

Interaction & Multiple views

CS424: Visualization & Visual Analytics

Fabio Miranda

<https://fmiranda.me>

Big data example



Distribution of NYC Taxi
Pickups and Dropoffs in
Midtown Manhattan

Big data example

VendorID	tpep_pickup_datetime	tpep_dropoff_datetime	passenger_count	trip_distance	RatecodeID	store_and_fwd_location	PULocationID	DOLocationID	payment_type	fare_amount	extra	mta_tax	tip_amount	tolls_amount	improvement_surcharge	total_amount
1	1/1/2018 0:21	1/1/2018 0:24	1	0.5	1	N	41	24	2	4.5	0.5	0.5	0	0	0.3	5.8
1	1/1/2018 0:44	1/1/2018 1:03	1	2.7	1	N	239	140	2	14	0.5	0.5	0	0	0.3	15.3
1	1/1/2018 0:08	1/1/2018 0:14	2	0.8	1	N	262	141	1	6	0.5	0.5	1	0	0.3	8.3
1	1/1/2018 0:20	1/1/2018 0:52	1	10.2	1	N	140	257	2	33.5	0.5	0.5	0	0	0.3	34.8
1	1/1/2018 0:09	1/1/2018 0:27	2	2.5	1	N	246	239	1	12.5	0.5	0.5	2.75	0	0.3	16.55
1	1/1/2018 0:29	1/1/2018 0:32	3	0.5	1	N	143	143	2	4.5	0.5	0.5	0	0	0.3	5.8
1	1/1/2018 0:38	1/1/2018 0:48	2	1.7	1	N	50	239	1	9	0.5	0.5	2.05	0	0.3	12.35
1	1/1/2018 0:49	1/1/2018 0:51	1	0.7	1	N	239	238	1	4	0.5	0.5	1	0	0.3	6.3
1	1/1/2018 0:56	1/1/2018 1:01	1	1	1	N	238	24	1	5.5	0.5	0.5	1.7	0	0.3	8.5
1	1/1/2018 0:17	1/1/2018 0:22	1	0.7	1	N	170	170	2	5.5	0.5	0.5	0	0	0.3	6.8
1	1/1/2018 0:41	1/1/2018 0:46	1	0.6	1	N	162	229	1	5.5	0.5	0.5	1.35	0	0.3	8.15

Data transformation



- Filter the data:
 - Only rows within Manhattan.
 - Only rows inside certain blocks of Manhattan.
- Merge data with other data:
 - Traffic accidents within 100 meters and 1 hour of pickup and dropoff.
- Aggregate the data:
 - Number of pickups in each hour.
 - Number of pickups in each day of the week..

Data transformation

VendorID	tppep_pickup_datetime	tppep_dropoff_datetime	passenger_count	trip_distance	RatecodeID	store_and_fPULocationID	DOLocationID	payment_fare_amoextra	mta_tax	tip_amo	tolls_amo	improven	total_amount
1	1/1/2018 0:21	1/1/2018 0:24	1	0.5	1 N	41	24	2 4.5 0.5	0.5	0	0	0.3	5.8
1	1/1/2018 0:44	1/1/2018 1:03	1	2.7	1 N	239	140	2 14 0.5	0.5	0	0	0.3	15.3
1	1/1/2018 0:08	1/1/2018 0:14	2	0.8	1 N	262	141	1 6 0.5	0.5	1	0	0.3	8.3
1	1/1/2018 0:20	1/1/2018 0:52	1	10.2	1 N	140	257	2 33.5 0.5	0.5	0	0	0.3	34.8
1	1/1/2018 0:09	1/1/2018 0:27	2	2.5	1 N	246	239	1 12.5 0.5	0.5	2.75	0	0.3	16.55
1	1/1/2018 0:29	1/1/2018 0:32	3	0.5	1 N	143	143	2 4.5 0.5	0.5	0	0	0.3	5.8
1	1/1/2018 0:38	1/1/2018 0:48	2	1.7	1 N	50	239	1 9 0.5	0.5	2.05	0	0.3	12.35
1	1/1/2018 0:49	1/1/2018 0:51	1	0.7	1 N	239	238	1 4 0.5	0.5	1	0	0.3	6.3
1	1/1/2018 0:56	1/1/2018 1:01	1	1	1 N	238	24	1 5.5 0.5	0.5	1.7	0	0.3	8.5
1	1/1/2018 0:17	1/1/2018 0:22	1	0.7	1 N	170	170	2 5.5 0.5	0.5	0	0	0.3	6.8
1	1/1/2018 0:41	1/1/2018 0:46	1	0.6	1 N	162	229	1 5.5 0.5	0.5	1.35	0	0.3	8.15
1	1/1/2018 0:52	1/1/2018 1:17	1	3.5	1 N	141	113	2 16.5 0.5	0.5	0	0	0.3	17.8
2	1/1/2018 0:17	1/1/2018 0:22	1	1.04	1 N	137	224	2 5.5 0.5	0.5	0	0	0.3	6.8
2	1/1/2018 0:24	1/1/2018 0:34	1	1.22	1 N	224	79	2 7.5 0.5	0.5	0	0	0.3	8.8
2	1/1/2018 0:37	1/1/2018 0:53	1	1.92	1 N	234	100	2 10 0.5	0.5	0	0	0.3	11.3
1	1/1/2018 0:35	1/1/2018 0:52	1	5.7	1 N	13	189	1 19 0.5	0.5	4.05	0	0.3	24.35
2	1/1/2018 0:30	1/1/2018 1:13	1	3.74	1 N	48	236	1 25.5 0.5	0.5	6.7	0	0.3	33.5
1	1/1/2018 0:21	1/1/2018 0:25	2	0.6	1 N	163	162	1 4.5 0.5	0.5	1.7	0	0.3	7.5
1	1/1/2018 0:31	1/1/2018 1:07	1	10.9	1 N	229	61	2 35 0.5	0.5	0	0	0.3	36.3
2	1/1/2018 0:15	1/1/2018 0:21	5	1.22	1 N	236	75	2 6 0.5	0.5	0	0	0.3	7.3
2	1/1/2018 0:25	1/1/2018 0:45	5	3.13	1 N	263	143	2 13 0.5	0.5	0	0	0.3	14.3
2	1/1/2018 0:51	1/1/2018 1:04	5	2.22	1 N	239	24	2 9.5 0.5	0.5	0	0	0.3	10.8
2	1/1/2018 0:09	1/1/2018 0:30	1	2.93	1 N	90	233	1 14.5 0.5	0.5	2	0	0.3	17.8
2	1/1/2018 0:32	1/1/2018 0:58	1	3.52	1 N	233	125	2 18 0.5	0.5	0	0	0.3	19.3
1	1/1/2018 0:41	1/1/2018 0:54	4	3	1 N	161	146	1 12 0.5	0.5	2.65	0	0.3	15.95
2	1/1/2018 0:17	1/1/2018 0:21	5	0.25	1 N	234	234	2 4.5 0.5	0.5	0	0	0.3	5.8
2	1/1/2018 0:24	1/1/2018 0:46	5	3.31	1 N	234	143	1 16 0.5	0.5	3.46	0	0.3	20.76
2	1/1/2018 0:48	1/1/2018 0:51	5	0.57	1 N	142	239	1 4 0.5	0.5	1.06	0	0.3	6.36
1	1/1/2018 0:24	1/1/2018 0:31	2	0.7	1 N	170	162	2 6 0.5	0.5	0	0	0.3	7.3
1	1/1/2018 0:36	1/1/2018 0:43	1	1.8	1 N	233	263	2 7.5 0.5	0.5	0	0	0.3	8.8
1	1/1/2018 0:49	1/1/2018 0:57	2	1.2	1 N	236	237	2 7.5 0.5	0.5	0	0	0.3	8.8
1	1/1/2018 0:13	1/1/2018 0:23	1	2.7	1 N	142	166	1 10.5 0.5	0.5	2.35	0	0.3	14.15
1	1/1/2018 0:33	1/1/2018 1:18	2	4.3	1 N	238	249	2 27.5 0.5	0.5	0	0	0.3	28.8
2	1/1/2018 0:15	1/1/2018 0:22	1	0.89	1 N	151	238	2 5.5 0.5	0.5	0	0	0.3	6.8
2	1/1/2018 0:25	1/1/2018 0:29	1	0.49	1 N	238	238	1 4.5 0.5	0.5	1.45	0	0.3	7.25
2	1/1/2018 0:32	1/1/2018 0:36	2	0.8	1 N	238	151	1 5 0.5	0.5	1.26	0	0.3	7.56
2	1/1/2018 0:45	1/1/2018 0:58	1	2.09	1 N	238	143	1 11 0.5	0.5	2.46	0	0.3	14.76
2	1/1/2018 0:31	1/1/2018 0:45	1	2.32	1 N	186	231	1 11 0.5	0.5	3.08	0	0.3	15.38
2	1/1/2018 0:47	1/1/2018 1:26	1	9.49	1 N	231	116	1 35 0.5	0.5	9.08	0	0.3	45.38
1	1/1/2018 0:21	1/1/2018 0:28	2	2.5	1 N	141	145	1 9.5 0.5	0.5	2.7	0	0.3	13.5
1	1/1/2018 0:32	1/1/2018 0:47	1	4.6	1 N	145	263	1 15.5 0.5	0.5	4.2	0	0.3	21
1	1/1/2018 0:54	1/1/2018 1:03	1	3	1 N	141	146	2 10.5 0.5	0.5	0	0	0.3	11.8
1	1/1/2018 0:23	1/1/2018 0:52	1	7.3	1 N	90	82	1 26.5 0.5	0.5	1	5.76	0.3	34.56
1	1/1/2018 0:04	1/1/2018 0:15	1	1.3	1 N	144	234	1 9 0.5	0.5	2.05	0	0.3	12.35
1	1/1/2018 0:17	1/1/2018 0:41	1	0.8	1 N	234	164	2 14.5 0.5	0.5	0	0	0.3	15.8
1	1/1/2018 0:42	1/1/2018 0:44	1	0.1	1 N	164	164	2 3 0.5	0.5	0	0	0.3	4.3
1	1/1/2018 0:48	1/1/2018 0:55	2	0.2	1 N	164	164	1 6 0.5	0.5	1.45	0	0.3	8.75

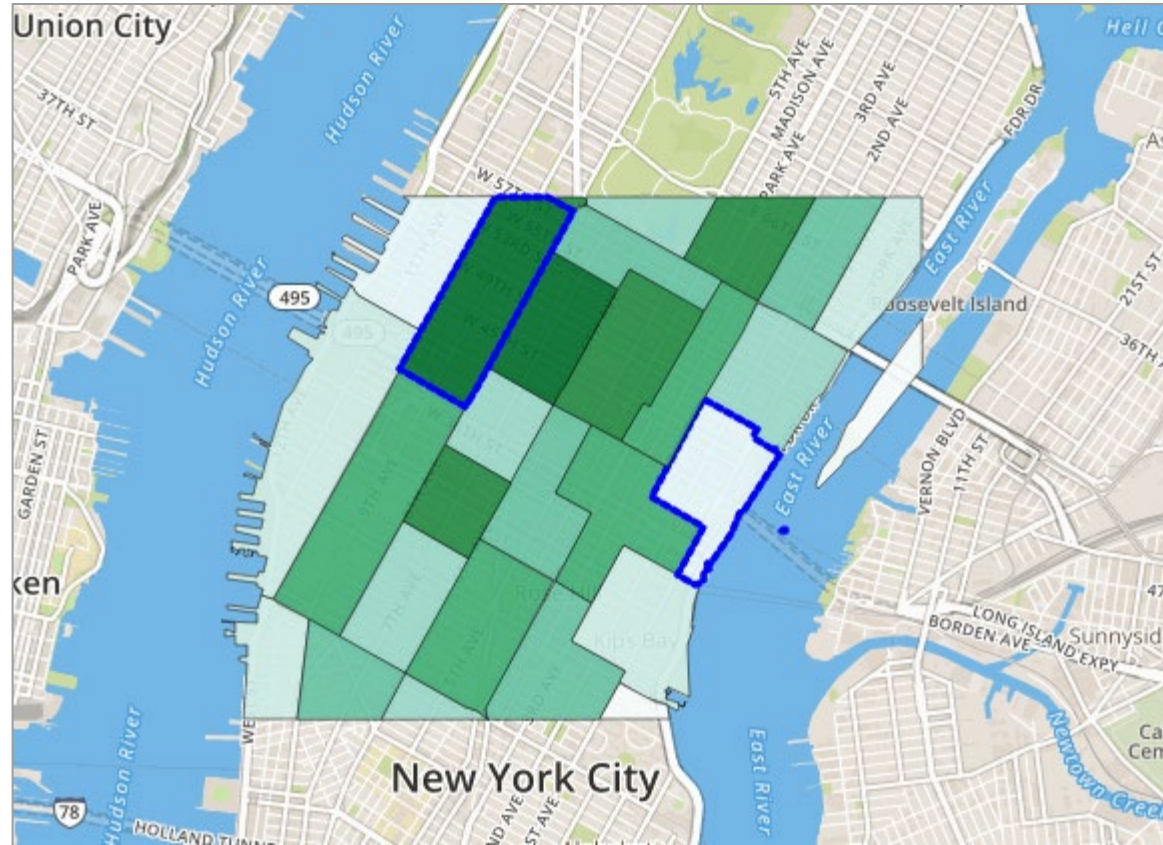


Data transformation

VendorID	tpep_pickup_datetime	tpep_dropoff_datetime	passenger_count	trip_distance	RatecodeID	store_and_fwd_flag	PULocationID	DOLocationID	payment_type	fare_amount	extra	mta_tax	tip_amount	tolls_amount	improvement_surcharge	total_amount	Area
1	1/1/2018 0:21	1/1/2018 0:24	1	0.5	1	N	41	24	2	4.5	0.5	0.5	0	0	0.3	5.3	Midtown
1	1/1/2018 0:44	1/1/2018 1:03	1	2.7	1	N	239	140	2	14	0.5	0.5	0	0	0.3	15.3	Chelsea
1	1/1/2018 0:08	1/1/2018 0:14	2	0.8	1	N	262	141	1	6	0.5	0.5	1	0	0.3	8.3	Downtown
1	1/1/2018 0:20	1/1/2018 0:52	1	10.2	1	N	140	257	2	33.5	0.5	0.5	0	0	0.3	34.3	Downtown
1	1/1/2018 0:09	1/1/2018 0:27	2	2.5	1	N	246	239	1	12.5	0.5	0.5	2.75	0	0.3	16.5	Downtown
1	1/1/2018 0:29	1/1/2018 0:32	3	0.5	1	N	143	143	2	4.5	0.5	0.5	0	0	0.3	5.3	Midtown
1	1/1/2018 0:38	1/1/2018 0:48	2	1.7	1	N	50	239	1	9	0.5	0.5	2.05	0	0.3	12.3	Downtown
1	1/1/2018 0:49	1/1/2018 0:51	1	0.7	1	N	239	238	1	4	0.5	0.5	1	0	0.3	6.3	Downtown
1	1/1/2018 0:56	1/1/2018 1:01	1	1	1	N	238	24	1	5.5	0.5	0.5	1.7	0	0.3	8.3	Downtown
1	1/1/2018 0:17	1/1/2018 0:22	1	0.7	1	N	170	170	2	5.5	0.5	0.5	0	0	0.3	6.3	Downtown
1	1/1/2018 0:41	1/1/2018 0:46	1	0.6	1	N	162	229	1	5.5	0.5	0.5	1.35	0	0.3	8.1	Midtown
1	1/1/2018 0:52	1/1/2018 1:17	1	3.5	1	N	141	113	2	16.5	0.5	0.5	0	0	0.3	17.3	Downtown
2	1/1/2018 0:17	1/1/2018 0:22	1	1.04	1	N	137	224	2	5.5	0.5	0.5	0	0	0.3	6.3	Downtown
2	1/1/2018 0:24	1/1/2018 0:34	1	1.22	1	N	224	79	2	7.5	0.5	0.5	0	0	0.3	8.3	Downtown
2	1/1/2018 0:37	1/1/2018 0:53	1	1.92	1	N	234	100	2	10	0.5	0.5	0	0	0.3	11.3	Downtown
1	1/1/2018 0:35	1/1/2018 0:52	1	5.7	1	N	13	189	1	19	0.5	0.5	4.05	0	0.3	24.3	Downtown
2	1/1/2018 0:30	1/1/2018 1:13	1	3.74	1	N	48	236	1	25.5	0.5	0.5	6.7	0	0.3	33.3	Downtown
1	1/1/2018 0:21	1/1/2018 0:25	2	0.6	1	N	163	162	1	4.5	0.5	0.5	1.7	0	0.3	7.3	Midtown
1	1/1/2018 0:31	1/1/2018 1:07	1	10.9	1	N	229	61	2	35	0.5	0.5	0	0	0.3	36.3	Midtown
2	1/1/2018 0:15	1/1/2018 0:21	5	1.22	1	N	236	75	2	6	0.5	0.5	0	0	0.3	7.3	Midtown
2	1/1/2018 0:25	1/1/2018 0:45	5	3.13	1	N	263	143	2	13	0.5	0.5	0	0	0.3	14.3	Midtown
2	1/1/2018 0:51	1/1/2018 1:04	5	2.22	1	N	239	24	2	9.5	0.5	0.5	0	0	0.3	10.3	Midtown
2	1/1/2018 0:09	1/1/2018 0:30	1	2.93	1	N	90	233	1	14.5	0.5	0.5	2	0	0.3	17.3	Midtown
2	1/1/2018 0:32	1/1/2018 0:58	1	3.52	1	N	233	125	2	18	0.5	0.5	0	0	0.3	19.3	Midtown

Visual mapping

Quantitative data
Mark: polygon areas
Channel: color



Visualization so far...



Up until now in the course, all visual representations were presented as static pictures...

... but digital devices enable people to interact with graphical representations.

Interaction



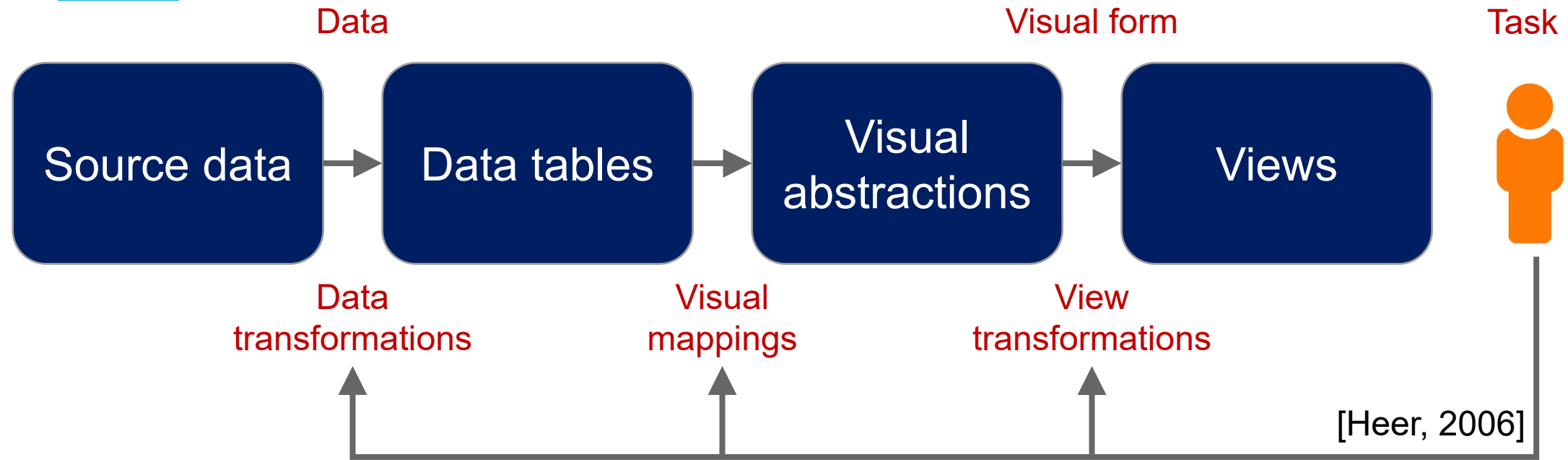
- Two main questions:
 - What is **possible** to do with interaction in visualization?
 - When is it **useful** to make visualizations interactive?

Interaction



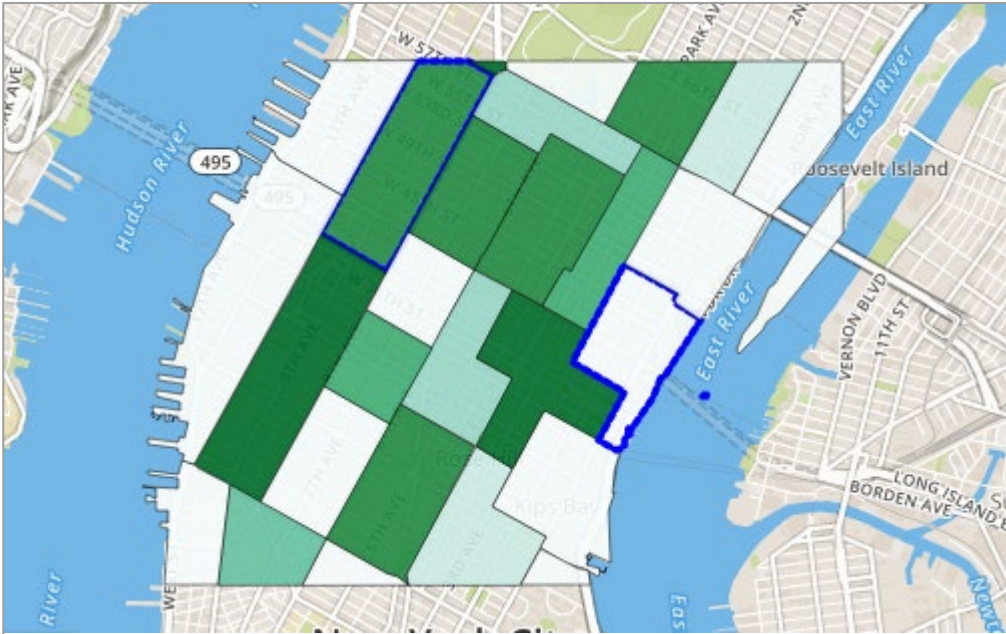
- What we will cover:
 - Interaction methods.
 - Multiple linked views.
 - Why / when these methods are useful.

Visualization design

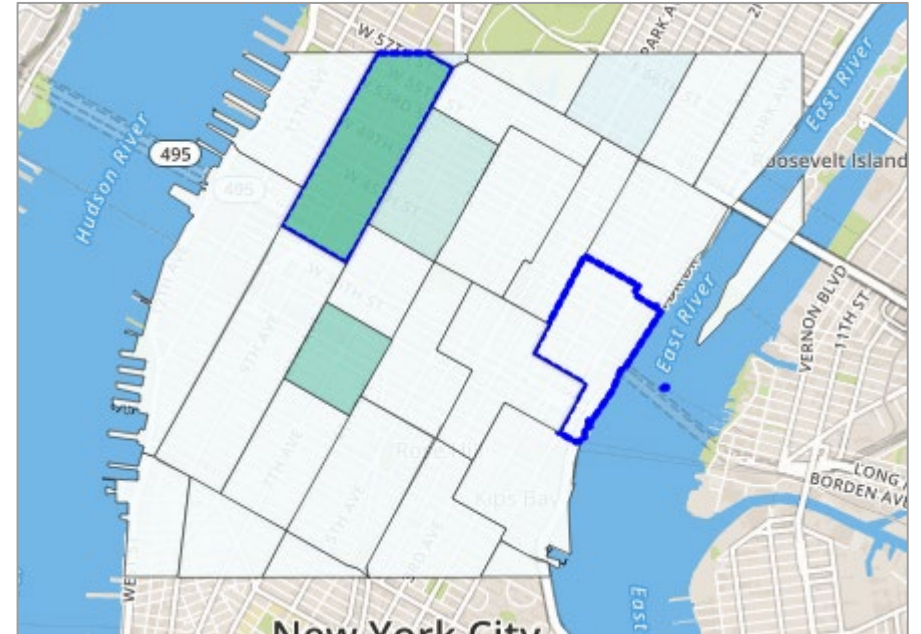


- Creating a data visualization is easy; creating a **good** visualization is hard.
- Visualization design space is huge, it's important to make good choices in each stage.

Visual interaction



12pm– 2pm pickups



6am pickups

Interaction



- Interaction can be used to manipulate:
 - Data
 - Visual mapping
 - View

Manipulating the data

- Data transformations (see last lectures):
- Aggregation: changing the level of granularity of a given data set.
 - Space and time are hierarchical and often require observing patterns at different resolutions.
- Filtering: filtering data interactively according to some criteria or constraints.

The map displays the density of bus stops in downtown Seattle. The highest concentration of stops is located along the waterfront, particularly in the area between Pike Street and Union Street. Other areas with moderate density include the area around the University of Washington and the area around the downtown business district. The map also shows major streets and parks.

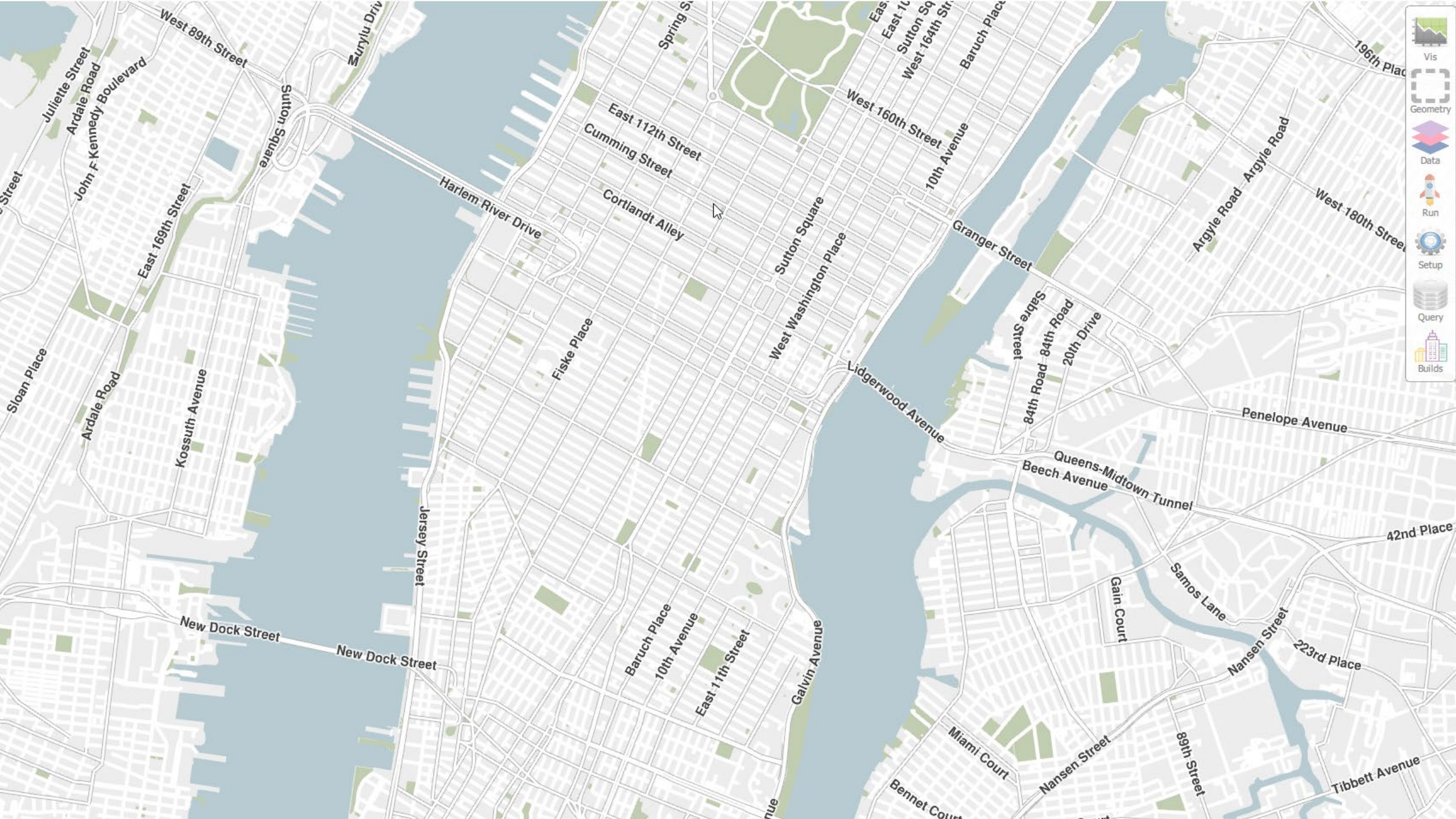
The screenshot shows the UrbanSim application interface. On the right is a map of New York City with various regions highlighted in blue and orange. On the left is a window titled 'UrbanSim' containing four line graphs and a table of data.

The four line graphs are:

- Crime: Count(reported_crime)
- Noise: Count(noise_complaint)
- Schools: Score(school)
- Taxi: Count(pickup)

The table below shows the data for the regions highlighted on the map:

Name	Crime: Count(reported_crime)	Noise: Count(noise_complaint)	Schools: Score(school)	Taxi: Count(pickup)
Average	173.43	33.53	50.916	14823.65
Borough Park	155	24.0	66.2	361
Astoria	43.0	12.0	74.3	31.0
Murray Hill	104	32.0	68.1	94.0
Bayside-Bayside Hills	82.0	13.0	58.6	61.0
Homerest	101	32.0	60.5	181
Westchester-Unionport	140	48.0	63.7	171
Fresh Meadows-Utopia	30.0	8.00	72.6	38.0
Corona	122	34.0	57.5	491
Madison	98.0	21.0	63.3	108
Kensington-Ocean Parkway	93.0	40.0	60.5	980
Gravesend	99.0	23.0	65.9	90.0



Manipulating the view

- **Selection**: any action aimed at selecting one or more elements of the visualization.

Action:

- Click
- Hover
- Click + Drag



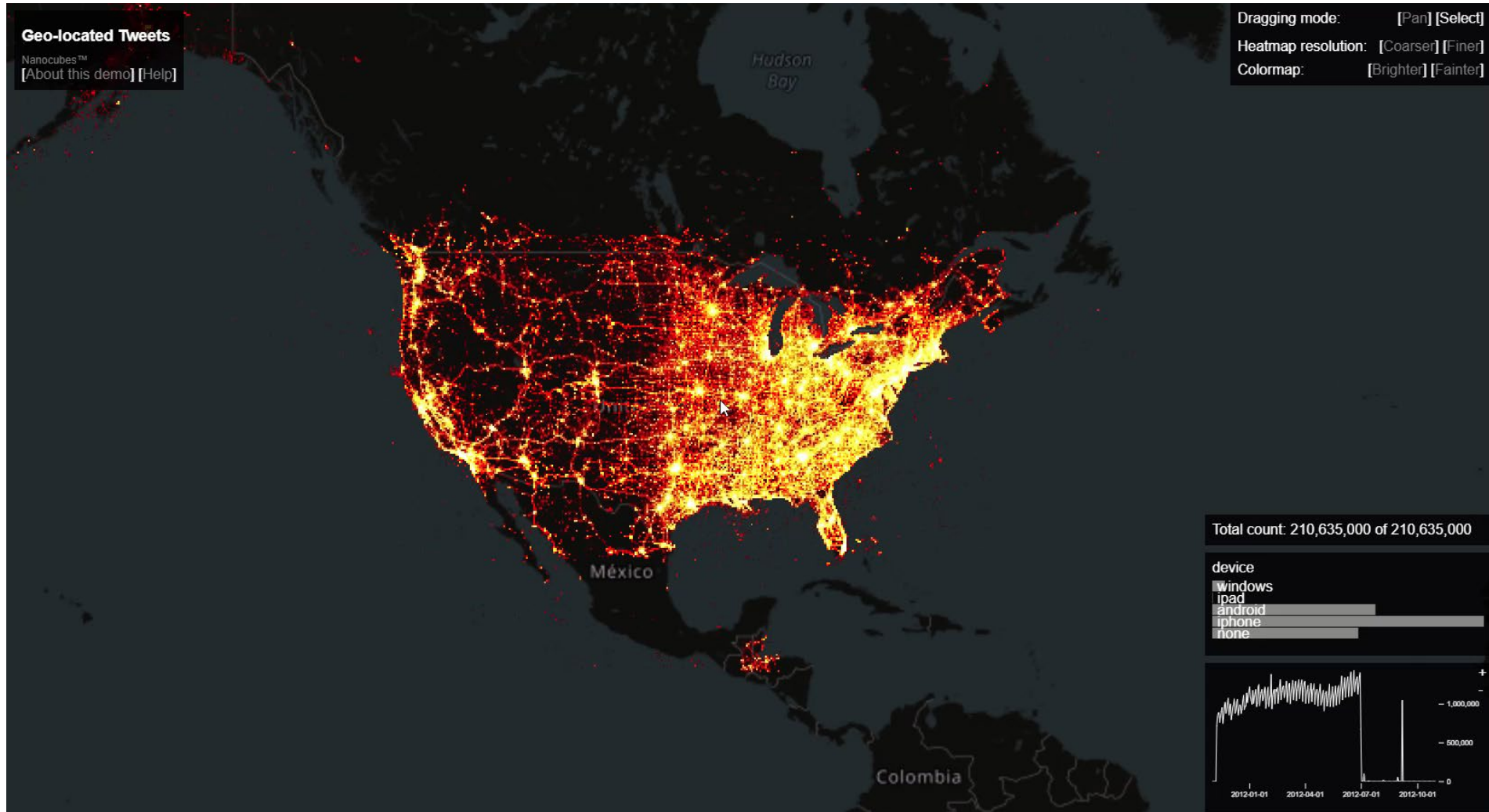
Change:

- Highlight
- Show more info
- Apply operation

Manipulating the view

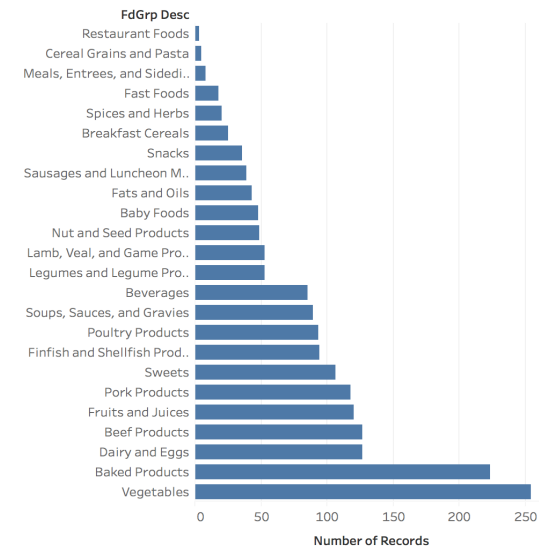
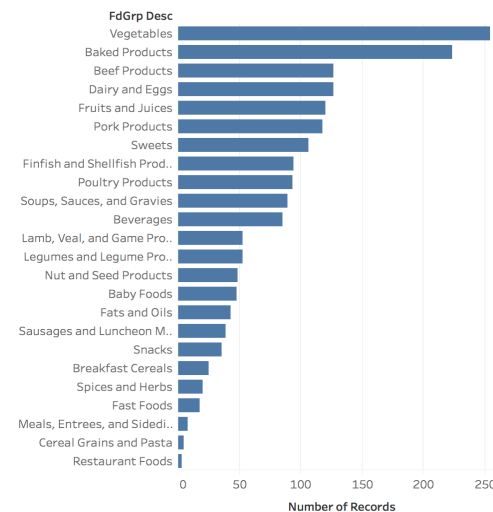
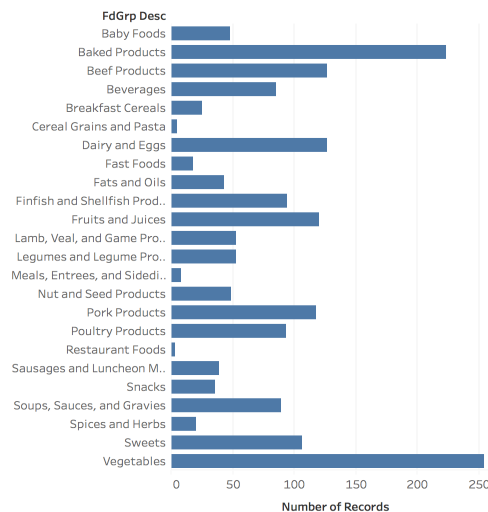
- **Navigation**: changing the level of details and moving the viewpoint.
 - Panning and zooming.
 - Semantic zooming: type and quantity of information show changes with the zoom level.

Manipulating the view: panning and zooming



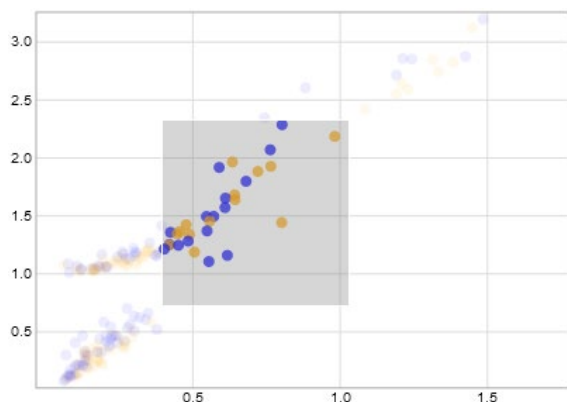
Manipulating the view

- **Spatial arrangement**: change the way elements of the visualization are arranged / ordered.
 - Reordering: fundamental to make visual patterns apparent.



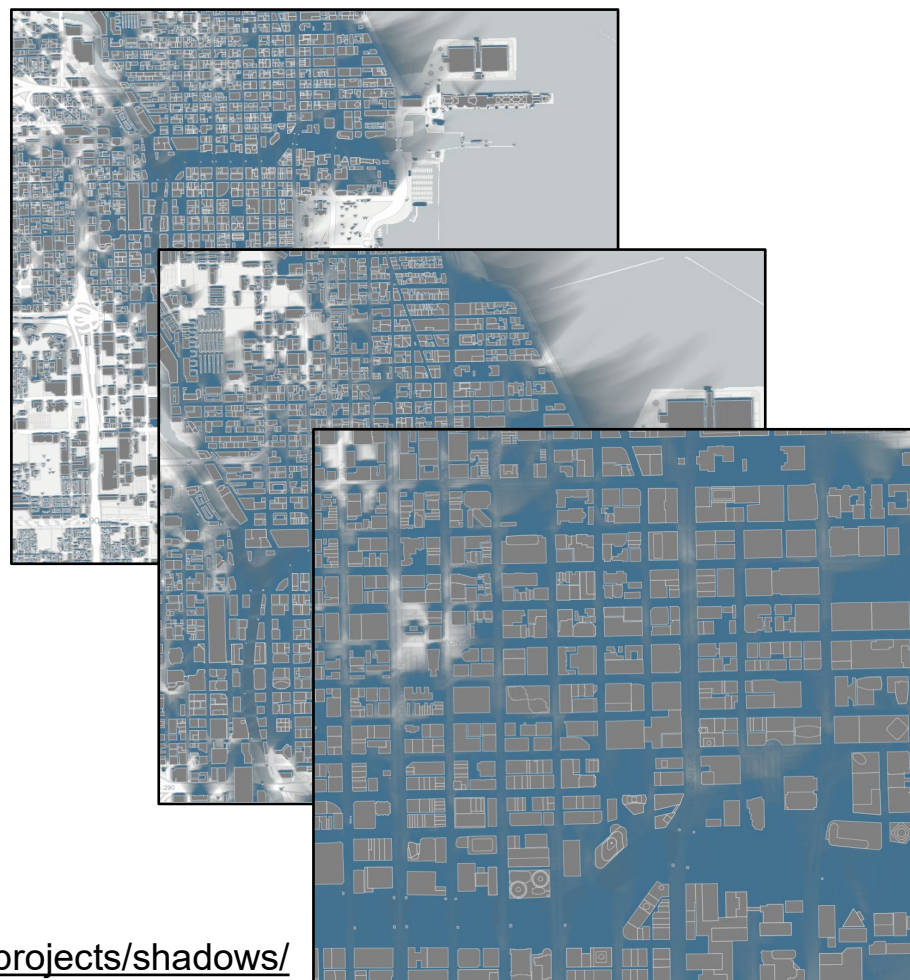
Manipulating the view

Selection



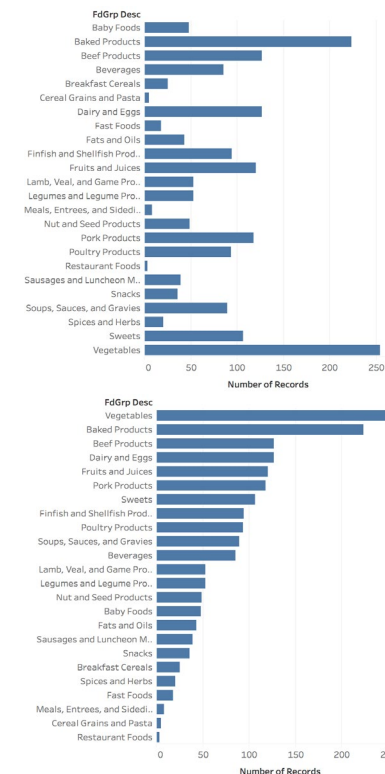
<https://vgc.poly.edu/projects/urban-pulse/>

Navigation



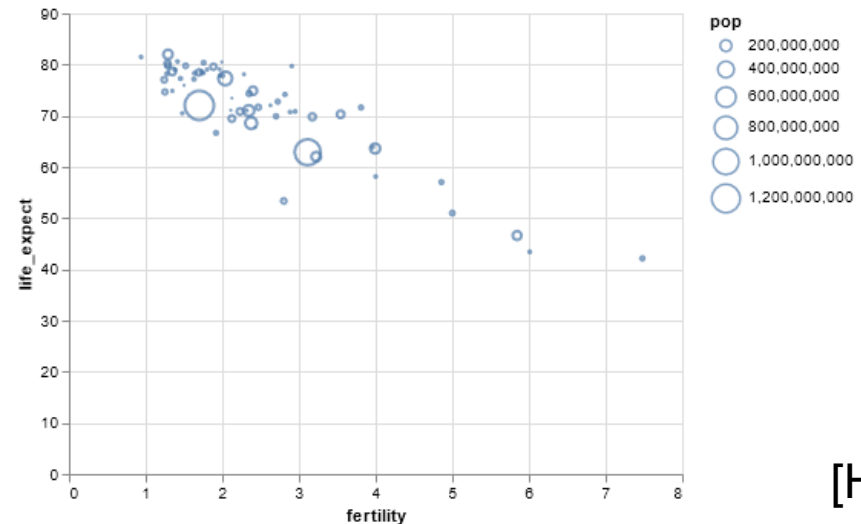
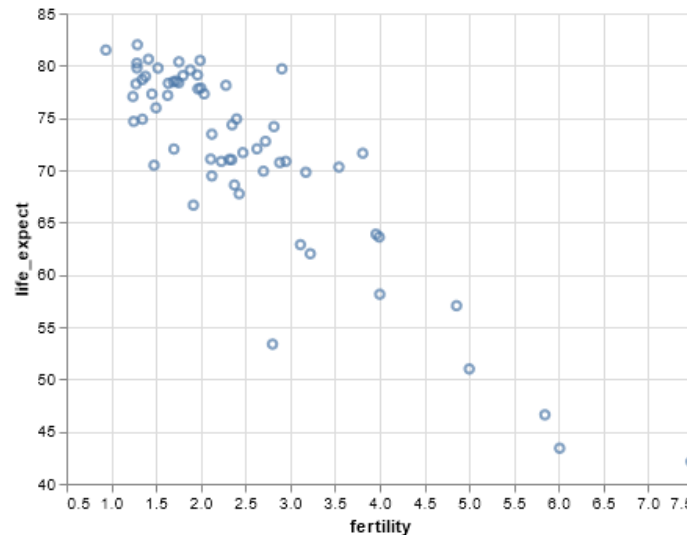
<https://vgc.poly.edu/projects/shadows/>

Spatial arrangement



Manipulating the visual mapping

- Change mapping: changing the way attributes are encoded with visual channels.
 - Completely different plot or changes in properties of a given plot.



[Heer, 2020]

View interaction methods

- Selection: any action aimed at selecting one or more elements of the visualization.
 - Click → highlight (change color and/or borders, grey out the rest, etc.)
 - Hover → show more info (labels, info in linked view, etc.)
 - Click + drag → apply operation
- Navigation: changing the level of details and moving the viewport.
- Spatial arrangement: changing the way elements of the visualization are arranged / ordered.
 - Reordering → make visual patterns apparent.

Manipulating the visual mapping

- Changing the color scale used to depict an attribute?
- Changing the order of bars in a bar chart?
- Filtering items that do not belong to a given category?

Manipulating the visual mapping?

- Changing the color scale used to depict an attribute?
- Changing the order of bars in a bar chart?
- Filtering items that do not belong to a given category?

Manipulating the visual mapping?

- Changing the color scale used to depict an attribute?
 - True.
- Changing the order of bars in a bar chart?
 - False – order of the bars is a parameter of the graph, so it belongs to manipulation of the view.
- Filtering items that do not belong to a given category?
 - False – filtering is an action that takes place at the level of the data.

Why manipulate visualizations?

- Often not possible to visualize all the information needed to answer all questions in one single static view.
- Interaction permits to adapt / change the visualization so that it's possible (or easier) to answer multiple questions.
- Especially useful when visualization is used as a general-purpose application for data analysis and exploration.

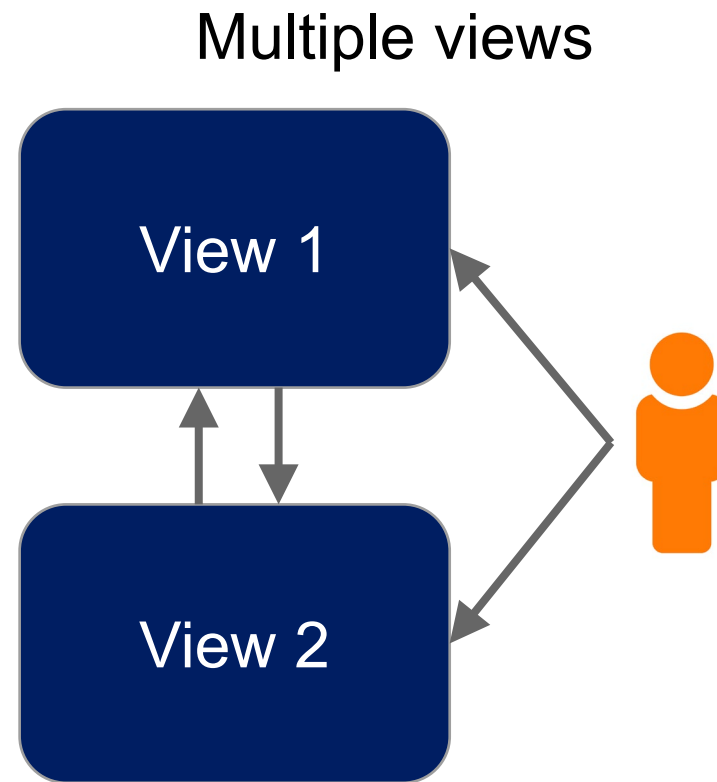
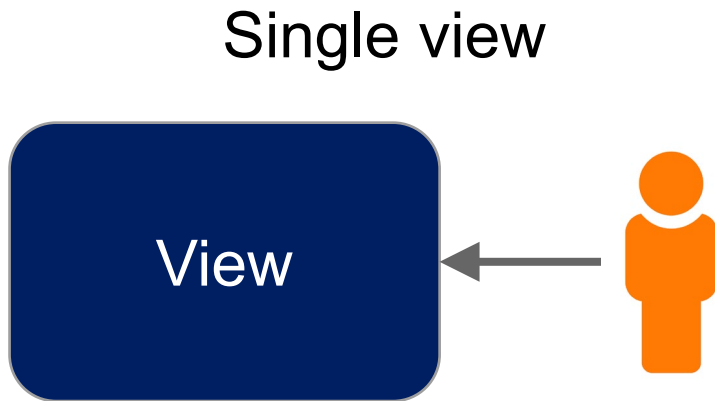
Manipulating the visual mapping?

- It makes perceiving information faster?
- It permits to visualize more information that you can fit in one vis?
- It permits to ask multiple questions using the same vis?

Manipulating the visual mapping?

- It makes perceiving information faster?
 - False – interaction may make answering questions slower.
- It permits to visualize more information that you can fit in one vis?
 - True.
- It permits to ask multiple questions using the same vis?
 - True.

Interaction



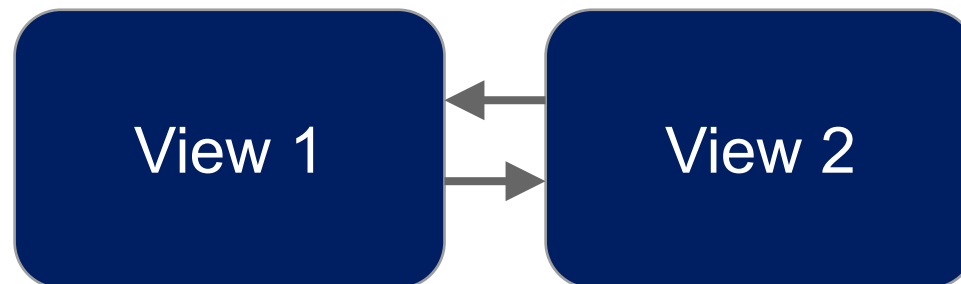
[Bertini, 2020]

Single view interactions

Manipulate	Methods
Data	Aggregation Filtering
Mapping	Change mapping
View	Selection Navigation Spatial arrangement

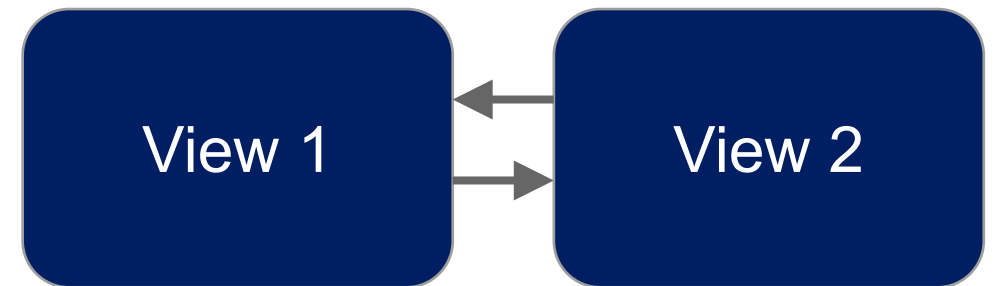
Multiple linked views

- Why multiple linked views?
 - Show different properties of the same data simultaneously.
 - Use one view to navigate, select, filter information in the other view.

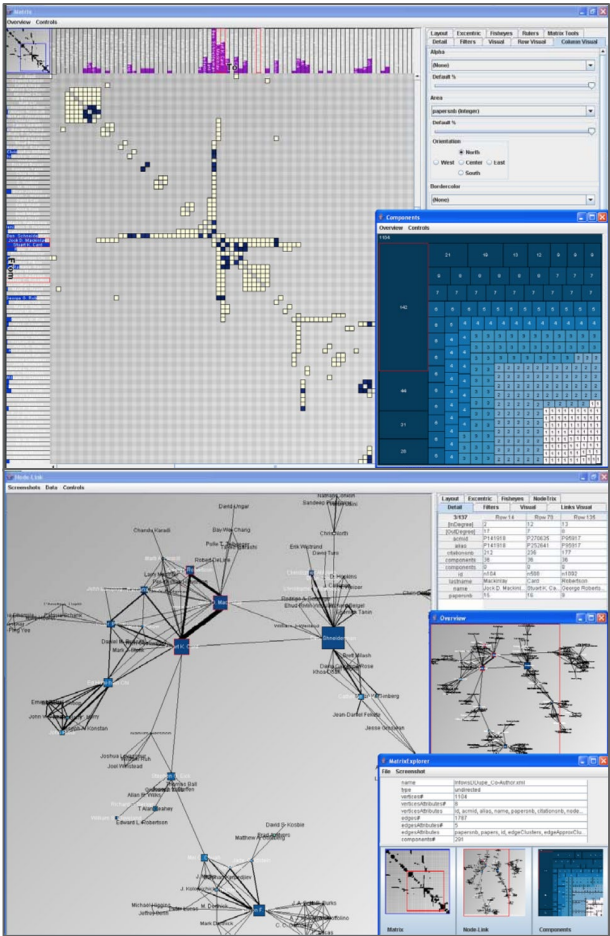


Multiple linked views

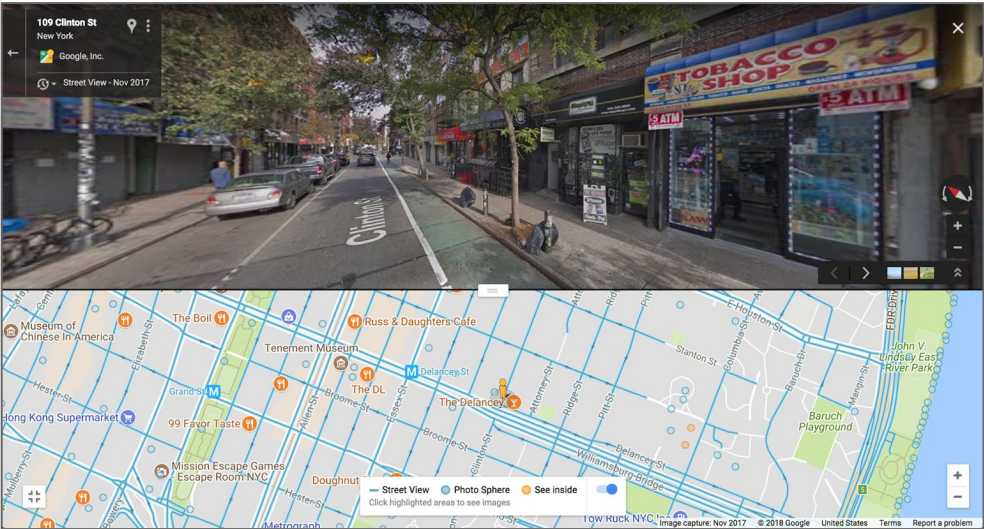
- How to show different properties?
 - Different information
 - Subset of data
 - Different attributes
 - Different granularity
 - Transformation
 - Different representation



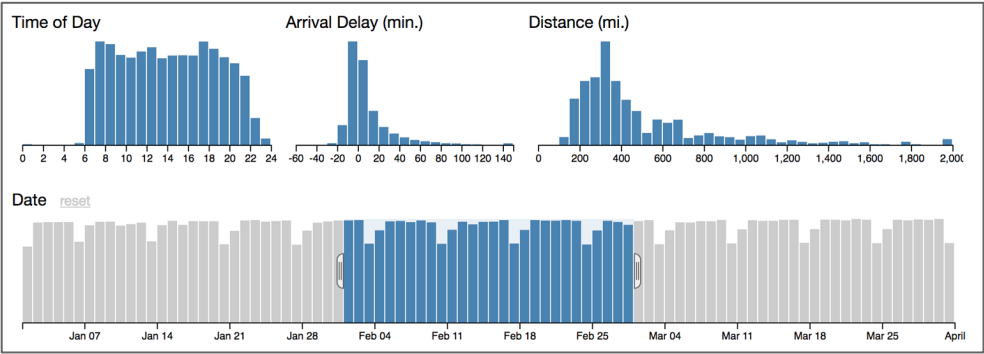
Multiple linked views



Same information,
different representation
[Riche, 2006]

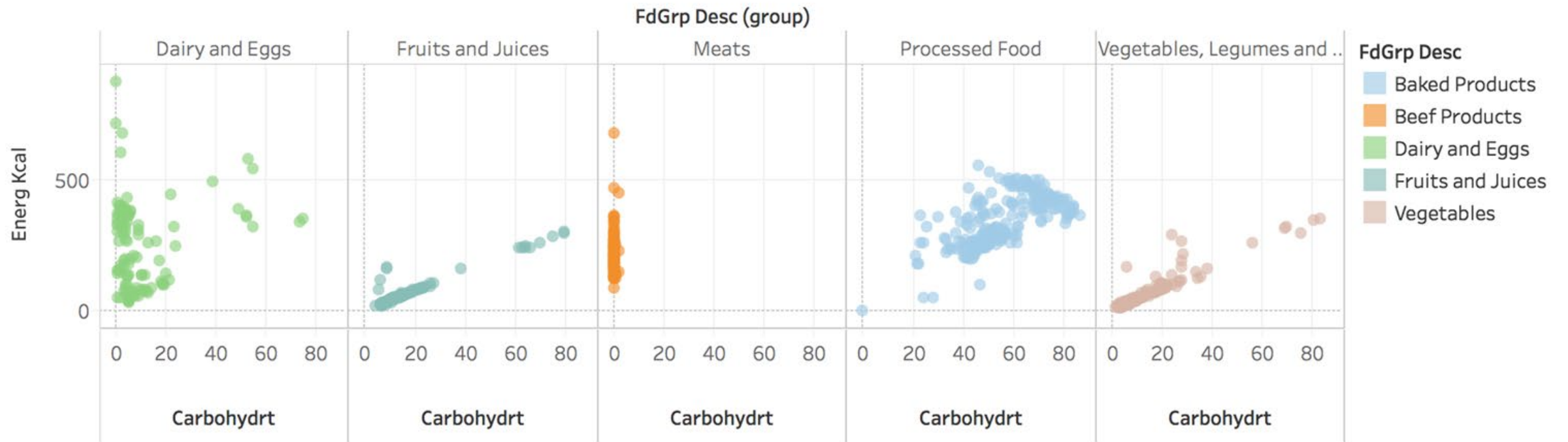


Different information & representation

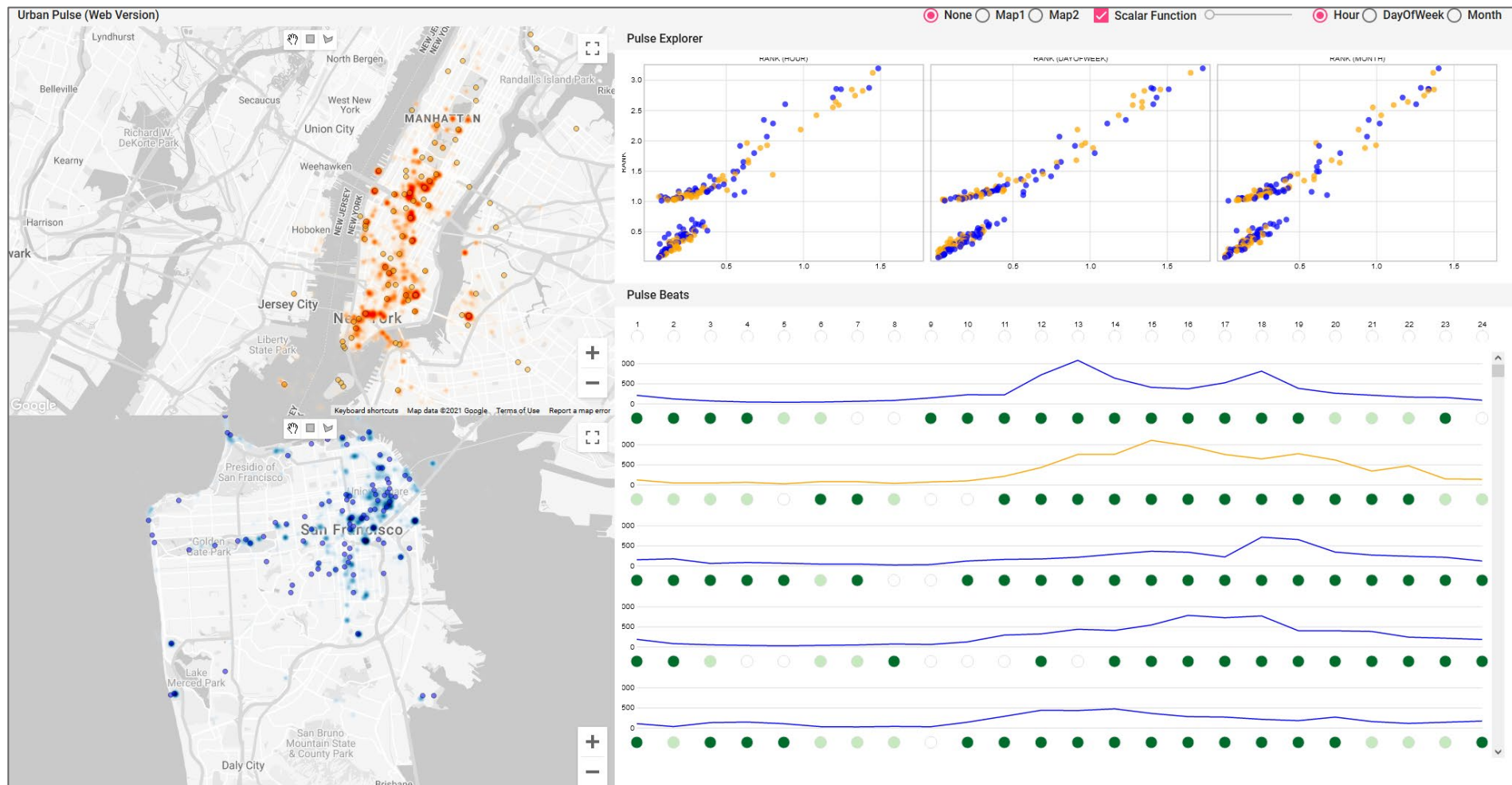


Different information,
same representation

Multiple linked views



Multiple linked views

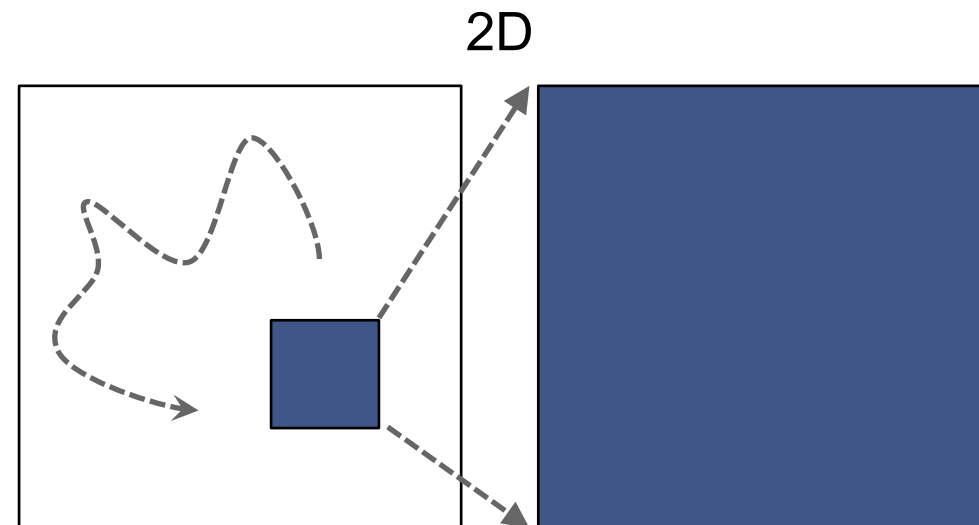
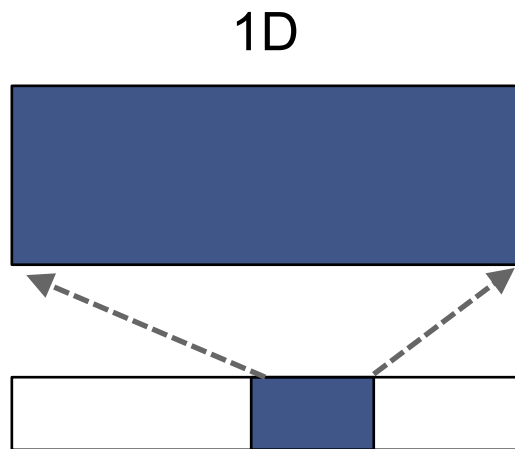


<http://vgc.poly.edu/projects/urban-pulse/>

Overview + detail

- Visualization mantra:
“Overview first, zoom and filter, then details on demand”

[Shneiderman, 1996]



Overview + detail

- **Ideal scenario**: can't fit all information on the screen without panning / scrolling.
- And why can panning and scrolling be a problem?
 - Hard to gain an overview.
 - Hard to make comparisons (it relies too heavily on human memory).

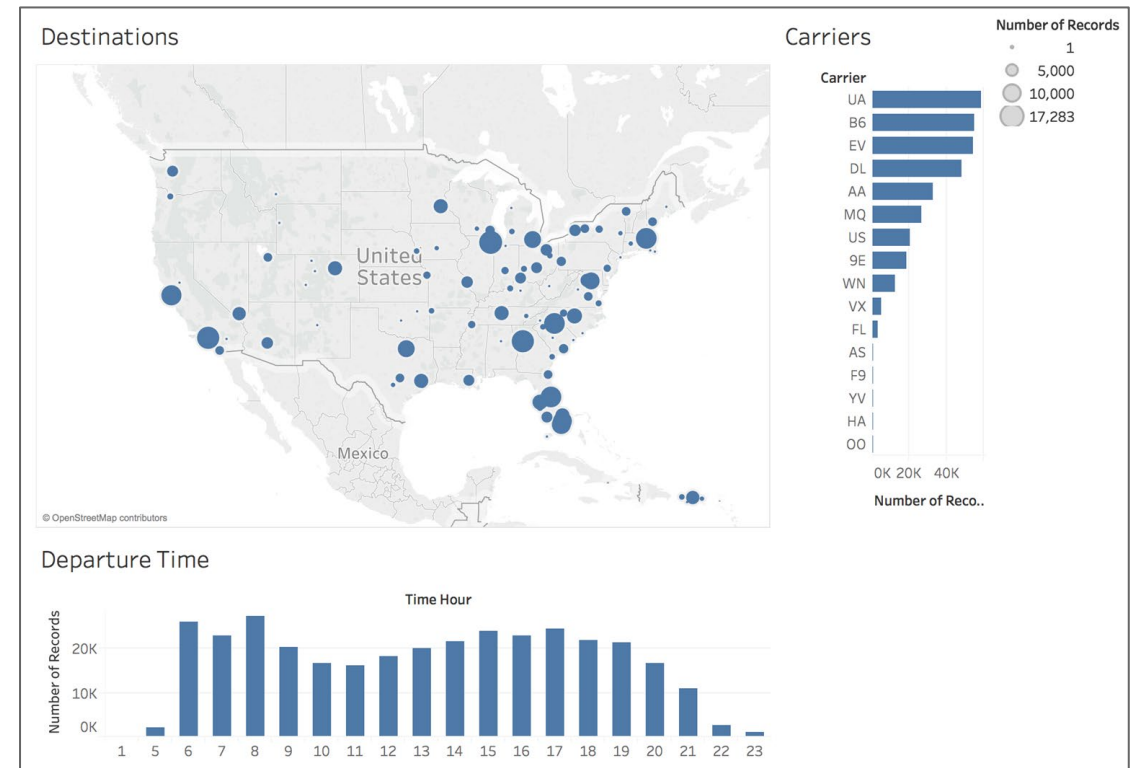
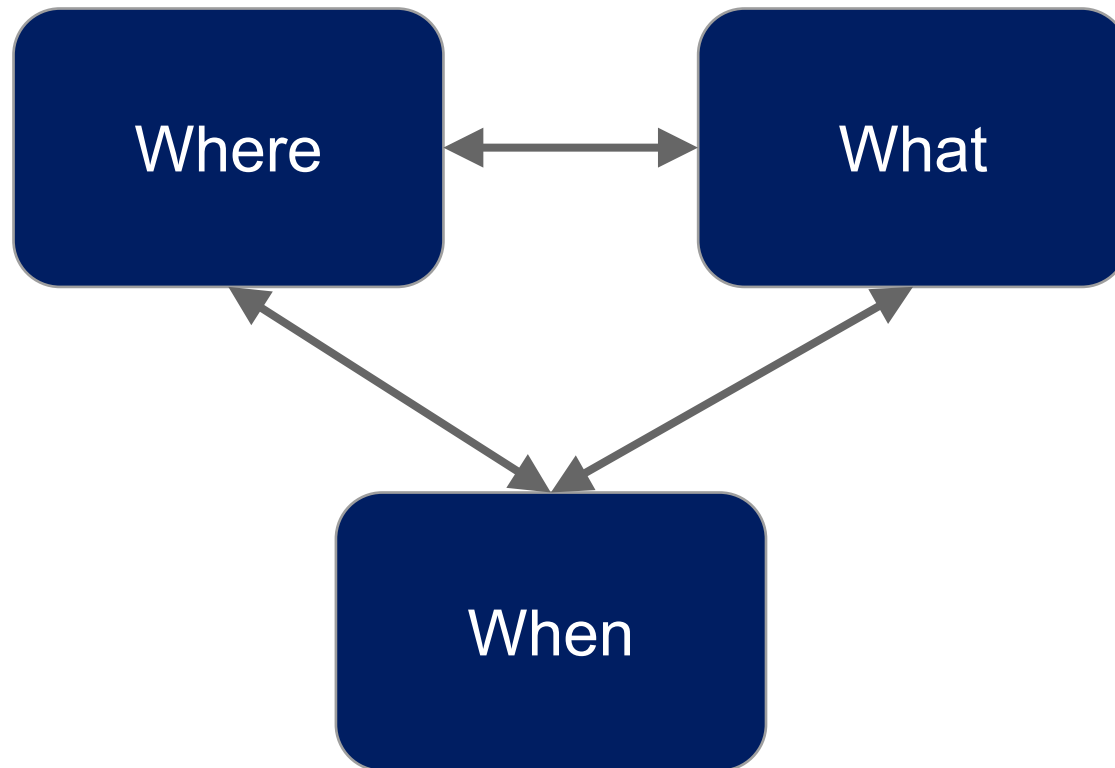
Overview + detail

- It is possible to use the overview to navigate towards areas of the visualization we want to see in detail without losing the overview of the entire dataset.
- It permits to visualize some objects at a much higher resolution.
- It permits to gain an overview of the whole dataset.

Overview + detail

- It is possible to use the overview to navigate towards areas of the visualization we want to see in detail without losing the overview of the entire dataset.
 - True.
- It permits to visualize some objects at a much higher resolution.
 - True, but other visualizations also permit that (e.g., zooming).
- It permits to gain an overview of the whole dataset.
 - True, but other views can also help gain an overview.

Where, what, when



Where, what, when



- **Ideal scenario**: need to visualize different facets of the same data simultaneously.