Learning Visual Importance for Graphic Designs and Data Visualizations

Zoya Bylinskii, Nam Wook Kim, Peter O’Donovan, Sami Alsheikh, Spandan Madan, Hanspeter Pfister, Fredo Durand, Bryan Russell, Aaron Hertzmann
“Today, we’re on the verge of another revolution, as artificial intelligence and machine learning turn the graphic design field on its head again.”

https://www.wired.com/story/when-websites-design-themselves

Sept 20, 2017
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Learning Visual Importance
• bottom-up pop-out

fonts, colors, styles
• bottom-up pop-out fonts, colors, styles
• bottom-up pop-out fonts, colors, styles
• bottom-up pop-out
  fonts, colors, styles

• design elements
  title, annotation, visual
• bottom-up pop-out
  fonts, colors, styles
• design elements
  title, annotation, visual
• element locations
  layout priors
Retargeting

Authoritative Leadership: What Workers Prefer and What They Get

29% vs. 4%

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25 endurance tips to push yourself to the next level

THE BEST GEAR OF 2016

Olympic Nutrition Tips

Catch a free ride today

STATSHOT

A Leadership Disconnect Exists Between What Workers Prefer and What They Get

Design feedback

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related work

O’Donovan, Agarwala, Hertzmann [TVCG’14]

O’Donovan, Agarwala, Hertzmann [CHI’15]

Graphic Design Importance (GDI) dataset
related work

Rosenholtz, Dorai, Freeman [ACM 2011]

Pang, Cao, Lau, Chan [Siggraph Asia’16]
How to define and measure importance?

• Eye fixations

• Mouse clicks

• Explicit importance annotations
What Makes a Visualization Memorable? [InfoVis 2013]
Beyond Memorability: Visualization Recognition and Recall [InfoVis 2015]

The most read books in the world. The order was like 1) The Holy Bible, 2) Some Chinese guy's quotes, 3) Harry Potter.
Eye fixations can give us important clues about how people perceive visualizations.

massvis.mit.edu

*What Makes a Visualization Memorable?* [InfoVis 2013]
*Beyond Memorability: Visualization Recognition and Recall* [InfoVis 2015]
What design elements are most important?

What Makes a Visualization Memorable? [InfoVis 2013]  
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What design elements are most important?

What Makes a Visualization Memorable? [InfoVis 2013]
Beyond Memorability: Visualization Recognition and Recall [InfoVis 2015]
data collection

eye fixations

experimenter

head stabilization

specialized hardware

infrared camera
BubbleView: an interface for crowdsourcing image importance maps and tracking visual attention. [TOCHI, in press]
BubbleView: an interface for crowdsourcing image importance maps and tracking visual attention. [TOCHI, in press]
Fixations

Clicks

data collection  bubble clicks
Relative Importance Score

Spearman's $r = 0.96$

- eye gaze
- bubble clicks
Graphic Design Importance (GDI) dataset
Choosing an importance representation

Annotations  Clicks
We create importance models for:

- data visualizations
- graphic designs
We create importance models for:

**data visualizations**
- MASSVIS Dataset
  - 1411 visualizations

**graphic designs**
- GDI Dataset
  - 1078 designs
Training our importance model

- fully-automatic prediction
- real-time performance
FCN adapted from semantic segmentation
Bitmap design in, importance out
We make importance predictions for:

**data visualizations**

<table>
<thead>
<tr>
<th>Ground truth</th>
<th>Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td><img src="image3.png" alt="Image" /></td>
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</tbody>
</table>

**graphic designs**

<table>
<thead>
<tr>
<th>Ground truth</th>
<th>Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5.png" alt="Image" /></td>
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<tr>
<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
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</tbody>
</table>
Ground truth | Our model | Judd
--- | --- | ---
[Image of visualizations] | [Image of visualizations] | [Image of visualizations]

DeepGaze | SalNet | SALICON
[Image of visualizations] | [Image of visualizations] | [Image of visualizations]

results | visualizations
<table>
<thead>
<tr>
<th></th>
<th>CC↑</th>
<th>KL↓</th>
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</thead>
<tbody>
<tr>
<td>Judd</td>
<td>0.11</td>
<td>0.49</td>
</tr>
<tr>
<td>SalNet</td>
<td>0.24</td>
<td>0.77</td>
</tr>
<tr>
<td>SALICON</td>
<td>0.54</td>
<td>0.76</td>
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<tr>
<td>DeepGaze2</td>
<td>0.54</td>
<td>0.47</td>
</tr>
<tr>
<td>DeepGaze</td>
<td>0.57</td>
<td>3.48</td>
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<tr>
<td>Our model</td>
<td><strong>0.69</strong></td>
<td><strong>0.33</strong></td>
</tr>
</tbody>
</table>
results

visualizations

Input visualization

Ground truth

Predicted importance
(CC=0.89, KL=0.12)

(CC=0.79, KL=0.24)

(CC=0.39, KL=0.83)
Is element importance preserved?

Ground truth

Prediction

Spearman’s $r = 0.96$
Limitations

Ground truth

Prediction
Results for graphic designs
Model

Input

graphic designs

results
results

graphic designs

O’Donovan, Agarwala, Hertzmann [TVCG’14]
Ground truth  OD-Full  OD-Automatic  Our model
<table>
<thead>
<tr>
<th></th>
<th>RMSE ↓</th>
<th>$R^2$ ↑</th>
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</thead>
<tbody>
<tr>
<td>Saliency</td>
<td>0.229</td>
<td>0.462</td>
</tr>
<tr>
<td>OD-Automatic</td>
<td>0.212</td>
<td>0.539</td>
</tr>
<tr>
<td>Our model</td>
<td>0.203</td>
<td>0.576</td>
</tr>
<tr>
<td>OD-Full</td>
<td>0.155</td>
<td>0.754</td>
</tr>
</tbody>
</table>
applications

Retargeting

Thumbnailing

Design feedback
applications  retargeting

Original design

Importance heatmap

Our model

Edge-energy

Judd

DeepGaze
M Turk evaluation

Predicted importance performed:

- better than: edge energy ✓ Judd saliency ✓ random crops ✓
- similar to: DeepGaze (deep natural image saliency) ≈
A leadership disconnect exists between what workers prefer and what they get.

Input:

<table>
<thead>
<tr>
<th>Authoritative Leadership</th>
<th>Workers Who Experience It</th>
<th>Workers Who Prefer It</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>29%</td>
<td>ONLY 4%</td>
</tr>
</tbody>
</table>

Importance heatmap:

Thumbnail:
Find an image with a given caption.

Instructions
1. Please wait until all images finish loading.
2. Scroll to find the graphic that matches the caption below. The thumbnails summarize each graphic.
3. Click on a thumbnail to see the full graphic.
4. Once you click on the correct graphic you will be able to submit.

Find a graphic image that matches the caption provided.

Image Caption
This graph shows that workers don’t get what they prefer. There is a disconnect between leadership and workers.
Can retrieve visualizations more efficiently:
• **1.96** clicks with importance-based thumbnails
• **3.25** clicks with resized visualizations
Design Improvement Dataset
applications

interactive

Ground truth

Prediction
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visimportance.csail.mit.edu
website: visimportance.csail.mit.edu
code: github.com/cvzoya/visimportance