A Tutorial on Mobile Visualization

Benjamin Watson  
*North Carolina State University*

Vidya Setlur  
*Tableau Research*
Download these apps!

Strava  Fitbit  Runkeeper

download your fitness app!
Agenda

• Part I
  – Introduction
  – Motivation
  – Guidelines and constraints
• Part II
  – Mobile visualization in the field
  – Applications
• Part III
  – Research
  – Open problems
• Discussion
• Wrap-Up
Agenda

• Part I
  – Introduction
  – Motivation
  – Guidelines and constraints
• Part II
  – Mobile visualization in the field
  – Applications
• Part III
  – Research
  – Open problems
• Discussion
• Wrap-Up
Ben Watson

- Background in virtual reality, computer graphics, visualization, HCI and user experience
- PhD from Georgia Tech GVU Center in 1997
- Currently at NC State University Computer Science
- Previously at Northwestern and University of Alberta
Vidya Setlur

- Background in computer graphics, mobile and natural language processing.
- PhD from Northwestern University in 2005
- Currently at Tableau Research
- Previously worked at Nokia Research for 7 years
Agenda

• Part I
  – Introduction
  – Motivation
  – Guidelines and constraints
• Part II
  – Mobile visualization in the field
  – Applications
• Part III
  – Research
  – Open problems
• Discussion
• Wrap-Up
What is information visualization?

“Transformation of the symbolic into the geometric” - McCormick et al., 1987

“... finding the artificial memory that best supports our natural means of perception.”
- Bertin, 1983

The depiction of information using spatial or graphical representations, to facilitate comparison, pattern recognition, change detection, and other cognitive skills by making use of the visual system.
Information visualization

• Problem:
  – HUGE Datasets: How to understand them?
• Solution
  – Take better advantage of human perceptual system
  – Convert information into a graphical representation.
• Issues
  – How to convert abstract information into graphical form?
  – Do visualizations do a better job than other methods?
Visualization is ubiquitous
Visualization success story

Mystery: what is causing a cholera epidemic in London in 1854?
Visualization success story

Illustration of John Snow's deduction that a cholera epidemic was caused by a bad water pump, circa 1854.

Horizontal lines indicate location of deaths.

Can it even fit on a mobile device? Almost sounds like an oxymoron.
Mobile dominates computing...

The smartphone industry dwarfs PCs

4bn people buying every 2 years instead of 1.6bn buying every 5 years

Quarterly unit shipments (m)

...so visualization must also be mobile
Mobile dominates computing...

...so visualization must also be mobile
Mobile makes data...

...it would be nice to view that data at its source
Mobile makes data...

...it would be nice to view that data at its source
Mobile will control our things...

...monitoring and control of them all will need visualization
Mobile will control our things...

...monitoring and control of them all will need visualization
Mobile brings ever more info...

...visualization can help us manage and understand it
Mobile brings ever more info...

...visualization can help us manage and understand it
Agenda

• Part I
  – Introduction
  – Motivation
  – Guidelines and constraints
• Part II
  – Mobile visualization in the field
  – Applications
• Part III
  – Research
  – Open problems
• Discussion
• Wrap-Up
Goals of Information Visualization

• Make data more understandable
• Present information from various sides of the story
• Present information at several levels of detail
• Support visual comparisons
• Tell stories about the data
Why visualization?

People are good at
  - scanning
  - recognizing
  - remembering imagery
Graphical elements facilitate comparisons via
  - length
  - shape
  - orientation
  - texture
Animation shows changes across time
Color helps make distinctions
Aesthetics make the visual analysis process appealing
Visual principles

- Types of Graphs
- Pre-attentive Properties
- Visual Cues
Types of symbolic displays
(Kosslyn 89)

- Graphs
- Charts
- Maps
- Diagrams
Types of symbolic displays
(Kosslyn 89)

• Graphs
• Charts
• Maps
• Diagrams
Anatomy of a graph  (Kosslyn 89)

• Framework
  – sets the stage
  – kinds of measurements, scale, ...
• Content
  – marks
  – point symbols, lines, areas, bars, …
• Labels
  – title, axes, tic marks, …
Basic types of data

• Nominal (qualitative)
  – (no inherent order)
  – city names, types of diseases, ...
• Ordinal (qualitative)
  – (ordered, but not at measurable intervals)
  – first, second, third, ...
  – cold, warm, hot
• Interval (quantitative)
  – list of integers or reals
Common graph types

Image Source: http://d3js.org
When to use which type?

- Line graph
  - x-axis requires quantitative variable
  - Variables have contiguous values
  - familiar/conventional ordering among ordinals
- Bar graph
  - comparison of relative point values
- Scatter plot
  - convey overall impression of relationship between two variables
- Pie Chart?
  - Emphasizing differences in proportion among a few numbers
Pre-attentive processing

• < 200 - 250ms qualifies as pre-attentive
  – eye movements take at least 200ms
  – yet certain processing can be done very quickly, implying low-level processing in parallel

• If a decision takes a fixed amount of time regardless of the number of distractors, it is considered to be preattentive.
Viewer can rapidly and accurately determine whether the target (red circle) is present or absent. Difference detected in color.
Viewer can rapidly and accurately determine whether the target (red circle) is present or absent. Difference detected in form (curvature)
Viewer *cannot* rapidly and accurately determine whether the target (red circle) is present or absent when target has two or more features, each of which are present in the distractors. Viewer must search sequentially.
Gestalt properties

- *Gestalt*: form or configuration
- Idea: forms or patterns transcend the stimuli used to create them.
Gestalt laws

• Law of Proximity
  – Stimulus elements that are close together will be perceived as a group

• Law of Similarity
  – like the preattentive processing examples

• Law of Common Fate
  – like preattentive motion property
    • move a subset of objects among similar ones and they will be perceived as a group
Which properties are appropriate for which information types?
Graphical Perception and Graphical Methods for Analyzing Scientific Data, Cleveland & McGill, 1985
How might mobile change vis?

+ = ?

[Graph showing financial trends]
Tech constraints

formats are wonderfully/ridiculously variable...
Tech constraints

...as are bandwidth and CPU
Tech implications

Mobile visualizations must respond to:

Aspect ratio
- much like most websites do

Bandwidth and rendering ability
- like the best websites do
Perceptual constraints

the obvious one: mobile displays are small
Perceptual constraints

their displays are dirty, and used while in motion
Perceptual implications

Mobile visualizations must be:

Easier to see
- only higher contrast detail
- only larger detail

Easier to understand
- only the most important info
- summarized info
Interactive constraints

another obvious one: touch not mice

user cannot see what they are interacting with

unlike desktop, the spatial resolution of mobile I and O are drastically different
Interactive constraints

input surface unstable

Users will often make mistakes during interaction
Interactive implications

Mobile visualizations must:

Offer simplified interactions
- fewer, simpler actions available
- correspondingly simpler visualizations

Maintain context and continuity
- animations for seamless transitions
- global undo when users get lost

Possibility of automatic highlighting of interesting features for interaction? See Healey’s work on guided tours of data.

Overviews and perhaps guided tours may be crucial to give users the “lay of the land”

Look to prior work on animated transitions in UI. Lowers mental load.

What happened to undo on mobiles? The industry is forgetting hard earned lessons.
Contextual constraints

users are traveling
Contextual constraints

users are interrupted and multitasking
Contextual implications

Mobile visualizations must:

Vary the “gain” of visuals and interaction
  ● amount of attention needed to
    ○ understand
    ○ navigate

Offer manual or automated gain control
  ● users can adjust gain as needed
  ● or better, sense context and adjust gain to match
Data constraints

data is noisy and incomplete
Data constraints

data often streams are live (e.g. traffic, social, finance)
Data implications

Mobile visualizations must:

“Wrangle” data just-in-time
  ● robustly display heterogenous data

Communicate (in)accuracies
  ● display margins of error
  ● time since last update
Agenda

• Part I
  – Introduction
  – Motivation
  – Guidelines and constraints
• Part II
  – Mobile visualization in the field
  – Applications
• Part III
  – Research
  – Open problems
• Discussion
• Wrap-Up
Phone is not just a device for making calls anymore!
How many of you remember using a GPS in your car?

Maps are fascinating - they align with one’s model of spatial context and historically cartographers have already been ahead of other viz folks in thinking thoughtfully about level of detail, semantic zoom and aspect ratios.
Now phones have become the predominant device for navigation. Pushing the limits is Google Glass.
It’s not just a smartphone that is a gateway to data. There has been an explosion of other smart connected devices like the Apple watch, Samsung watch, Nest, fitbit that either function as accessories to the mobile phone or stand-alone. Users are now even more empowered to see and understand the data that these devices collect and display.
In addition, there are specific ways in which people try to see and understand information - be it checking the stock price of their favorite company, the weather in Copenhagen, checking the important headlines, or in retrospective seeing the distance run and the calories burned. Each of these purposes have very specific ways of visualizing information.
With all these trends in wearables and mobile device data, there is a growing need for ways to analyze one’s own data.

Further, with the processing power of these devices going up, for the ‘executive on-the-go’ this will be the device for showing data analytics in different forms.
**Yellowfin BI**: An Aussie company that is taking over EMEA. USP: integrated collaboration. Offers offline support.

**Qlik Sense**: Completely built using HTML5. Is designed for touch/gestures, designed for different screen sizes

**Domo**: Very heavily service-dependent, but their solution is very well-rounded.

**Microsoft Power BI**: Only iOS

**Salesforce Wave**: Enterprise app. Offers dashboard authoring.
A visualization dashboard is a user interface that organizes and presents information in a way that is easy to read.

A dashboard can be used for presenting related vizes about data to tell a story or insight as seen in the first image.

It can also be used for monitoring changes or anomalies in the data by triggering certain actions when such an event occurs, as seen in the second image.

Images sources: Tableau Public, *Perceptual Edge* - Stephen Few
Mobile devices are becoming part of the dashboard ecosystem, both for presentation and for receiving monitoring updates.
Now, remember the apps we asked you to download?

Agenda

• Part I
  – Introduction
  – Motivation
  – Guidelines and constraints
• Part II
  – Mobile visualization in the field
  – Applications
• Part III
  – Research
  – Open problems
• Discussion
• Wrap-Up
Let's look into each of these in more detail. If you haven't used any of them, we strongly encourage you to try it out as you walk and bike in Copenhagen.
Strava lets you track your running/cycling activities riding with GPS, join challenges, share photos from your activities, and follow friends. It creates an interactive dashboard. Hovering on a row in the table will show the corresponding detail in the map. It will detect when you are resting and will automatically pause your run. Also shows elevation (last column).
Fitbit also has several views to see different aspects of one’s fitness profile.

It allows users to synchronize multiple Fitbit Trackers to their account through the mobile app.

Notice how certain vizes are used to visualize certain types of data: trend lines for time, bars for various categories and map for location.

The marks are interactive to display more information when one taps on them.

Less of a dashboard functionality though.
Runkeeper allows you to set personal goals and run routines. Rewards you with promotions with partners if you achieve your goal.
Now that we discussed the various state-of-the-art apps and tools for mobile visualization, let's look more into research and the sorts of interesting problems in this domain.

**Agenda**

- **Part I**
  - Introduction
  - Motivation
  - Guidelines and constraints
- **Part II**
  - Mobile visualization in the field
  - Applications
- **Part III**
  - Research
  - Open problems
- Discussion
- Wrap-Up
The first one is semantic resizing. When I say ‘semantic’ I mean that the resizing is not just a scale down of the original viz. The resizing is rather more thoughtful and driven by the important semantics of the underlying data.
Some of the common problems with too much data to visualize are overplotting as seen in the scatterplot (point to 1st image), a “spaghetti chart” when there are just too many lines, and a hairball of nodes and links in the last image. While these examples are problems in general, they become more pertinent when trying to render on a limited real estate such as a mobile device.
Visualization resizing is critical and required for the current use of visualizations (e.g., dashboards, mobile devices,

Too many variation to deal with resizing visualizations. (e.g., display resolution/size/application window width/aspect ratio/etc.)

Impossible for a visualization designer to consider every possible combination of these variation.

Needs to support a smarter way to adapt and represent a visualization based upon different scales.
How do we take a line chart like this and...
render for smaller sizes?

These are examples of line charts optimized in display for mobile.
motivation is cartographic generalization. Alan Maceachren has a great definition for this concept.

Cartographic generalization

• “Process of selecting and representing information of a map in a way that adapts to the scale of the display medium of the map.”

*How Maps Work, Alan Maceachren*
Going into more detail to give you an idea…

Generalization involves various set of operations for emphasizing visual primitives that are important and de-emphasizing the unimportant ones. For example, here, addition is used to add more detail to important portions of the map, while in contrast, elimination removes detail that just contributes to visual clutter.
Similarly, exaggeration is another way to emphasize data that is important - for example making certain lines in a line chart thicker to highlight just them.

Simplification on the other hand de-emphasized the visual primitives in the viz.
As I mentioned, overplotting is a common problem with data, especially on smaller screen sizes. These operators perform various types of aggregation to give visual cues that there is more than one data point under the aggregated mark.
These operations further help remove visual clutter and distractions to the user.
Marks are important elements in a viz. On small displays, the icons need to be recognizable and visually discriminable in order to function as effective data encodings. Here are some operators that help with that very goal.
Lastly, label operations help with readability and help with making labels function as effective references to the data marks. This would involve elimination to remove clutter, insertion and appearance to highlight something important in the viz at that scale, and positioning to readjust in the modified screen real-estate.
In summary <talk through the bullet points> and mention that from a research standpoint the emphasis part is not the hard problem. De-emphasizing portions of the viz, yet ensuring that it is analytically useful at that screen size is important.
Another way of managing the amount of information on a mobile screen is through the technique of overview + detail.

The basic idea with overview + detail visualizations is to enable viewers to see the object of primary interest presented in full detail while at the same time getting an overview–impression of all the surrounding information or context available.
TableLens presents a compact overview of large data sets, displaying all rows and columns simultaneously by encoding values as small bars. Fisheye effects are available to selectively expand rows and columns to reveal the attribute values of the associated data. Expansion can be applied independently to rows and columns, allowing multiple focal points, but preserving the familiar rectangular format of cells.

As users pan and zoom, display content can disappear into off-screen space, particularly on small-screen devices. The clipping of locations, such as relevant places on a map, can make spatial cognition tasks harder. Halo is a visualization technique that supports spatial cognition by showing users the location of off-screen objects. Halo accomplishes this by surrounding off-screen objects with rings that are just large enough to reach into the border region of the display window. From the portion of the ring that is visible on-screen, users can infer the off-screen location of the object at the center of the ring.

The last paper by (Doob-wa) and others, focusses on the
translation task, i.e. how to move the Detail view (displayed on the smartphone) on a 3D environment, the Overview (displayed on the public display).
The previous methods focus on techniques that are content dependent. How about separating layout and appearance?
So both of these are not optimal. In the first, you lose context, involves scrolling horizontally and vertically.

Second one, can't read.
Showing how dashboards can be made responsive to smaller sizes.

Filters to view one category or a subset of categories at a time.

Data aggregation, fonts and so forth.
What is it? A website layout that responds to a users’ device automatically.

- Adaptive, Responsive and Mobile are *somewhat* interchangeable ways of talking about the same thing.

(In general, they all intend to make it so that people viewing your site on a smart phone or tablet can navigate and read content without doing an excessive amount of pinching and zooming...that the experience is optimized for their device.)

industry may be ahead of us on responsive.
Uses CSS (style sheets) to display the content in the appropriate order, font, etc., depending upon device.

Separating content and appearance is the way to go. How can we describe data semantics, separately from appearance? Data is mapped to appearance in viz. But data may have to be augmented with importance and significance in some fashion. To start, perhaps manual. Later, automated would be great.
There are mainly three aspects of responsiveness...while

Aspects of responsiveness

• Layout - target sizes (desktop, tablet, phone)
• Data Semantics
• Interaction
With more devices come varying screen resolutions, definitions and orientations. New devices with new screen sizes are being developed every day, and each of these devices may be able to handle variations in size, functionality and even color. Some are in landscape, others in portrait, still others even completely square. As we know from the rising popularity of the iPhone, iPad and advanced smartphones, many new devices are able to switch from portrait to landscape at the user's whim. How is one to design for these situations?

Yes, it is possible to group them into major categories, design for each of them, and make each design as flexible as necessary. But that can be overwhelming, and who knows what the usage figures will be in five years?
A few years ago, when flexible layouts were almost a “luxury” for websites, the only things that were flexible in a design were the layout columns (structural elements) and the text. Images could easily break layouts, and even flexible structural elements broke a layout’s form when pushed enough. Flexible designs weren’t really that flexible; they could give or take a few hundred pixels, but they often couldn’t adjust from a large computer screen to a netbook. Now we can make things more flexible. Images can be automatically adjusted, and we have workarounds so that layouts never break (although they may become squished and illegible in the process). While it’s not a complete fix, the solution gives us far more options. It’s perfect for devices that switch from portrait orientation to landscape in an instant or for when users switch from a large computer screen to an iPad.
For extreme size changes, we may want to change the layout altogether, either through a separate style sheet or, more efficiently, through a CSS media query. This does not have to be troublesome; most of the styles can remain the same, while specific style sheets can inherit these styles and move elements around with floats, widths, heights and so on.

For example, we could have one main style sheet (which would also be the default) that would define all of the main structural elements, such as #wrapper, #content, #sidebar, #nav, along with colors, backgrounds and typography. Default flexible widths and floats could also be defined.

If a style sheet made the layout too narrow, short, wide or tall, we could then detect that and switch to a new style sheet. This new child style sheet would adopt everything from the default style sheet and then just redefine the layout’s structure.
Responsive table example.

Notice how the number of columns are reduced in the smaller table by performing temporal aggregation.
The number of columns displayed in the table below depends on the available screen space, by default; a smartphone will display 2 columns, for example, while an expanded desktop browser displays the full set. This is accomplished by assigning semantic classes to the column headings that indicate which data values take precedence (essential vs optional), in combination with media queries to display them at different screen widths (a.k.a., responsive design).

We added a bit of JavaScript logic so you can control which data is displayed by checking column names in the "Display" menu on the right. Once an option is checked, the associated data will persist and display at all screen widths until the option is unchecked.

You can also set a column to always persist by assigning a class in the markup, in which case it has no menu option. Here, the "Company" column is persistent.

<table>
<thead>
<tr>
<th>Company</th>
<th>Last Trade</th>
<th>Change</th>
<th>Prior Close</th>
<th>Open</th>
<th>Bid</th>
<th>1y Target Est</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOOG, Google Inc.</td>
<td>977.74</td>
<td>14.81</td>
<td>(2.54%)</td>
<td>982.55</td>
<td>987.05</td>
<td>977.73 x 100</td>
</tr>
<tr>
<td>AAPL, Apple Inc.</td>
<td>376.86</td>
<td>6.74</td>
<td>(1.64%)</td>
<td>383.60</td>
<td>381.00</td>
<td>375.60 x 980</td>
</tr>
<tr>
<td>AMZN, Amazon.com Inc.</td>
<td>101.55</td>
<td>3.35</td>
<td>(3.18%)</td>
<td>98.20</td>
<td>99.00</td>
<td>101.52 x 1000</td>
</tr>
<tr>
<td>ORCL, Oracle Corporation</td>
<td>31.15</td>
<td>1.41</td>
<td>(4.75%)</td>
<td>29.74</td>
<td>32.50</td>
<td>31.14 x 4500</td>
</tr>
<tr>
<td>MSFT, Microsoft Corporation</td>
<td>25.50</td>
<td>0.85</td>
<td>(3.37%)</td>
<td>24.65</td>
<td>20.70</td>
<td>25.50 x 7710</td>
</tr>
<tr>
<td>CSCO, Cisco Systems, Inc.</td>
<td>18.65</td>
<td>0.87</td>
<td>(5.45%)</td>
<td>17.78</td>
<td>19.23</td>
<td>18.65 x 10000</td>
</tr>
<tr>
<td>YHOO, Yahoo Inc.</td>
<td>13.81</td>
<td>0.11</td>
<td>(0.87%)</td>
<td>13.70</td>
<td>13.94</td>
<td>13.79 x 910</td>
</tr>
</tbody>
</table>
Here columns become rows - essentially pivoting or folding the table.

<table>
<thead>
<tr>
<th>Selector</th>
<th>IE7</th>
<th>IEB</th>
<th>IE9</th>
<th>FF 3.6</th>
<th>FF 4</th>
<th>Safari 5</th>
<th>Chrome 5</th>
<th>Opera 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>* selector</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>:before :after</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>:nth-of-type</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>incorrect</td>
</tr>
<tr>
<td>background-clip</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
<td>-webkit-</td>
<td>-webkit-</td>
<td>buggy</td>
</tr>
<tr>
<td>background-repeat</td>
<td>incomplete</td>
<td>incomplete</td>
<td>yes</td>
<td>incomplete</td>
<td>incomplete</td>
<td>incorrect</td>
<td>incorrect</td>
<td>yes</td>
</tr>
<tr>
<td>:selection</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>-moz-</td>
<td>-moz-</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Selector</th>
<th>* selector</th>
<th>before</th>
<th>after</th>
<th>:nth-of-type</th>
<th>background-clip</th>
<th>background-repeat</th>
<th>:selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE7</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>incomplete</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>IEB</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>complete</td>
<td>no</td>
</tr>
<tr>
<td>IE9</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>FF 3.6</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>incomplete</td>
<td>-moz-</td>
<td></td>
</tr>
<tr>
<td>FF 4</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>incomplete</td>
<td>-moz-</td>
<td></td>
</tr>
<tr>
<td>Safari 5</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>-webkit-</td>
<td>incorrect</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Chrome 5</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>-webkit-</td>
<td>incorrect</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Opera 10</td>
<td>yes</td>
<td>yes</td>
<td>incorrect</td>
<td>buggy</td>
<td>yes</td>
<td>yes</td>
<td></td>
</tr>
</tbody>
</table>
Table cards

<table>
<thead>
<tr>
<th>First Name</th>
<th>Last Name</th>
<th>Company</th>
<th>Job Title</th>
<th>Donation Amount</th>
<th>Location</th>
<th>Date of Birth</th>
<th>Arbitrary Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>James</td>
<td>Mathias</td>
<td>Infosys</td>
<td>Sales Accountant</td>
<td>$3200.00</td>
<td>Austin, TX</td>
<td>January 13, 1979</td>
<td>REX-12</td>
</tr>
<tr>
<td>Alicia</td>
<td>Harman</td>
<td>PayPal</td>
<td>Software Engineer</td>
<td>$4500.00</td>
<td>Sunnyvale, CA</td>
<td>July 19, 1968</td>
<td>N/A</td>
</tr>
<tr>
<td>Benjamin</td>
<td>Collington</td>
<td>Twitter</td>
<td>UX Designer</td>
<td>$1500.00</td>
<td>Costa Mesa, CA</td>
<td>February 22, 1975</td>
<td>TP-13</td>
</tr>
<tr>
<td>Cindy</td>
<td>Beyler</td>
<td>Tesla</td>
<td>Sales Representative</td>
<td>$3600.50</td>
<td>Chicago, IL</td>
<td>July 3, 1956</td>
<td>2441</td>
</tr>
<tr>
<td>Georgina</td>
<td>Hampton</td>
<td>Tableau Software</td>
<td>Product Manager</td>
<td>$3200.00</td>
<td>Seattle, WA</td>
<td>December 13, 1982</td>
<td>SST-43</td>
</tr>
</tbody>
</table>

The cards layout displays each row of the table as an index card. This layout gives you the flexibility to present your data in other ways than a horizontal row. You can customize the layout of the cards.
Perhaps there are columns that are all not important - analogous to the overview + detail idea. A visual indicator says that there is more info for each row.

<table>
<thead>
<tr>
<th>First name</th>
<th>Last name</th>
<th>Position</th>
<th>Office</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airi</td>
<td>Satou</td>
<td>Accountant</td>
<td>Tokyo</td>
</tr>
<tr>
<td>Angelica</td>
<td>Ramos</td>
<td>Chief Executive Officer (CEO)</td>
<td>London</td>
</tr>
<tr>
<td>Ashton</td>
<td>Cox</td>
<td>Junior Technical Author</td>
<td>San Francisco</td>
</tr>
<tr>
<td>Bradley</td>
<td>Greer</td>
<td>Software Engineer</td>
<td>London</td>
</tr>
<tr>
<td>Brenden</td>
<td>Wagner</td>
<td>Software Engineer</td>
<td>San Francisco</td>
</tr>
<tr>
<td>Brielle</td>
<td>Williamson</td>
<td>Integration Specialist</td>
<td>New York</td>
</tr>
<tr>
<td>Bruno</td>
<td>Nash</td>
<td>Software Engineer</td>
<td>London</td>
</tr>
<tr>
<td>Caesar</td>
<td>Vance</td>
<td>Pre-Sales Support</td>
<td>New York</td>
</tr>
<tr>
<td>Cara</td>
<td>Stevens</td>
<td>Sales Assistant</td>
<td>New York</td>
</tr>
<tr>
<td>Cedric</td>
<td>Kelly</td>
<td>Senior Javascript Developer</td>
<td>Edinburgh</td>
</tr>
</tbody>
</table>
Collapsing detail

Clicking on that visual indicator, shows you detail like this.
Different fonts with the same size occupy different amounts of pixels on the screen
The Dynamic Type lets developers specify which fonts to use at each font size. This allows them to select heavier weights when type is small, for example. Compare this to the example on the left which demonstrates a simple decrease in size of the headline weight only, and the one on the right which shows just the text font getting larger.
This is an example of a really wide Caltrain schedule. For example, in the evening after work, everytime this is loaded on the mobile device, a user has to pan to the appropriate time slot.
This is a video to show how location and time can ‘zoom’ into this really wide caltrain schedule so that the user can view the relevant schedule slot. This is an example to show how mobile context can further enhance the responsiveness of a viz.
The last topic concerns making mobile search easier and less time-consuming. This is another facet of information visualization, along the lines of using effective visual imagery for information retrieval.

Each erroneous click leads to backtracking and trying to find the information one needs.
Why visualize documents?

• To help with information retrieval
• Provide an overview of a collection
• Show a user what aspects of their interests are present in a collection
• Help user understand why documents retrieved as a result of a query

Searching for documents on a mobile isn’t fun. Whether these are files, web pages. From all the background you’ve heard so far, being able to visualize the contents of the documents quickly makes the experience less painful.
One key aspect of visualizing documents is by using icons.

Characteristics of visual summaries

• Memorable
• Semantic and visual depiction
• Advertising most interesting part of the viz.
• Semantically related to blog or underlying story
There’s a lot of related work in the space.

Enhanced thumbnails by Woodruff and others, combine the advantages of image thumbnails and text summaries.

Summary thumbnails contain enough readable text to allow users to identify the area containing the sought content. The user may then zoom in on the abstract or click the link for the complete story.

Visual snippets take different snippets of a web page: salient image, title.
This is some more related research. This is to show you that semantics is important when thinking of effective thumbnails…

These two papers are generating icons for files.

Though VisualDS are visually distinctive, they are not semantically relevant.

Semanticons might come up with some funny imagery (looking at this example of a Japanase VGA Driver file), and hence are memorable.
So, what are thumbnails used for in the visualization world?

Here is a screenshot of Tableau Public - an online website for people to upload their Tableau workbooks.
Now this problem of generating thumbnails for vizes becomes more pertinent for mobile. This is some research exploration I’ve been working on...

It’s still an open problem as viz saliency is an active research topic.

Here, do we show the outlier?
Or just a marijuana to make the icon more memorable?
Do we pick the most salient aspect of this chart such as the peak?
Or do we show a crop around the area where most of the activity lies such as the concentration of fires on the west coast of the US
Dashboards can get tricky. Do we scale down the entire dashboard to preserve recognizability or pick one viz from it?
Once we’ve thought about icons as tools for helping with search, there is also research to think about making the search experience itself better.

Here is some research on different facets of mobile search:

1st image: Using location as a context for search

2nd image: Trajectory-Aware Search predicts the user’s destination based on location data from the current trip traveling from purple triangle to red square, and shows search results near the predicted location.

3rd image: Using node link relationships to center around a data neighborhood.
While considerable work exists for fact-finding and browsing type of mobile searches, there is a third type which we call ‘imprecise search.’

In fact, this year at MobileHCI we have a paper called ‘GraphTiles’ describing how entities and relationships are leveraged to create search neighborhoods for supporting this type of search.
Agenda

• Part I
  – Introduction
  – Motivation
  – Guidelines and constraints
• Part II
  – Mobile visualization in the field
  – Applications
• Part III
  – Research
  – Open problems
• Discussion
• Wrap-Up
Techniques we need
Responsive visualization

That adjusts depictions to fit variations in display format
Honest visualization

That uses uncertainty visualization to tell users about data loss and noise in live streams.
“Variable gain” visualization

That uses transitional animations as well as adjustments in display mappings, data content and interaction complexity to respond to changes in technical, perceptual, cognitive and contextual mobile constraints. Taking lessons from map generalization.
Context-sensitive visualization

That uses mobile sensing to respond to changes in user state and context, reducing the degree of mechanical, perceptual and cognitive effort required when the user is in some way stressed or challenged.
Just-in-time visualization

That wrangles streaming data into something meaningful in real time, by using probabilistic methods to interpret heterogenous data, as well as prediction and smoothing to fill data gaps and smooth noise.
Potential apps for mobile vis
As society relies on mobile phones to become increasingly visual in its communication, so visualization will play an ever more important role in that communication. There is much research to be done on how visualization can be an effective tool in persuasion.
Search is now dominated by Google. But in fact there are many other apps that perform search in a niche: Amazon, IMDB, allmusic. We believe that mobiles, with all the unique constraints we’ve spoken of, are in need of such innovation.
How can we use visualization not to create, confirm or communicate knowledge, but to help viewers monitor its changes?
Agenda

• Part I
  – Introduction
  – Motivation
  – Guidelines and constraints
• Part II
  – Mobile visualization in the field
  – Applications
• Part III
  – Research
  – Open problems
• Discussion
• Wrap-Up
Agenda

• Part I
  – Introduction
  – Motivation
  – Guidelines and constraints
• Part II
  – Mobile visualization in the field
  – Applications
• Part III
  – Research
  – Open problems
• Discussion
• Wrap-Up
For more information

- <insert QR code for tutorial>:

- Ben Watson
  - bwatson@ncsu.edu
  - http://www.csc.ncsu.edu/people/bwatson

- Vidya Setlur
  - vsetlur@tableau.com
  - https://research.tableau.com/user/vidya-setlur
Thank you for coming to our tutorial. Hope you found it useful. Ending this evening with a funny anecdote!

"Rather than redesign our site to be responsive, we will require our customers to buy bigger mobile devices."