A User-centred Taxonomy for Urban Transportation Application Visualization

The iCity case study
At the Visual Analytics Lab for iCity we are developing decision support tools combining social media and mobile data with GIS, demographic, socio-economic and transit data.

Image: iCity Visualization; **ESRI cityengine, Betaville**, Carl Skelton, Marcus Gordon, Carnevalle, Manpreet Juneja
This work & paper focuses on a design process adopted to create a taxonomy prototype & framework for application for user-centred visualization interfaces.

Image: iCity Visualization; Jeremy Bowes, Manpreet Juneja
Research approach & process

- Literature Review / taxonomy
- Comparative Methodology in Urban Transportation software applications, tools and methods
- Expert Interviews

Image: Design Process, iCity process phases, Jeremy Bowes, Manpreet Juneja
Definitions

Taxonomy

Taxonomy can thus be understood as meaning ‘laws of arrangement and division’.

Eg: Library, arrangement of books

A taxonomy provides researchers with a common language with which to categorize and review existing systems, classify new ones and address gaps towards further development. (Price, et al., 1993).
Key Findings

Comparative Methodology: A survey of the application landscape to understand the types of software, and toolsets that exist and the functions already being served.

Use Domains: Software Application Categories

- **User Stories & Narratives**
  - Navigation
  - Route Mapping
  - User Generated Data
  - Social Media Use

- **Transportation**
  - Traffic Movement
  - Parking Management

- **Urban Design: Built Environment**
  - Neighborhood Planning
  - Complete Streets

- **Data Analysis**
  - Intelligent Predictive Analysis
  - Simulation

- **Land Use**
  - Agent-based Micro-simulation

- **Entertainment & Games**
  - Interactive & Location Based Games
  - Mixed Reality

- **Infrastructure Management**
  - Signal & Transit Operations
  - Sustainability Resilient Cities

- **Mapping**
  - Cartography
  - Geo-Visualization

Image: Comparative Methodology, iCity process phases, Manpreet Juneja, Marcus Gordon, Jeremy Bowes
## Comparative Methodology Categories of Table

<table>
<thead>
<tr>
<th>Type of Urban System Application</th>
<th>Software</th>
<th>Technology / Platform</th>
<th>Description / application</th>
<th>User Type</th>
<th>Tasks (High Level)</th>
<th>Engagement Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qualitative and Quantitative Data Exploration and Analysis and Presentation Tool</td>
<td>StoryFacets</td>
<td>HTML, Javascript, D3 framework, Meteor, MongoDB</td>
<td>Explore data through interaction, visual history, presentation, generate consumable overviews, high level-search/browser, visualization dashboard, visualization slide shows,</td>
<td>technicians, transportation engineers, citizens, Business analysts</td>
<td>dataset/media asset navigation, dataset visualization, dataset history and analysis, dataset history visualization, decision support</td>
<td>expose ( consuming, learning and viewing) involve (interacting) analyze (finding trends) synthesis ( testing hypothesis) Decide (Deriving decisions),</td>
</tr>
</tbody>
</table>

### Interaction (Low level tasks)

- zooming inset, brushing and linking, scrolling, panning, filter, pivot, compare

### Data Visualization

- Bar chart, Pie chart, Gather plot, Markup language

### Data Attributes

- Categorical, Ordinal, Interval, Provenance, audio, video, text, image

### Open / Private Source

- Agnostic

### Data Format (input)

- Tabular, Markup

### File Format

- CSV (Comma Separated Values), Markdown

### Link

- storyfacets-test.herokuapp.com

### Contact

- Cody Dunne

This survey helped us in aggregating **User Types, Use Domains, User Tasks**, and the **type of Data** being used for Urban Transportation Applications, and we recorded the info into a large spreadsheet database.
The VAL research assistants Marcus Gordon, Davidson Zheng and Michael Carnevale, created a first iteration of a web based prototype. This allowed for the dataset modelled from the master spreadsheet, to be explored interactively.
Most approaches to establishing a visualization taxonomy essentially fell into three areas: **User Task**, **Level of Interaction** or Engagement and **Data Type**. (Mahyar, et al., 2015)
Research approach & process

- Use Case Survey
- Use Case Mapping
- Design Charrette, Priority identification / mapping

Thus, the challenge is to ensure diverse groups of users have appropriate levels of accessibility to data in usable forms, which in turn requires understanding the visualization needs of multiple user groups.
Definitions

Use Case

A use case is a **series of related interactions between a user** (or more generally, an “actor”) and a **system** that enables the user to achieve a goal.

Whether experts or casual users, different user groups can have varied information-seeking motivations and objectives, and desire **diverse representations** of urban data.

*Eg: Pedestrian searching a destination*
Use Case survey

User Type
Gender, Age, Nationality, Occupation

Application Scenario
Description of Tasks
Preconditions
Technology
Software, Environments and Frameworks
Assets
Formats, Functions

Task interaction
How are you using this software/tool?

Data Visualization
What is the visualization functionality of this software/tool?

Improvements
How could the software/tool be changed to support the required tasks?
Use Case Mapping

Selected Integrated Use Domain Example

Image: Use Case Mapping - Users, Tasks and Data, Jeremy Bowes, Manpreet Juneja, iCity Team
Design Charrette

Test Taxonomy Sketch
Establish priorities to build interface prototypes
Research approach & process

- User-Centred Taxonomy for Urban Transportation Applications - Template
- Applications and Visualization Prototype implementation

- Design a taxonomy prototype that qualifies **types of users**, **use domains** and detailed context of use, integrates **user engagement goals** with the essential components of visualization, and highlights the **end user** and their **intended interactions with the visualization**.

Image: iCity Visualization; Jeremy Bowes, Manpreet Juneja
# User-centred Taxonomy for Urban Transportation Applications

## User engagement goals

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**Context for User Engagement**

- **Engagements**
  - Decide (Deriving decisions)
  - Synthesize (Testing hypothesis)
  - Analyze (Finding Trends)
  - Author (Adding content)
  - Involve (Interacting)
  - Expose (viewing)

- **Tasks**
  - share, distribute, publish
  - derive, simulate,
  - explore, compare, encode, infer, survey, etc.
  - comment, query, upload
  - navigation, way finding, search, locate, games, etc

**Data Type**

<table>
<thead>
<tr>
<th>Data (Da/Ds)</th>
<th>Visual (Va/Vs)</th>
<th>Navigation (Na/Ns)</th>
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<tbody>
<tr>
<td>a/&lt;-&gt;a</td>
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<td>Ds/&lt;-&gt;Ns</td>
<td>Va/&lt;-&gt;Ns</td>
<td>Na/&lt;-&gt;Ns</td>
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</tbody>
</table>

**Visualization components**

**Feedback**

**Context for Interactive Controls in Visualizations**

- **High Level**
  - Representation Intent
  - Depict, Differentiate, Identify, Show outliers, Compare
  - Representation Technique
  - Charts, Graphs, Networks, Treemaps, Parallel Coordinates

- **Low Level**
  - Interaction Intent
  - Select, Explore, Reconfigure, Encode, Elaborate, Filter, Connect, Simulation, Authoring, Modelling
  - Interaction Technique
  - Selection, Brushing, Dynamic query, Pan/Zoom,...

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Image: Based on Pike (2009), Mahyar (2015) and Sorger (2015), iCity process phases, Taxonomy, iCity Team
Testing the Taxonomy template

Use Case – the architectural technician
This use case from our user group research depicts the technician working on the review of a rezoning proposition for a new building. Two main tasks occupy this technician’s work on such a project:

(1) the exploration of datasets, and
(2) analysis of land use, parking resources, and demographics.

Using our template taxonomy chart, we can first classify our user engagement goals with the technician as user and urban planning as use domain.

Use Domain of the Architectural Technician tasks
Use Case – the architectural technician

- technician is required to perform **quantitative data exploration and analysis** in order to determine if the building application in question would create any issues with parking lot spaces being overwhelmed by new users.

- the taxonomy’s **user engagement context** would classify this **technicians’ activity as analysis** and the **finding of trends**, (to unravel the patterns that will help the technician to generate decision support data for synthesis.)
Use Case – the architectural technician

- In Sorger et al.’s (2015) model-based taxonomy, integration is triggered through interaction.
- A source domain is what the user interacts with, and in the architectural technician example, these include sheets, tables, maps, and charts.
- The target domain is what is affected through the integration. If the source and target domains are the same, they are of coordination rather than integration. These tables, maps, and charts are both source and target domains in the case of the technician’s GIS software used.

<table>
<thead>
<tr>
<th>Data Type</th>
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<th>Spatial (s)</th>
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<tr>
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<table>
<thead>
<tr>
<th>Da/Ds</th>
<th>Visual (Va/Vs)</th>
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<td>Ds&lt;--&gt;Da  Ds&lt;--&gt;Ds</td>
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</tbody>
</table>

Source and Target Data Types of Use Case Example

Image: Based on Pike (2009), Mahyar (2015) and Sorger (2015), iCity process phases, Taxonomy, iCity Team
Use Case – the architectural technician

- The technician’s work in this use case involves **geospatial data**, making use of (a) abstract and (b) spatial data types.

- The use case also identifies the technician’s use of geographical information systems (GIS) software, web, and graphic frameworks.

- Components of the ArcGIS software gives the technician the ability to explore abstract data in the form of information visualizations and provides the technician with a host of spatial navigation features.

<table>
<thead>
<tr>
<th>Representation Intent</th>
<th>Interaction Intent</th>
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<tbody>
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<td>Depict, Differentiate, Identify, Show outliers, Compare</td>
<td>Select, Explore, Reconfigure, Encode, Elaborate, Filter, Connect, Simulation, Authoring, Modelling</td>
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<table>
<thead>
<tr>
<th>Representation Technique</th>
<th>Interaction Technique</th>
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</thead>
<tbody>
<tr>
<td>Charts, Graphs, Networks, Treemaps, Parallel Coordinates</td>
<td>Selection, Brushing, Dynamic query, Pan/Zoom,...</td>
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</tbody>
</table>

**Vizland** suggested options are added here

Image: Based on Pike (2009), Mahyar (2015) and Sorger (2015), iCity process phases, Taxonomy, iCity Team
The visualization landscape project (VIZLAND for short)
The ability to query keywords associated to these visualizations is to give the user quick access to matching keywords that relate to the visuals. This is done by the user typically matching functions that are prominent in selected visualizations.

Image Data Source: Severino Ribecca, Data Visualization Catalogue, VIZLAND development By Marcus Gordon, VAL
### USER CENTRED TAXONOMY

**Use Case – the architectural technician**

#### User Engagement Goals

<table>
<thead>
<tr>
<th>Use Domains</th>
<th>Context for User Engagement</th>
<th>Data Type</th>
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<td>Tasks</td>
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#### Visualization Components

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#### Context for Interactive Controls in Visualizations

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<tr>
<th>(High Level)</th>
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<td>Interaction Technique</td>
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<td><strong>Charts, Graphs, Maps, Networks, Tables, Roommaps, Parallel Coordinates</strong></td>
<td><strong>Selection, Brushing, Dynamic query, Pan/Zoom,...</strong></td>
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Conclusions

• These findings focused our approach to establishing a visualization taxonomy focused on three areas: User Task, Level of Interaction or Engagement and Data Type, and the detailed classification of interactive elements based on user tested needs for spatial and non-spatial data types within our research groups.

• The taxonomy prototype outlines a key framework to create a series of interactive dashboards that provide the integration of these functional user elements to provide visualization support for a variety of users.
Questions?
Acknowledgements
The authors gratefully acknowledge the support of OCAD University and the Visual Analytics Lab, Canada Foundation for Innovation, the Ontario Ministry of Research & Innovation through the ORF-RE program for the iCity Urban Informatics for Sustainable Metropolitan Growth research consortium; IBM Canada and MITACS Elevate for support of post-doctoral research; NSERC Canada CreateDAV, and Esri Canada and MITACS for support of graduate graduate internships; Artjem Disterhof at the Media2Culture (M2C) Institut für Angewandte Medienforschung at the University of Applied Sciences of Bremen for development work on the Betaville html5 prototype; the Rockefeller Foundation through its Cultural Innovation Fund; Microsoft Research; the Bundesministerium für Bildung und Forschung; and the department of Informatics of the City University of Applied Sciences, Bremen.
Bibliography


Bibliography


