DEVA UPDATE

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Designing Visually Accessible Spaces
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Lawrence Berkeley National Laboratories, U.C Berkeley
What’s in front of you?
Here is a different scene,
Let’s take a walk...
Ouch!!
Snap !!!!!
Ouch!!
Groan !!!!!
very high risk at ~20/1000

Ouch!!
Groan !!!!!!
!! SUE !!!!
New subject with \( \sim 20/600 \) acuity, new path...
Ouch!!
Groan !!!!!
Ouch!!
Groan !!!!!
!! SNAP !!!!!
very high risk at ~20/600

Ouch!!
Groan !!!!!
!! SUE !!!!!
Same acuity with Lighting Adjustment
AH! A Step!!
AH! A Step!!
It’s not flat!

Modest risk at ~20/600
Material Adjustment
Increases step contrast

Low risk rating at ~20/600

\( \wedge \text{reflectance} \quad \vee \text{reflectance} \)
Visual Accessibility  Improved

Low risk rating at ~20/600
Visually Accessible?

Modest > high risk at 20/20

Condition 1
20/20 acuity
Visual Accessibility  Improved

Low risk at 20/20

Condition 1

Condition 2

20/20 acuity
Visual Accessibility Optimized

Very low risk at 20/20

Condition 1
Condition 2
Condition 3

20/20 acuity
Visual Accessibility Evaluations
(exploratory scenarios, risk factors estimated for illustration)

Condition 1
Very low risk at 20/20
Low risk at ~20/600

Condition 2
Modest risk at ~20/600

Condition 3
Low risk at 20/20

Very high risk at ~20/600
DEVA aims to develop tools to:

Identify regions with potential visual hazards

Provide designers with feedback to assist in reducing visual hazard risk

Increase Visual Accessibility
Interactive tool 1:

A range of acuities aids designer in determining areas of challenge and in working through iterative fixes.

Designer determines success.
Interactive tool 2:

If a Radiance data set, diagnostics available to designer, in this case geometric change without luminance change is highlighted.

**Designer determines success.**
Automated tool: Important rationale

Difficult for someone with normal vision, who has observed the scene previously (at 20/20) to appreciate how difficult it is to interpret a blurry scene that has not been seen before (low-vision person entering a space for the first time).

If we've seen the full-resolution scene before viewing the blurry one, our visual system automatically applies our memories to improve the interpretation of the blurry scene.
Automated tool workflow

Scene model → Image rendering

Low-vision model

Information loss → Flag regions of potential risk

Geometrical Transitions → Visibility metric

Task-relevant regions
Geometric transitions generate: Ground Truth (independent of luminance)

Normals to determine geometrical changes

```bash
## create normal at surface text file
set norflnm = $bfnm"nor"$t
vwrays -fd $dirhdrfnm | rtrace -fda `vwrays -d $dirhdrfnm` -oN $octree > $subd/$norflnm &
```
Geometric transitions generate:

**Ground Truth** (independent of luminance)

Normals to determine geometrical changes

```bash
## create 3d coordinate text file
set xyzflnm = $bfnm"xyz"$t
vwrays -fd $dirhdrfnm | rtrace -fda `vwrays -d $dirhdrfnm` -oN $octree > $subd/$xyzflnm &
```

Range data to extract task relevant regions

```bash
## create normal at surface text file
set norflnm = $bfnm"nor"$t
vwrays -fd $dirhdrfnm | rtrace -fda `vwrays -d $dirhdrfnm` -oN $octree > $subd/$norflnm &
```

```bash
## create distance to surface text file
set dstflnm = $bfnm"dst"$t
vwrays -fd $dirhdrfnm | rtrace -fda `vwrays -d $dirhdrfnm` -os $octree > $subd/$dstflnm &
```
Task relevant regions:

User defines height above/below “floor”

Tool finds potential hazard within N radius or user selected
Task relevant regions:

User defines height above/below “floor”

Tool finds potential hazard within N radius or user selected

Zone is dilated to create mask then combined with Peli* filtered low acuity image(s)

*Low vision simulation filter, Eli Peli, Professor of Ophthalmology, Harvard Medical School
Zone evaluated by comparing discontinuities between luminance patterns and ground truth surfaces in original and blurred images, in addition to other metrics resulting in a visual risk/visibility score...

...Independent of designer

(Note: Peli filter is responsive to visual luminous threshold and glare factors.)
Analysis delivered to designer..

High risk
Low visibility

Low risk
A low value of geometry-based metric predicts low visibility.

This is when locations of large intensity changes don’t match the locations of the depth/slope changes.
Exploring VISIBILITY METRICS

- Region is selected, ready for automated analysis
- Various visibility indicators generated per picture
Day Sequence Analysis

- Geo
- Vis
- D prime

July 4th

Minneapolis

Clear Sky

05 hrs

0.075

0.550

0.500

0.525

1.225

0.100

0.550

0.800

0.800

0.850

0.500

0.850

2.980

-0.800

1.700

-0.800

1.500

-1.100

1.000

-1.100

1.600

-0.200

0.950

-0.300

0.700

-0.500

0.575

-0.300

0.575

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Exploring VISIBILITY METRICS

- Predicted hours of highest and lowest step visibility:
  - Normal acuity and contrast

![Image showing different visibility levels with times: SELECT (8 hours), LOW, HIGH (15 hours)]
Exploring VISIBILITY METRICS

- Predicted hours of highest and lowest step visibility:
  - Normal acuity and contrast
  - Reduced acuity and contrast:

Higher Risk

SELECT

LOW 08 hrs

Higher Risk

SELECT

LOW 08 hrs

Lower Risk

High 15 hrs

High 11 hrs
Other VISIBILITY METRICS explorations

Very high risk at ~20/600

Modest risk at ~20/600

Raw analysis

Mapped to ground truth

Edge pixel count: 2056

Edge pixel count: 2471

Edge pixel : Maximum change in Low Vision Response Function
discontinuities in edge contours at step/ramp transitions are important cues for detection:
contour kinks, bends and L junctions
Other VISIBILITY METRICS explorations

Discontinuities in edge contours at step/ramp transitions are important cues for detection: contour kinks, bends and L junctions.

Scan for signature kinks, bends and contours in luminance images.
MANY human study experiments >>> validation
Local case study –
LBNL Guest House Stairs (mockup)

6:55 am today
Filtered ~20/600
Desaturated
Local case study –
LBNL Guest House Stairs (mockup)

White stripe  Filtered ~20/600  Desaturated
Local case study – LBNL Guest House Stairs (mockup)

Color contrast aids 20/20 vision

Luminance contrast aids ~20/600
Visual Accessibility

Challenges:

The balance between safe visual navigation and aesthetics…
Visual Accessibility

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The balance between safe visual navigation and aesthetics...

What acuity range should we design for?
Visual Accessibility

Challenges:

The balance between safe visual navigation and aesthetics…

What acuity range should we design for?

How do you “rate” the visibility of a hazard?
Visual Accessibility

Why should we be concerned?
Visual Accessibility

Why should we be concerned?

LV effects a HUGE & GROWING percentage of the population!
Visual Accessibility

Why should we be concerned?

LV effects a HUGE & GROWING percentage of the population!
To date we typically design only for “normal” vision
Visual Accessibility

Why should we be concerned?

LV effects a HUGE & GROWING percentage of the population!
To date we typically design only for “normal” vision

What is low vision?
- Fully sighted acuity: 20/20
- Low vision (US definition): 20/40
- Legal Blindness Threshold (US): 20/200
- Utah site foil (sample): 20/678
Low Vision = Useful Vision

- US Low vision population is growing as population ages. Most low vision is age related. 40m > 65yrs

- Blindness and low vision: 1 in 28 adults over age 40

- There are many more people with low vision than with blindness. Only 20% of those classified as legally blind have no useful vision

- Majority of those with low vision able to see well enough to perform many tasks under the right conditions

- Legal blindness is not the same as absence of vision
Bygone Stereotype:
ageing equals...
Bygone Stereotype: ageing equals...rocking chairs
Bygone Stereotype: ageing equals...rocking chairs

- TODAY, individuals with low vision traverse Subway stations, libraries, malls, restaurants, spas, parks, airports, casinos, universities, art galleries, gyms...

- Any place you find normally sighted individuals

- This is a rapidly increasing percentage of the population
DEVA’s tools aim to assist:

- Fully sighted acuity: 20/20
- Low vision (US definition): 20/40
- **Legal Blindness Threshold (US):** 20/200
- Utah site foil (sample\(^1\)): 20/678
DEVA’s tools aim to assist:

- Fully sighted acuity: 20/20
- Low vision (US definition): 20/40
- **Legal Blindness Threshold (US):** 20/200
- **Utah site foil (sample¹):** 20/678

Typically persons with acuities up to ~20/600 will tend not use a cane or aids which “indicate” a “blind” person.

They HAVE visual ability but we do not meaningfully include their visual needs in our environments.
Designer focus: interior, lighting, architect…

(possibly used to evaluate future compliance)

Designer work flow:

1. Octree + HDR + LV model + vwrays > scene data

2. Data Analysis

3. Output: rating (optional visual diagnostics and metrics)

4. Modify lighting/materials/geometry, return to 1.
What’s in front of you?
The floor region and granite bench particularly, likely score very high risk at \(~20/600\) acuity, and modest risk at 20/20 acuity.
Designer fix #1. Add area light, reduce indirect. N/C in total E
At ~20/600 improved granite bench/floor contrast: modest risk. Modest > low risk at 20/20 acuity.
Designer fix #1. At ~20/1000 still high risk
Designer fix #2. Boost area light, reduce indirect. N/C in total E
Designer fix #2. Modest > Low risk at ~20/600

Low risk at 20/20
Designer fix #2. **Modest risk at 20/1000**

Low risk at 20/20
Original challenge

Fix #1

Fix #2

Iteratively refined solution
False Positive Identification
Food for thought...

False Positive Identification
Food for thought...

Specular surface confusion
Food for thought...

Recently constructed public spaces
Food for thought...
Food for thought...
Current and Future Work

- A better understanding of low vision perception and action involving mobility

- Better methods for simulating the effects of low vision in design systems (recently validated our application of Peli filter)

- Better computational models for automating the prediction of the effects of lighting and other aspects of architectural design on visual accessibility

- Develop a scale to report visual feature detectability

- Integration with the real-world design process
Thank You

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