Emergic Modeling
(http://dpleibovitz.upwize.com/?p=1751)

David Pierre Leibovitz
http://dpleibovitz.upwize.com
Rules – I hate rules!

- I am against oversimplifications
  - Question my oversimplifications
  - Question my interpretations

- I use words in a weird way with weird meanings
  - Ask questions; but in this context...

- I am not right, and am a devil’s advocate
  - Disagree; teach me! Give me feedback afterwards...
  - Explore viewpoints, and pick your own

- Be bold; have fun
  - More about inspiration than knowledge
  - More about discussion than evangelism
Background

- Call me David
  - VSIM 5210Q (Rob’s Lab)
  - dpleibovitz@ieee.org

- Past Life: Computer Engineer; worked at Nortel
  - Senior systems architect; manager
  - Disciplined systems development process (unlike science)
  - Unified systems analysis – an art form
  - Code refactoring – an even higher art form

- New Life: PhD, Cognitive Science
  - Unifying cognitive modeling – highest art form
    - Actual & philosophy of
  - Disciplining scientific progress
(From Prospectus)

- Non representational approach
  - Start with raw sensation
- Bottom up and top down effects
  - Involves perception and attention
- Highly integrative phenomena
  - Currently no working model of this
- Goal for thesis
  - Visual infrastructure to support eventual explanation
Hard-Core Simulation

What I built
The Emergic Cognitive Model (ECM) forms the virtual agent/person/eye part of the system.

- Virtual eye “sees” the screen
- Virtual eye jitters
- Virtual eye saccades
- Virtual eye blinks
- Virtual eye has blind spot
- Objects move
- Non-representational interaction
**Thesis shows:** 2 *fuzzy* functionings  
→ 8 *fuzzy* phenomena (Unified)

<table>
<thead>
<tr>
<th>Chapters: 2-5</th>
<th>Appendices: A-D</th>
</tr>
</thead>
<tbody>
<tr>
<td>2: Homogeneity</td>
<td>A: Anorthoscopic</td>
</tr>
<tr>
<td>3: Transsaccadic</td>
<td>B: Foveal Blue Scotoma</td>
</tr>
<tr>
<td>4: Brief</td>
<td>C: Blinks</td>
</tr>
<tr>
<td>5: Blind-spot</td>
<td>D: Imagination</td>
</tr>
</tbody>
</table>

[http://emergic.upwize.com/?page_id=26](http://emergic.upwize.com/?page_id=26)
Emergic Cognitive Model

Premonition

- How does it work?

- Well, everything gets weird...

- And everything gets philosophical...
  - What are “fuzzy” functionings?

- So...
Philosophizing...

Why David’s modeling system is so strange...
What is philosophy?

- (vs. science)
- Class?

See:
- [https://en.wikipedia.org/wiki/PhD](https://en.wikipedia.org/wiki/PhD)
- [https://en.wikipedia.org/wiki/Philosophy](https://en.wikipedia.org/wiki/Philosophy)
Why philosophizing?

- Research question was NOT how to understand a phenomenon through the lens of an *instrument* (a methodology, process, paradigm, world view, etc.), e.g., of Maslow’s hammer.

- Research question WAS to understand the limitations of our research process (& modeling). Is there a positive path towards unifying theorizing (as part of actually doing so)?
  - Merely griping is not productive
  - ~Philosophy of science
  - Look for: *Why* did David choose to do such and such
### Dueling Proverbs - Class Exercise

**Brainstorm: add *smarts***

<table>
<thead>
<tr>
<th>1</th>
<th>2+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Too many cooks spoil the broth</td>
<td>Many hands make light work</td>
</tr>
<tr>
<td>&lt;Class? Blackboards, Volunteers...&gt;</td>
<td>&lt;Class?...&gt;</td>
</tr>
</tbody>
</table>
Find context: add *wisdom*

- Find domain of applicability: add *wisdom*
- Go back to previous brainstorm and discuss
Dueling Proverbs - Class Exercise
Decompose better questions

- Two classes of proverbs are example of dichotomous thinking.
  - Obviously, they can’t both be generally right.
  - Although each could be analogized to a psychology experiment in a particular context with p<.001 (and a large effect size)
- Decompose better questions
  - Finer grained issues/parts/concerns
  - Interactions to be formalized
  - Trade-offs
  - Splitting & chunking; splitting & chunking; ...
- Class?
Emergic Modeling
Thursday, February 1, 2018

Approaches to Decomposition

- **Isomorphism Crisp Functions**
  - $$P_1, P_2, \ldots, P_p$$
  - $$F_1, F_2, \ldots, F_f$$
  - Top-Down: Use stipulated crisp parts for crisp behaviors, e.g., ACT-R as a tool

- **Emergic Fuzzy Functionings**
  - $$EP_1, EP_2, \ldots, EP_p$$
  - $$EF_1, \ldots, EF_{ef}$$

- **Simplicity?**
  - $$(M_i < EM) \land (F_f < EF_f)$$, but
  - $$(EM < M_1 + M_2 + \ldots + M_m) \land (ef < f)$$

Bottom-up: Uncover/refactor unifying bottom of crisp parts for fuzzy behaviors – there are no higher levels of explanation, e.g., ACT-R as a theory
Emergic Cognitive Model
- **Ecological validity**
  - Detailed retina
  - Motion
- **Biological plausibility**
  - Multiscale hierarchy
  - Massive Recurrence
Two parallel & interactive *fuzzy* functionings:

1. **Maintaining Information Coherence**
   - When old information in a recurrent flow meets new information, compensate for motion so that they “refer” to the same “thing”

2. **Handling Missing Data**
   - If bottom-up information is missing, fill it in using lateral or top-down flows
   - (This is not an isomorphic “filling-in” process)
Handling Missing Data Fuzzy Functioning

- This cognitive function is simple
  - If I don’t have a **bottom-up value**, e.g., blinks
    - use **lateral value**
  - If I still don’t have a value,
    - use **top-down value**
  - Send out my value

- Note: Three flows despite single output as value directed up, down & laterally
This cognitive function is complex:

- Distribute motor plans in advance
- Shift coordinates to maintain infocentric reference frame
- Broadcast information locally (~Local Area Network)
- Tag information (~Internet protocol)
- Interpolative summation
Emergic filling-in behaviour, but...

No isomorphic functional filling-in
- Due to interactions
- Filling-in over sensory irregularities (absences) but not over stimuli irregularities
Classical vs. Emergic Units

Simple Value

Structured Values

Highly Recurrent

2018-02-01  David Pierre Leibovitz (Carleton University)

Emergic Modeling 23
The Emergic Cognitive Model is an Emergic Network.
Oversimplifications can limit
Each Emergic Unit is Turing Complete on its own
  - Overlay network
  - Dendritic+ processing
Still have a simplifying (but not limiting) level of analysis – the *information* of information processing.
  - Don’t worry *how* it is encoded
  - Worry about *what* information is needed
  - Only model the fuzzy *whys* that you can understand, not the phenomena to be blindly reproduced
Biological Realism (Photoreceptor Topology) (Schultze, 1866) Emergic Cognitive Model (ECM) Actually $L$, $M$, $S$
Visual Realism: Biological (Photoreceptor Variance)

<table>
<thead>
<tr>
<th>(Hofer et al, 2005)</th>
<th>ECM</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>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
</tr>
<tr>
<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
</tr>
</tbody>
</table>

David Pierre Leibovitz (Carleton University)

Emergic Modeling 28
Why detailed retina?

- Oversimplifications can limit & lead to implicit assumptions
- How to fill-in to borders, if borders have holes?
- Class?
Flowcentric Phenomenology
(Model behaviour)

Narrow Slit View
Anorthoscopic Perception
Direct perception

RFs (Level 1)
The Paint Flows

Wider View
Indirect Perception

Photoreceptors
Blinks
Blind Spot
Distribute Motor Plans (Shifts)

- Compensate for eye motion
- Allow the shifting of sensory information
Broadcast Locally

- Like a LAN
  - Cognitive fan-out parameters
- Up needs no broadcast (better precision)
Tag Spatial Information in Structured Values

- **ValueXY((x, y, v, w) ...)**
  - x: the spatiotopic x-coordinate of this sample value
  - y: the spatiotopic y-coordinate of this sample value
  - v: the L, M or S colour value of this sample from 0 to 255
  - w: the weight assigned to this sample value
  - ...: repeatable, in which case this emergic value represents the descriptive statistics for all the samples weighted accordingly

- **Internal Representation (for L, M & S)**
  - n: the number of samples = \( \sum 1 \)
  - sw: sum of sample weights = \( \sum w_n \)
  - swx: weighted sum of X coordinates = \( \sum w_n x_n \)
  - swy: weighted sum of Y coordinates = \( \sum w_n y_n \)
  - swv: weighted sum of colour values = \( \sum w_n v_n \)
  - swxx: weighted sum of X coordinate squared = \( \sum w_n x_n^2 \)
  - swxy: weighted sum of X coordinate multiplied by Y's = \( \sum w_n x_n y_n \)
  - swyy: weighted sum of Y coordinate squared = \( \sum w_n y_n^2 \)
  - swvv: weighted sum of colour value squared = \( \sum w_n v_n^2 \)

- Tag

- **Mean(x) = swx/sw; variance(x) = (swxx – swx^2/sw)/sw; sd(x) = √variance(x)**
Interpolation but no Extrapolation (No Filling-In à la diffusion)

Showing the mean of each RF value ± 1 standard deviation
Emergic Cognitive Model (ECM)

Legend:
- Information Coherence Function
  - Shift ➔ Shift Distribute Shift Top-Down
  - Shift ➔ Shift Distribute Shift Bottom-Up

- Spatiotemporal Summation
  - Sum ➔ Sum Bottom-Up (RGB)

- Handle Missing Data Function
  - Sum ➔ Sum Lateral/Shift Memory (RGB)
  - Sum ➔ Sum Top-Down Summary (RGB)

Flowcentric
- Units: retinotopic (but delayed)
- Values: ~spatiotopic (despite flowing through units)

Receptive Field Hierarchy

Photoreceptors - heterogeneous
Image Stability

- **Retinotopic**
  - Varies with eye motion, e.g., photoreceptors

- **Spatiotopic: neurocentric**
  - Invariant to motion
  - “Paints a stable image onto dedicated neurons”
  - Most commonly sought out, but not found

- **Spatiotopic: flowcentric**
  - Invariant to motion
  - Maintains coherence among moving flows of information
  - Values maintain spatiotopic tags
### Overlap Processing

(Statistical Based Routing/Summing)

#### A: Four RFs perfectly aligned with coloured stimuli

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>r=255±0.0</td>
<td>(n=8)</td>
<td></td>
</tr>
<tr>
<td>g=?</td>
<td>(n=0)</td>
<td></td>
</tr>
<tr>
<td>b=?</td>
<td>(n=0)</td>
<td></td>
</tr>
</tbody>
</table>

#### B: Eye shifts right by ½ RF width (across blink)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>r=255±0.0</td>
<td>(n=8)</td>
<td></td>
</tr>
<tr>
<td>g=?</td>
<td>(n=0)</td>
<td></td>
</tr>
<tr>
<td>b=255±0.0</td>
<td>(n=0)</td>
<td></td>
</tr>
</tbody>
</table>

#### C: New RF values via overlap processing of lateral flows

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>r=212±60</td>
<td>(n=3)</td>
<td></td>
</tr>
<tr>
<td>g=212±60</td>
<td>(n=3)</td>
<td></td>
</tr>
<tr>
<td>b=42±60</td>
<td>(n=3)</td>
<td></td>
</tr>
<tr>
<td>r=255±0.0</td>
<td>(n=4)</td>
<td></td>
</tr>
<tr>
<td>g=255±0.0</td>
<td>(n=1)</td>
<td></td>
</tr>
<tr>
<td>b=51±102</td>
<td>(n=5)</td>
<td></td>
</tr>
</tbody>
</table>

2018-02-01  David Pierre Leibovitz (Carleton University)

Emergic Modeling 37
Bottom-up is not primary

- Also examples of “perfect” memories (no diffusion)
Feedback

- Feel free to email dpleibovitz@ieee.org
- Drop in at VSIM 5210 Q (Rob’s Lab)
- Give Rob “anonymous” feedback next class