Evaluating UML Class Diagram Layout based on Architectural Importance

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Problem Description

- Investigate new layout guidelines for UML class diagrams considering architectural importance

- Architectural importance in a UML class diagram is identified by control, boundary and entity class stereotypes
Hypothesis

- Layout of UML class diagrams based on architectural importance is more helpful in system comprehension compared to layouts focusing primarily on aesthetics and/or abstract graph guidelines.
Approaches

- **Layout algorithms**
  - Eiglsperger et al., Eichelberger, Gutwenger et al.,
  - Sun et al.

- **User Aesthetics and Empirical Studies**
  - Purchase et al., Ware et al.

- **Navigation**
  - Musial et al.
Pilot Study Design

**Preparation**
- Questionnaire
  - Classify into 3 groups

**Experiment**
- Comprehension
  - 20 questions
- Preference
  - 7 questions

**Analyses**
- Results

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<table>
<thead>
<tr>
<th></th>
<th>Number of subjects</th>
<th>Number of groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>Controlled</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Uncontrolled</td>
<td>9</td>
</tr>
<tr>
<td>Subject's Level</td>
<td>Expert</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Intermediate</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Basic</td>
<td>8</td>
</tr>
<tr>
<td>Familiarity with Hippodraw</td>
<td>Very Familiar</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Somewhat Familiar</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Not Familiar</td>
<td>15</td>
</tr>
</tbody>
</table>
Study Details

- The study used HippoDraw (approx. 200 classes)
- Questions were multiple choice and related to maintenance, identifying the role of a class and refactoring
- Each quantitative question had a time limit
  - Speed and accuracy of each participant's response was recorded
- Qualitative questions had no time limit
Layouts Used

Orthogonal Layout

Layout 1
(Multiple Clusters)

Layout 2
(3 Clusters)
Results on Comprehension

Comparing 3 class diagram layouts for comprehension

<table>
<thead>
<tr>
<th>Layout Type</th>
<th>Number of subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial Layout</td>
<td>1</td>
</tr>
<tr>
<td>Layout using multiple clustering based on B/C/E stereotypes</td>
<td>3</td>
</tr>
<tr>
<td>Layout using 3 clusters each containing B, C or E</td>
<td>6</td>
</tr>
</tbody>
</table>

Legend:
- Green: Expert
- Blue: Intermediate
- Grey: Basic
Results on Aesthetics

Comparing 3 class diagram layouts for preference

- Industrial Layout
- Layout using multiple clustering based on B/C/E stereotypes
- Layout using 3 clusters each containing B, C or E

Number of subjects

Expert | Intermediate | Basic
Results on Refactoring Questions

Clustered layout helped in answering questions based on refactoring.
Result Distribution for 18 questions – Intermediate Level

Distribution of answers to 18 questions at the intermediate level

Percentage of correct, incorrect and unanswered questions

- **Industrial Layout**
  - Correct: 50%
  - Incorrect: 25%
  - No answer: 25%

- **Layout using multiple clustering based on B/C/E stereotypes**
  - Correct: 50%
  - Incorrect: 25%
  - No answer: 25%

- **Layout using 3 clusters each containing B, C or E**
  - Correct: 60%
  - Incorrect: 15%
  - No answer: 25%
Result Distribution for 18 questions – Expert Level

Distribution of answers to 18 questions at the expert level

Percentage of correct, incorrect and unanswered questions

Industrial Layout

Layout using multiple clustering based on B/C/E stereotypes

Layout using 3 clusters each containing B, C or E

- correct
- incorrect
- no answer
Results on Colors and Stereotype Annotations Used

Distribution of subjects on the matter of colors and text annotations for stereotypes

- **Helped**: 9 (Expert: 4, Intermediate: 4, Basic: 1)
- **Caused Problems**: 7 (Expert: 3, Intermediate: 3, Basic: 1)
- **Did not help**: 8 (Expert: 4, Intermediate: 3, Basic: 1)
Results

- Most participants preferred clustered layouts, however experts preferred multiple clusters to single clusters

- Numbers show no preference for curved lines but comments indicated that curved lines quickly brought attention to the dependency relationship

- The group with the multiple cluster layout had less unanswered questions than the other two groups
Conclusions

- This study shows support for our hypothesis

- Clustered layouts were found to be more helpful in answering questions and in system comprehension