TwinList

Visualizing List Differences

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Motivation

- Comparing list-based data
  - Which items are identical, similar or unique?
    - Similarity can be a function of multiple item attributes
  - Taking action: which items to keep and which to discard?

- Applications:
  - Medication list reconciliation
  - Comparison shopping
  - Lexical analysis (e.g. political rhetoric)
  - Gene comparison
# Real World Examples of List Comparison

**2011 Ford Fiesta**
SE 4dr Hatchback (1.6L 4cyl 5M)
Get a Free Price Quote

**2011 Toyota Corolla**
4dr Sedan (1.8L 4cyl 4A)
Get a Free Price Quote

## Pricing Summary

<table>
<thead>
<tr>
<th></th>
<th>Ford Fiesta</th>
<th>Toyota Corolla</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MSRP</strong></td>
<td>$15,520</td>
<td>$16,700</td>
</tr>
<tr>
<td><strong>Invoice</strong></td>
<td>$14,954</td>
<td>$15,782</td>
</tr>
</tbody>
</table>

## True Market Value

<table>
<thead>
<tr>
<th></th>
<th>Ford Fiesta</th>
<th>Toyota Corolla</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>$15,749</strong></td>
<td><em>Price with options</em></td>
<td><em>Price with options</em></td>
</tr>
<tr>
<td><strong>$16,783</strong></td>
<td><em>Price with options</em></td>
<td><em>Price with options</em></td>
</tr>
</tbody>
</table>

## Inventory

<table>
<thead>
<tr>
<th></th>
<th>Ford Fiesta</th>
<th>Toyota Corolla</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>102 vehicles available</strong></td>
<td>*</td>
<td><em>12 vehicles available</em></td>
</tr>
</tbody>
</table>

## Mechanical Features

### Base Engine

<table>
<thead>
<tr>
<th></th>
<th>Ford Fiesta</th>
<th>Toyota Corolla</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.6 L</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1.8 L</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Cylinders

<table>
<thead>
<tr>
<th></th>
<th>Ford Fiesta</th>
<th>Toyota Corolla</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inline 4</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Inline 4</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Drive Type

<table>
<thead>
<tr>
<th></th>
<th>Ford Fiesta</th>
<th>Toyota Corolla</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Example: Medication List Reconciliation

- Person X is taking various medications to treat both depression and high blood pressure
- X is admitted to the E.R. for chest pains; assigned regimen of blood thinners
- Before discharge, a physician compares medications assigned prior to admission with those administered as a result, checking for redundancies/conflicts
  - What if the E.R. medication is a duplicate of one X is already taking?
  - What if the blood thinners interact with the antidepressants?
Medication List Reconciliation

- Preventable adverse drug events (PADEs) account for 19% of post-treatment complications
- One study found that 94% of patients had medication errors, of which nearly all were caught by implementing a process for medication list reconciliation

- How can visualization facilitate this process?
  - Visualizing similarities/conflicts
  - Enabling workflow optimization via overview, zoom/filter, details on demand
  - Allowing users to take action (accept/reject medication)
<table>
<thead>
<tr>
<th>Patient Unique (Accept All)</th>
<th>Patient Similar (Accept All)</th>
<th>Identical (Accept All)</th>
<th>E.R. Similar (Accept All)</th>
<th>E.R. Unique (Accept All)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calcitrol</strong>&lt;br&gt;daily Supplement Rickets 0.25 mg PO</td>
<td><strong>Calcium Carbonate</strong>&lt;br&gt;TID CC Supplement Low Calcium 500 mg PO</td>
<td><strong>Darbepoetin</strong>&lt;br&gt;qFriday ESA Anemia 60 mg SC</td>
<td><strong>Calcium Carbonate</strong>&lt;br&gt;TID CC Supplement Low Calcium 1000 mg PO</td>
<td><strong>Ciproflaxocin</strong>&lt;br&gt;daily Antibiotic Infection 500 mg PO</td>
</tr>
<tr>
<td><strong>Meloxicam</strong>&lt;br&gt;daily NSAID Analgesic Pain 7.5 mg PO</td>
<td><strong>Ramipril</strong>&lt;br&gt;daily ACE Inhibitor High Blood Pressure 5 mg PO</td>
<td><strong>Atorvistatin</strong>&lt;br&gt;daily Statin High Cholesterol 40 mg PO</td>
<td><strong>Atorvistatin</strong>&lt;br&gt;daily Statin High Cholesterol 60 mg PO</td>
<td><strong>Omeprazole</strong>&lt;br&gt;daily Proton Pump Inhibitor Acid Reflux 40 mg PO</td>
</tr>
<tr>
<td><strong>Aspirin</strong>&lt;br&gt;daily Analgesic NSAID Pain 81 mg PO</td>
<td><strong>Docusate Sodium</strong>&lt;br&gt;BID Fecal softener Constipation 100 mg PO</td>
<td></td>
<td></td>
<td><strong>Ferrous Gloconate</strong>&lt;br&gt;TID Supplement Anemia 300 mg PO</td>
</tr>
</tbody>
</table>
Color

- Color helps identify user interaction - hover, select
- Use different colors for different lists
- Opposite hues (blue/yellow)

- Background colors:
  - Pale colors - avoid visual distraction
  - "Divergent" palette from identical to similar to unique
    - (blue <- green -> yellow)

- Highlight with stronger intensity colors to clearly show differences
Animation

Items are animated by moving to their respective locations, and the columns gradually change color to match the layout.

- 3-stage animation
  - Identical items
  - Unique items
  - Similar items

- The animation can be viewed in full or step-by-step
- The animation speed can be adjusted
Panels

Full control over several aspects of the interface

- Controls Panel
  - Size by, color by, group by, and sort by
  - Level of detail to show for each item

- Filters Panel
  - Filter by value for numerical and categorical items

- Options Panel
  - Font size, animation speed, and other options
Evaluation

- Goal: Improve features + design from qualitative feedback
- Method: User Experience (UE) evaluation scenario

- Test cases:
  - 2 MDs worked on medication reconciliation tasks
  - CS/HCI students explored the car data set
- Protocol:
  - Users watched a ~7 minutes demo video
  - Users encouraged to *think aloud*
  - Audio and screen captured during sessions
  - User filled out a questionnaire
Selected Results

Overall, users approved the 5-lists reconfiguration, highlighting of attribute differences and matching animations. Some issues:

- Medication reconciliation
  - Users wanted coupled acceptance/rejection of corresponding items in the Similar columns
  - Usability aspects, such as trouble to operate the Accept/Reject pop-up menu and gaps in the viewer with acceptance/removal of items
  - Trouble with the step-wise animation
- Car data set
  - Usability aspects, such as increasing the size of the viewer and automatic re-sizing while filtering

- **TwinList**: Compare Lists by separating items into 3 categories:
  - Identical: Same in both lists
  - Unique: Occur in only one list
  - Similar: Occur in both lists, but with differences

- **Support comparison with visualization:**
  - Spatial placement: 5-column layout separates categories
  - Animation: Demonstrates list matching, category placement
  - Color: Visual reminder and indicator of different lists/attributes

- **Evaluate through Usability Testing**
  - Generally positive comments from doctors and HCI students
  - Implemented some new features in response to expert needs
  - Interaction details still need to be perfected

**Thank You!**