ELEUSIS
Bridging the three ILLC areas

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January 28, 2011
What is ELEUSIS?

- **Inductive inference game**
  invented by Robert Abbott in 1956.

- Related to:
  - Formal Languages
  - Language Learning
  - Inductive Inference
  - Reasoning
  - Complexity theory
  - Syntax
  - Parsing
  - Game theory
  - Natural Language Semantics
  - Logic representation of Natural Language Expressions
  - ...


Example

black red black red ...
Inducting Inference

Goal: Finding the rule!

Step 1: define a set of plausible rules
Step 2: collapse equivalent rules
Step 3: select those that fit the sequence of accepted and rejected cards (if any).
Step 4: (if many) propose the card which eliminates most of the hypotheses.
Formalizing Rules

Card* × Card → \{YES, NO\}

Previously accepted cards

Proposed card

Accepted/Rejected

\[\text{Card}^* \rightarrow \{\text{YES, NO}\}\]
# Rule Syntax

<table>
<thead>
<tr>
<th>Types</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOOLEAN</td>
<td>CARD → proposed( )</td>
</tr>
<tr>
<td>CARD</td>
<td>CARD → last( )</td>
</tr>
<tr>
<td>COLOR</td>
<td>INTEGER → acceptedCards( )</td>
</tr>
<tr>
<td>SUIT</td>
<td>BOOLEAN → isEven( CARD )</td>
</tr>
<tr>
<td>INTEGER</td>
<td>COLOR → getColor( CARD )</td>
</tr>
<tr>
<td>...</td>
<td>BOOLEAN → COLOR == COLOR</td>
</tr>
<tr>
<td>...</td>
<td>BOOLEAN → COLOR != COLOR</td>
</tr>
<tr>
<td>...</td>
<td></td>
</tr>
</tbody>
</table>
Rule Syntax

getColor( proposed() ) != getColor( last() )
Defining Rules

• Given a grammar we can generate all rules it can produce (of a certain length).

• Select **only and all** the ones which are **plausible**.

  \[
  \text{isEven}(\text{proposed}()) \quad \text{OK}
  \]

  \[
  \text{!isEven}(\text{proposed}()) \iff \text{isOdd}(\text{proposed}()) \quad \text{OK}
  \]

  \[
  \text{!!!isEven}(\text{proposed}()) \quad \text{NO!}
  \]
Which rule syntax

Idea: should be close to the way we formulate rules using natural language expressions.

• “The color of the proposed card should differ from the color of the previous card.”
  
  \[
  \text{getColor( proposed() ) } \neq \text{getColor( last() )}
  \]

• “The last card and the previous card should differ in color.”
  
  \[
  \text{differentColor(proposed(), last())}
  \]

• “Black, Red, Black, Red, ...”
  
  \[
  \text{cycle(2, isBlack(proposed()), isRed(proposed()))}
  \]
Rule Complexity

- `isEven(proposed())`
- `differentColor(proposed(), last())`
- `true()`
- ...

Simple  |  Complex
Empirical Study

• Building an **online game** for playing Eleusis.

• Collect rules players invent. Good for building a syntax.

• Record game sessions.

• Empirical study of complexity: how easily players guessed each rule.
Testing Rule Interface

Try it out, and send us your favorite rules!
Bridging the gap

LaCo
- Formal Languages
- Language Learning
- Syntax
- Parsing
- ...

LoLa
- Natural Language Semantics
- Logic representation of Natural Language Expressions
- ...

LoCo
- Reasoning
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...
LaCo
LoLa
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...