Modern Vision Science for Designers: Making Designs Clear at a Glance

Ruth Rosenholtz
Computer Science & Artificial Intelligence Lab
Department of Brain & Cognitive Sciences
MIT, Cambridge, MA
rruth@mit.edu

Dian Yu
Computer Science & Artificial Intelligence Lab
MIT, Cambridge, MA
dianyu@mit.edu

ABSTRACT

Why do some interfaces allow users to find what they need easily while others do not? What information can the visual system effortlessly extract, and what requires slower, more cognitive processes? What does eye-tracking data tell us about what users perceive? Vision scientists have recently made ground-breaking progress in understanding many aspects of vision that are key to good design. A critical determining factor is what information is available at a glance. This course reviews state-of-the-art vision science, including a computational model that visualizes the available information. We will demonstrate use of this model in evaluating and guiding visual designs.

CCS CONCEPTS

• **Human-centered computing** → Human computer interaction (HCI) – *HCI design and evaluation methods*

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KEYWORDS
Human Peripheral Vision; Crowding; Saliency; Gist; Texture-Tiling Model; Visual Design Evaluation.

Figure 1: The phenomena of crowding in peripheral vision. Peripheral vision is extremely vulnerable to nearby clutter. Fixating on the white star in the top panel, it is very hard to see the path of the brown subway line. This difficulty is not due to peripheral vision's loss of acuity and color vision. The task becomes trivially easy when other visual elements are removed, as in the bottom panel. The major limitation of peripheral vision is not loss of acuity and color vision.

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1 INTRODUCTION

Understanding and exploiting the abilities of the human visual system is an important part of the design of usable user interfaces and information visualizations. Good designs use the natural visual processing power of the brain: they make important alerts "salient" [3], provide strong cues to perceptual organization [4], and minimize clutter [7]; they make use of human ability to extract the "gist" of a complex scene [1] or set of similar items [9], and avoid subtle dynamic changes that a user may be blind to [6]. Such design enables quick, easy and veridical perception, improving usability.

Recent paradigm-shifting breakthroughs have occurred in the study of human vision. These breakthroughs mean that HCI practitioners can no longer rely on that vision class they once had in college. The good news, however, is that practitioners for the most part only need to know about one aspect of vision: the strengths and limitations of peripheral vision.

Visual designs that are easy to interact with provide abundant information at one glance: a well-designed remote control allows users to notice a button rather than searching for it. In turn, the information that is easily accessible at a glance depends critically upon the information available in the periphery. Nearly 99% of what we see, at any given moment, is processed by our peripheral vision. Peripheral vision is quirky and unintuitive; it loses considerable information while also preserving the information necessary for many visual tasks. The major loss of information in the periphery is not loss of acuity but rather loss of spatial localization, known as 'crowding' [5]. Recent work in human vision has shown that many of the visual phenomena of importance to design – saliency, search, change blindness, rapid perception of the "gist" of a scene or a set of similar items – arise from the strengths and limitations of peripheral vision. For many applications, peripheral vision is the one thing that designers need to understand about human vision.

Importantly, vision research has produced quantitative models of peripheral vision [2],[8]. These models take as input arbitrary, complex images of a design or scene and produce as output visualizations of the information available at a glance (Figure 2). The instructors are making their peripheral vision visualization tool freely available. This course will include examples of how to use the tools to evaluate designs.

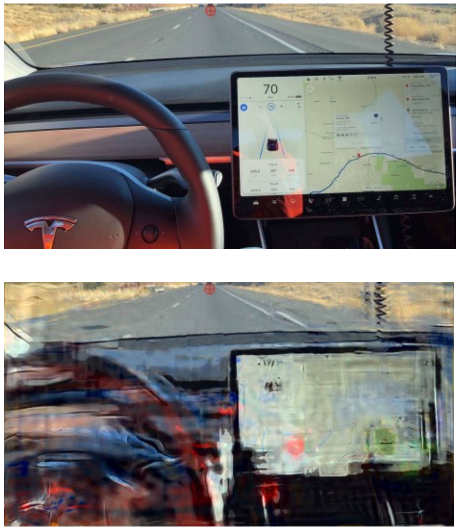

Figure 2: We use TTM to simulate what the driver sees in the top image when she/he is fixating at the end of his/her lane (indicated by the red crosshair). Our model prediction (visualized in the bottom image) shows that the driver would not be able to gain any useful information from the screen without moving his/her eyes off the road and saccading to the screen.

2 LEARNING OUTCOME

By introducing the CHI audience to these paradigm-shifting developments, we hope to achieve 4 goals: (i) update researchers about the state of the art in vision science; (ii) enable participants to better interpret the results of eye tracking studies; (iii) educate the CHI community about the importance of designing "for the periphery"; and (iv) train designers in use of a tool to enable such "peripherally-aware" designs.

3 INTENDED AUDIENCE & PREREQUISITE

The course will benefit a broad audience, including:

- Students who want a quick overview of the state of the art in vision science.
- Industrial and academic researchers, who will gain updated perspective on vision for design usability, and implications for design guidelines.
- Designers and developers, who will learn about new tools to evaluate their designs, and will gain insights into how visual perception influences user experience.

We welcome anyone who has an interest in creating designs that better utilize human vision for fast and effortless processing.

3 CONTENT

In the first section of the course, we will cover relevant vision science along with the modern understanding of peripheral vision as a critical bottleneck. After a break, the second section will provide practical experience in applying knowledge of peripheral vision to visual designs. Below are detailed contents for each section.

3.1 Basic phenomena of vision science

We will review important aspects of human vision, including:

- Do salient items draw attention and/or eye movements?
- Getting the gist of scenes and sets
- Human vision misses the details: change blindness and other phenomena
- Peripheral vision determines vision at a glance
- Human vision is not good at integrating information across multiple glances

Activities: The class will participate in interactive demos to experience the limitations of vision.

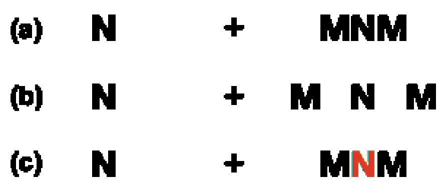

Figure 3: (a) This figure illustrates crowding in letters. Fixating on the cross, the letter N to the right of the fixation is hard to recognize compared to the one to the left. (b) The N to the right of the fixation becomes legible again when the flanking letters are positioned at a certain distance from it. (c) The N to the right is easier to read when it has a distinctive color compared to the flanking letters.

3.2 Basics of peripheral vision:

We will review popular understanding of peripheral vision, dispel a number of myths, and present the modern understanding of peripheral vision:

- Loss of acuity and color vision
- Sensitivity to motion
- Myths of peripheral vision
- The most important loss in peripheral vision: *visual crowding* (see Figure 1 for illustration).
- Crowding and critical spacing (see Figure 3a&b)
- How saliency and grouping reduce peripheral crowding (see Figure 3c)

3.3 Revisiting visual phenomena relevant to design:

A number of visual phenomena that are relevant for design, previously thought of as separate phenomena, in fact arise from the nature of the encoding in peripheral vision. We review the evidence for this claim, and demonstrate how this can enable design intuitions.

- What “pops out” and “draws your attention”?
- How hard it will be for the user to find what they are looking for?
- Can the user get the “gist” of the display, and what does this mean?
- If something changes, will the user notice? (Change blindness)

Activities: Participants will practice evaluating design examples in small groups.

[Break]

3.4 Implications for design:

We will train participants to translate modern understanding of human vision into insights for design. First, how to use your own visual system: The well-known rule of ‘squinting’ at the design only mimics the loss of acuity and perhaps contrast sensitivity in peripheral vision. Instead, we advocate ‘fixating’ -- looking at task-relevant parts of the design while attending to the periphery. Second, because introspecting on peripheral vision is difficult, we will demonstrate use of our peripheral vision visualization tool. We examine applications to design of subway maps, mail clients, GPS systems, and augmented reality, as well as examples provided by the participants.

Activities: Class practice evaluating a range of visual designs. Group discussion about how changes to visual elements improves ‘readability’ in visual periphery. Participants can each submit one design one week before the class. We will select a subset of designs for visualization (the software requires significant computation time), and guide the class in evaluating them together.

4 INSTRUCTOR INFORMATION

Ruth Rosenholtz is a Principal Research Scientist in MIT's Department of Brain and Cognitive Sciences, and a member of CSAIL. She has a Ph.D. in EECS (Computer Vision) from UC Berkeley. Her work focusses on developing predictive models of visual processing, and on applying understanding of human vision to image fidelity (NASA Ames), and to design of user interfaces and information visualizations (Xerox PARC and MIT). She is a world expert in peripheral vision and its implications for how we think about vision, attention, and design.

Dian Yu is a postdoctoral associate at CSAIL, MIT. She has a Ph.D. in Psychology from Northwestern University. Dian is passionate about applying vision science to solve design problems. She was awarded the *Cognitive Science Graduate Fellowships for Interdisciplinary Research Projects* (2013) and *best talk award* at OPAM (2015). Her current work focuses on researching how to improve design by providing grouping information or structure that can be well perceived in the visual periphery.

5 AVAILABLE RESOURSES

Information about the course is available at
https://sites.google.com/u.northwestern.edu/chi2019-vision.
Code for the Texture Tiling Model will be made freely available prior to the course.

ACKNOWLEDGMENTS

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