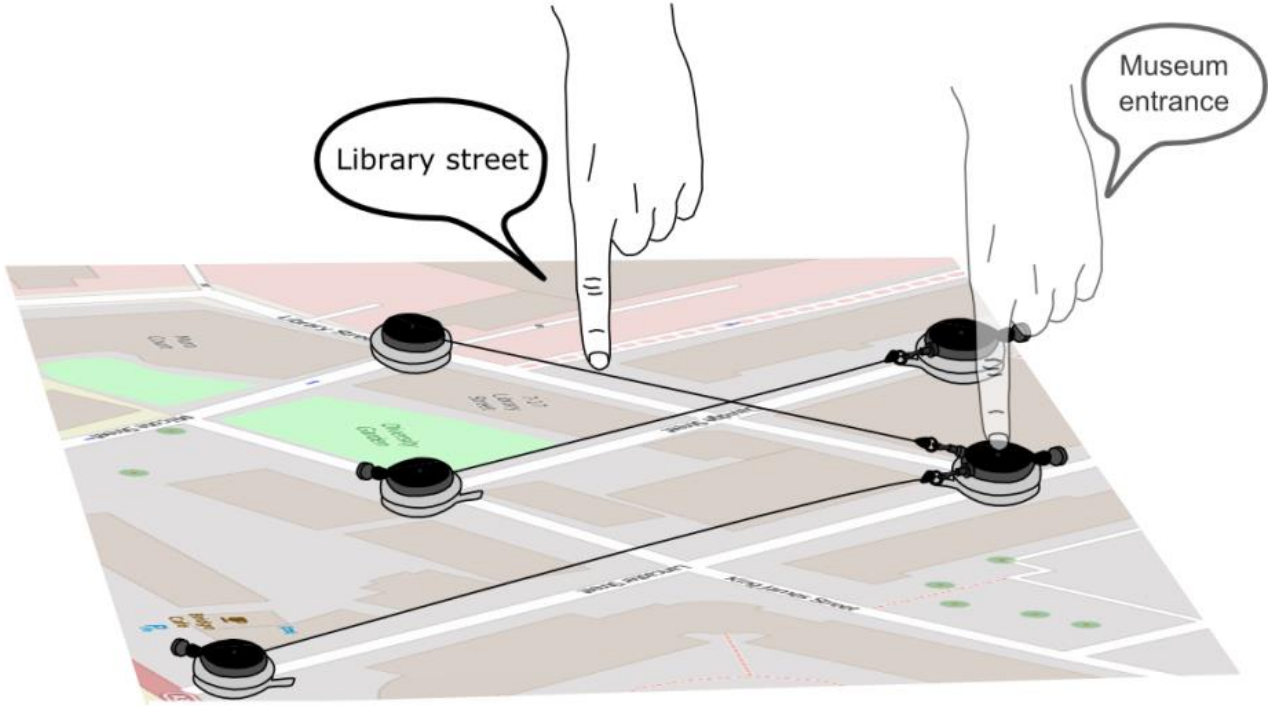
[Miele et al., 2006]

[Brock et al., 2014]

Related work

Tangible maps

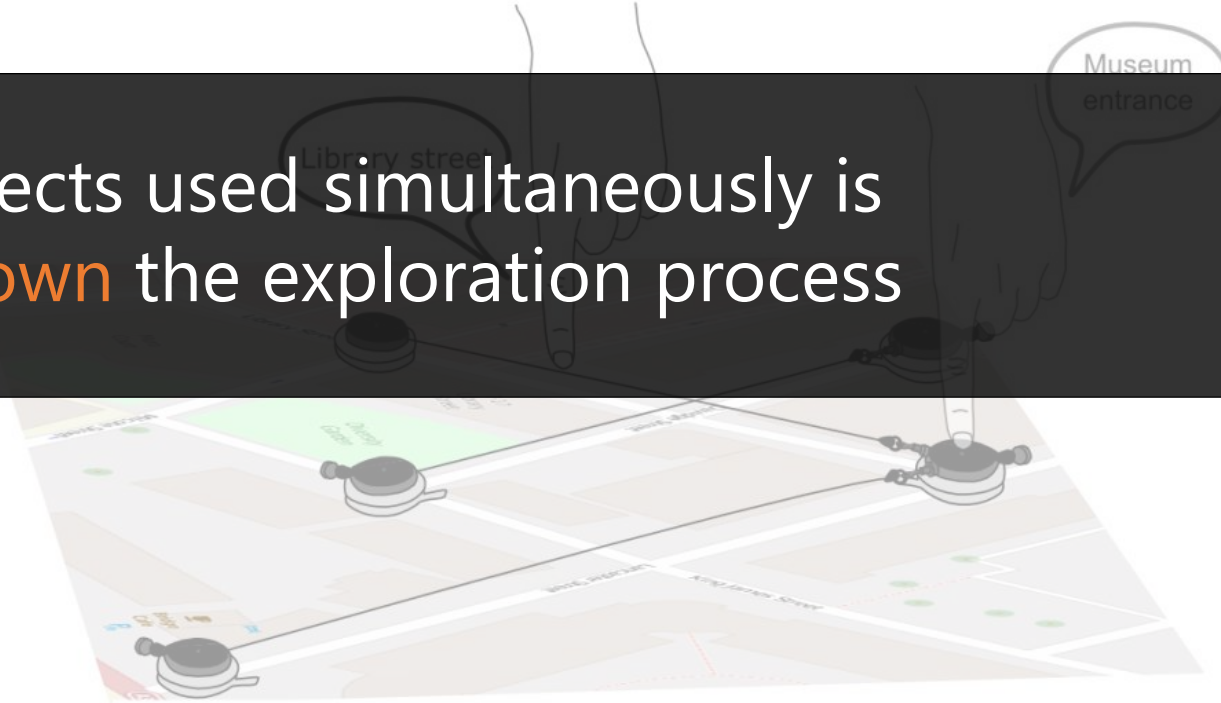
[McGookin et al., 2010]



[*Ducasse et al., 2016*]

Related work

Tangible maps



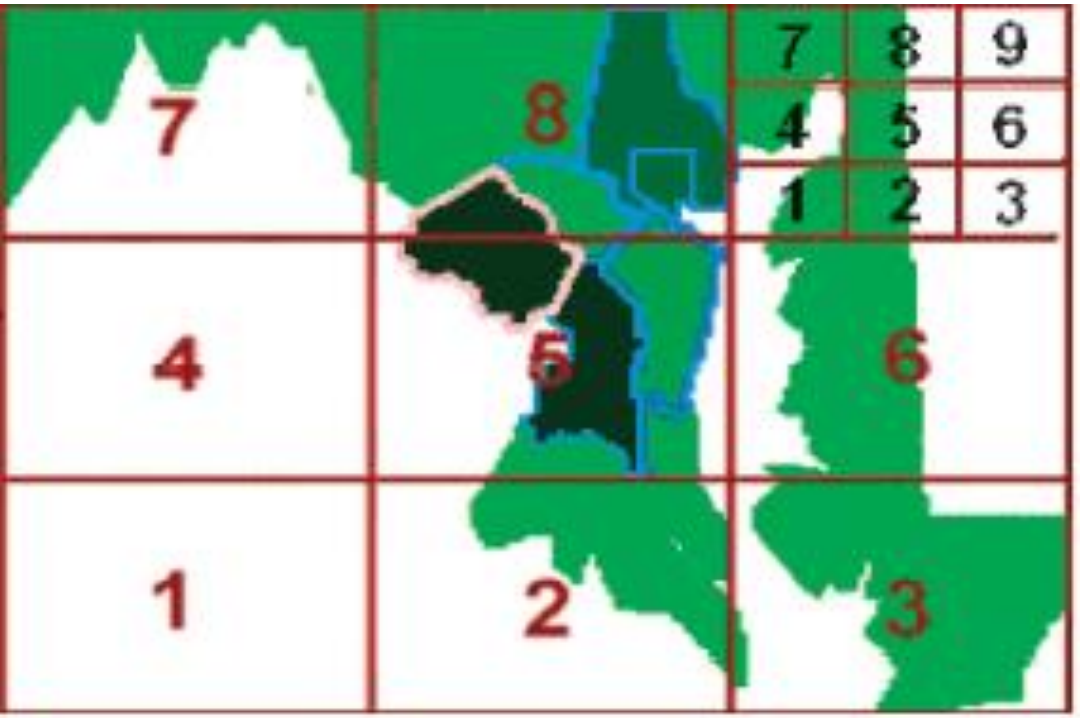
The number of physical objects used simultaneously is limited and tends to slow down the exploration process

[McGookin et al., 2010]

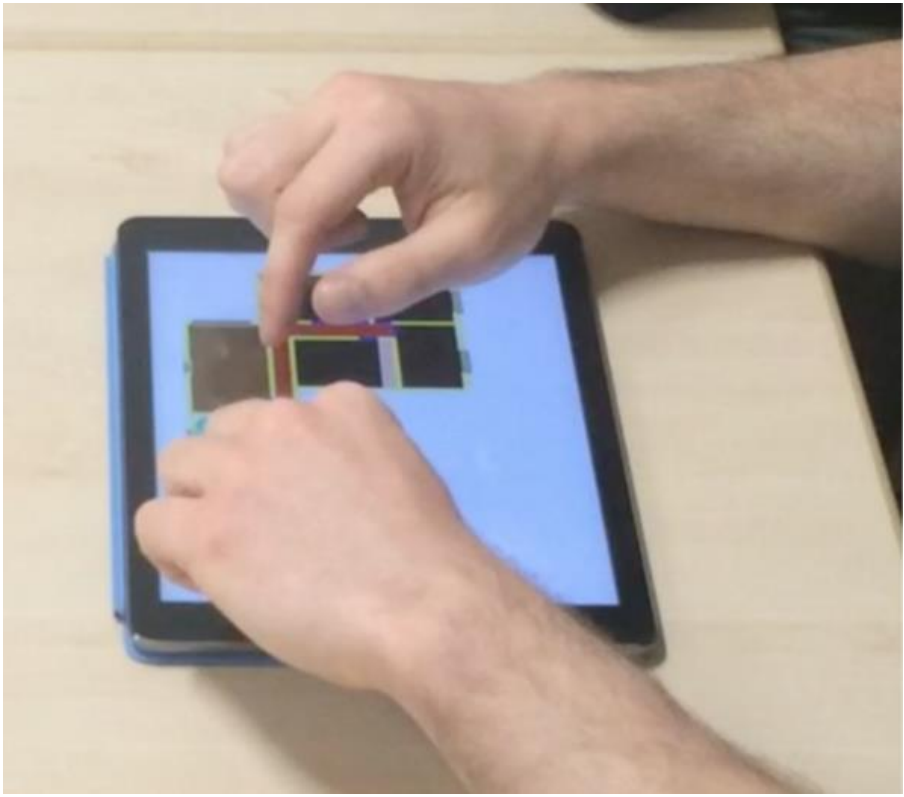
[Ducasse et al., 2016]

Related work

Virtual maps



[Zhao et al., 2008]



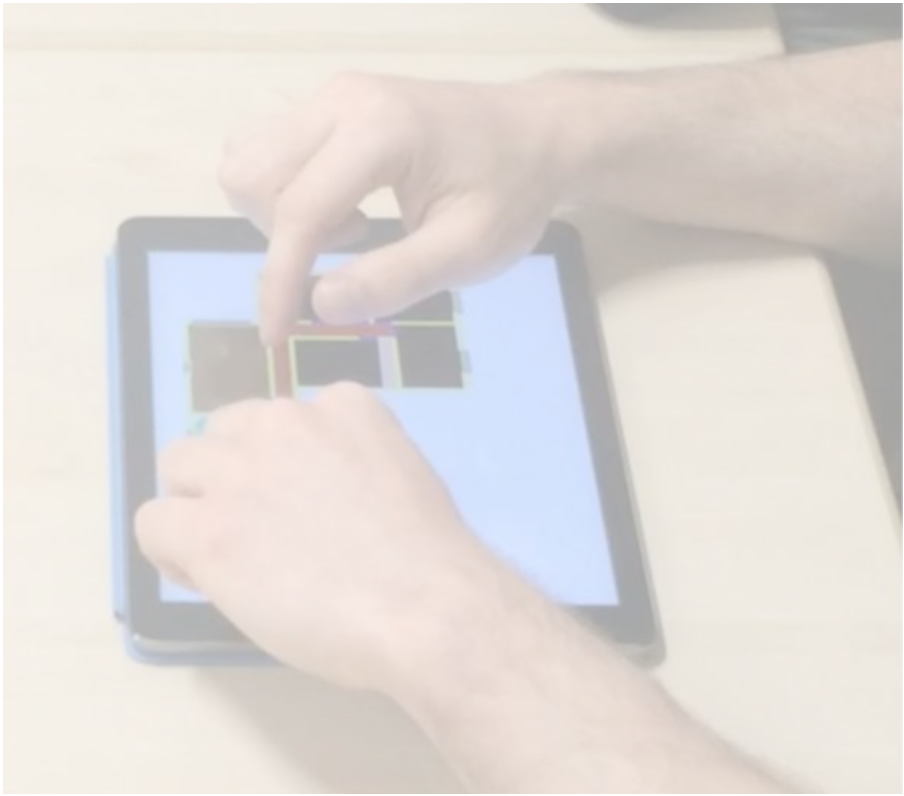
[Goncu et al., 2015]

Related work

Virtual maps

Keyboard exploration is strictly discrete, required more cognitive effort

[Zhao et al., 2008]



[Goncu et al., 2015]

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Keyboard exploration is strictly discrete, required more cognitive effort

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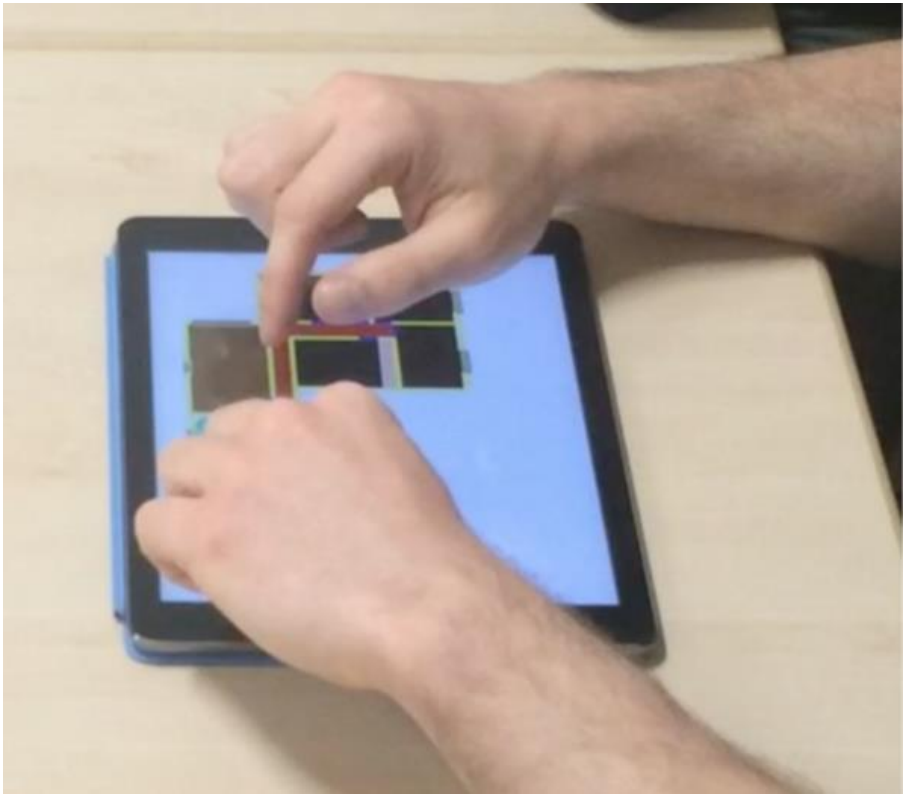

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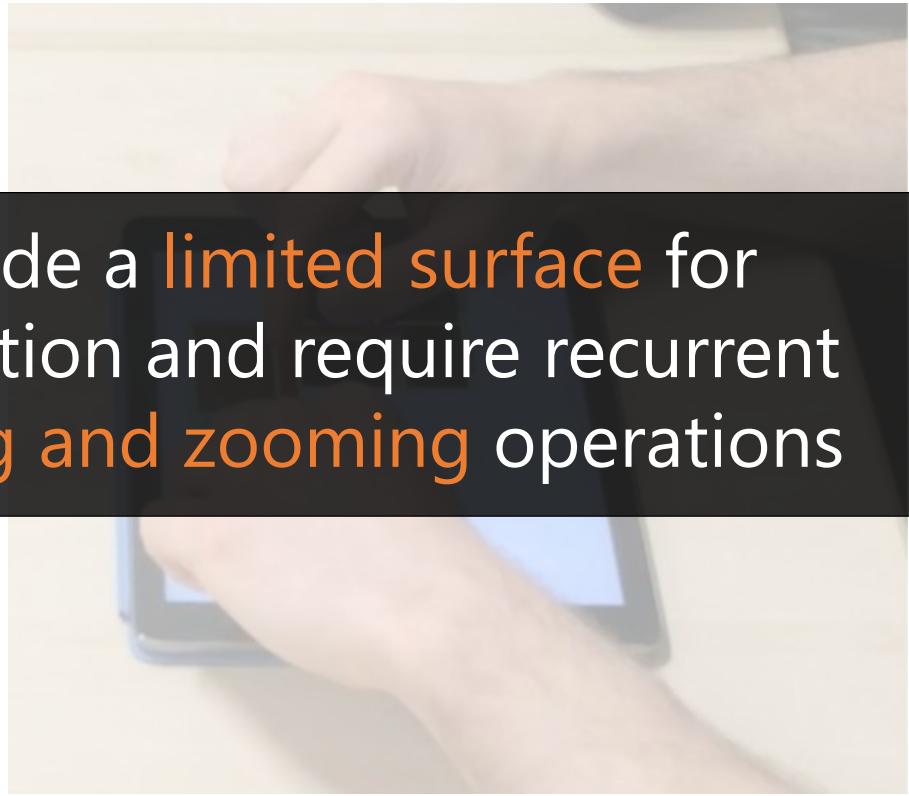


Provide a limited surface for exploration and require recurrent panning and zooming operations

[Goncu et al., 2015]

Research Goals

1) Improve the spatial direct exploration

2) Provide the user with large surfaces and collocated feedback

3) Provide the user with map access in any situation (home, school, work, etc.)

Proposed technique

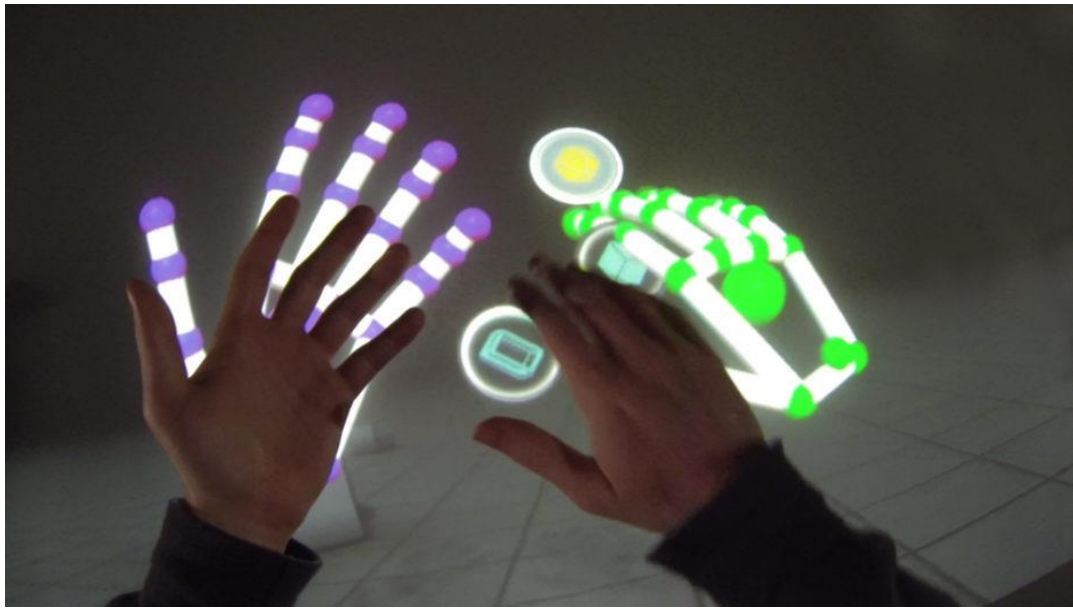
Hand tracking

Frequent and cheap

Smartwatch

Personal device

Provide audio and vibrotactile feedback



Source: http://venturebeat.com/2016/08/28/leap-motions-interaction-engine-puts-the-handy-into-hand-tracking/

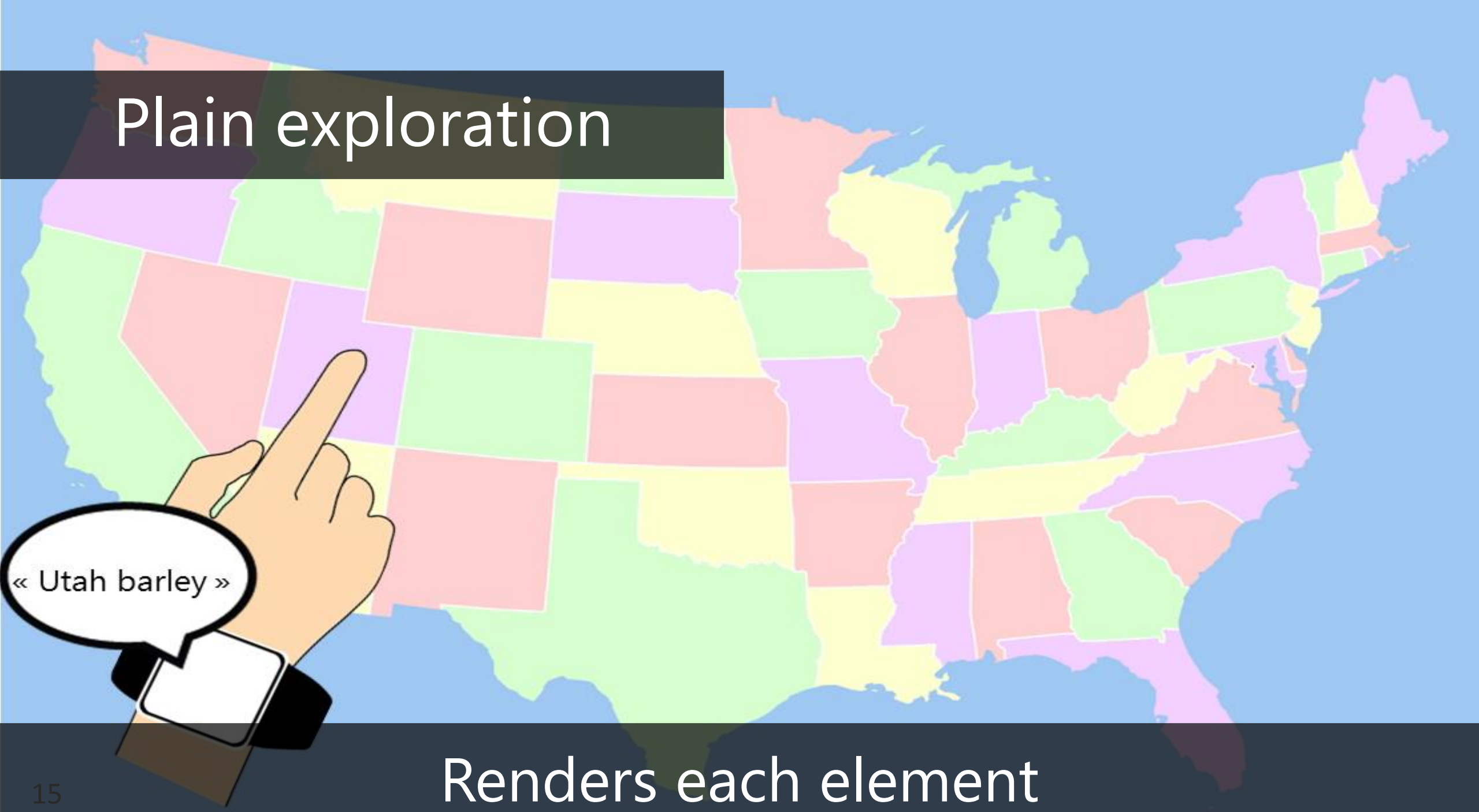
Proposed technique

Smartwatch use as input and output

Design 3 versions of the technique:

- Plain
- Filter
- Grid + Filter

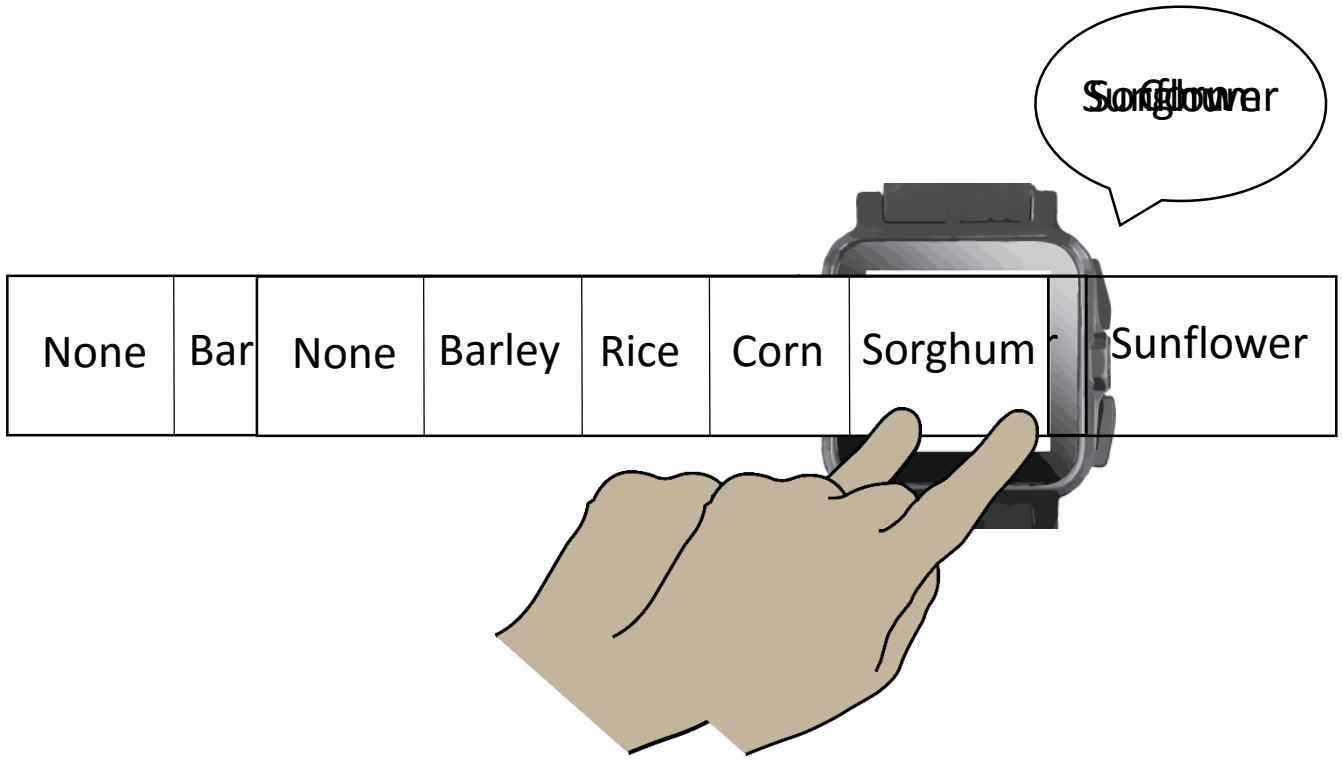
Plain exploration



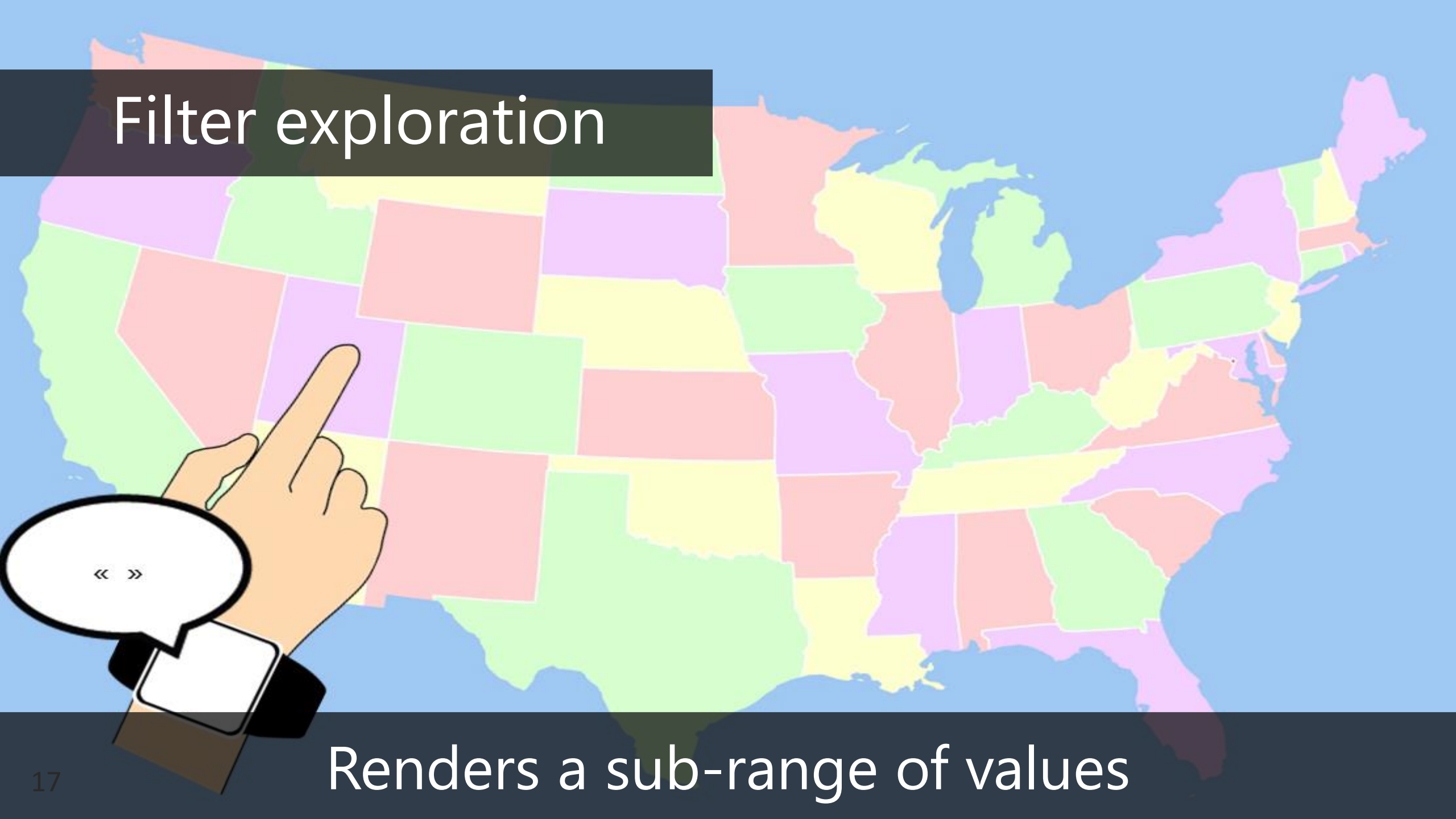
Renders each element

Filter exploration

Swipe gesture to select a data

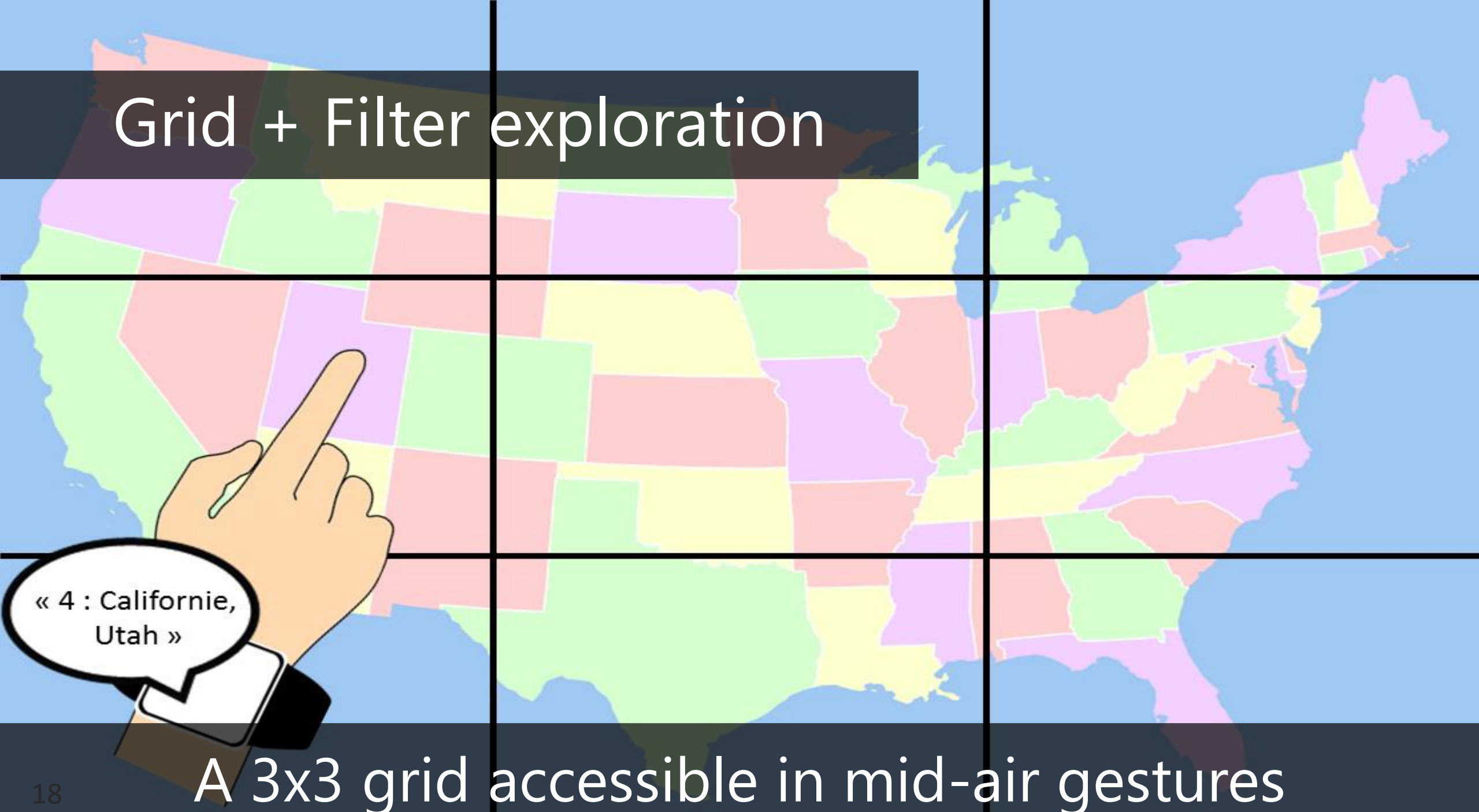


Filter exploration



Renders a sub-range of values

Grid + Filter exploration



A 3x3 grid accessible in mid-air gestures

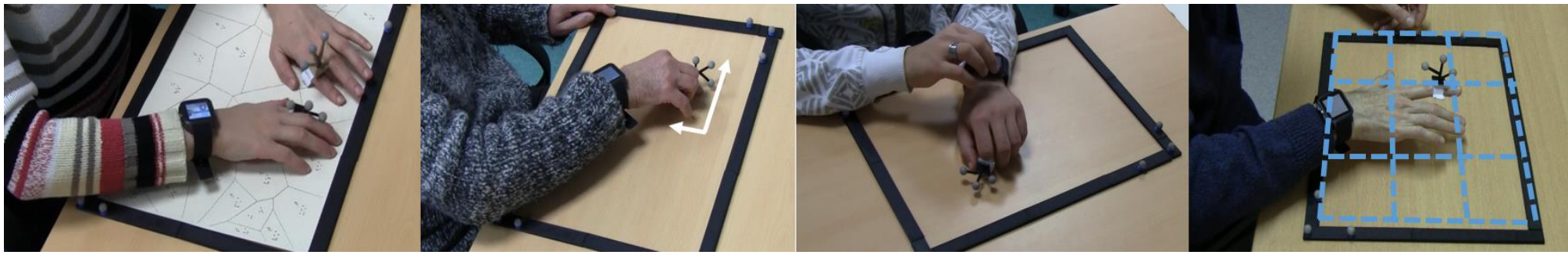
Study

Goal: Compare the usability of our 3 techniques vs raised-line printed

Task: Find 4 specific regions

12 visually impaired people

4 techniques



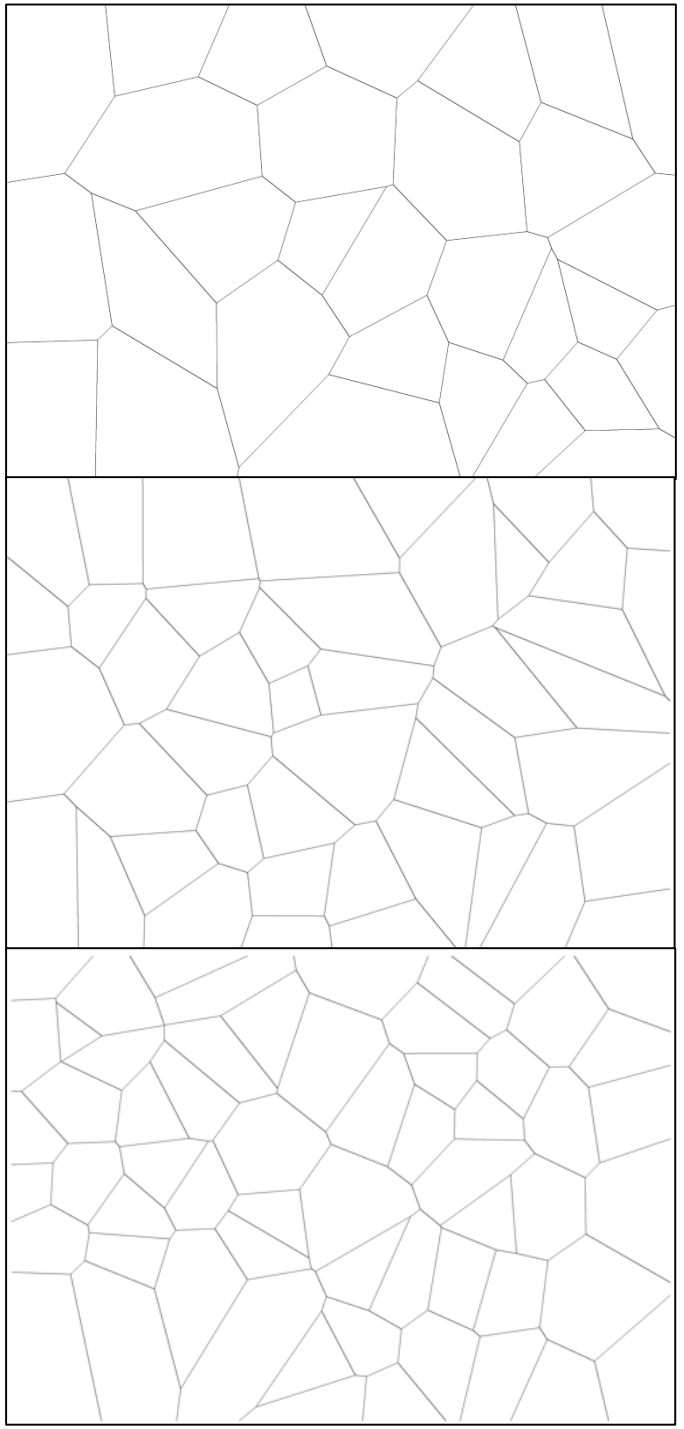
Study

3 types of maps: 30, 45 and 60 regions

Randomly generate regions

Measures:

- Time
- Accuracy
- User preference



Apparatus

8 infrared cameras

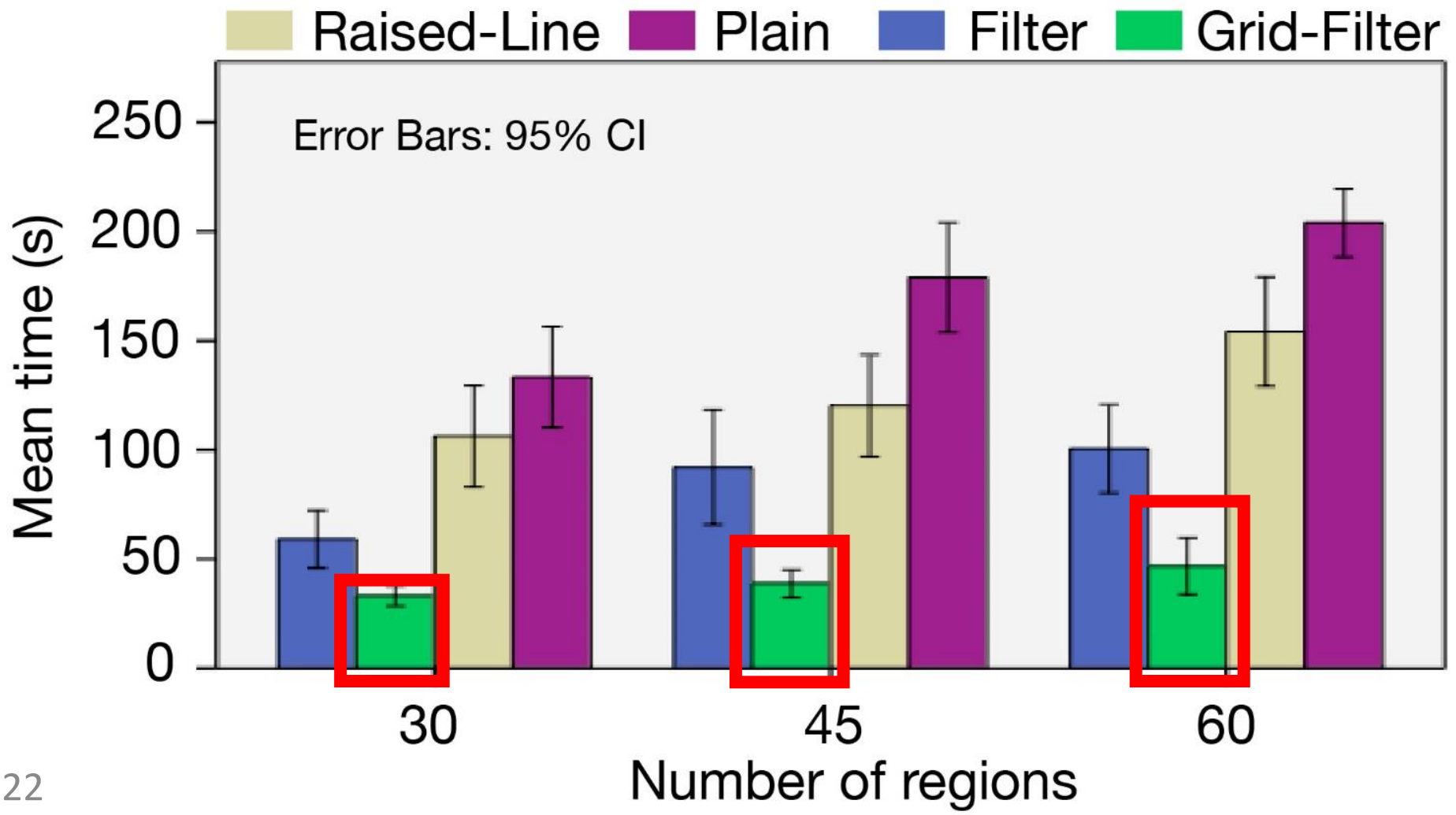
Markers on index finger

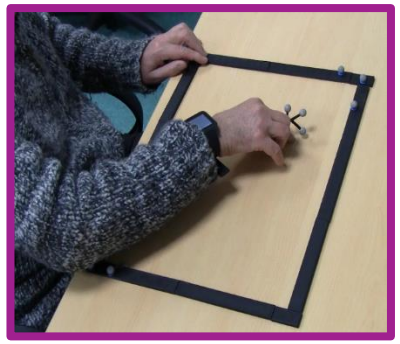
Android Smartwatch SimValley

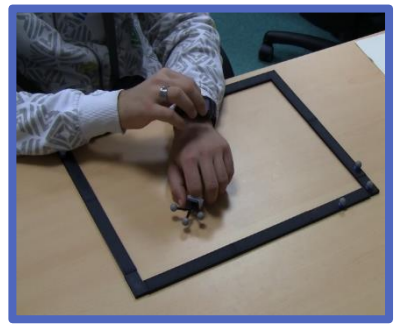
Google TTS

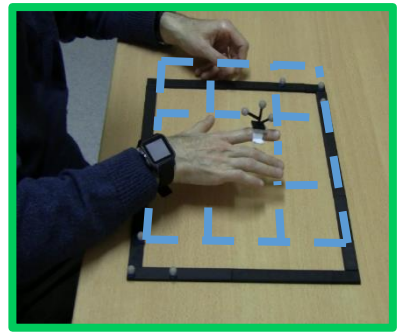
User test to define parameters of the smartwatch

Time performance

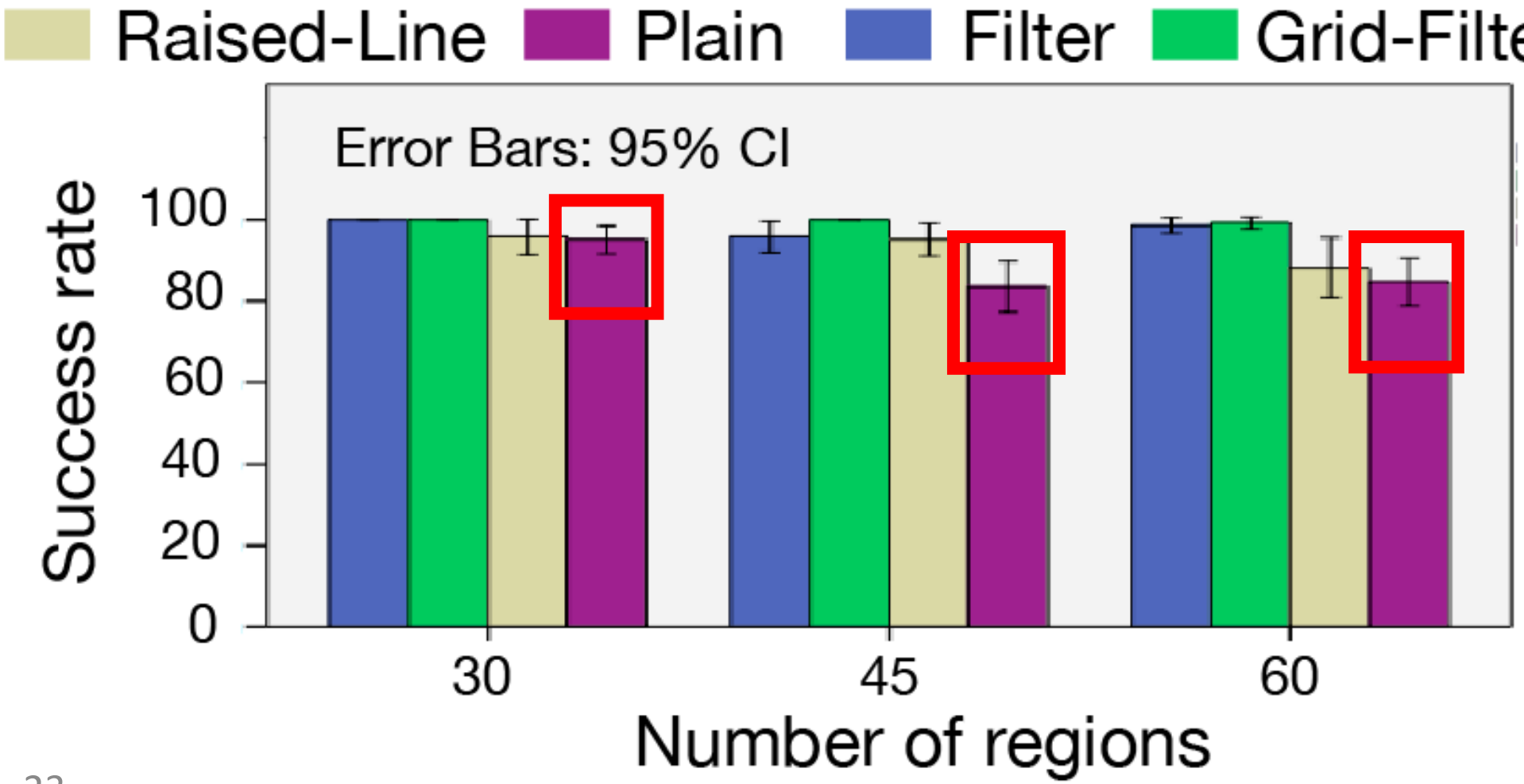


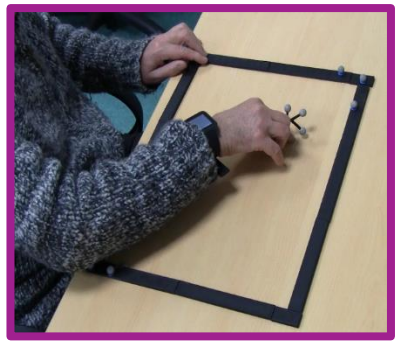


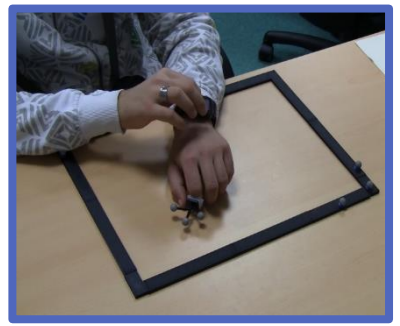


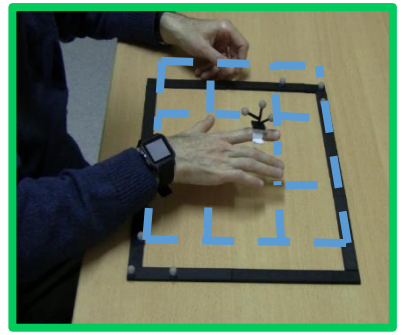


Accuracy

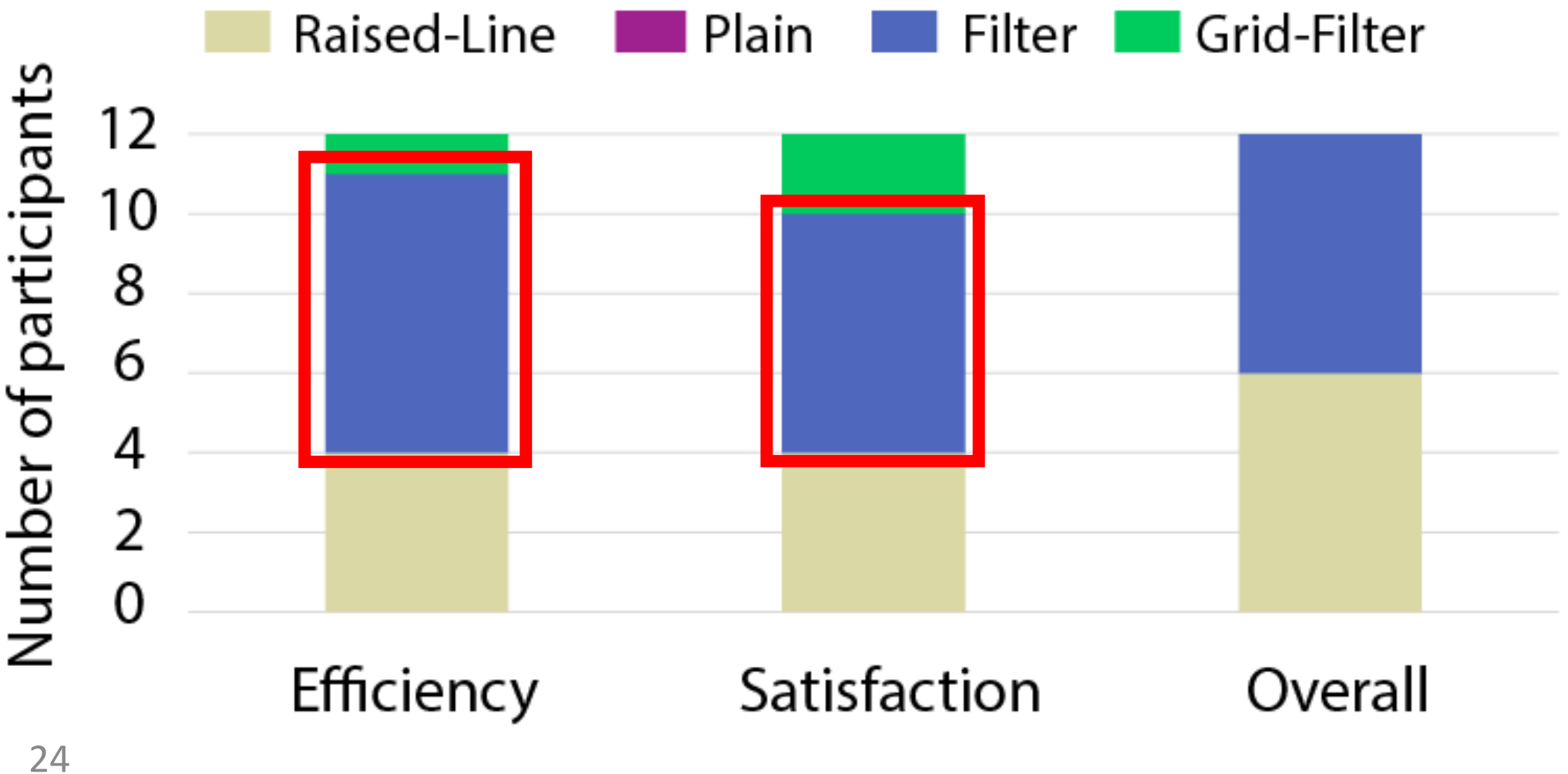

Raised-Line
Plain
Filter
Grid-Filter
Error Bars: 95% CI
Success rate
100
80
60
40
20
0
30
45
60
Number of regions

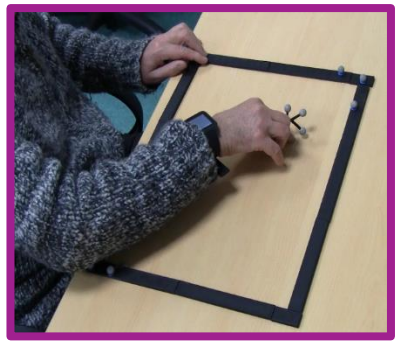


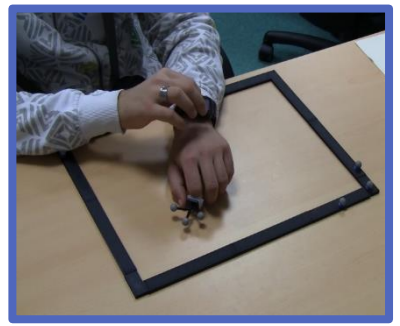


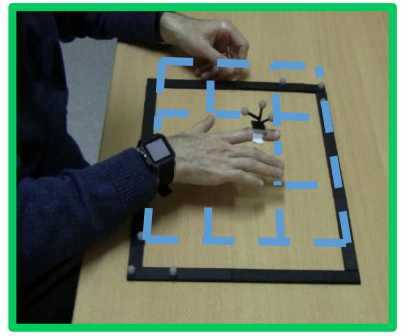


User preference









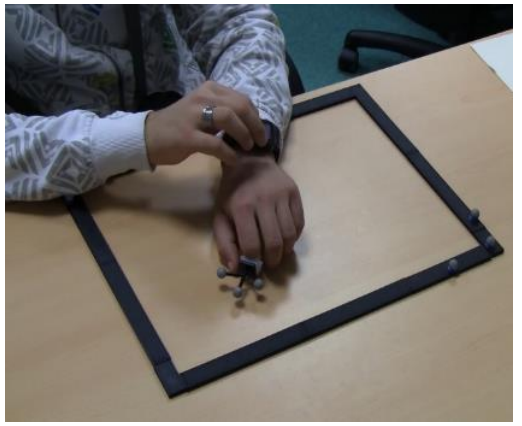
Qualitative study – Real case

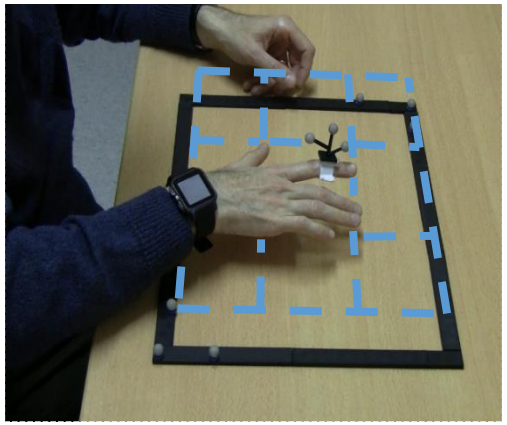
2 techniques: Filter and Grid-Filter

Exploring with two types of data: population and unemployment

4 visually impaired people

Task: Find data correlation trends in spatial data visualization





Summary

Data correlation

Get the two values at the same time, on the same map was convenient (P1)

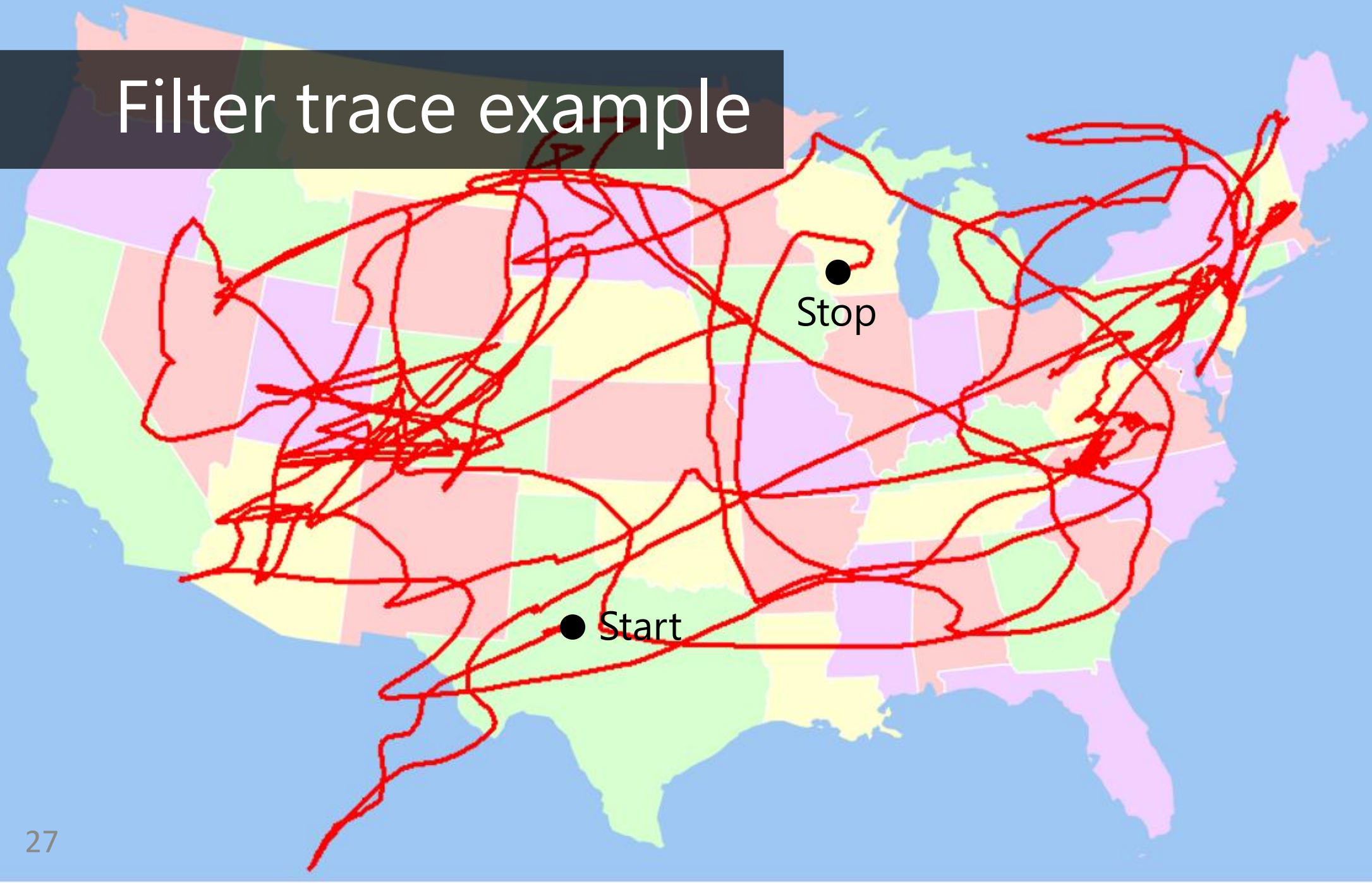
Swipe gesture

Perform horizontal and vertical swipes to filter data systematically (P1, P3, P4)

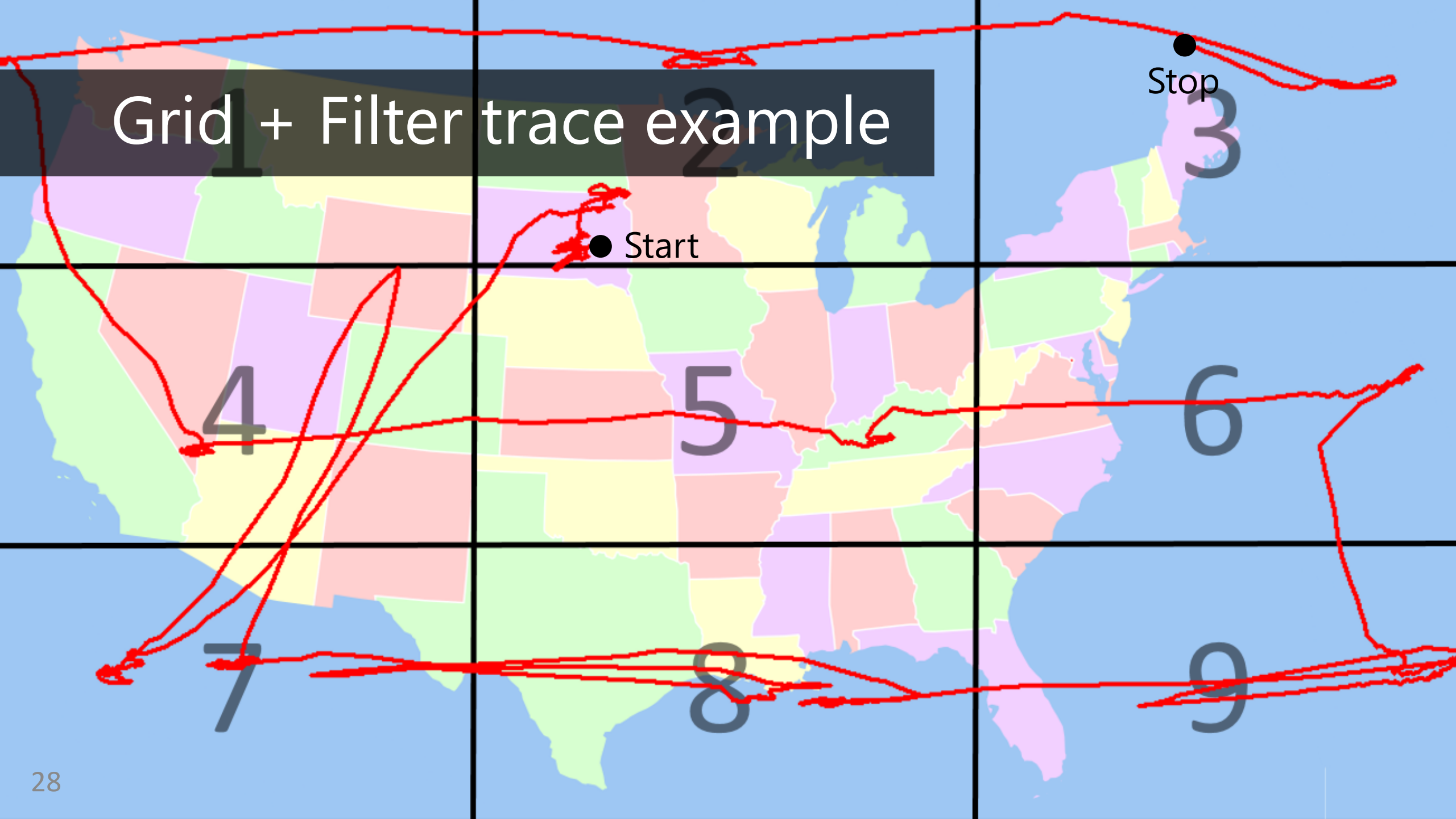
Mid-air gestures

Difficult to estimate precisely hand elevation and that they felt uncomfortable (P2, P4)

Filter trace example



Grid + Filter trace example



Conclusion

3 techniques to explore virtual spatial maps

Combined hand tracking and a smartwatch for feedback

Grid-Filter is the fastest technique but generates discomfort

Virtual techniques are usable to perform complex tasks

Future work

Two hands for virtual exploration

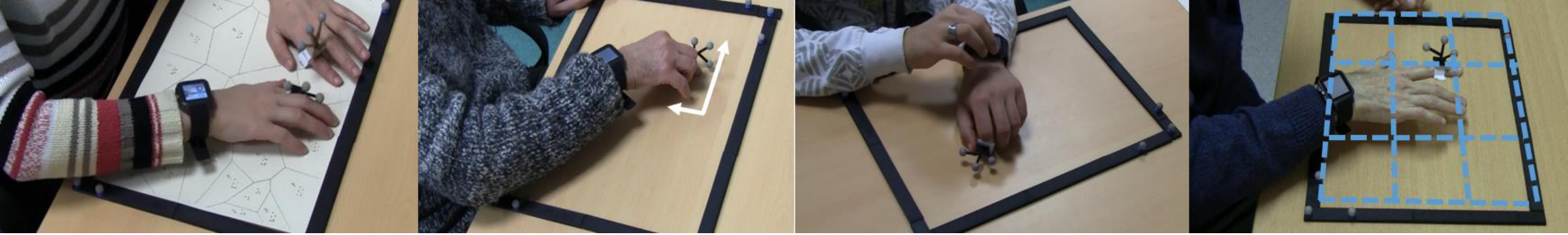
Future work

Smartwatches for pervasive access to maps

Leverage map exploration for visually impaired users everywhere (office, school, home, etc.)

Use head-mounted camera

[Colaço et al., 2013]



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