Exploration of Time-Oriented Data in Immersive Virtual Reality Using a 3D Radar Chart Approach

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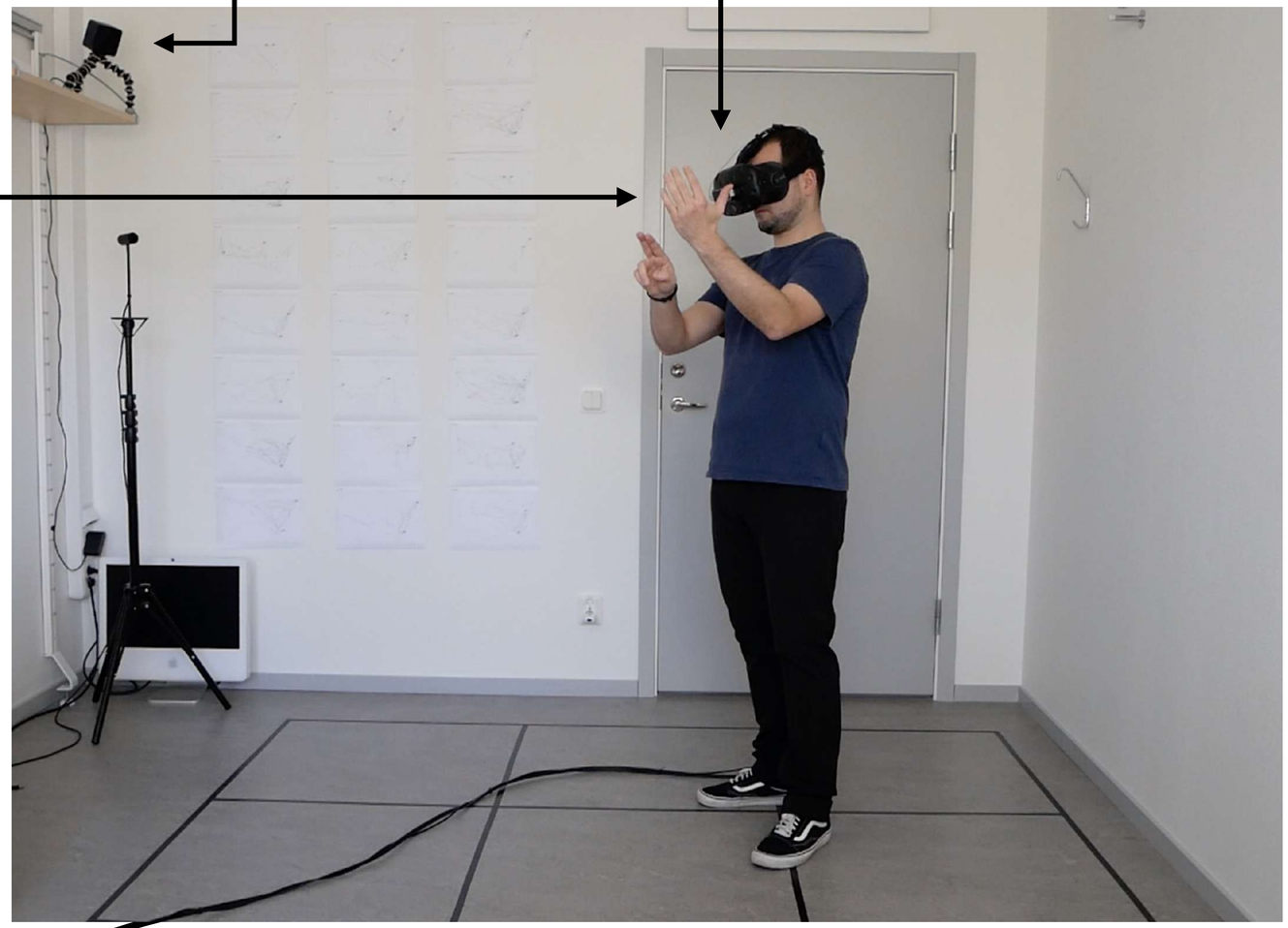
Linnéuniversitetet

[vrxar.lnu.se]
[cs.lnu.se/isovis/]

head-mounted display
(HMD; “VR headset”)

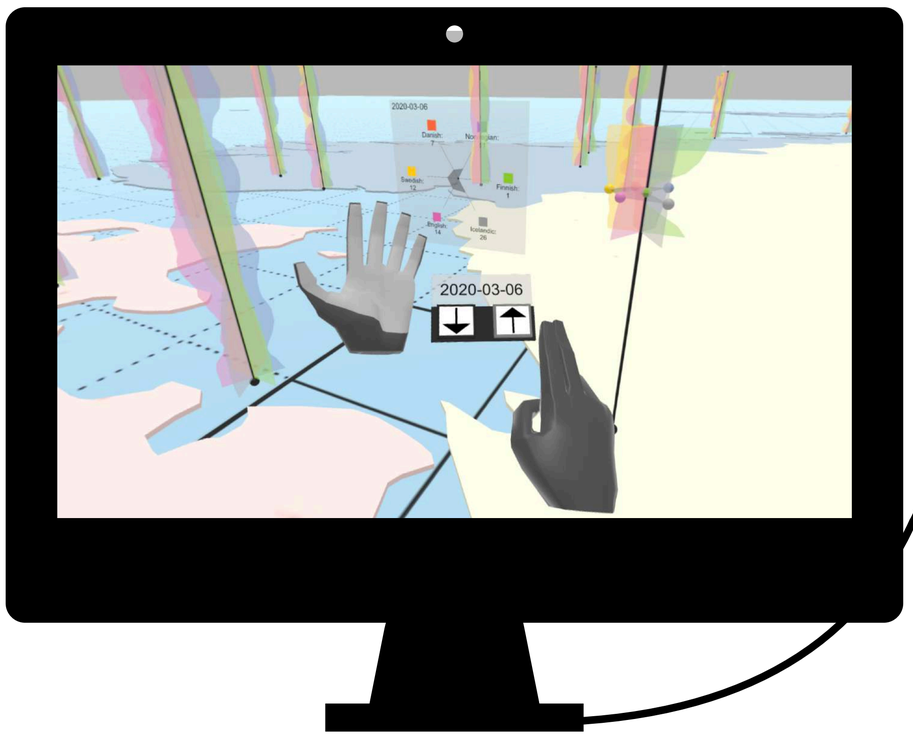
tracking sensors

3D user interface
(i.e., 3D gestural input)



physical real-world space

computer-generated, virtual
three-dimensional (3D) environment



Exploration and analysis of time-oriented data in VR:

1. Usability **2. User Engagement**

3. Interaction aspects **4. Approach validation**

Immersive Analytics

Immersive display and interaction technology

Virtual Reality
Augmented Reality
Augmented Virtuality
3D User Interfaces
...

Data exploration, interaction, and interpretation

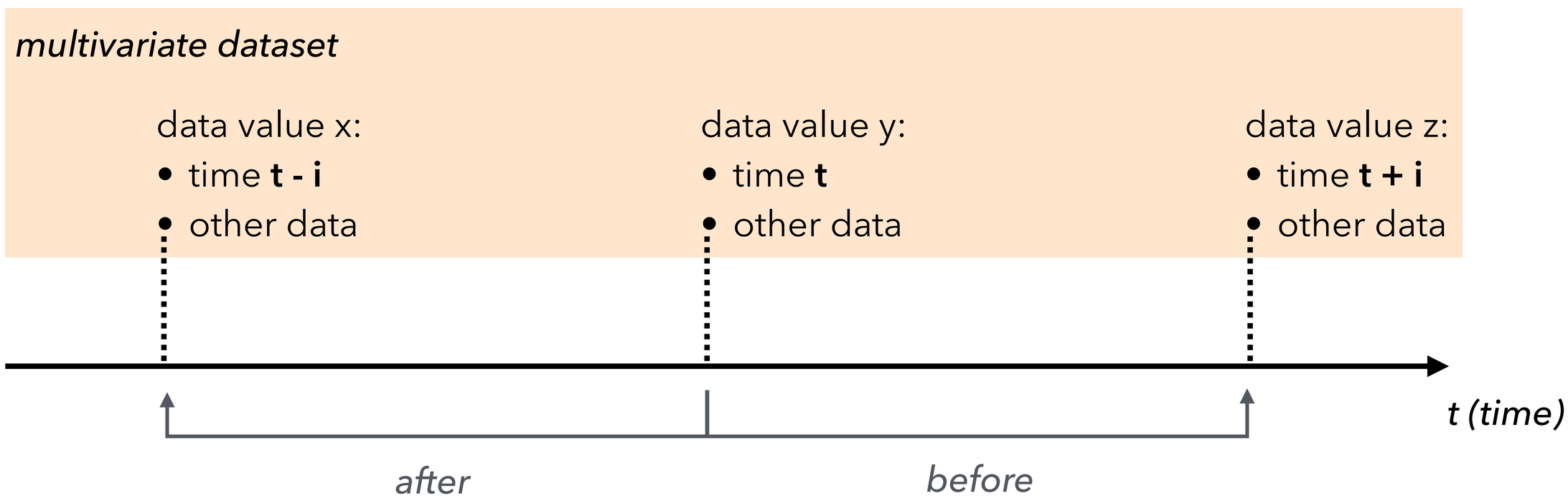
Analytical meaning- and decision-making

interdisciplinarity

Human-Computer Interaction
Virtual Reality
3D User Interfaces

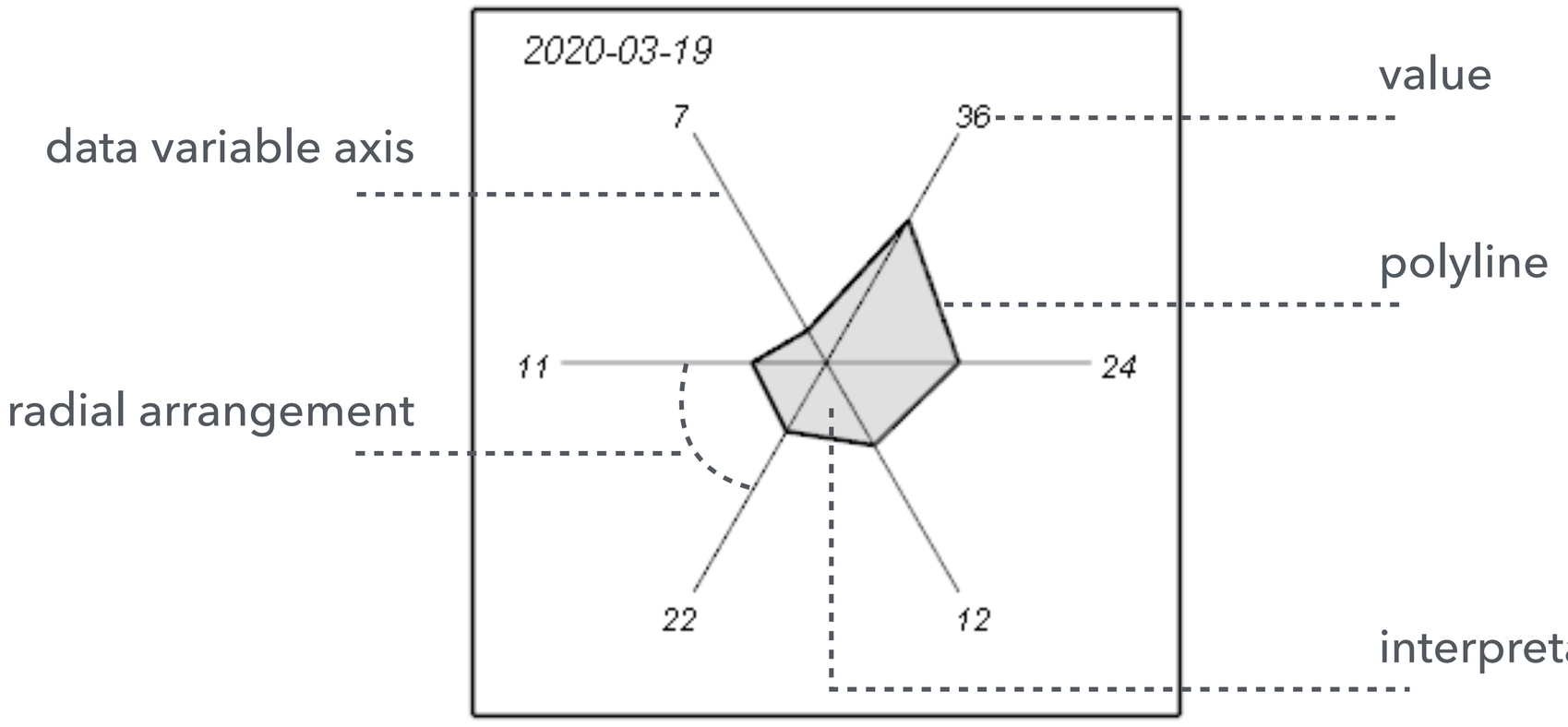
Information Visualization
Visual Analytics

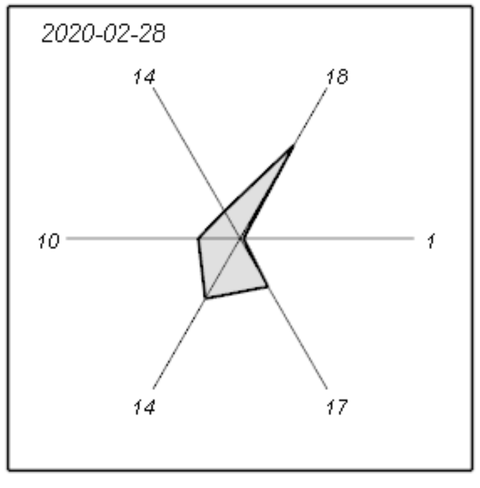
synergy / complementation

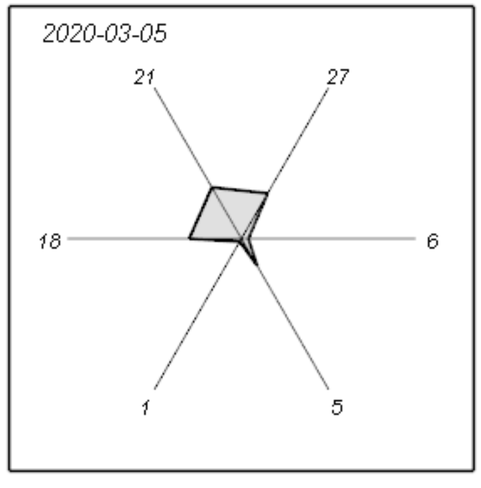


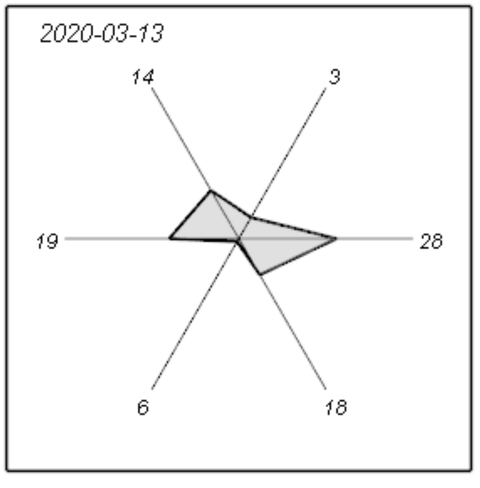
Time-oriented Data: Typical Tasks

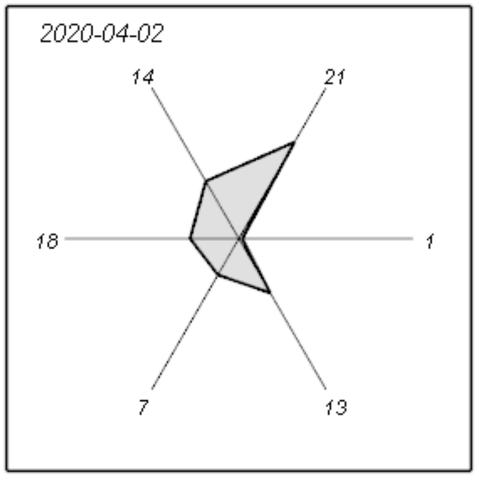
- Encoding / Visualization
- Selection
- Navigation / Exploration

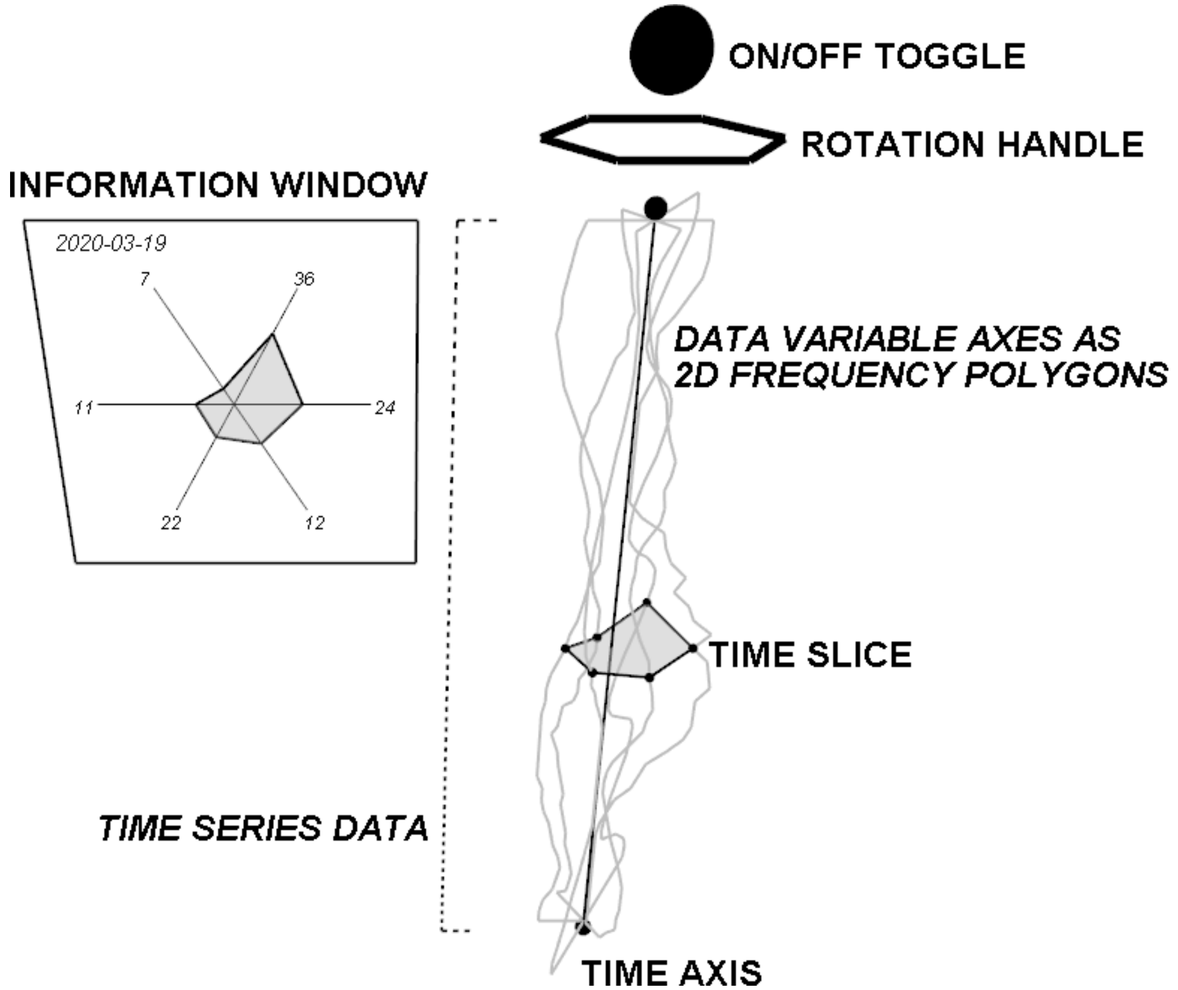

2020-03-19
7
36
11
24
22
12
data variable axis
radial arrangement
value
polyline
interpretable pattern


2020-02-28
14
18
10
1
14
17

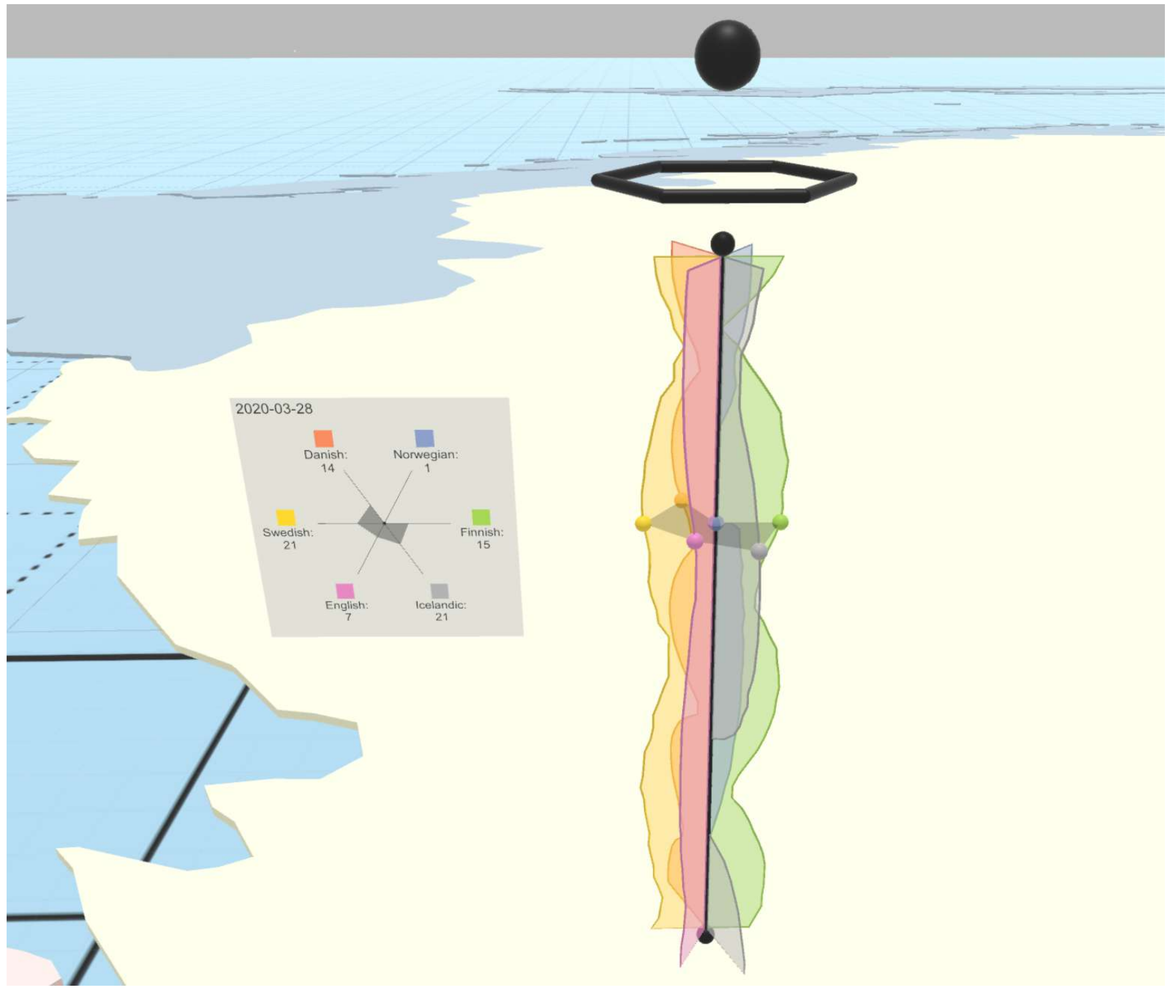

2020-03-05
21
27
18
6
1
5


2020-03-13
14
3
19
28
6
18

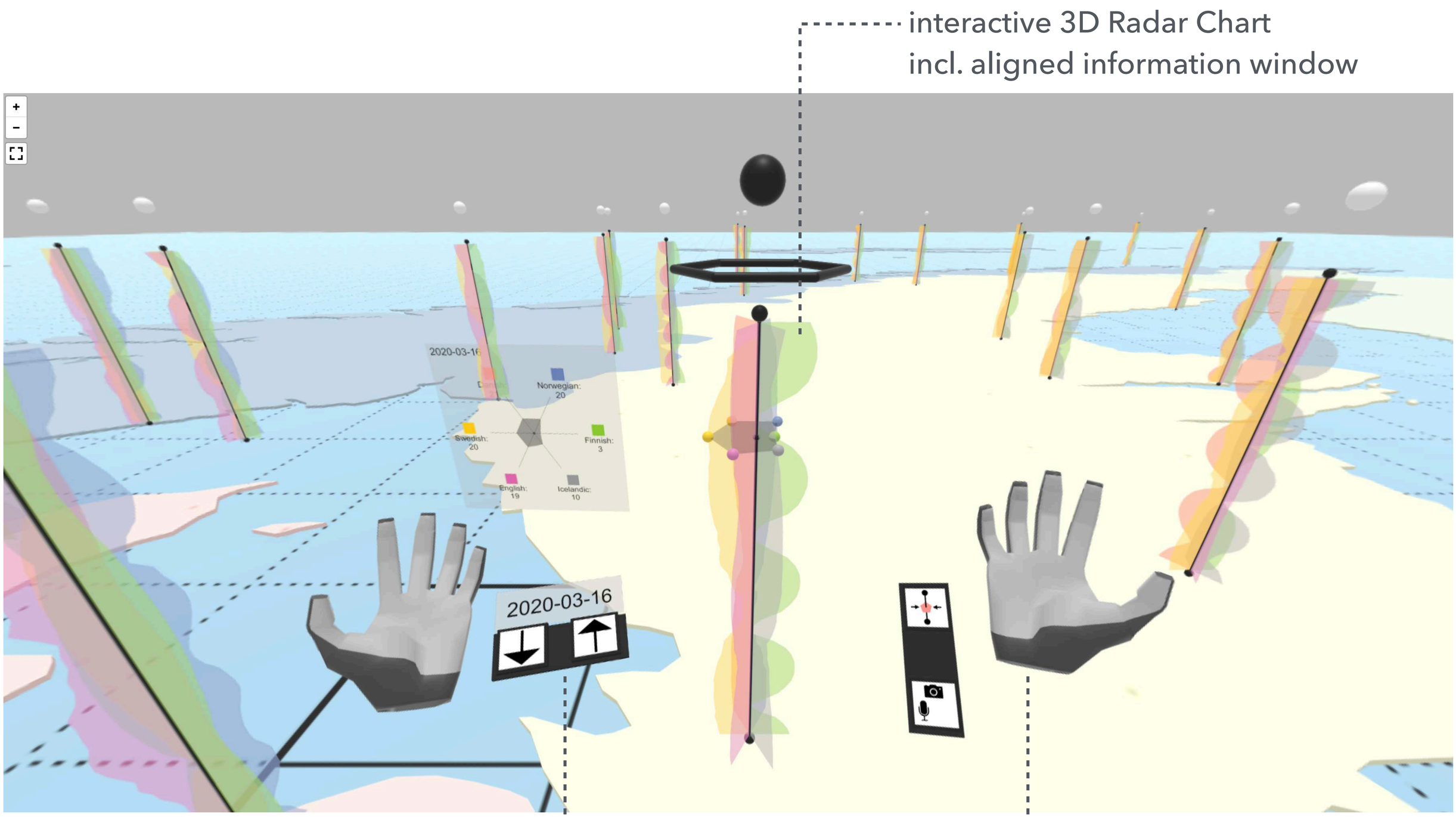

2020-04-02
14
21
18
1
7
13

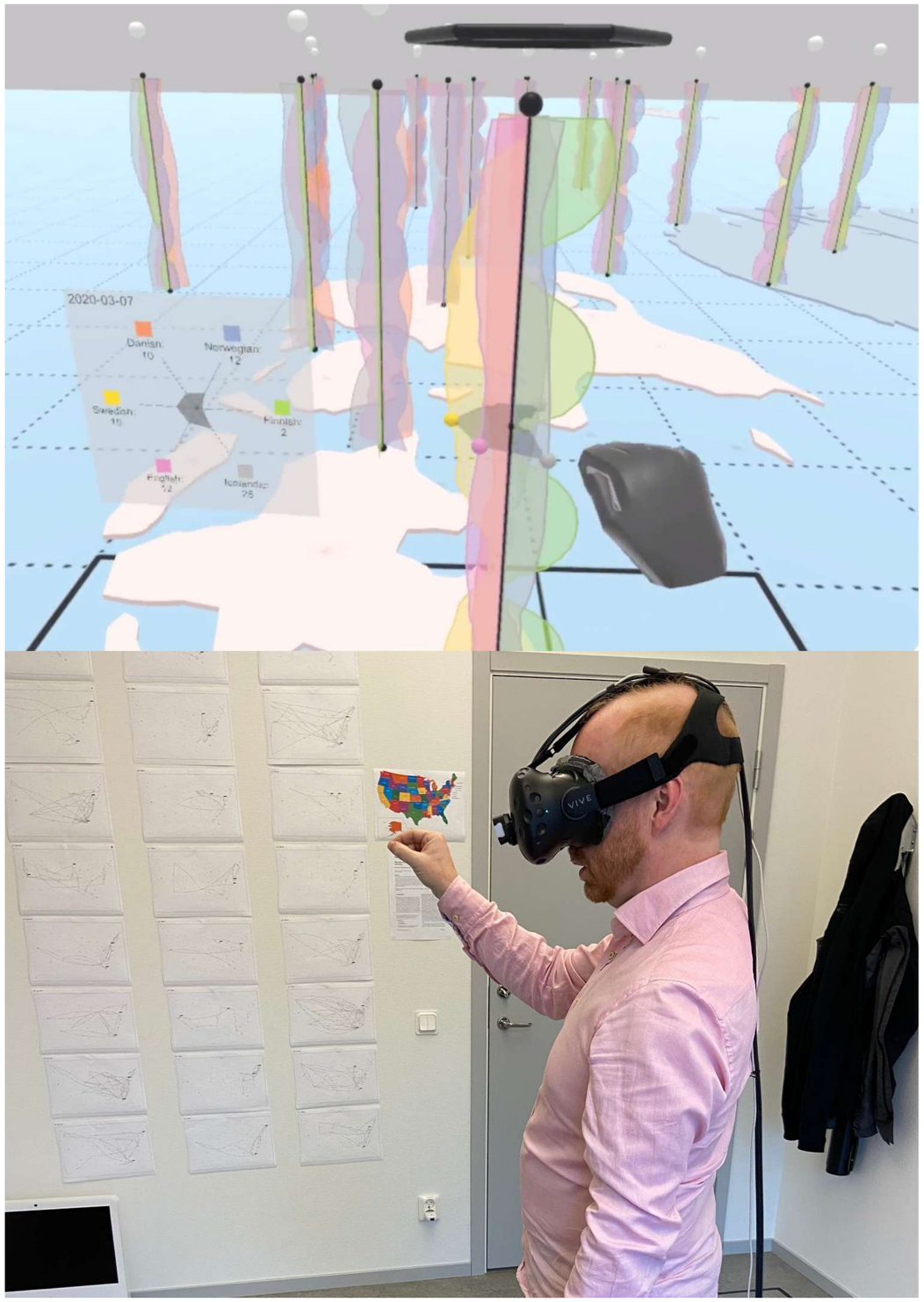


Concept

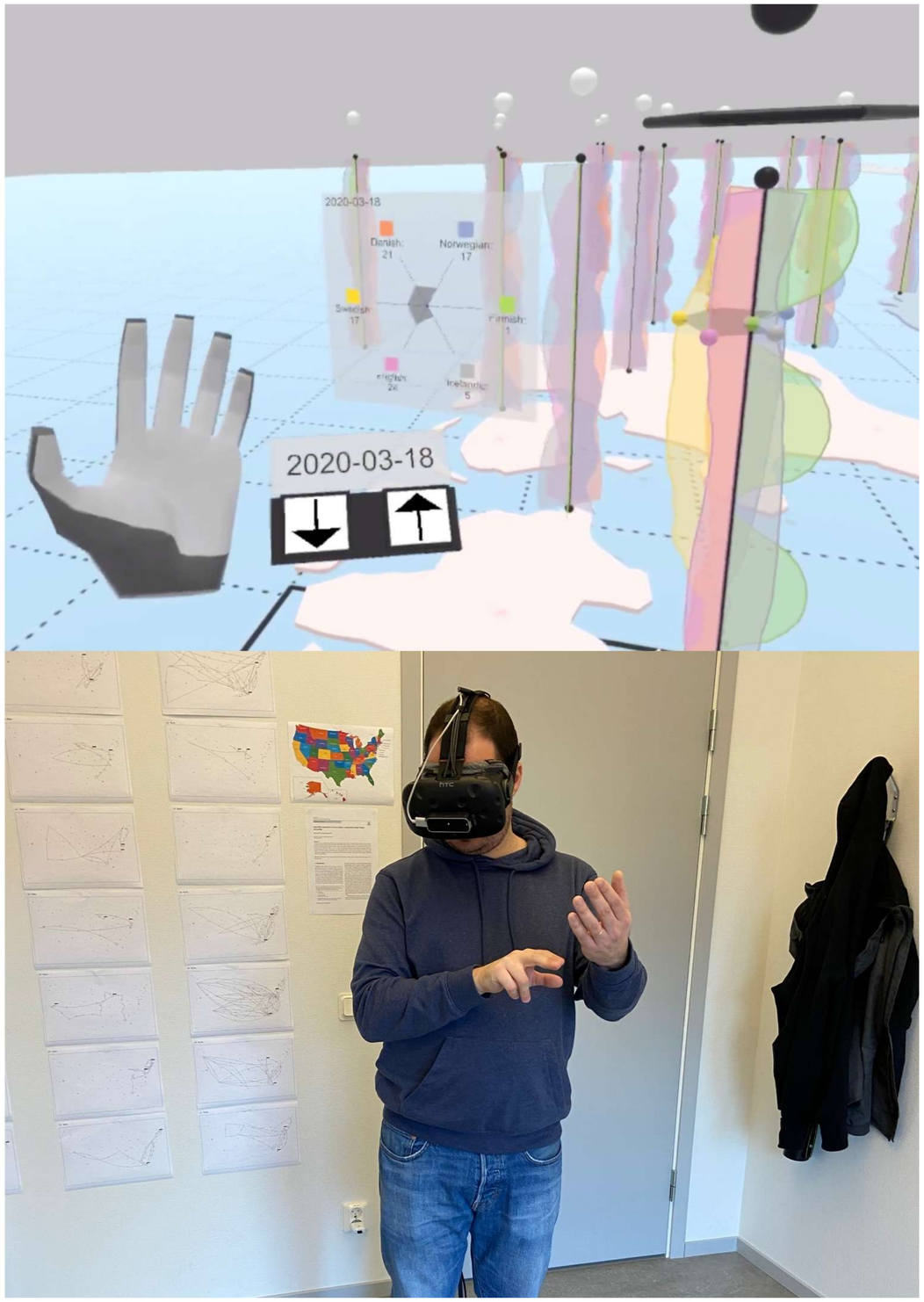


Implementation


interactive 3D Radar Chart
incl. aligned information window
2020-03-16
Norwegian: 20
Finnish: 3
Icelandic: 10
English: 19
Swedish: 20
2020-03-16
graphical hand menu
3D gestural input

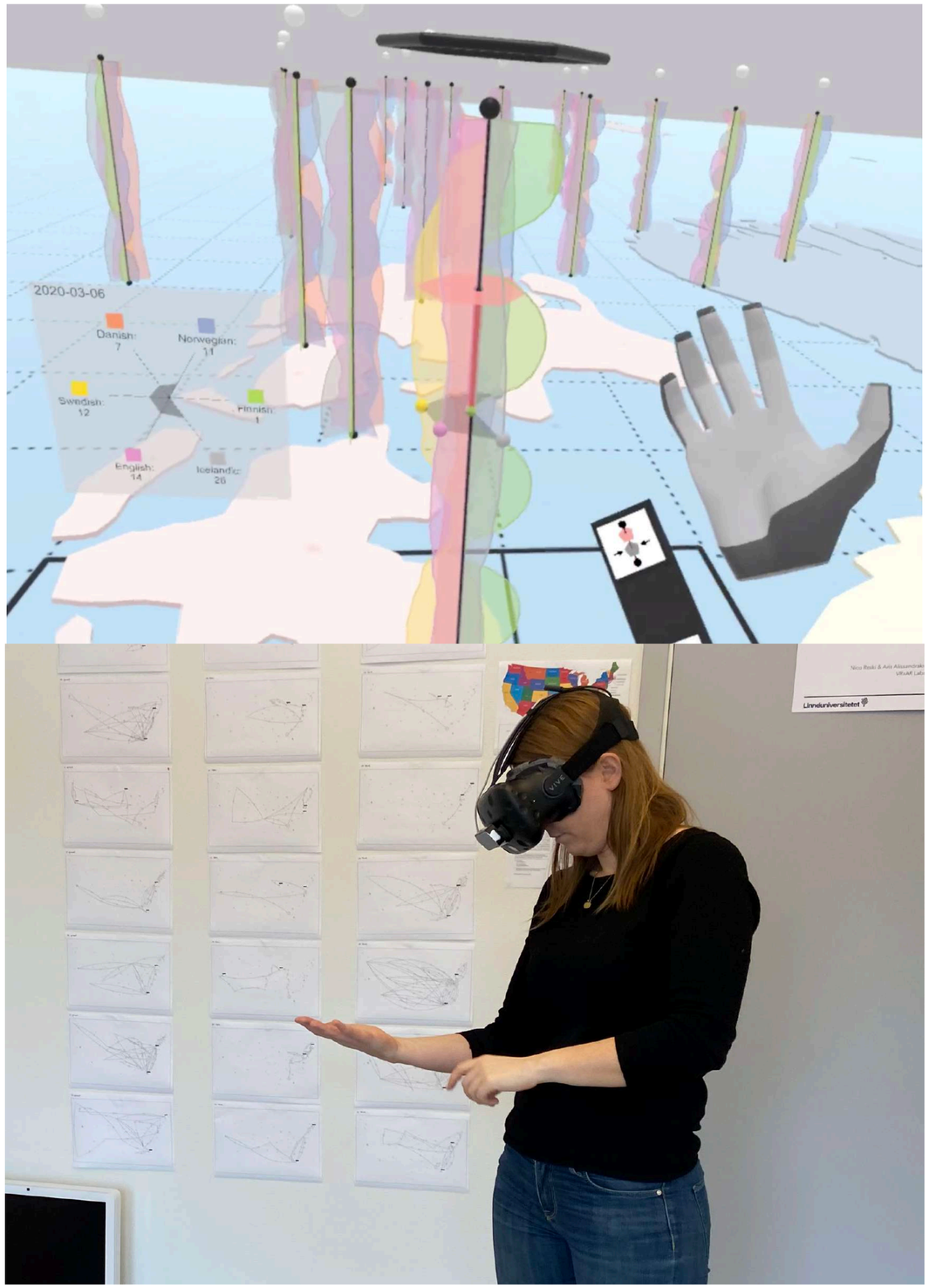


Direct manipulation
"grasping metaphor"

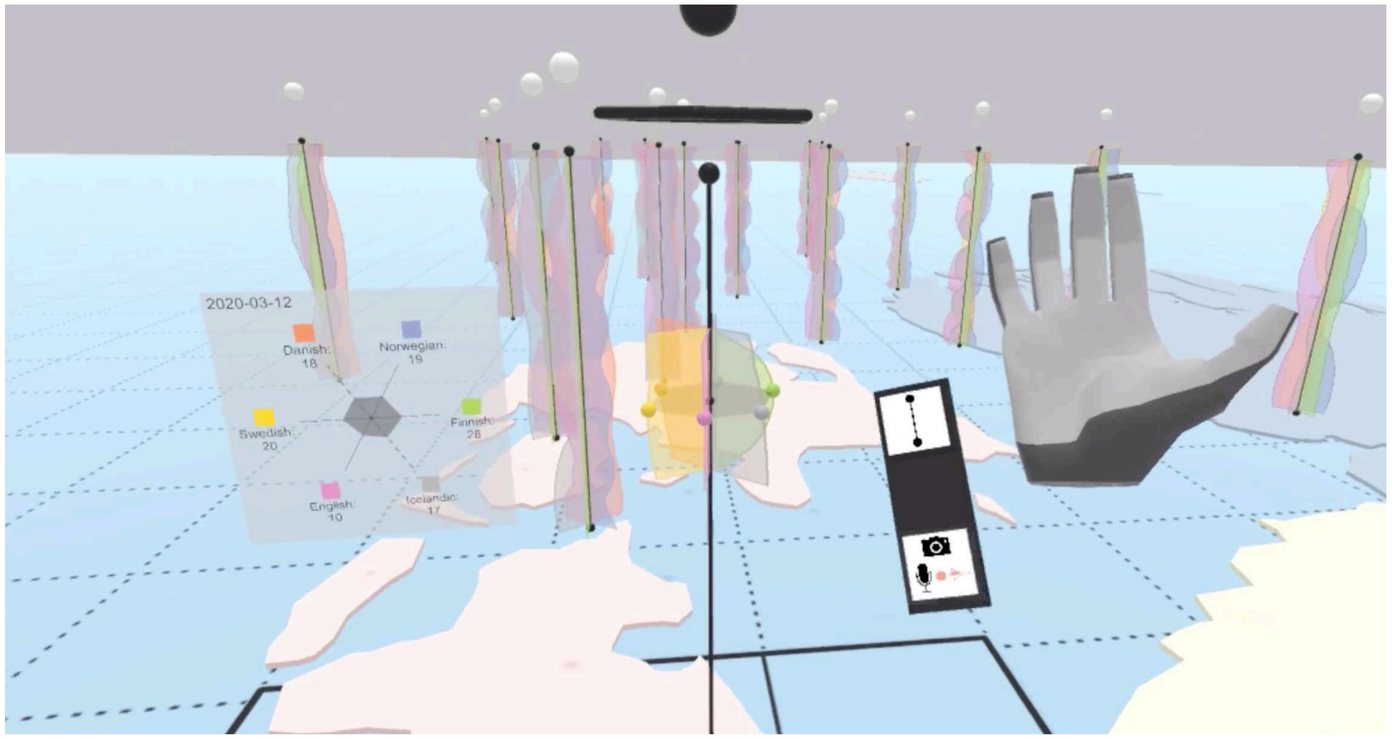


System-control
two button hand menu

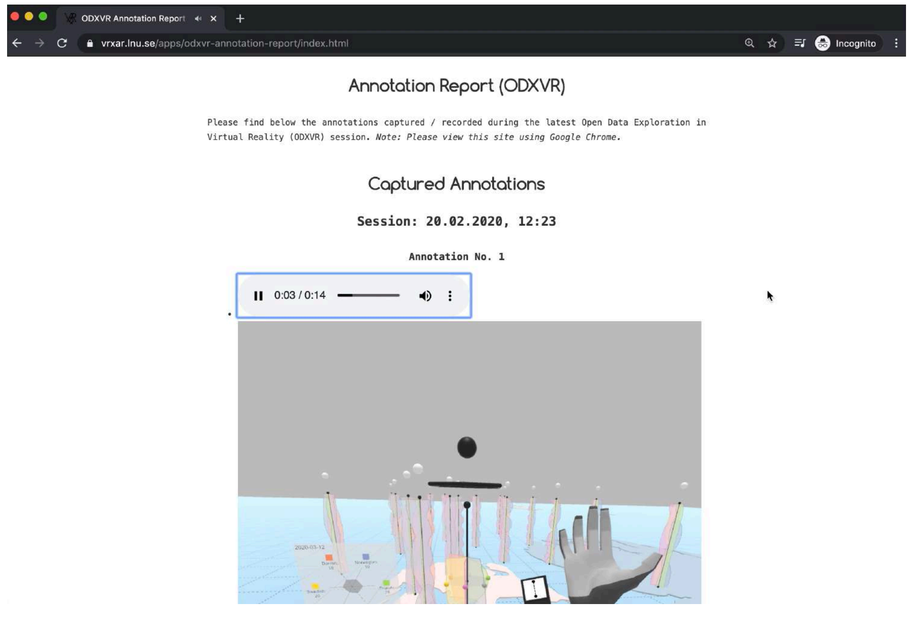
Direct manipulation
“grasping metaphor”



System-control
one button hand menu

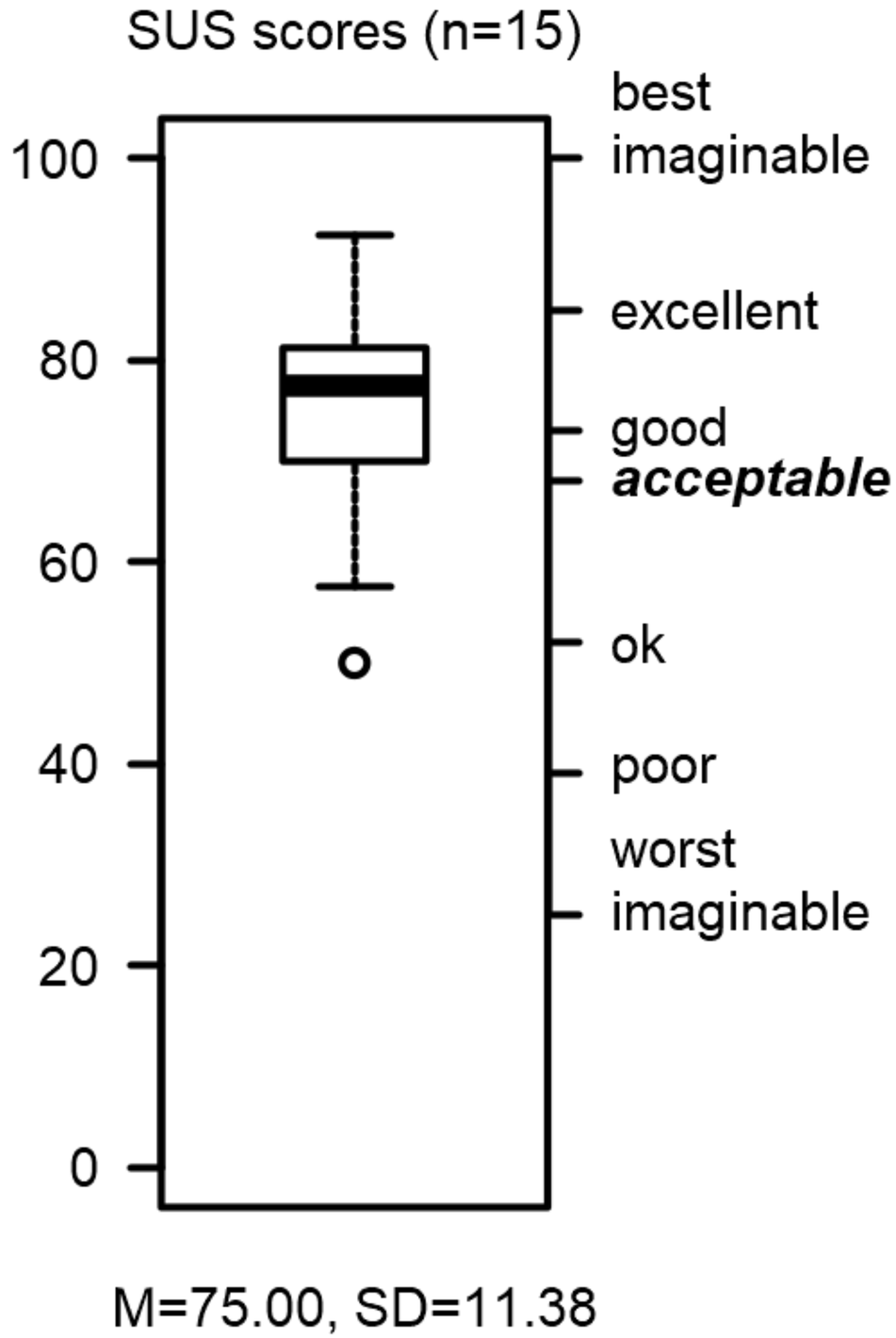


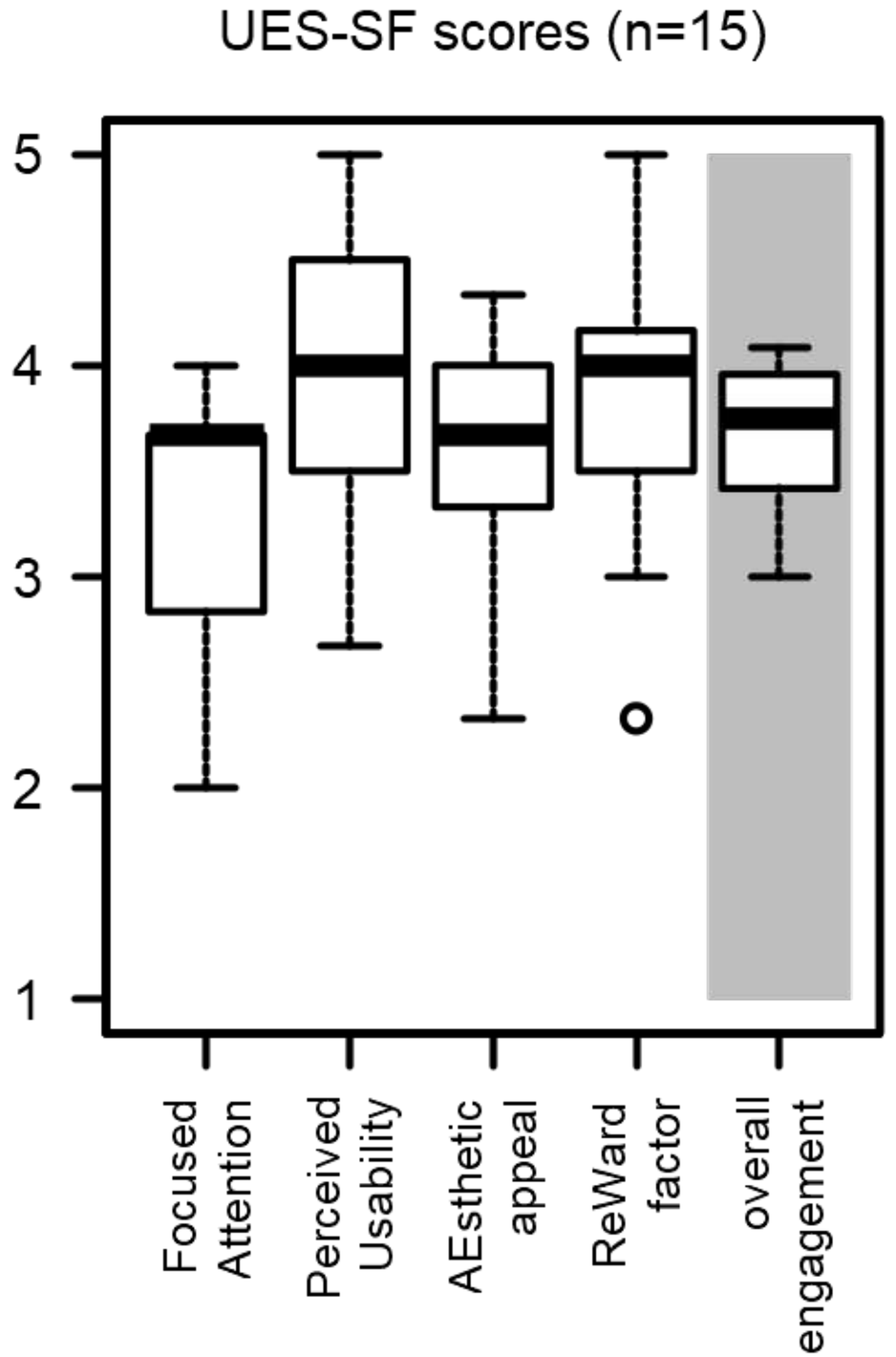
Capture audio and images, upload to server, and re-visit in web browser.



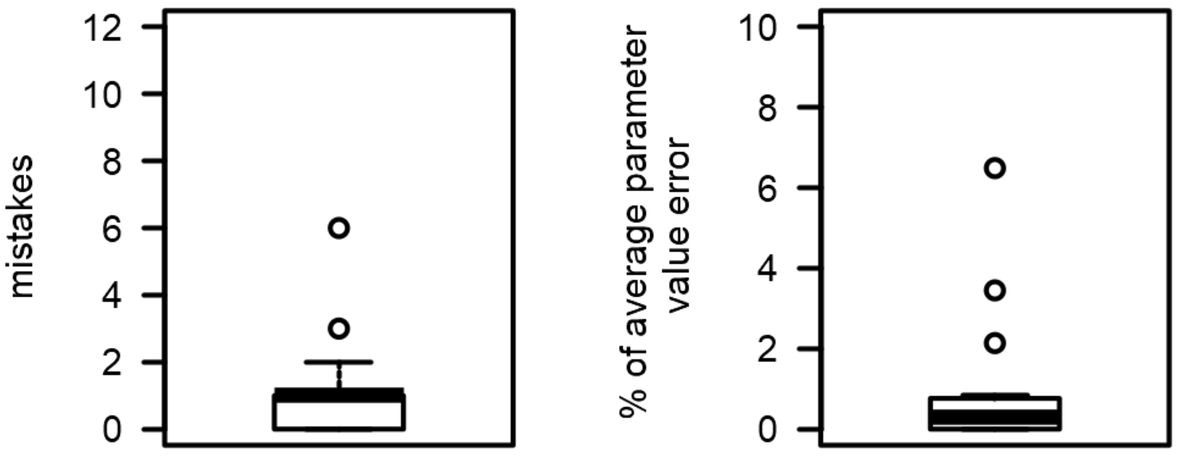
User Interaction Study

- aim: visual / interaction design validation
- participants: 15 participants
- two 3D Radar Charts, each with six data variable axes, composed of 50 time events
- tasks: six representative, typical analytical tasks
- data collection: System Usability Scale (SUS), User Engagement Scale - Short Form (UES-SF), observations, semi-structured interview

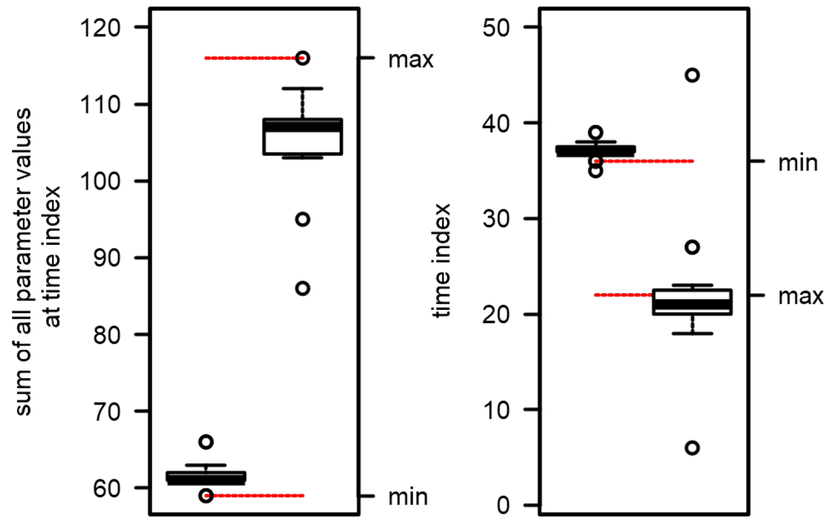

SUS scores (n=15)
100
80
60
40
20
0
best
imaginable
excellent
good
acceptable
ok
poor
worst
imaginable
M=75.00, SD=11.38


UES-SF scores (n=15)
5
4
3
2
1
Focused Attention
Perceived Usability
AEsthetic appeal
ReWard factor
overall engagement

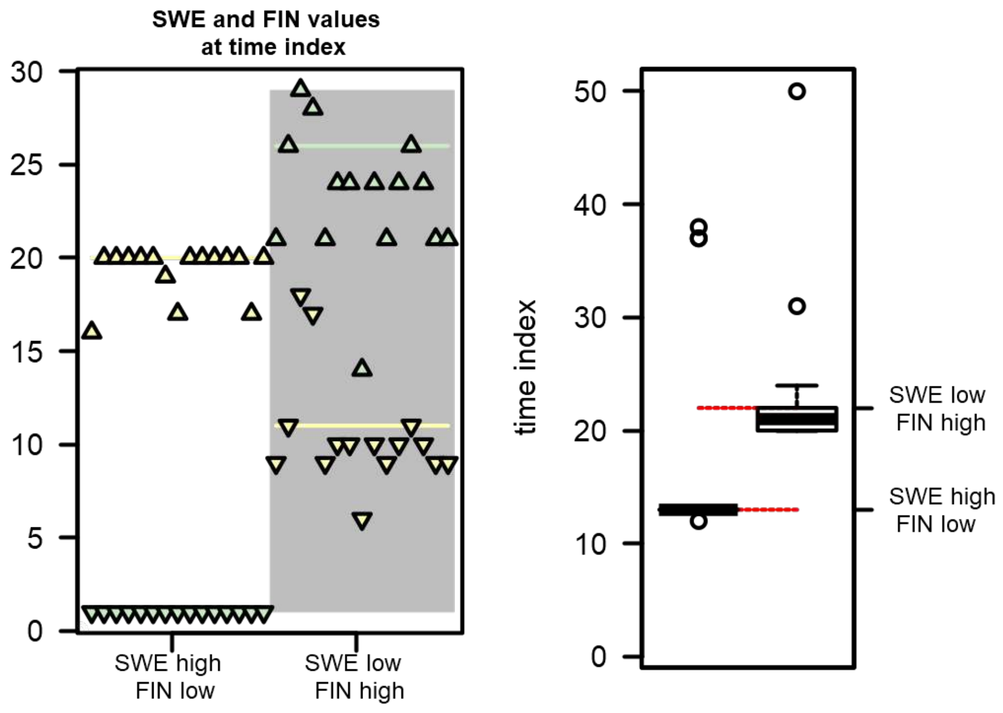
Task 1: Determining min / max values for each data variable.



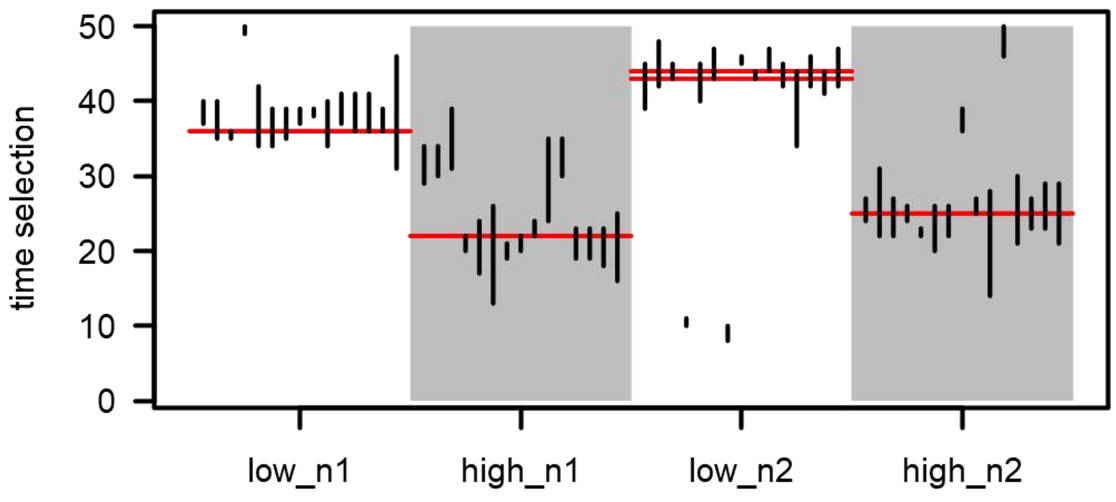
Task 2: Determining time indexes for low / high activity across all data variable.



Task 3: Determining time indexes for low / high and high / low events comparing two data variables.

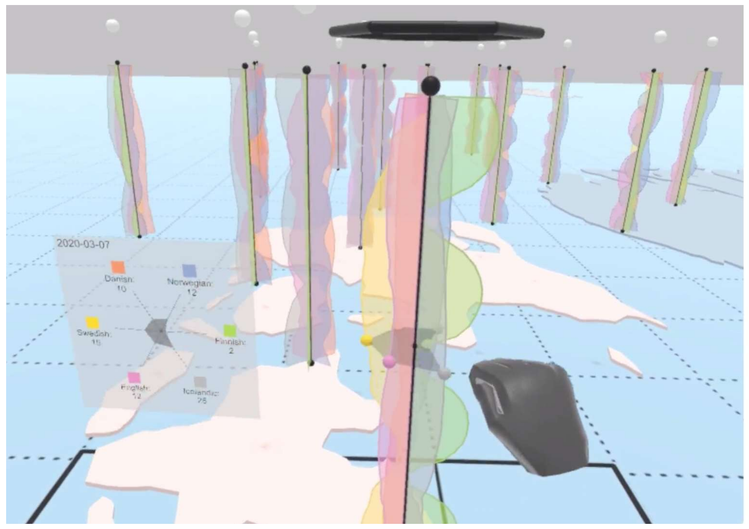


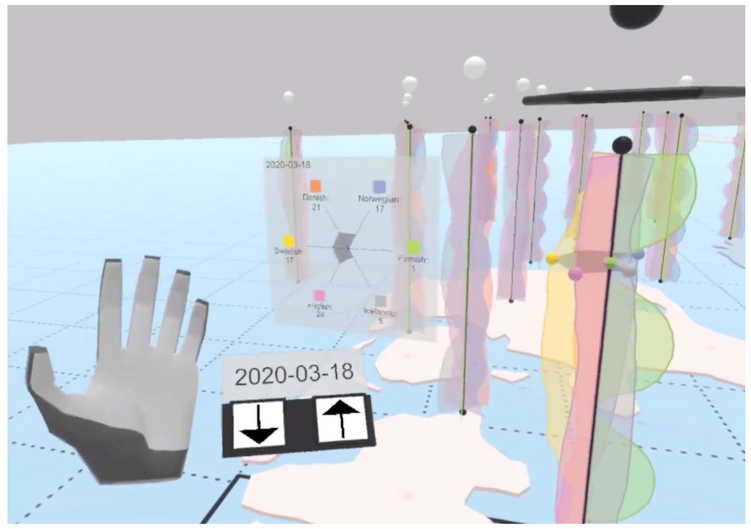
Task 4: Determining time period for most low / high continuous values across all data variables in both 3D Radar Charts.

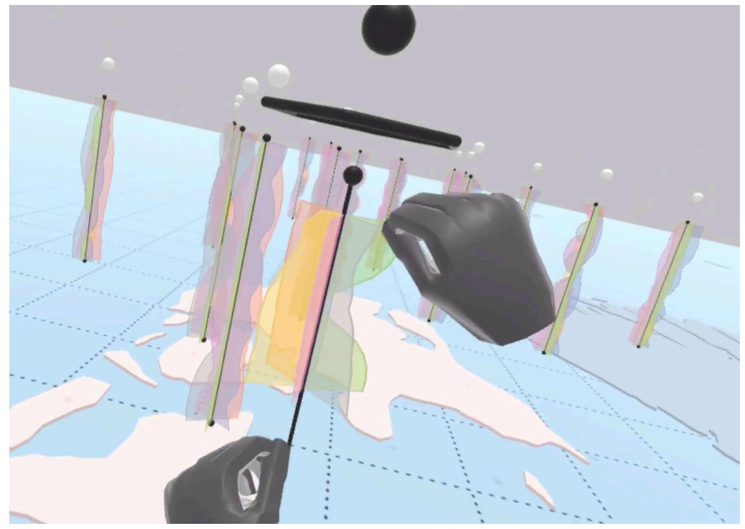


Interaction

- data exploration in strategic manner possible, "*overview first, details on demand*"
- mixed use of different interaction techniques (direct manipulation vs. system control) depending on situation
- direct manipulation: more natural, intuitive, quicker selection possible
- system control: more precise to select a specific time index





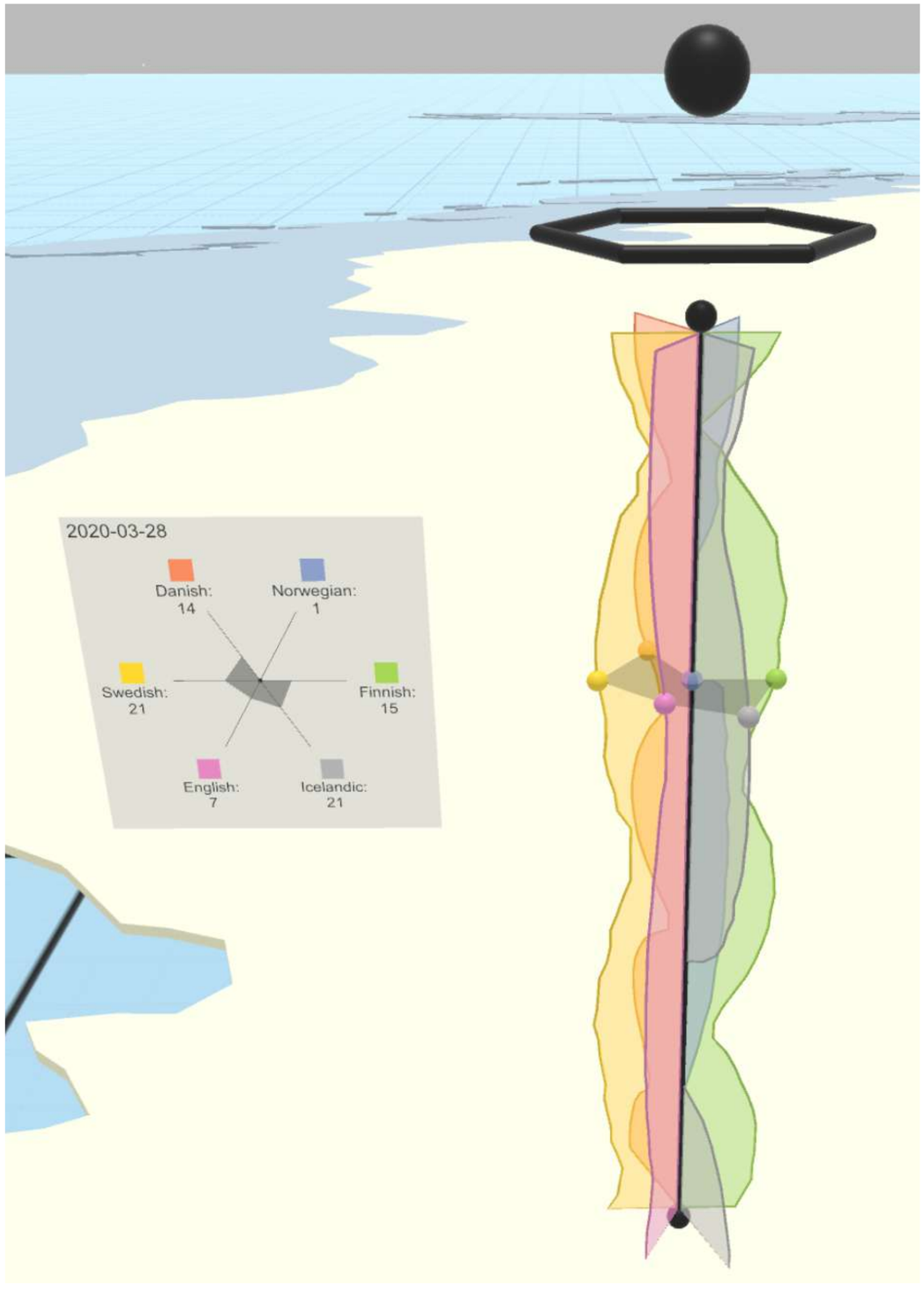


Conclusion

- validation of an approach towards exploration of time-oriented data using 3D Radar Charts within the context of Immersive Analytics
- encouraging usability and user engagement scores
- interesting observations in regard to data exploration strategies

Future Work

- extension of the VR application: zoom, filter, comparison features
- further design investigations in regard to data annotation in VR



1. Usability?
2. User Engagement?
3. Interaction aspects?
4. Approach validation?

immersive display and
interaction technologies

exploration and analysis
of time-oriented data

ALTERNATIVE SLIDE 1

Immersive Analytics

immersive display and
interaction technology

Virtual Reality
Augmented Reality
Augmented Virtuality
3D User Interfaces
…

data exploration, interaction,
and interpretation

analytical meaning-
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interdisciplinarity

Human-Computer Interaction

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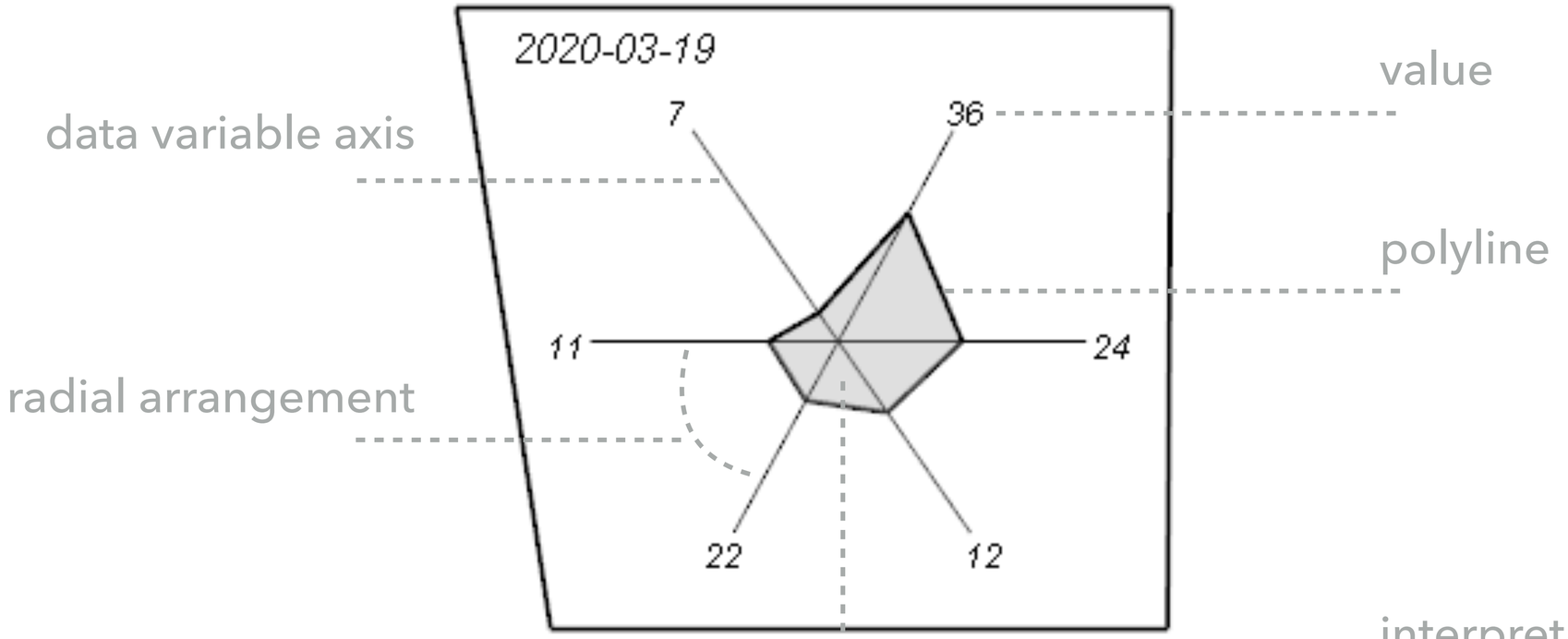
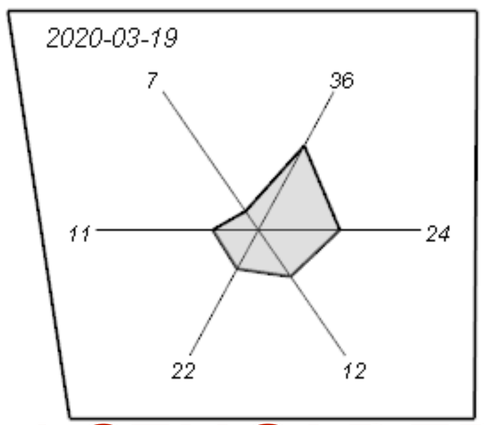
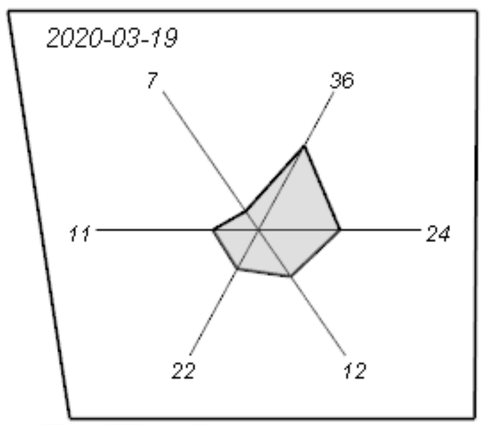
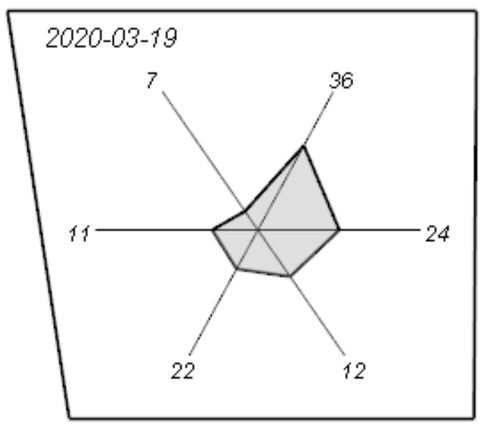
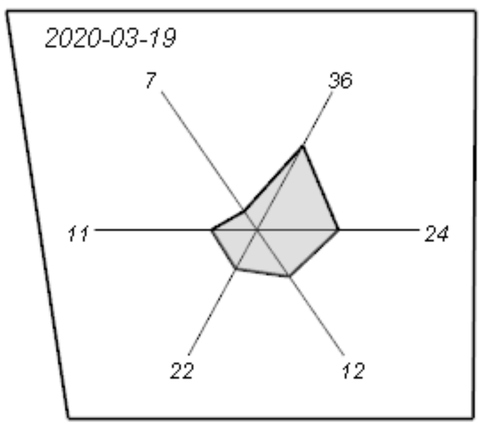
synergy / complementation











PLACEHOLDER SLIDE 4

User Interaction Study

- aim: visual / interaction design validation
- participants: 15 participants
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- data collection: System Usability Scale, User Engagement Scale - Short Form, observations, semi-structured interview

Tasks

3D Radar Chart No. 1
- T1 the min and max values for all parameters;
- T2 the date when all parameters are minimized/maximized simultaneously as much as possible;
- T3 the date when Swedish has the highest value and Finish has the lowest value, and vice versa;
- T4a a period that contains the most low/high parameter values.

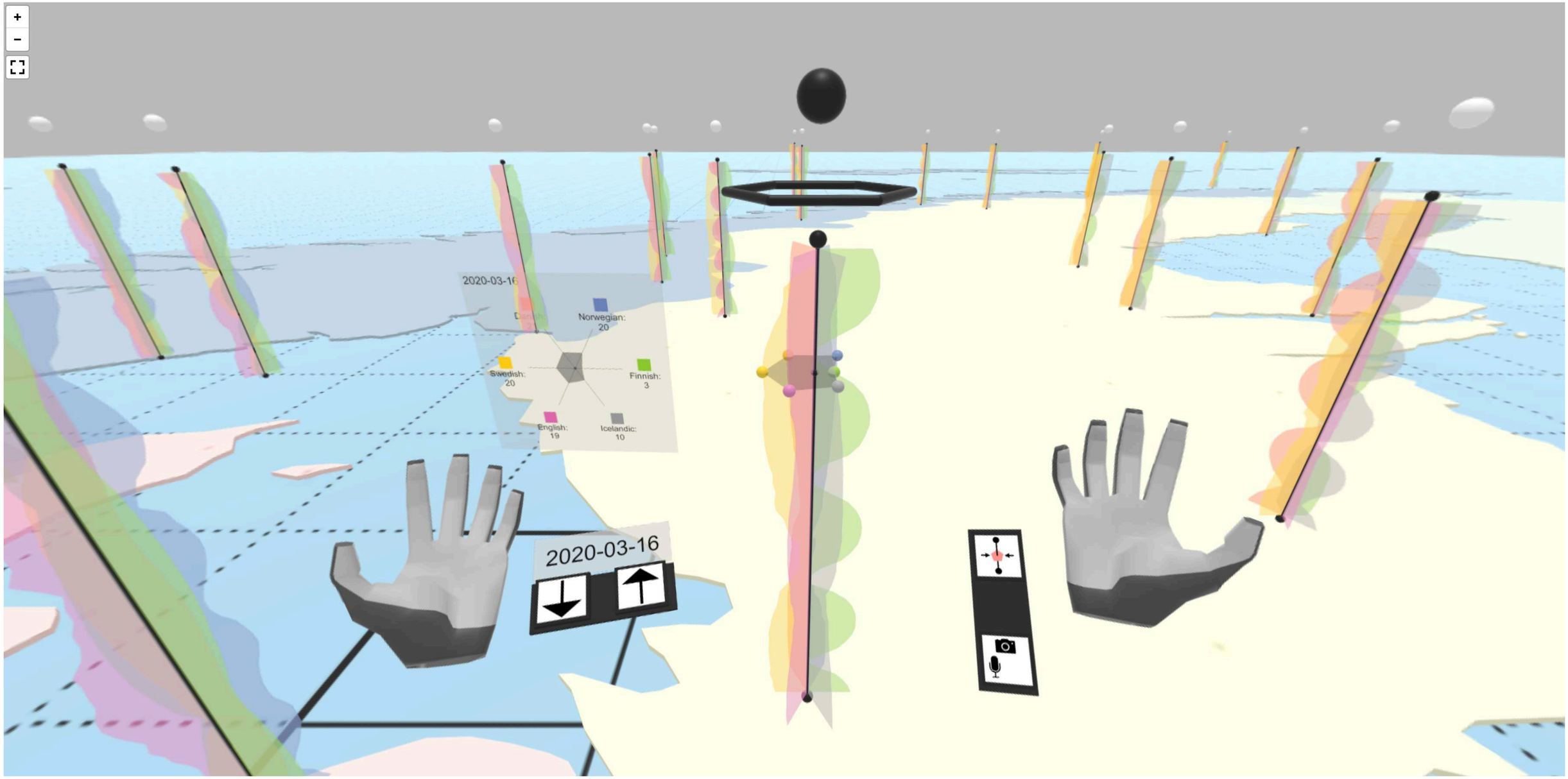
3D Radar Chart No. 2
- T4b a period that contains the most low/high parameter values.

3D Radar Chart No. 1 + 2
- T5 a period in each that contains the most low/high parameter values.

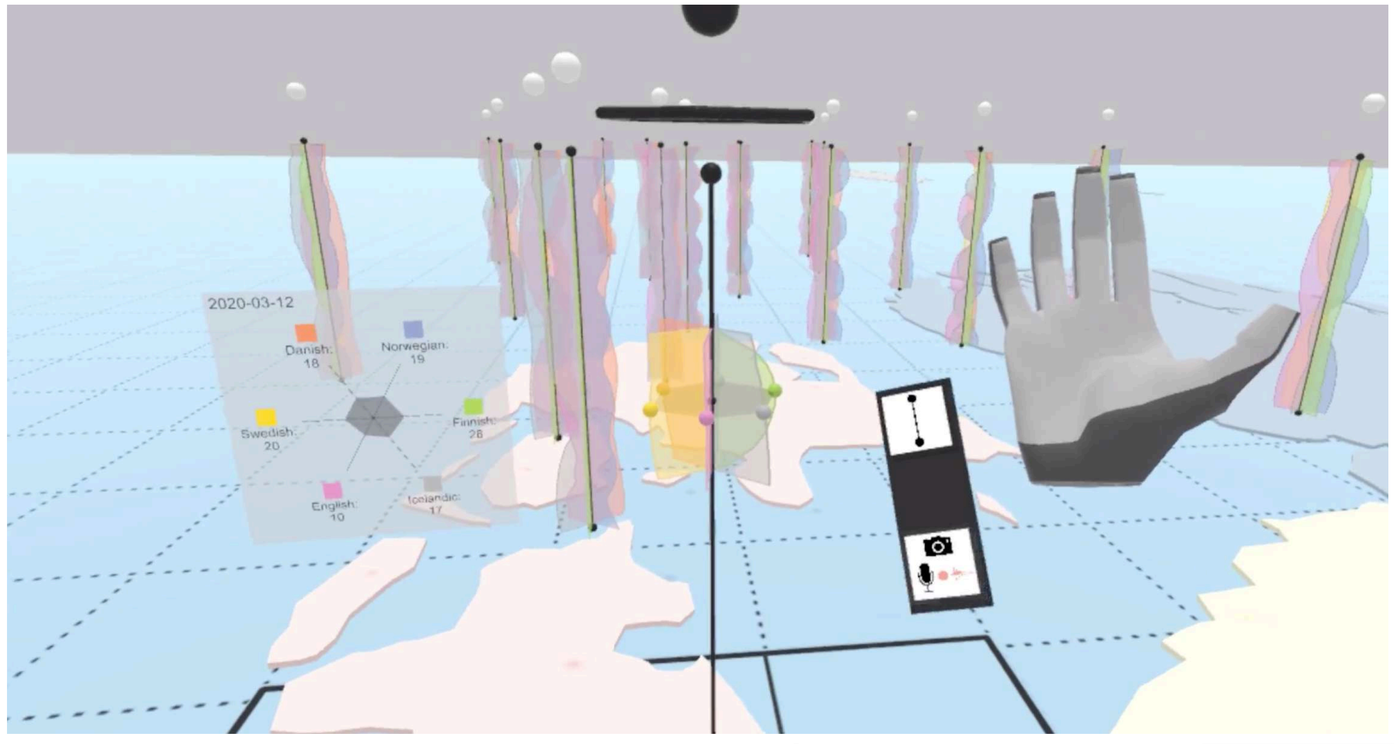
ALTERNATIVE SLIDE 10

Try yourself, and get a “visual impression” (in 2D) of the computer-generated, virtual 3D environment (on your mobile or desktop device):

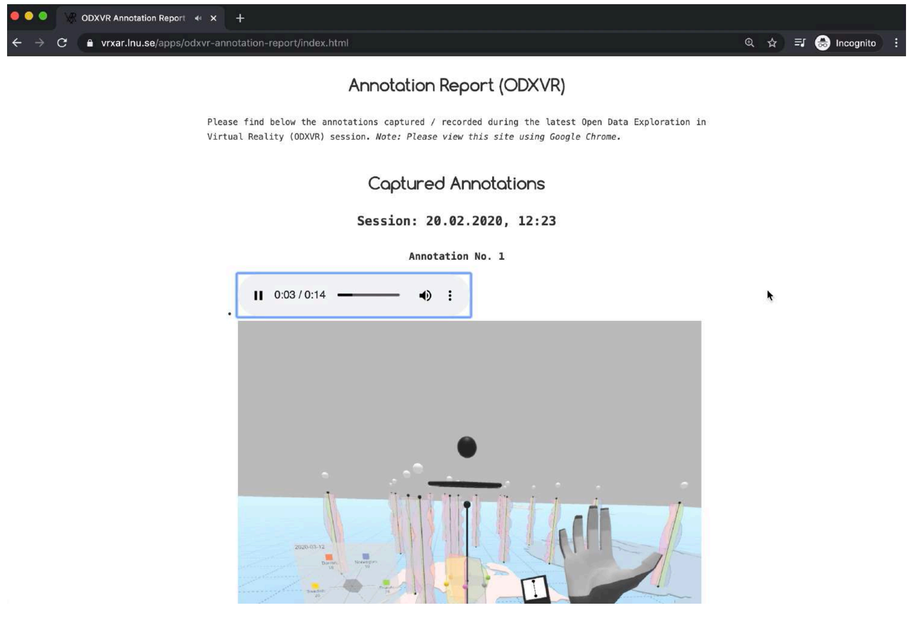
[vrxar.lnu.se/apps/2020-nordichi-3drc/]



Comprehensive video demo: [vimeo.com/393378221]



Capture audio and images,
uploaded to server,
and re-visit in web browser.



Annotation

- different annotation strategies observed: “to-the-point” vs. “elaborate” audio recordings
- some participants made use of their own contextual knowledge, starting to enthusiastically hypothesize about certain observed phenomena (even though the data was artificial)
- positive acknowledgements in regard to usefulness, and necessity in the future

System Architecture