‘Let me send relevant pictures to my friends while we chat.’

Select a picture from a collection

Locate relevant items
Display a collection of pictures
Confirm a selection

Show pictures aligned with text

Send pictures over a chat connection

Builder

Chat {
    void sendPicture(Picture p) {
        byte[] data = p.serialize();
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Builder
Let people specify their instructions informally

- avoid premature precision
- more helpful to programmers
- enable a new generation of flexible, intelligent (?) programs
Managing Ambiguity by Example

Kenneth C. Arnold and Henry Lieberman
MIT Media Lab & Mind Machine Project
{kcarnold, lieber}@media.mit.edu
Informality

Managing Ambiguity

by Example

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MIT Media Lab & Mind Machine Project
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Informality vs. Ambiguity

• Specs and tests are formal but ambiguous.
• Formal = controlled semantics; incl. programming languages.
Select a picture from a collection

Show pictures aligned with text

Send pictures over a chat connection

Executing informal descriptions is hard!
Strategy: Examples Clarify

Select a picture from a collection

- Locate relevant items
- Display a collection of pictures

Builder

Send relevant pictures to my friends while we chat

Chat

```java
void sendPicture(Picture p) {
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Strategy:
Examples Clarify

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Builder
Two hard parts

• Acquiring and interacting with examples

• Finding appropriate examples for new queries
Progress on both fronts

• Acquiring and interacting with examples

• **Zones:** integrate intent into development process

• Finding appropriate examples for new queries

• **ProcedureSpace:** relates code and informal descriptions using code features and natural language background knowledge
Zones Demo
Backend: Code search?

• At the lowest level (directly to code), if keywords match, maybe.

• Finding vocabulary is a large part of the problem-solving process.

• Need to understand the relationship between code and statements of its purpose.
ProcedureSpace Relates Code and Descriptions

natural language descriptions

follow
chase

code fragments

(FOREVER
(pointTowards: "mouse")
(forward: 10))

background knowledge

kind of movement opposite of lead

static analysis

forever > pointTowards:
forever > forward:
pointTowards: ~ forward:
Informal Inference

### Current knowledge

<table>
<thead>
<tr>
<th>Suggestion</th>
<th>Author</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>→ reading to your children is for educating them.</td>
<td>kinchin</td>
<td>6</td>
</tr>
<tr>
<td>→ teaching other people is for educating them.</td>
<td>Jake512</td>
<td>4</td>
</tr>
<tr>
<td>→ seeing art is for Education.</td>
<td>MarkFarrar</td>
<td>4</td>
</tr>
<tr>
<td>→ Education is acquisition of knowledge and understanding</td>
<td>Bryan</td>
<td>4</td>
</tr>
<tr>
<td>→ answering questions is for educating.</td>
<td>Laserjoy</td>
<td>3</td>
</tr>
<tr>
<td>→ watching television is for education.</td>
<td>justjim</td>
<td>3</td>
</tr>
<tr>
<td>→ The effect of going to school is education</td>
<td>damien29</td>
<td>3</td>
</tr>
<tr>
<td>→ education can further your career.</td>
<td>budo</td>
<td>3</td>
</tr>
</tbody>
</table>

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### Open Mind wants to know...

<table>
<thead>
<tr>
<th>Pair</th>
<th>Similarity</th>
<th>+</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>educate</td>
<td>similar to</td>
<td>learn</td>
<td></td>
</tr>
<tr>
<td>learn</td>
<td>similar to</td>
<td>educate</td>
<td></td>
</tr>
</tbody>
</table>

One of the things you do when you attend class is educate.
Informal Inference

AnalogySpace (Speer et al., AAAI 2008)
Informal Inference

<table>
<thead>
<tr>
<th></th>
<th>cat</th>
<th>dog</th>
<th>airplane</th>
<th>toaster</th>
</tr>
</thead>
<tbody>
<tr>
<td>... IsA pet</td>
<td>+6</td>
<td>+5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>... AtLocation home</td>
<td>+8</td>
<td>+2</td>
<td></td>
<td>+1</td>
</tr>
<tr>
<td>... CapableOf fly</td>
<td>−3</td>
<td>−5</td>
<td>+9</td>
<td></td>
</tr>
<tr>
<td>... MadeOf metal</td>
<td></td>
<td></td>
<td>+1</td>
<td>+1</td>
</tr>
<tr>
<td>fur PartOf ...</td>
<td>+6</td>
<td>+5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AnalogySpace (Speer et al., AAAI 2008)
Informal Inference

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Informal Inference

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Informal Inference

AnalogySpace (Speer et al., AAAI 2008)
Can also *blend* multiple knowledge sources.

Like code and descriptions.

Blending (Havasi et al., IEEE Intelligent Systems 2009)
Procedure Space Blends
Code and Descriptions

- Zones Annotations
- Code Features
  - static analysis now, dynamic analysis soon?
- Commonsense Knowledge
- Domain Knowledge

Diagram:
- English features
- ConceptNet
- domain-specific knowledge
- code fragments
  - English concepts
  - code structural features
  - Static Analysis
  - Purpose Annotations
Search Results

Users searched for:

- gravity
- follow player

Neither result was annotated.
Related Ideas

• Keyword Programming: Match keywords, align types, synthesize code. (Little and Miller, ASE ’07)

• Example-Centric Programming: integrated search for examples (Brandt et al., CHI ’10)
Natural Language Programming

• Many attempts to formalize or restrict natural language.

• But that’s unnatural!
Natural Language Programming

• Many attempts to formalize or restrict natural language.

• But that’s unnatural!

• Imprecision is a feature.
Tests, not code?
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Do not hallucinate.

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Builder
Let programmers be informal!
Have you heard of x?

- Probably not.
- Talk afterwards, or email: kcarnold@mit.edu
- (thanks, Professor Forrest)
Getting familiar with existing programs
Try on Python, Java, ... the essence of the analysis is simple