A General Learning Theory and its Application to Schema Abstraction
Contents

- The ACT system
  - An Example of a production system
- Learning in ACT
  - Designation
  - Generalization and discrimination
  - Production strength
- Application to Schema Abstraction
The ACT System

- **ACT System**
  - Is a computer simulation program
  - Use propositional network to represent knowledge of general facts
  - A set of productions to represent procedural knowledge

- **Basic control structure**
  - Production selection phase
  - Execution phase
An Example of a production System

P1: IF the goal is to add LVnumber1 and LVnumber2
      and LVnumber1 begins with a LVdigit1
      and LVnumber2 begins with a LVdigit2
      THEN the subgoal is to then add LVdigit1 and LVdigit2

P2: IF the subgoal is to add LVdigit1 and LVdigit2
      and LVsum is the sum of LVdigit1 and LVdigit2
      THEN the subgoal is to put out LVsum

P3: IF the subgoal is to put out LVsum
      and the subgoal is to add LVdigit1 and LVdigit2
      THEN write LVsum
      and the subgoal is to add the digits after LVdigit1 and LVdigit2

P4: IF the subgoal is to put out LVsum
      and the subgoal is to add LVdigit1 and LVdigit2
      and there is a carry
      and LVsum1 is the sum of LVsum plus 1
      THEN write LVsum1
      and the subgoal is to do the digits after LVdigit1 and LVdigit2
      and remove the carry flag

P5: IF the subgoal is to put out LVsum
      and the subgoal is to add LVdigit1 and LVdigit2
      and LVsum is greater than 9
      and LVsum is the sum of LVdigit1 and 10
      THEN write LVdigit0
      and the subgoal is to do the next digits after LVdigit1 and LVdigit2
      and set the carry flag

P6: IF the subgoal is to put out LVsum
      and the subgoal is to add LVdigit1 and LVdigit2
      and there is a carry
      and LVsum is greater than 9
      and LVsum is the sum of LVdigit1 and 9
      THEN write LVdigit3
      and the subgoal is to do the digits after LVdigit1 and LVdigit2

P7: IF the subgoal is to put out the digits after LVdigit1 and LVdigit2
      and the LVdigit1 is followed by a LVdigit3
      and the LVdigit2 is followed by a LVdigit4
      THEN the subgoal is to add LVdigit1 and LVdigit2

P8: IF the subgoal is to add the digits after LVdigit1 and LVdigit2
      and the goal is to add LVnumber1 and LVnumber2
      and LVnumber1 ends with the LVdigit1
      and LVnumber2 ends with the LVdigit2
      THEN the goal is satisfied
An Example of a production System

Let's consider how production set would apply to the addition problem of 32+18

P1: the goal is to add \( L\text{V}number1 \) and \( L\text{V}number2 \)
   = the goal is to add 32 and 18
   \( L\text{V}number1 \) begins with a \( L\text{V}digit1 \) = 32 begins with a 2
   \( L\text{V}number2 \) begins with a \( L\text{V}digit2 \) = 18 begins with a 8

Then, P2 \( \rightarrow \) P5 \( \rightarrow \) P7 \( \rightarrow \) P2 \( \rightarrow \) P4 \( \rightarrow \) P8

The principle of specificity
- If two productions match but the condition of one of them is a subset of the condition of the other, then production with the larger number of conditions will apply
Learning in ACT

- **Designation**
  - Refers to the ability of productions to call for the creation of new productions

- To understand LISP encoding rule, ACT uses procedural knowledge

LISP Encoding Rule

1. If an expression is a number it is an atom.
2. If an expression is a literal (a string of characters) it is an atom.
3. If an expression is an atom it is an S-expression.
4. If an expression is a dotted pair, it is an S-expression.
5. If an expression begins with a left parenthesis, followed by an S-expression, followed by a dot, followed by an S-expression, followed by a right parenthesis, it is a dotted pair.

<table>
<thead>
<tr>
<th>P9</th>
<th>IF there is a sentence beginning: &quot;IF an expression is a LVword...&quot; and LVconcept is the concept for LVword THEN save an object is a LVconcept for a new condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>P10</td>
<td>IF the sentence ends: &quot;...it is a LVword&quot; and LVconcept is the concept for LVword and LVcondition is the saved condition THEN BUILD IF LVcondition THEN it is a LVconcept</td>
</tr>
<tr>
<td>P11</td>
<td>IF there is a sentence beginning: &quot;IF an expression begins with a LVword...&quot; and LVconcept is the concept for LVword THEN save IF an object begins with an LVconcept for a new condition and LVconcept is the last concept</td>
</tr>
<tr>
<td>P12</td>
<td>IF the sentence continues: &quot;...followed by a LVword&quot; and LVconcept is the last concept and LVconcept1 is the concept for LVword THEN add the LVconcept1 is before a LVconcept to the new condition and LVconcept1 is the last concept</td>
</tr>
</tbody>
</table>

A set of productions
Learning in ACT

- If P9 → P10 is applied, you can create new production

P13 : IF an object is a @NUMBER
      THEN IT IS AN @ATOM
Learning in ACT

- Generalization and discrimination
  - Refer to complementary processes that produce better performance by either extending or restricting the range of situation in which a production will apply

- Generalization

  P16: IF a *triangle* is to the right of a *circle* and a *square* is to the right of a *heart* and the first pair is *above* the second pair
  THEN this is an instance of the study material

  P17: IF a *circle* is to the right of a *triangle* and a *square* is to the right of a *heart* and the first pair is *above* the second pair
  THEN this is an instance of the study material

  P18: IF a *LVshape1* is to the right of a *LVshape2* and a *square* is to the right of a *heart* and the first pair is *above* the second pair
  THEN this is an instance of the study material

  P19: IF a *LVshape1* is to the right of a *LVshape2* and a *LVshape3* is to the right of a *LVshape4* and the first pair is *above* the second pair
  THEN this is an instance of the study material

→ No more than a half of the constants in the production can be replaced in
Learning in ACT

- **Discrimination**
  - to correct overgeneralization
  - A production can be made either by adding clauses to the condition or by replacing variables

P23: IF a stimulus has two large red triangles THEN it is in category A

P24: IF a stimulus has two large blue circles THEN it is in category A

P25: IF a stimulus has two \textcolor{red}{LVcolor} \textcolor{red}{LVshape} THEN it is in category A

P26: IF a stimulus has two large \textcolor{red}{LVshape} THEN it is in category A

P27: IF a stimulus has two large \textcolor{red}{LVcolor} circles THEN it is in category A
Learning in ACT

- Production strength
  - To perform the evaluation of competing production
  - The first time production is created, strength is 0.1
  - If production is recreated, strength is incremented by 0.05. Furthermore by 0.025
  - Receiving error feedback, strength is reduced by $\frac{1}{4}$
Application to Schema Abstraction

- Schema Abstraction
  - Studying prototype of formation

- ACT framework
  - Forming concept by the action of a general set of production
  - Forming concept by the action of the automatic learning mechanisms of generalization, discrimination, and strengthening
  - ACT’s automatic learning mechanisms is a straightforward application to schema abstraction