Psychology and the internet: An European Perspective

Computerized Adaptive Psychological Testing
A Personalisation Perspective

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Introduction

• Mixed Model of IRT and ES
  – ES
  – IRT-based CAT
  – Manage the selection of test questions according to both ES rules and IRT parameters with priority to the first ones
  – Main benefit
Basic CAT Algorithm

Logic:

✓ find out the “best” next item
✓ administer the "best" next item and get the examinee’s respond
✓ a new ability estimate is computed based on the responses to all of the administered items
✓ steps 1 through 3 are repeated until a stopping criterion is met
IRT-model

\[ I_i(\Theta) = \frac{P_i'(\Theta)^2}{P_i(\Theta)(1 - P_i(\Theta))} \]

\[ \Theta_{s+1} = \Theta_s + \frac{\sum S_i(\Theta_{s+1})}{\sum I_i(\Theta_{s+1})} \]

\[ S_i(\Theta) = (u_i - P_i) \frac{P_i'}{P_i(1 - P_i)} \]

\[ P(\Theta) = c + \frac{1 - c}{1 + \exp(-\alpha(\Theta - b))} \]
Computer Adaptive Testing

- Key Technical and Procedural Issues
  - Balancing content
  - Administering items belong to sets
  - Examinee Considerations
  - Item exposure
  - Item pool size
  - Shifting parameter estimates
  - Stopping rules
Computer Adaptive Testing

Potential

• Significantly less time both for examinee and administrator is needed since fewer items are needed to achieve acceptable accuracy
  – CATs can reduce testing time by more than 50% while maintaining the same level of reliability
  – fatigue reducing

• CATs can provide accurate scores over a wide range of abilities while traditional tests are usually most accurate for average examinees
Computer Adaptive Testing

Limitations

- CATs are not applicable for all subjects and skills.
- CATs require careful item calibration.
- With each examinee receiving a different set of questions, there can be perceived inequities.
- Examinees are not usually permitted to go back and change answers.
- The answers of an examinee are analysed only according to their accuracy that imply a lack of personalisation.
Expert System

- ES as a tool of Artificial Intelligence
- Knowledge accumulation
- IF-THEN rules

Basic properties of ES

Accumulation and organization of knowledge

- High-quality experience utilization
- Knowledge representation in natural notation
- Ability to train and learn
- Ability to explain the decision
Basic Structure of an Expert System

- **User Interface**
- **Explanation Facility**
  - Interpreter
  - Scheduler (Rule Dispatcher)
  - Consistency Enforce
- **Knowledge Acquisition**
- **Workplace**
  - Input data
  - Results of inference
  - Temporary results
- **Knowledge Base**
  - Facts: What is known about the Domain Area
  - Rules: Logical Reference (e.g., Between Symptoms and Causes)

- **Inference Engine**
  - Draws Conclusions
Mixed Model of IRT and ES

- Manage the selection of test questions according to both ES rules and IRT parameters with priority to the first ones
Basic Model of VCAS

Visual Constructor of Adaptive Scripts

- Expert System
- HCI Module
- IRT model

Script Developer
(Psychologist)
GUI of VCAS

• Possibilities to:
  – create IF-THEN rules;
  – manage with IRT model
  – visualise tree-structure of cards when such structure exists
Advantages of the Mixed Model

• Aggregation of benefits from ES and CAT and overcoming of CAT limitations
  – analysing the answers not only according to their accuracy benefits
  – more sophisticated test script personalisation to an examinee, comparing to conventional CAT systems
Examples of ES & battery

• Use ES rules to define the problem and then provide an IRT-based test battery
• by switching between IRT and rules
Patterns of dissociation between operations predicted by the triple-code model of number processing (Cohen & Dehaene, 2000)

<table>
<thead>
<tr>
<th>Multiplication</th>
<th>Addition</th>
<th>Subtraction</th>
<th>Commentary</th>
</tr>
</thead>
<tbody>
<tr>
<td>×</td>
<td>–</td>
<td>–</td>
<td>Impaired rote verbal memory</td>
</tr>
<tr>
<td>–</td>
<td>–</td>
<td>×</td>
<td>Impaired quantity manipulations</td>
</tr>
<tr>
<td>×</td>
<td>×</td>
<td>–</td>
<td>Impaired rote verbal memory + reliance on rote memory for addition</td>
</tr>
<tr>
<td>–</td>
<td>×</td>
<td>×</td>
<td>Impaired quantity manipulations + reliance on quantity manipulations for addition</td>
</tr>
<tr>
<td>×</td>
<td>×</td>
<td>×</td>
<td>Global acalculia</td>
</tr>
<tr>
<td>×</td>
<td>–</td>
<td>×</td>
<td>Impossible pattern</td>
</tr>
<tr>
<td>–</td>
<td>×</td>
<td>–</td>
<td>Impossible pattern</td>
</tr>
</tbody>
</table>
Description of the patterns by the set IF-THEN rules in an Expert System

<table>
<thead>
<tr>
<th>IF</th>
<th>Problems in</th>
<th>THEN Provide test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiplication</td>
<td>Impaired rote verbal memory</td>
<td></td>
</tr>
<tr>
<td>Subtraction</td>
<td>Impaired quantity manipulations</td>
<td></td>
</tr>
<tr>
<td>Multiplication AND Addition</td>
<td>Impaired rote verbal memory AND reliance on rote memory for addition</td>
<td></td>
</tr>
<tr>
<td>Addition AND Subtraction</td>
<td>Impaired quantity manipulations + reliance on quantity manipulations for addition</td>
<td></td>
</tr>
<tr>
<td>Multiplication AND Addition AND Subtraction</td>
<td>Global acalculia</td>
<td></td>
</tr>
<tr>
<td>(Multiplication AND Subtraction) OR Addition</td>
<td><strong>ERROR</strong> in the set of facts in the working memory of ES: Impossible pattern</td>
<td></td>
</tr>
</tbody>
</table>
Application to NEURE

• What is NEURE?
  – Netexperimental generation tool
  – Tool for computer-aided assessment and rehabilitation at developmental disorders, namely learning disorders and cognitive disabilities in perception

• Why to NEURE?

• Where to NEURE?
Preliminary results

- Mixed model is implemented with Java programming tools
- Integration process with NEURE, namely with TaskEditor part is going on
Future work: Main Focus

• Problems of classification, feature extraction, etc.
• Neural Networks as a tool for run-time data processing
• Adaptive selection of a tool to provide an improved script adaptiveness
Extended conceptual VCAS Model

- Classification
- Neural Networks
- Data Mining
- A priori information about class hierarchy
- Run-Time Data
- Run-Time Script Generator
- LDA
- Repository of Statistic Data
- KDB
- Feature Extraction
- Data Mining
- Script Developer (Psychologist)
- HCI Module
- IRT model
- GUI
- Classification Feature Extraction
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