Avoiding Drill-down Fallacies with VisPilot: Assisted Exploration of Data Subsets

Doris Jung-Lin Lee, Himel Dev, Huizi Hu, Hazem Elmeleegy, Aditya Parameswaran
### Overall Population

<table>
<thead>
<tr>
<th>Candidate</th>
<th>Age</th>
<th>Edu</th>
<th>City</th>
<th>Gender</th>
<th>Income</th>
<th>Race</th>
<th>Candidate Voted</th>
<th>% of Vote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinton</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>Trump</td>
<td>46</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

### African-American

<table>
<thead>
<tr>
<th>Candidate</th>
<th>Age</th>
<th>Edu</th>
<th>City</th>
<th>Gender</th>
<th>Income</th>
<th>Race</th>
<th>Candidate Voted</th>
<th>% of Vote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinton</td>
<td>89</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>89</td>
<td></td>
</tr>
<tr>
<td>Trump</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

The Drill-Down Lattice
The Drill-Down Lattice

Overall

Clinton | Trump | Other
--- | --- | ---
48 | 46 | 6

The diagram represents a lattice structure with vertices and edges connecting them, possibly illustrating a network or a decision-making process. The bar chart indicates the distribution of overall votes, with Clinton and Trump having significant votes compared to Other.
The Drill-Down Lattice

Gender = Female

Clinton: 54
Trump: 41
Other: 5
The Drill-Down Lattice

Gender = Female

0 25 50 75 100

Clinton Trump Other

54 41 5

State = California

0 25 50 75 100

Clinton Trump Other

63 32 5
The Drill-Down Lattice

Gender = Female

Age=65+

State = California

3
The Drill-Down Lattice

Gender = Female

Race = White

Age=65+

State = California
The Drill-Down Lattice
The Drill-Down Lattice
Lattice is HUGE!
Lattice is HUGE!
Lattice is HUGE!
Lattice is HUGE!
Lattice is HUGE!
Lattice is HUGE!
Lattice is HUGE!
Lattice is HUGE!
Lattice is HUGE!
Lattice is HUGE!

![Diagram showing a lattice structure with a symbol for Clinton, Trump, and Other, along with bar charts representing the percentage of vote for each category.](Image)
Lattice is HUGE!

% of vote

Clinton Trump Other

Clinton Trump Other

Clinton Trump Other

Clinton Trump Other

Clinton Trump Other
Lattice is HUGE!
Lattice is HUGE!
Outline

★ Challenges of Manual Drill-Downs
★ Design Objectives for Assistive Drill-Downs
★ System Overview: VisPilot
★ User Study Results
Present Challenges

Design Principles

VisPilot System

User Study

---

**Overall**

<table>
<thead>
<tr>
<th></th>
<th>Clinton</th>
<th>Trump</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>48</td>
<td>46</td>
<td>6</td>
</tr>
</tbody>
</table>

**Female**

<table>
<thead>
<tr>
<th></th>
<th>Clinton</th>
<th>Trump</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>54</td>
<td>41</td>
<td>5</td>
</tr>
</tbody>
</table>

**African-American**

<table>
<thead>
<tr>
<th></th>
<th>Clinton</th>
<th>Trump</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>89</td>
<td>8</td>
<td>3</td>
</tr>
</tbody>
</table>

**African-American Female**

<table>
<thead>
<tr>
<th></th>
<th>Clinton</th>
<th>Trump</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>94</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>
Uninformative reference visualizations result in Drill-Down Fallacy
Uninformative reference visualizations result in Drill-Down Fallacy
To ensure safety (avoid drill-down fallacy):
Select proper parent reference to compare against

\[ \min D \]
To find *salient* distributions:
Select visualizations that look different from its parents

\[
\max D
\]
★ Key Insight

A visualization is interesting if even its closest parent is unable to explain its behavior.

\[
\min D \{ \text{Safety} \} \rightarrow \max D \{ \text{Saliency} \}
\]
Select $k$ visualizations that are maximally salient, while enforcing $\geq 1$ informative parent for context.
Select k visualizations that are maximally salient, while enforcing $\geq 1$ informative parent for context.

Max-Utility Connected Subgraph Problem $\rightarrow$ NP-Hard!
Present Challenges

Design Principles

VisPilot System

User Study

Overall:
- Arrest: 6.22%
- Ticket: 69.9%
- Warning: 23.87%

Contraband Found: True
- Arrest: 41.21%
- Ticket: 54.3%
- Warning: 4.49%

Duration: 30+ min
- Arrest: 52.55%
- Ticket: 35.83%
- Warning: 4.62%

Driver Race: Asian, Contraband Found: True
- Arrest: 20%
- Ticket: 80%
- Warning: 0%

Contraband Found: True, Driver Age: 60 and over
- Arrest: 61.54%
- Ticket: 30.77%
- Warning: 7.69%
Study Methodology

★ Dashboard Generation Conditions

★ Study Tasks

Labeling

Prediction

Ranking

1. Age
2. Gender
3. Race
4. Income

...
Study Methodology

★ Dashboard Generation Conditions

★ Study Tasks

Gender = F

Gender = F & Age > 60

1. Age
2. Gender
3. Race
4. Income

Labeling

Prediction

Ranking
Study Methodology

Dashboard Generation Conditions

VisPilot

BFS

Cluster

Study Tasks

Labeling

Prediction

Ranking

1. Age
2. Gender
3. Race
4. Income

Gender = F
& Age > 60

Gender = F
Study Methodology

Dashboard Generation Conditions

VisPilot

BFS

Cluster

Study Tasks

Gender = F

Gender = F & Age > 60

Labeling

Prediction

Ranking

1. Age
2. Gender
3. Race
4. Income

....
Study Methodology

★ Dashboard Generation Conditions

VisPilot

BFS

Cluster

★ Study Tasks

Gender = F

Gender = F & Age > 60

Labeling

Prediction

Ranking

1. Age
2. Gender
3. Race
4. Income
Study Methodology

Dashboard Generation Conditions

Study Tasks

Gender = F
Gender = F & Age > 60

Labeling
Prediction
Ranking

1. Age
2. Gender
3. Race
4. Income
...
Study Methodology

★ Dashboard Generation Conditions

VisPilot

BFS

Cluster

★ Study Tasks

Gender = F & Age > 60

Labeling

Prediction

1. Age
2. Gender
3. Race
4. Income
...
Study Methodology

**Dashboard Generation Conditions**

**Study Tasks**

**Labeling**

**Prediction**

**Ranking**

1. Age
2. Gender
3. Race
4. Income

Gender = F & Age > 60
**Labeling**

1. Gender = F
2. Gender = F & Age > 60

**Prediction**

- Gender = F
- Age > 60

**Ranking**

1. Age
2. Gender
3. Race
4. Income

---

**VisPilot System**

<table>
<thead>
<tr>
<th>Condition</th>
<th>VisPilot</th>
<th>BFS</th>
<th>Cluster</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interesting</td>
<td>66</td>
<td>61</td>
<td>51</td>
</tr>
<tr>
<td>Not Interesting</td>
<td>10</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>Interesting (Normalized)</td>
<td>0.87</td>
<td>0.75</td>
<td>0.7</td>
</tr>
</tbody>
</table>

**Polishing Labeling**

- BFS
- Cluster

**Autism**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Police</th>
<th>Autism</th>
</tr>
</thead>
<tbody>
<tr>
<td>VisPilot</td>
<td>F 0.750</td>
<td>F 0.723</td>
</tr>
<tr>
<td></td>
<td>AP 0.867</td>
<td>AP 0.600</td>
</tr>
<tr>
<td>Cluster</td>
<td>0.739</td>
<td>0.725</td>
</tr>
<tr>
<td></td>
<td>0.691</td>
<td>0.665</td>
</tr>
<tr>
<td>BFS</td>
<td>0.739</td>
<td>0.222</td>
</tr>
<tr>
<td></td>
<td>0.592</td>
<td>0.200</td>
</tr>
</tbody>
</table>
Key Findings

★ Better Task Performance

VisPilot helps users in finding interesting vis, predicting unseen vis, and judging attribute importance.

★ More Informed Context

★ More Interpretable
Key Findings

★ Better Task Performance
VisPilot helps users in finding interesting vis, predicting unseen vis, and judging attribute importance.

★ More Informed Context
VisPilot leads to more contextual comparisons overall and against more informative contextual references.

★ More Interpretable
Key Findings

★ Better Task Performance

VisPilot helps users in finding interesting vis, predicting unseen vis, and judging attribute importance.

★ More Informed Context

VisPilot leads to more contextual comparisons overall and against more informative contextual references.

★ More Interpretable

VisPilot was described as more natural and “human-like”.

Conclusion

- Challenges of Manual Drill-Downs

Drill-Down Fallacy

- Design Objectives for Assistive Drill-Downs
- System Overview: VisPilot
- User Study Results
Conclusion

★ Challenges of Manual Drill-Downs
★ Design Objectives for Assistive Drill-Downs

Safety

\[
\min D \quad \left\{ \begin{array}{c}
\text{Female} \\
\text{African-American} \\
\text{African-American Female}
\end{array} \right. \\
\max D \quad \left\{ \begin{array}{c}
\text{Clinton Trump Other} \\
\text{Clinton Trump Other} \\
\text{Clinton Trump Other}
\end{array} \right.
\]

Saliency

★ System Overview: VisPilot
★ User Study Results
Conclusion

★ Challenges of Manual Drill-Downs
★ Design Objectives for Assistive Drill-Downs
★ System Overview: VisPilot

★ User Study Results
Conclusion

★ Challenges of Manual Drill-Downs
★ Design Objectives for Assistive Drill-Downs
★ System Overview: VisPilot
★ User Study Results
Avoiding Drill-down Fallacies with VisPilot: Assisted Exploration of Data Subsets

Doris Jung-Lin Lee, Himel Dev, Huizi Hu, Hazem Elmeleegy, Aditya Parameswaran

github.com/zenvisage/vispilot