Hybrid-Image Visualization for Large Viewing Environments

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Large Viewing Environments

- large displays
- meeting rooms / war rooms
- emergency response rooms
- public viewing
- open spaces
- museums
Scenario: WILD Display Environment
Who to Optimize For?
# Example Data

23 years of daily temperatures for 32 cities

<table>
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<tr>
<th>Station, Country, Station ID, SQUID, Date, Temperature (decidegrees Celsius), Temperature Quality</th>
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Naïve Approach

Optimize for one specific viewing distance

Problem: detailed information lost

Problem: mental aggregation, comparison
Naïve Approach

Optimize for one specific viewing distance

Problem:
detailed information lost

detail from close

Problem:
mental aggregation, comparison

overviews from far
Possible Approaches

- Dynamic integration (tracking people & adapting content)
- Static integration
Static Approaches

Juxtaposition: global & local features next to each other
Static Approaches

Nesting: local inside global features

NodeTrix

SWViz

[NodeTrix: Henry et al., InfoVis 2007]

[SWViz: Auber et al., InfoVis 2003]
**Static Approaches**

**Visual aggregation:** local form global features

-FatFonts: Nacenta et al., AVI 2012

-Arcimboldo Paintings, Calligrams

-Extended Labels: Wong et al., InfoVis 2005
Static Approaches

**Blending:** local & global features overlap

Map regions over map detail

Label detail over bar chart

Hybrid image visualization
Hybrid Images

- Schyns & Oliva, 1994
Hybrid Images

- Oliva, Torralba & Schyns, 2006
Our Contributions

- **Theoretical grounding**
  why & when use hybrid images?

- **Tools**
  how to support their creation?

- **Examples**
  what are they really good for?

- **Design principles**
  how to build effective ones?
Can they Convey More Visual Information?

The WILD display environment at Université Paris-Sud
Frequency Domain Approach

![Diagram showing acoustic signal and sine waves in Hertz]

The acoustic signal in time domain can be transformed into a sum of sine waves in frequency domain, represented as:

$$\text{intensity} = \text{sine waves}$$
Frequency Domain Approach

image

(1D) Fourier Transform

= sinusoidal gratings

frequencies in cycles/degree of visual angle
Contrast Sensitivity Function

1 cycle per degree

1°
Contrast Sensitivity Function

Visual Response

Spatial Frequency (cycles/deg)

Lateral inhibition

limit of visual acuity

3-4 cycles/deg
What do we Perceive from a Large Display?

The WILD display environment at Université Paris-Sud
What do we Perceive from a Large Display?
What do we Perceive from a Large Display?
What do we Perceive from a Large Display?

256 pixels (1 pixel = 0.25 mm)

2 m
What do we Perceive from a Large Display?
What do we perceive from a large display?

Visual Response vs. Spatial Frequency (cycles/deg)

Visibility vs. Distance to the display

256 pixels

2 m
What do we Perceive from a Large Display?

![Graph showing visual response versus spatial frequency.](image)

- **Spatial Frequency (cycles/deg)**
- **Visual Response**

![Diagram illustrating visibility versus distance to the display.](image)

- **Visibility**
- **Distance to the display**: 50 cm, 1 m, 1.5 m, 2 m, 2.5 m, 3 m, 3.5 m, 4 m

![Illustration showing 256 pixels at 4 meters.](image)
What do we Perceive from a Large Display?

Spatial Frequency (cycles/deg)

Visual Response

Visibility

Distance to the display
What do we Perceive from a Large Display?

Spatial Frequency (cycles/deg)

Visual Response

Distance to the display

Visibility

256 pixels

20 cm

4 m

256 pixels
What do we Perceive from a Large Display?

Spatial Frequency (cycles/deg)

Visual Response

Visibility

Distance to the display

- 128 pixels
- 256 pixels
- 20 cm
- 4 m

- 100%
- 75%
- 50%
- 25%
- 0%
What do we Perceive from a Large Display?

Spatial Frequency (cycles/deg)

Visual Response

Visibility

Distance to the display

Distance:
- 20 cm
- 4 m

Spatial frequencies for different display sizes:
- 64 pixels
- 128 pixels
- 256 pixels
What do we Perceive from a Large Display?

![Graph showing the relationship between spatial frequency and visual response, as well as the visibility of different pixel counts at various distances from the display.](image-url)
What do we Perceive from a Large Display?

Visual Response

Spatial Frequency (cycles/deg)

Visibility

Distance to the display

- 64 pixels
- 128 pixels
- 256 pixels
- 32 pixels
- 16 pixels

- 20 cm
- 4 m
What do we Perceive from a Large Display?

![Graph showing visual response vs. spatial frequency and visibility vs. distance to the display.](image)

- **Spatial Frequency (cycles/deg)**
- **Visual Response**
- **Distance to the display**
- **Visibility**

- 20 cm
- 4 m
- 64 pixels
- 128 pixels
- 256 pixels
- 32 pixels
- 16 pixels
- 8 pixels
- 50 cm
- 1 m
- 1.5 m
- 2 m
- 2.5 m
- 3 m
- 3.5 m
- 4 m

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What do we Perceive from a Large Display?
What do we Perceive from a Large Display?

Visual Response

Spatial Frequency (cycles/deg)

Visibility

Distance to the display

- 100%
- 75%
- 50%
- 25%
- 0%

- 64 pixels
- 128 pixels
- 256 pixels
- 32 pixels
- 16 pixels
- 8 pixels
- 4 pixels
- 2 pixels

50 cm 1 m 1.5 m 2 m 2.5 m 3 m 3.5 m 4 m

20 cm

4 m
What do we Perceive from a Large Display?

How well
How much?
Information Capacity
Information Capacity

256 pixels

1.5 m

40°
What do we Perceive from a Large Display?

![Graph showing visibility of different pixel sizes at various distances.](image)
What do we Perceive from a Large Display?

Distance to the display

Information Visible

2 pixels
4 pixels
8 pixels
16 pixels
32 pixels
64 pixels
128 pixels
256 pixels
What do we Perceive from a Large Display?

Distance to the display

Information Visible

2 pixels

4 pixels

8 pixels

16 pixels

32 pixels

64 pixels

128 pixels

256 pixels

50 cm 1 m 1.5 m 2 m 2.5 m 3 m 3.5 m 4 m

2 pixels

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Comparison with a Desktop Display
Comparison with a Desktop Display

![Graph showing the percentage of information visible at different distances for various pixel sizes.](image-url)
Leveraging Large Displays
Ineffective Visualizations
Ineffective Visualizations
Ineffective Visualizations
Ineffective Visualizations
Ineffective Visualizations
Ineffective Visualizations
Ineffective Visualizations
Hybrid-Image Visualization

near image

Hi-pass Filter + contrast

far image

Lo-pass Filter

Alpha Blending + contrast
Hybrid-Image Visualization
Hybrid-Image Visualization

With filtering

Without filtering
Hybrid-Image Visualization

Hi-pass Filter + contrast

Lo-pass Filter

Alpha Blending + contrast
Hybrid-Image Visualization

- **Hi-pass Filter + contrast**
  - filter radius = 10 px
  - contrast = 1.5
  - brightness = 1.37

- **Lo-pass Filter + contrast**
  - filter radius = 15 px
  - opacity = 0.4
  - contrast = 2.3
  - brightness = 0.77
Hybrid Image Maker
Hybrid Images for Large-Scale Visualizations

- Theoretical grounding
  why & when use hybrid images?

- Tools
  how to support their creation?

- Examples
  what are they really good for?

- Design principles
  how to build effective ones?
Hybrid Images for Large-Scale Visualizations

- **Theoretical grounding**
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Examples

Tree of Life Treemap

co-authorship network

temperature data

...and more

http://aviz.fr/hybridvis
HI-Visualization Techniques

- Mixing multiple visualizations
- Navigation aids & summaries

http://aviz.fr/hybridvis
HI-Visualization Techniques

- Support perceptual grouping
- Highlight values
- Dual-scale reference structures

Hertzsprung-Russell diagram (think of this as a scatterplot)
Video
Limitations

• No fully-automated hybrid-image visualization possible
  • visibility ≠ legibility
  • yet, some feature legibility can be predicted (text, grids)
  • color may change due to filtering
  • contrast removed through blending
• Fast preview but final image production slow in full res
  (hardware acceleration possible)
Conclusion

• Theoretical grounding
  why & when use hybrid images?
• Tools
  how to support their creation?
• Examples
  what are they really good for?
• Design principles
  how to build effective ones?