Use case. <u>Depth perception in VR</u>

- Goal:
  - Evaluate performance of shading technique in VR environments
- Context:
  - Perception of complex, volume datasets is difficult in VR
 - Shading techniques may enhance shape and depth perception

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- Purpose of the test:
  - Analyze whether shading techniques influence the perception of shapes and depth in VR
- Methodology:
  - Provide images under different shading conditions
  - Ask the users to classify two points of the scene placed at different depths
  - Analyze the results obtained

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- Sample images:

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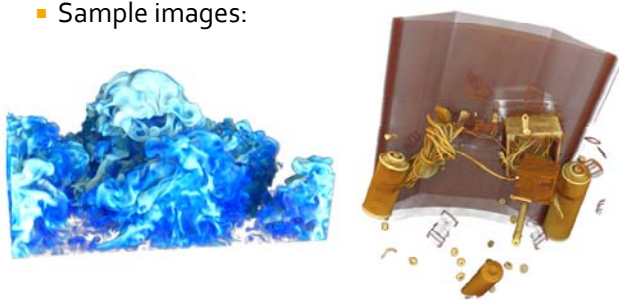
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- Test preparation:
  - Select shading models (4)
  - Select models (likely unknown to users)
  - Determine number of participants, iterations
    - Low level perception problem -> should be > 10
    - Latin squares balance results -> 16 per experiment
  - Two tasks

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- Shading techniques:

Phong   Soft shadows   Hard shadows   No shading

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- Images selection:
  - Select models likely unknown
    - Avoid previous knowledge
  - Random shading sorting
    - Avoid learning (shading)
  - Random model sorting
    - Avoid learning (model)
  - Latin squares
    - Avoid fatigue and learning (within users)

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- Task: Select the closer point. 2-alternative forced choice (2AFC)

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- Measures (what we measure in the test):
  - Time to answer
  - Correctness

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- Variables to include in the analysis (to discard confounding or correlating variables)
  - Shading technique
  - Depth values
    - May analyze if absolute difference correlates with correctness
  - Previous VR background
  - Information of images for left and right eye
  - Luminance of the points' environment
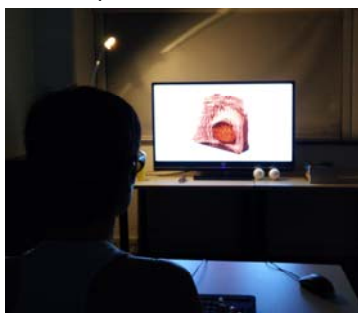 - Correlation between depth and shading maps

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- Experiment setup:
  - 3D TV
  - Users placed at fixed distance
    - Chair to reduce movements
      - Avoid parallax as confounding variable
  - Dark room
  - External light (for virtual light source consistency analysis)

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- Experiment setup:

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- Experiment setup:
  - Modified keyboard to facilitate entry
    - Will compute timings

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- Experiment setup:
  - Initial questionnaire (background, VR exposition...)
  - Initial training
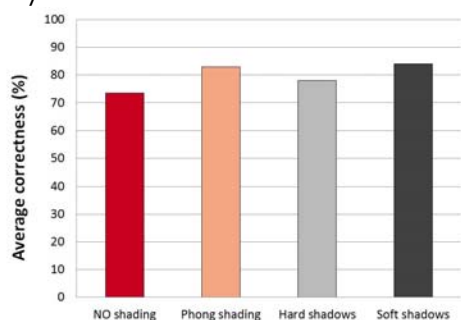 - Tasks
    - May rest between tasks
  - Post questionnaires

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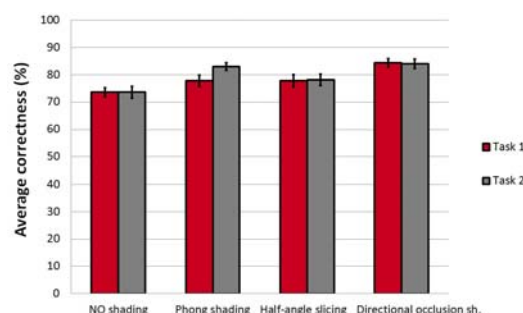- Task: Select the closer point. 2-alternative forced choice (2AFC)

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- Analysis of results

Slide 79 — Use case. Depth perception in VR

- Analysis of results

Slide 80 — Use case. Depth perception in VR

- Statistical analysis:
  - **ANOVA test:** One-way analysis of variance to reject the null hypothesis that all correctness means are equal between shading techniques.
  - For a significance level of $\alpha = 0.05$, a Bonferroni post-hoc test with the same acceptance level to reveal differences between the individual shading techniques
  - **Result:** reject the null hypothesis when $p < 0.05$

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- Statistical analysis.
  - Chi-square test of association for the categorical variables relative depth and users' answers from tasks 1 and 2

Variables	χ^2	p value	Correct answers for each depth category
T1: relative depth vs. users' answers	5.991	<0.0001	<0.05: 66 % 0.05–0.1: 88 % >0.1: 86 %
T2: relative depth vs. users' answers	5.991	<0.0001	<0.05: 63 % 0.05–0.1: 86 % >0.1: 87 %

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- Guidelines and recommendations
  - Using advanced volumetric shading improves depth perception
    - Among the tested shading models the simulation of soft shadows by using directional occlusion shading for desktop-based VR seem to yield better results

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- Guidelines and recommendations
  - Real illumination does not affect depth perception when using advanced volume illumination techniques
  - External lighting may be carefully controlled to provide a pleasant environment
    - Specular highlights on the screen, reflections, or over-illuminated areas will certainly affect the correct perception of the data

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- Guidelines and recommendations
  - When trying to judge depth in volume models, the X/Y relative position of the markers or the luminance of the points to classify seems to have no importance

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