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How deal with user interaction in 3D geovisualizations?

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Outline

- User testing of 3D geovisualizations
- Methods and tools
- Selected examples of methods for analysis of user interaction with 3D geovisualizations
- Proposed classification system of methods
- Outcomes and conclusions

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User testing of interactive 3D geovisualizations

- General usage versus limited number of studies
  - Kubíček et al., 2017; Juřík and Šašinka, 2016; McKenzie and Klippel, 2016; Herman and Stachoň, 2016; Schnűrer, Sieber, and Çöltekin, 2015; Wilkening and Fabrikant, 2013; Abend et al., 2012; Bleisch, Dykes, and Nebiker, 2008, etc.
- Research methods
  - Questionnaire
  - …
- Efficiency, effectiveness, **strategy**, …

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Methods and testing tools

- Methods
  - Screen logging + digital questionnaire + practical tasks
- Designed tools
  - For desktop virtual reality - only monoscopic/pseudo 3D

    3DmoveR and its variants – web-based testing tool (HTML, JS, WebGL, PHP)

    PC monitor, PC mouse, touchpad, touch screen
  - For immersive virtual reality - also stereoscopic/real 3D

    Unity engine

    Head-mounted displays (Occulus Rift, HTC Vive), shutter glasses (Nvidia 3D Vision2), Wii Remote controller

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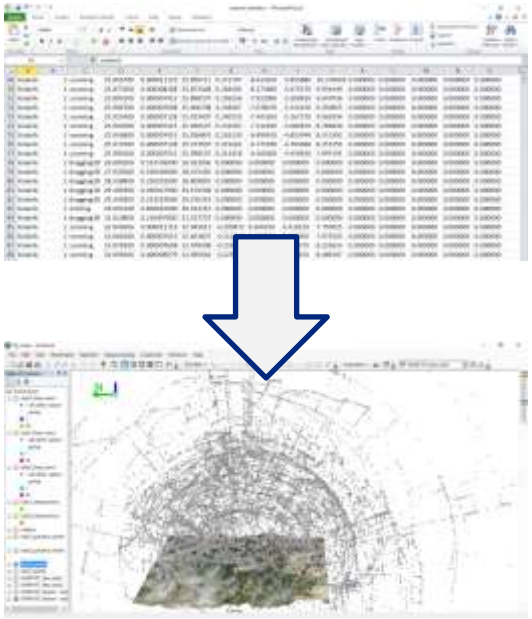
Example of Recorded Data



Time [sec.]

Position (X_p, Y_p, Z_p) **Orientation** (X_o, Y_o, Z_o, φ)

Mouse buttons (-1 – none – without movement, 0 – left – rotation, 1 – middle – pan, 2 – right – zoom)

…	…	…	…	…	…	…	…	…	…	…
40,52	292062,2	33596,18	-5079133	0,18298	0,712329	0,677574	3,521682	e	-1	-1
40,53	291980,6	33570,22	-5079686	0,18298	0,712329	0,677574	3,521682	e	0	-1
40,54	291863,1	33544,26	-5080218	0,18298	0,712329	0,677574	3,521682	e	0	-1
40,55	291761,9	33523,49	-5080639	0,18298	0,712329	0,677574	3,521682	e	1	-1
40,56	291761,9	33523,49	-5080639	0,18298	0,712329	0,677574	3,521682	e	-1	-1
41,26	291712,9	33507,91	-5080971	0,15268	0,723568	0,345694	3,421391	e	2	-1
…	…	…	…	…	…	…	…	…	…	…

Type of movement (e – examine, f – fly, w – walk, …)

Functional keys (-1 - none)

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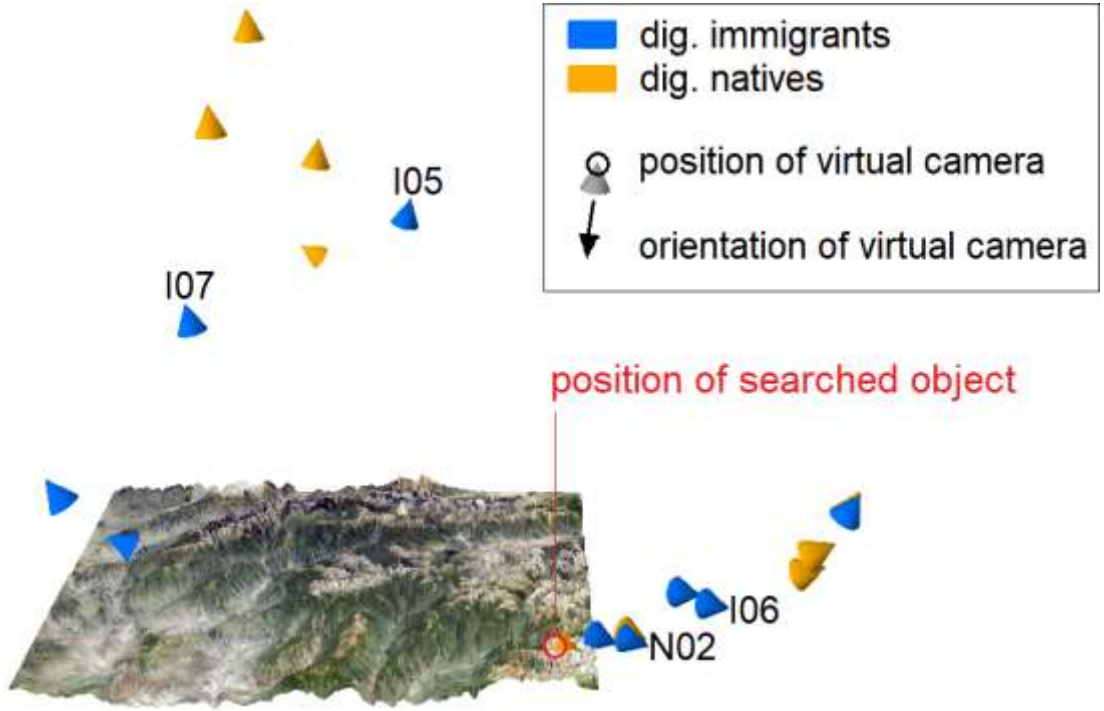
User viewpoints visualization

- Position and orientation of viewpoints
- We can visualize all viewpoints or some of them



Final viewpoints of individual participants
Task: find an object hidden in the terrain and move to them as close as possible

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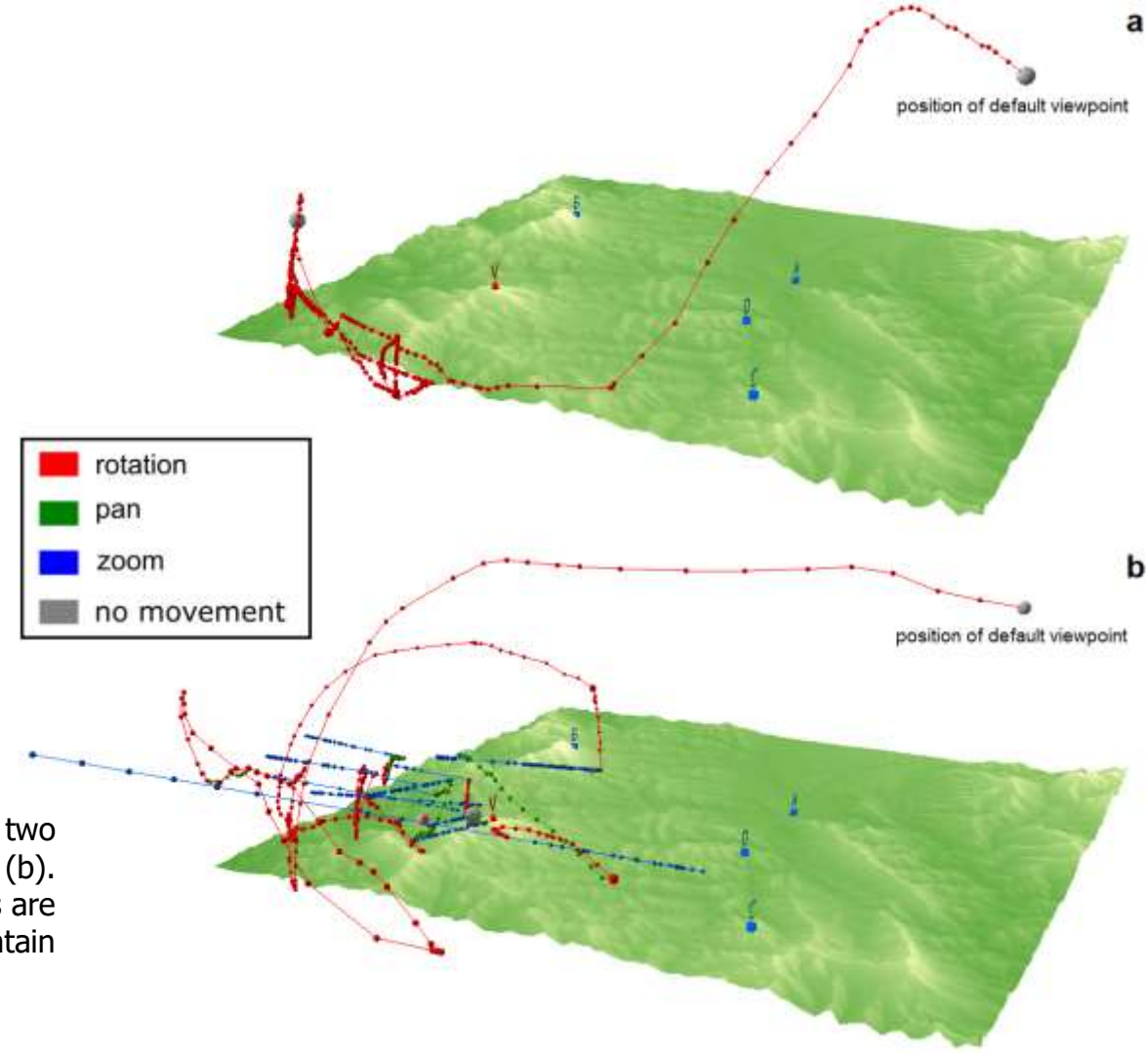
Virtual trajectories

- Connected viewpoints
- Suitable for comparison of individual users



Comparison of virtual trajectories of two participants – expert (a) and layman (b).
Task: determine which of four objects are visible from top of the mountain

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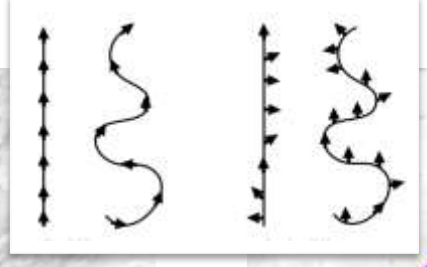
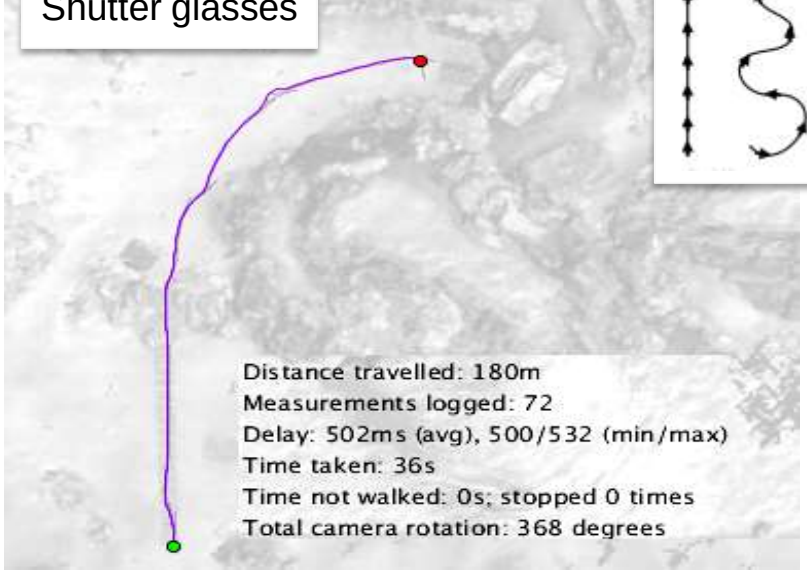
Trajectory + viewpoints

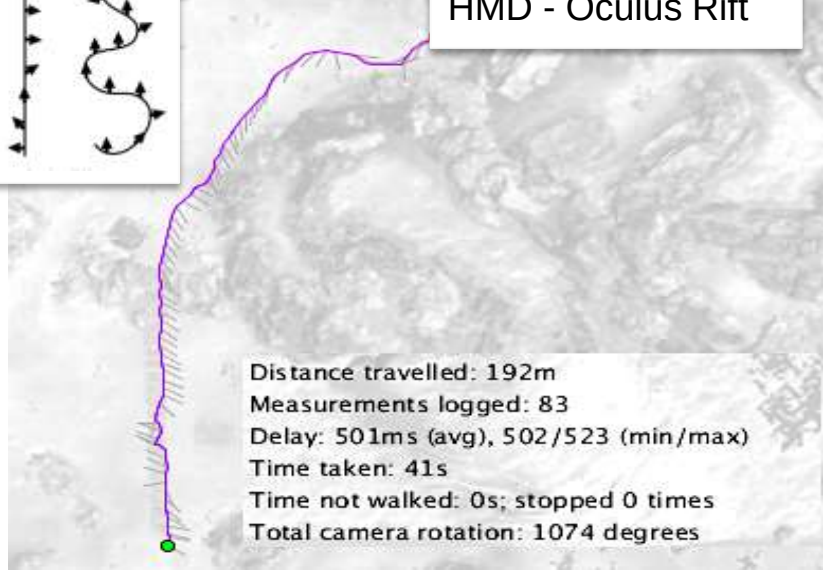
Comparison of virtual trajectories of two participants – one with shutter glasses and second one with HMD
Task: go from starting point (green) to finish point (red)



Shutter glasses



HMD - Oculus Rift



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Statistical analysis of measures

Measures are calculated from:
- virtual trajectory,
- virtual camera positions,
- totalled from the duration of individual movement types

Results of Mann Whitney test of differences between digital natives and digital immigrants (significance level α = 0.05
Task: find an object hidden in the terrain and move to them as close as possible

		Task 1	
		U	p
Response time [s]		**15.0**	**0.0273**
Length of virtual trajectory [km]		37.0	0.7911
Average speed [km/s]		**12.0**	**0.0134**
Total rotation [°]	Orthodrome centre angle	29.0	0.3314
	Horizontal (yaw)	37.0	0.7911
	Vertical (pitch)	38.0	0.8598
Average height of virtual camera [m]		23.0	0.1333
Length of delay at the beginning of solving a task [s]		**17.0**	**0.0423**
Total duration of individual gestures [s]	Pan	**16.0**	**0.0341**
	Pinch	18.0	0.0521
Number of collisions with terrain		35.5	0.6911
Distance to searched object at the end of solving a task [km]		36.0	0.7239

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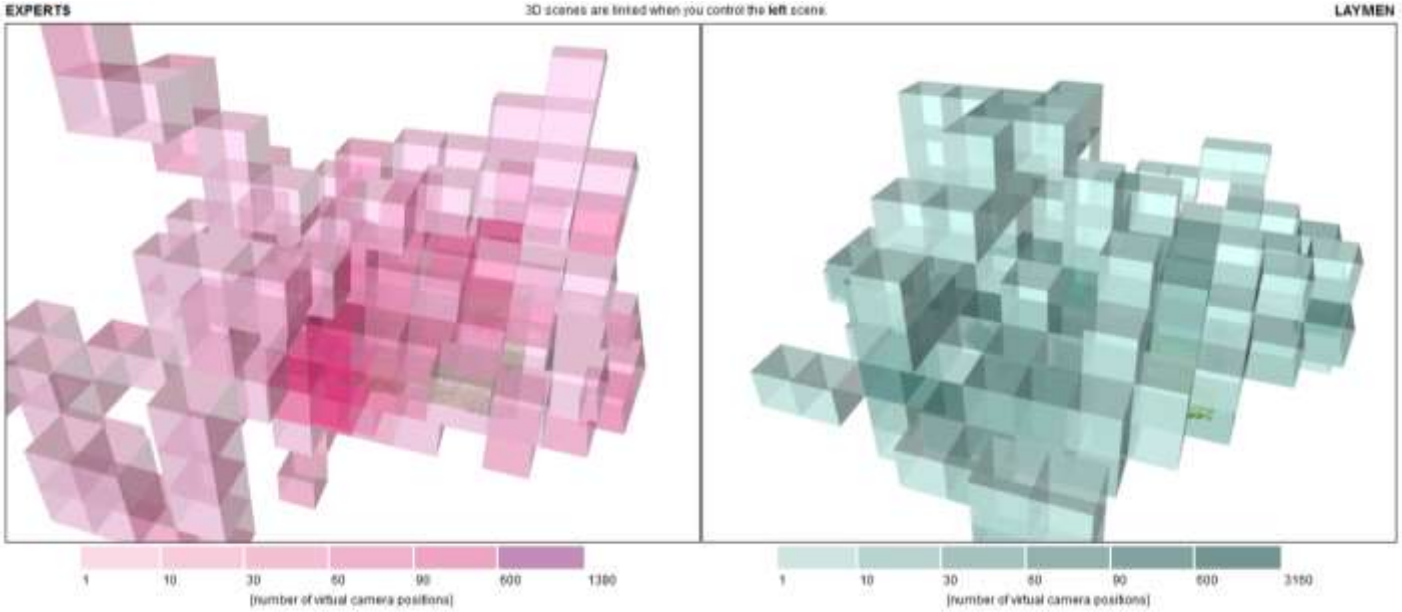
Regular Area of Interest (RAoI)

- RAoI are created as cubes (3D RAoI) using a minimum bounding box of all viewpoints



Comparison of two user groups – experts (left) and laymen.
Task: determine which of four objects are visible from top of the mountain

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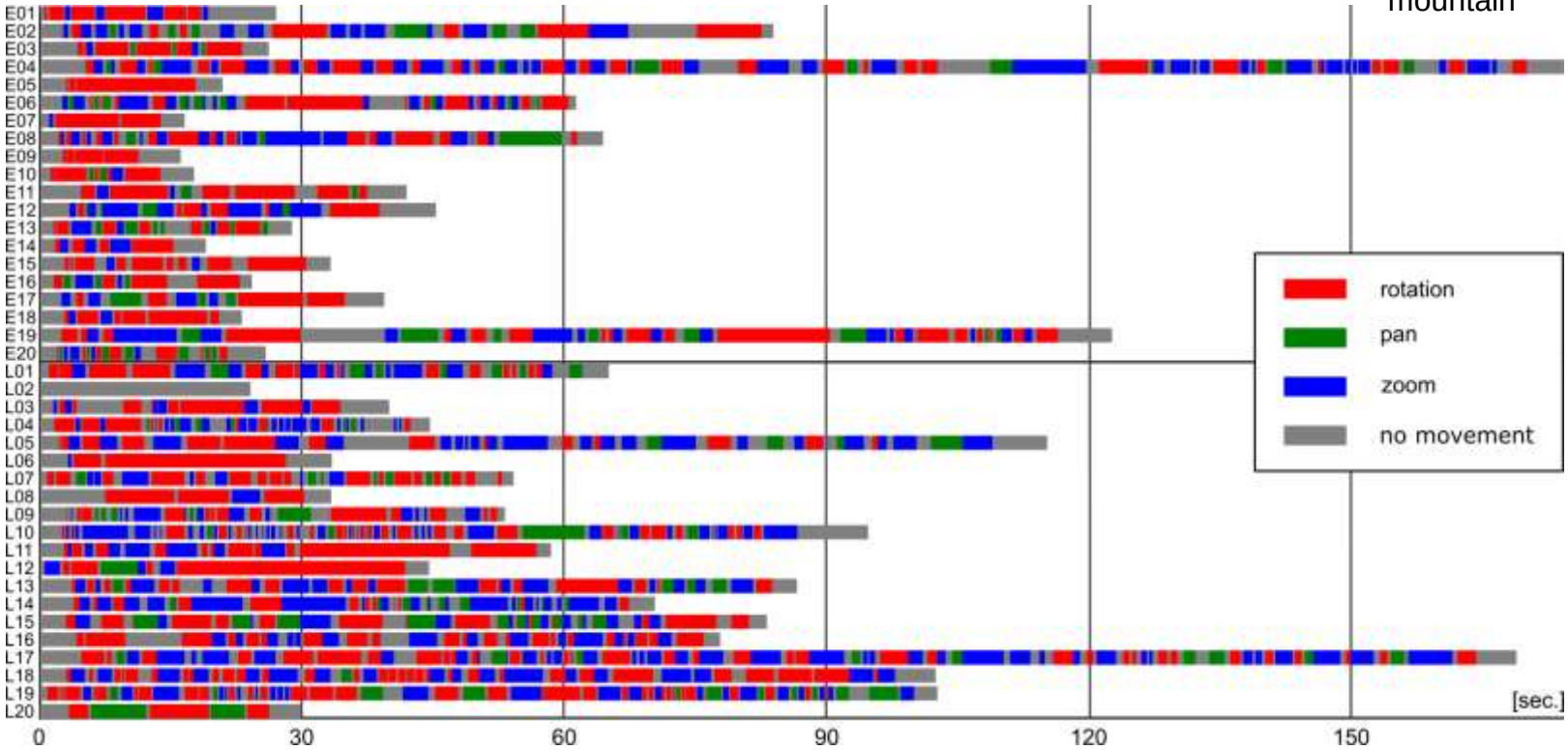
Sequence chart of user interaction

Comparison of two user groups – experts (top) and laymen.
Task: determine which of four objects are visible from top of the mountain



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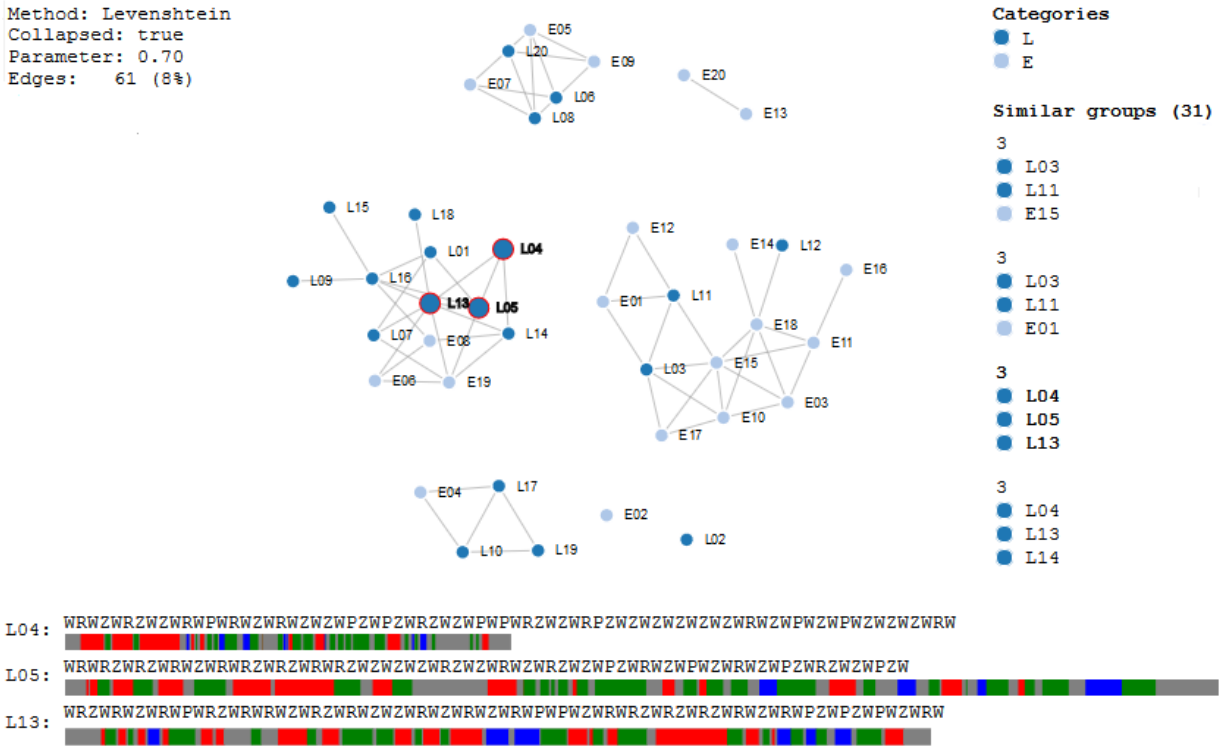
String Edit Distance Method

- specifically the Levenshtein Distance method
- calculated with a software tool called Scangraph - http://eyetracking.upol.cz/scangraph/



Comparison of two user groups – experts (top) and laymen. Task: determine which of four objects are visible from top of the mountain

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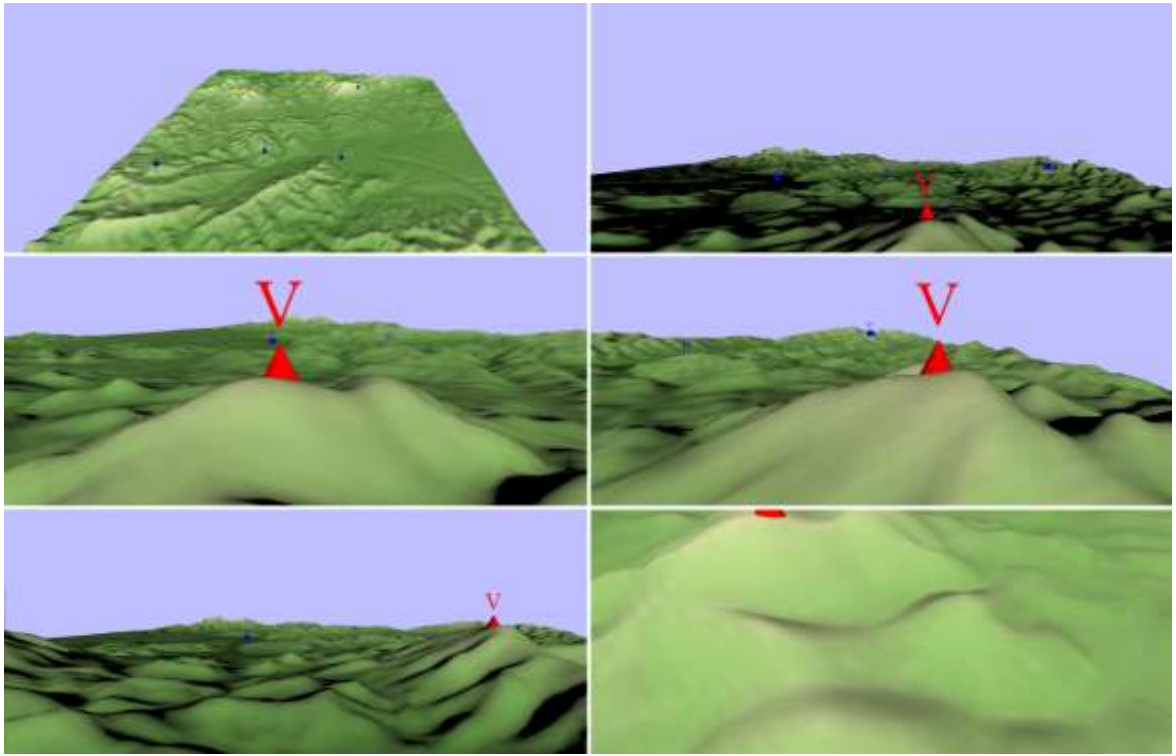
Selected (e.g. last) views

- Qualitative approach
- Get from last camera position and orientation data
- Or it is possible play back the movements of individual participants as video



Default (top, left) and final views positions of individual participants.
Task: determine which of four objects are visible from top of the mountain

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Possible classification of methods

- **Preservation of spatial component**
  - **Yes**
  - **No**
- **Attitude to temporal component**
  - **Preservation**
  - **Aggregation** to one value
  - Selected **moments**
- **Possibility of data comparison**
  - **Yes** - numerical, statistical
  - **Only visual**
- **Possibility of data aggregation**
  - Suitable only for comparison of **individuals users**
  - Suitable also for comparison of **groups of users**
- **Dimensionality**
  - **3D** – when movement is free in all three dimensions
  - **2D** – when walking on terrain or flat plane
  - **Both** of them
  - Does not make sense

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Outcomes

- **Comparison …**
  - individual users
  - group of users
    Laymen x experts, …
  - different types of geovisualizations
    Photorealistic x non-photorealistic, …
  - different types of user interfaces
    Monoscopic/pseudo 3D x stereoscopic/real 3D,
    HMD x shutter glasses,
    PC mouse x touch screen, …

- **Analysis of user strategies …**
  - Influences the strategy the efficiency and effectiveness?
  - …

- **Optimization of user interface and used cartographic methods …**
  - Will be the strategy more effective if we add overview map?
  - …

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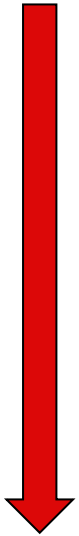
Conclusions and future work

- Used methods are inspired by Human-Computer Interaction and 3D User Interface research.
- Results based on screen logging and digital questionnaire methods.
- Available a lot of measures and possible visualizations, but still don know which are the most suitable.



- The suitability is potentially influenced by a particular task, user characteristics, and used stimuli.
- We believe that at least some of them will represent significant influencing factor.
- Our research is strongly related to the psychological theories like embodied cognition, ….

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QUESTIONS…

THANK YOU FOR YOUR ATTENTION!

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