Towards Explicitness as a Language Design Criterion

Martin Erwig

School of EECS
Oregon State University
Language Design

- Cognitive Dimensions Framework
- Semantics-First Approach
- ???
Tension in Language Design

Simplification

... ::= ... | ...

Domain Specificity

select ... from ... where ...
Language Design Criteria?

**Compositionality**

Gottlob Frege

**Explicitness**

*Martin Fowler, IEEE Software (2001)*

“... explicit code is easier to understand”

*Kent Beck*

“... explicit code is intention revealing”

Help balance the simplicity/domain-specificity trade-off
Explicitness Trade-Offs

Advantages

- Better expression of intent
- Avoidance of hidden assumptions
- Manipulability of representation

Disadvantages

- Bigger and more complicated languages
- Extra burden through notational overhead
- Proliferation of feature interaction in language design
Examples

Type Checking in Spreadsheets
Causal Reasoning Neuron Diagrams
Explaining Probabilistic Reasoning
Spreadsheets

\[ e ::= v \mid o(e, \cdots, e) \mid a \]

\[ s = a \rightarrow e \]

\[ a = \text{Int} \times \text{Int} \]

Provides structure among definitions \( \Rightarrow \)

Computation/value A “next to” or “above” computation B
### Label-Based Typing

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Month</td>
<td>Fruit</td>
<td>Orange</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>May</td>
<td>Apple</td>
<td>17</td>
<td>9</td>
<td>26</td>
</tr>
<tr>
<td>3</td>
<td>June</td>
<td>8</td>
<td>13</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Total</td>
<td>25</td>
<td>22</td>
<td>47</td>
<td></td>
</tr>
</tbody>
</table>

**May Apple**

**June Orange**

**May Fruit**
Labeling Rules

\[ e : L \text{ and } L : K \Rightarrow e : K \triangleright L \]

Fruit $\triangleright$ Apple

\[ e : L \text{ and } e : K \Rightarrow e : L \& K \]

Month $\triangleright$ May & Fruit $\triangleright$ Apple

\[ e : L \text{ and } e' : K \Rightarrow e + e' : L | K \]

May Apple | May Orange
May (Apple | Orange) $\quad$ Factoring
May Fruit $\quad$ Generalization
Error Detection

B5 = SUM(B2:B4)

B2 : Fruit
B3 : Fruit ➔ Apple
B4 : Fruit ➔ Apple

B2’s label cannot be factored ⇒ prevents generalization step
Explicitness Effect

Explicit notion of computation “position”

Fine-grained reasoning about consistency
Causal Reasoning With Neuron Diagrams

Desert traveler problem

- Firing neuron
- Stimulating edge
- Non-firing neuron
- Inhibiting edge
Counterfactual Reasoning

What would have happened if things had been different?*

*David Lewis, 1973

Dead is not CF-dependent on Poison or Poke
Counterfactual Reasoning

What would have happened if things had been different?*

*David Lewis, 1973

Dead is not CF-dependent on Poison or Poke
Preemption & Backup

Dead is CF-dependent on Poison and Poke together...

...but only Poke should be a cause of Dead
Causal Chains

Solution: exploit transitivity of causation*

*David Lewis, 1987

Poking is identified as the sole cause of death
Non-Transitive Causation

Unfortunately, causation is not always transitive ...

Boulder problem

The falling boulder causes the hiker to live?
Two Kinds of Neurons

Separate neurons into:
- Actions: choices, neurons we want to reason about
- Laws: immutable facts and relationships
Recursive Cause Inference
### Improved Precision & Correctness

#### Desert traveler

<table>
<thead>
<tr>
<th></th>
<th>CF</th>
<th>CC</th>
<th>SE</th>
<th>Hall</th>
<th>(\mathcal{C})</th>
</tr>
</thead>
<tbody>
<tr>
<td>FF</td>
<td>{P, K}</td>
<td>{P, K}</td>
<td>{P, K}</td>
<td>{P, K}</td>
<td>(P \land K)</td>
</tr>
<tr>
<td>FT</td>
<td>{K}</td>
<td>{K}</td>
<td>{K}</td>
<td>{K}</td>
<td>(K)</td>
</tr>
<tr>
<td>TF</td>
<td>{P}</td>
<td>{P, K}</td>
<td>{P}</td>
<td>{P}</td>
<td>(P \land K)</td>
</tr>
<tr>
<td>TT</td>
<td>{}\</td>
<td>{K}</td>
<td>{K}</td>
<td>{K}</td>
<td>(K)</td>
</tr>
</tbody>
</table>

#### Two doctors

<table>
<thead>
<tr>
<th></th>
<th>CF</th>
<th>CC</th>
<th>SE</th>
<th>Hall</th>
<th>(\mathcal{C})</th>
</tr>
</thead>
<tbody>
<tr>
<td>FF</td>
<td>{}\</td>
<td>{}\</td>
<td>{A, B}</td>
<td>{}\</td>
<td>(A \lor B)</td>
</tr>
<tr>
<td>FT</td>
<td>{A}</td>
<td>{A}</td>
<td>{A}</td>
<td>{A}</td>
<td>(A)</td>
</tr>
<tr>
<td>TF</td>
<td>{B}</td>
<td>{B}</td>
<td>{B}</td>
<td>{B}</td>
<td>(B)</td>
</tr>
<tr>
<td>TT</td>
<td>{A, B}</td>
<td>{A, B}</td>
<td>{A, B}</td>
<td>{A, B}</td>
<td>(A \land B)</td>
</tr>
</tbody>
</table>

#### Boulder

<table>
<thead>
<tr>
<th></th>
<th>CF</th>
<th>CC</th>
<th>SE</th>
<th>Hall</th>
<th>(\mathcal{C})</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>{}\</td>
<td>{B}</td>
<td>{B}</td>
<td>{B}</td>
<td>(B)</td>
</tr>
<tr>
<td>T</td>
<td>{}\</td>
<td>{B, D}</td>
<td>{D}</td>
<td>{B, D}</td>
<td>(D)</td>
</tr>
</tbody>
</table>

Plus 13 additional test cases from Hitchcock, 2009

---

1 Lewis, 1973
2 Halpern and Pearl, 2005
3 Hall, 2007
Explicitness Effect

Explicit distinction of neuron kinds

Improved causal reasoning algorithm
Riddle:
A family has two children. One child is a boy. What is the probability that the other child is a girl?

50% 66.7%
A family has two children. One child is a boy. What is the probability that the other child is a girl?
Explicitness Effect

Explicit probability distributions & story

Explanation of probabilistic reasoning
More Examples ...

Choice

Variational Algorithms

Inductive Graphs

Graph Constructor

Functional Graph Algorithms

Variational Programming

Lazy Typing

Type Inconsistencies

Precise Type Error Messages
Next Step ...

All examples: Explicit representation was accidental

Making explicitness explicit
Research Questions

- Scope of the explicitness criterion
- Dependencies among explicit things
- Syntactic/semantic characterization of explicitness
- Manipulability
- Evaluation of trade-off between explicit and implicit representations
The Explicit End

End