Modeling and Analysis of Controller’s Taskload in Different Predictability Conditions

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Outline

• Experiment Design
• Visualization of ATCO Interaction
• Taskload Model
• Calculation of Air Traffic Complexity Factors
• Results
• Taskload Analysis
• Future Work
Experiment Design

- 18 sets of data (each took around 2 hours)
- 6 sectors controlled by 6 controllers
- 3 different i4d equipage levels
  - 0% (zero automation level) – in 7 scenarios
  - 50% (medium automation level) – in 8 scenarios
  - 80% (high automation level) – in 3 scenarios
- In one scenario wind effects were considered
- In one scenario the aircraft appeared on screen by a little time difference
- Data consisted of controllers’ activity on radar screen (e.g. mouse clicks)

Figure is drawn using [http://daim.lfv.se/echarts/](http://daim.lfv.se/echarts/)
Visualization of ATCO Interaction with Radar Screen

SCN-5-0%

SCN-8-0%

SCN-12-80%

SCN-15-80%
Research Question

• Do the controllers actually benefit from a mixed-i4D equipped environment, having less taskload?

• Could different levels of i4D equipage affect controllers’ taskload to various extents?
Modeling Taskload (step I)


Model A

- $f_1(x)$
- $X$: Complexity Factors
- $Y$: Controllers CPDLC activity

The current work

Model 1-a

- $g_1(x)$
- $X$: Complexity Factors
- $Y$: Controllers Clicks

Model 1-b

- $g_2(x)$
- $X$: Complexity Factors + i4D equipage
- $Y$: Controllers Clicks
Modeling Taskload (step II)

Work of J. Djokic (2010)

\[ Y = \beta_0 + \sum_{i=1}^{n} \beta_i X_n \]

\[ Y = \lambda_b \times \tau_b + \lambda_c \times \tau_c + \lambda_t \times \tau_t + \lambda_r \times \tau_r \]

\[ \tau_b : \text{typical duration of a background task} = 2 \text{ seconds} \]
\[ \tau_c : \text{typical duration of a control task} = 50 \text{ seconds} \]
\[ \tau_t : \text{typical duration of a transitioning task} = 10 \text{ seconds} \]
\[ \tau_r : \text{typical duration of a recurring task} = 3 \text{ seconds} \]
\[ \lambda : \text{average occurrence frequency of a task in the whole experiment} \]
Calulation of Complexity Factors
Issue to Deal With: Boundary Effect
Typical Solution: Grid Shift
Calculation Strategy

• At each time step, all aircraft pairs within 5nm distance are found

• The ones that share one or two aircraft are gathered into a cluster

• The complexity factor is calculated for every cluster and the average is considered for the whole sector
## Models’ Effectiveness

### Implemented on En-route Sector

<table>
<thead>
<tr>
<th>Models</th>
<th>A</th>
<th>B</th>
<th>1-a</th>
<th>1-b</th>
<th>2-a</th>
<th>2-b</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2$</td>
<td>0.13</td>
<td>0.16</td>
<td>0.19</td>
<td>0.22</td>
<td>0.62</td>
<td>0.63</td>
</tr>
</tbody>
</table>

### Implemented on Terminal Sector

<table>
<thead>
<tr>
<th>Models</th>
<th>A</th>
<th>B</th>
<th>1-a</th>
<th>1-b</th>
<th>2-a</th>
<th>2-b</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2$</td>
<td>0.13</td>
<td>0.16</td>
<td>0.12</td>
<td>0.12</td>
<td>0.84</td>
<td>0.82</td>
</tr>
</tbody>
</table>
Results – (En-route)
Results – Cumulative Sum Plots in En-route Sector
Taskload Comparison

- **Blue**: medium automation level

- **Green**: medium automation level but aircraft had appeared with a little time difference

- **Red**: medium automation level, wind effects are considered
Future Work

• To consider cognitive processes and consider cognitive workload in the workload model.

• To consider controllers human factors characteristics differences in terms of experience, age etc. in workload model.
Future Work (continued)

• Analyze cognitive load by comparing ATCO eye-gazing activity with mouse clicks
Thank You