Drawing Visual Perception

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1. The world
1. The world

2. The perception of the world
1. The world

2. The perception of the world

3. The depiction of the world
1. The world

2. The perception of the world

3. The depiction of the world

4. The perception of the depiction of the world
Two kinds of display
How do we align what we perceive in our mental display when looking at the world with what we perceive when looking at physical displays?
The mental display

The world

The physical display

How can these be best aligned?
Here I’m talking about the geometry of visual space rather than colour, dynamic range, contrast, sensitivity, etc.
In terms of spatial geometry, for a long time the standard approach has been to use linear perspective...

Brunelleschi (c. 1420)
Linear perspective geometry
Physical display
Flat
Monocular
Non-dynamic
Linear geometry
Narrow field of view
<table>
<thead>
<tr>
<th>Physical display</th>
<th>Mental display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td>Deep</td>
</tr>
<tr>
<td>Monocular</td>
<td>Binocular</td>
</tr>
<tr>
<td>Non-dynamic</td>
<td>Dynamic</td>
</tr>
<tr>
<td>Linear geometry</td>
<td>Non-linear geometry</td>
</tr>
<tr>
<td>Narrow field of view</td>
<td>Wide field of view</td>
</tr>
</tbody>
</table>
Linear perspective does not reflect the non-linear geometry of visual space.

Helmholtz (1866)
Figure 1. The bulging grid.

Foster & Altschuler (2001)
Linear perspective cannot adequately represent the full scope of the human field of view

After Gibson (1950)
(a) A wide-angle photo with distortions on subjects’ faces.
150º horizontal
How can we align the space that appears on physical displays more closely with that of our mental display?
Natural perspectives based on non-linear projections...
Self Portrait (after Mach), 2012, Oil
Optical perspective (Fisheye)

Natural perspective

Fixated objects seem bigger and closer
JMW Turner, The South Wall of the Square Dining-Room, gouache and watercolour on paper, 1827 © Tate
Measuring the structure of visual space with art and science
Baldwin et al. (2015)
Fisheye monocular
very high  |  high  |  moderate  |  low  |  very low

Equirectangular
very high | high | moderate | low | very low

Fisheye cyclopean
N = 30

Baldwin et al. (2015)
Photographic stimuli

Natural perspective (NP)

Fisheye perspective (FP)

Linear perspective (LP)
Burleigh et al. (2018)

N = 30
Computational modelling of visual space geometry
Natural perspective rendering
FovoRender

- Runs in Unreal 4.27.2 (current primary) & past versions in Unity, Cinema 4D (with either C4D's standard renderer, or Octane, or Arnold Renderers using Open Shading Language)

- Real time and path tracing modes:
  - Real time rasterizer mode adjusts vertex shader and adds tessellation on GPU
  - Path tracing mode alters ray direction, origin, and shape

- Both modes employ non linear projection techniques to adjust an image volumetrically (not a screen space or lens effect)

- Default settings are provided mapped to features of visual perception

- Or flexible user controlled settings based on subjective values for creative effect
Gaming
Gaming
Visualisation

Linear Perspective: 120° Equivalent
Related work
**Non-linear rendering and computational photography**


Curvilinear and natural perspectives


Visual space geometry


Conclusion:

- We can improve alignment between mental and physical displays when depicting the perceived world.
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- This can be achieved by close analysis of the structure of visual space and by developing non-linear natural perspectives that more closely emulate that structure
Conclusion:

- The benefit of natural non-linear perspectives can be to improve the user experience of 3D content on standard displays.
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- Drawing is a key research tool that, along with science methods, can be used to investigate perceptual geometries.
‘What does the world really look like? I know it doesn’t look like photographs. The camera sees geometrically, and we must see psychologically.

So what does it really look like? I think you have to draw it.’

David Hockney, 2021
Alistair Burleigh
Computer coding
Vision research
Computer graphics

Joe Baldwin
Data collection
and analysis

Nicole Ruta
Psychophysical research
Data collection
and interpretation
and analysis

Heddwyn Loudon
Data collection
and analysis
Network proposal

Beyond linear perspective: Representing visual experience in art & technology