Visualization Fundamentals

Handbook

George Legrady © 2024
Experimental Visualization Lab
Media Arts & Technology
University of California, Santa Barbara

Lecture Topics (January 25, 2024)

Spatial Design & Basics (January 25, 2024)

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Interaction Design (January 30, 2024)

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Volumetrics, Time in Space, data to form, data density, cultural trends (February 6, 2024)

Lecture Topics (January 25, 2024)

Basics of Visual Language in 3D

Situating Data in space

3D visualization examples

How to give credit: code, data, refs, etc.

Exploratory Design process

Basics of Visual Language in 3D

Syntax: a set of rules by which language is structured. In visualization this involves decisions in how to organize visual elements in space.

Semantic: The study of meaning. In what ways, does visual elements convey meaning? To what degree does changing the visual elements transform meaning?

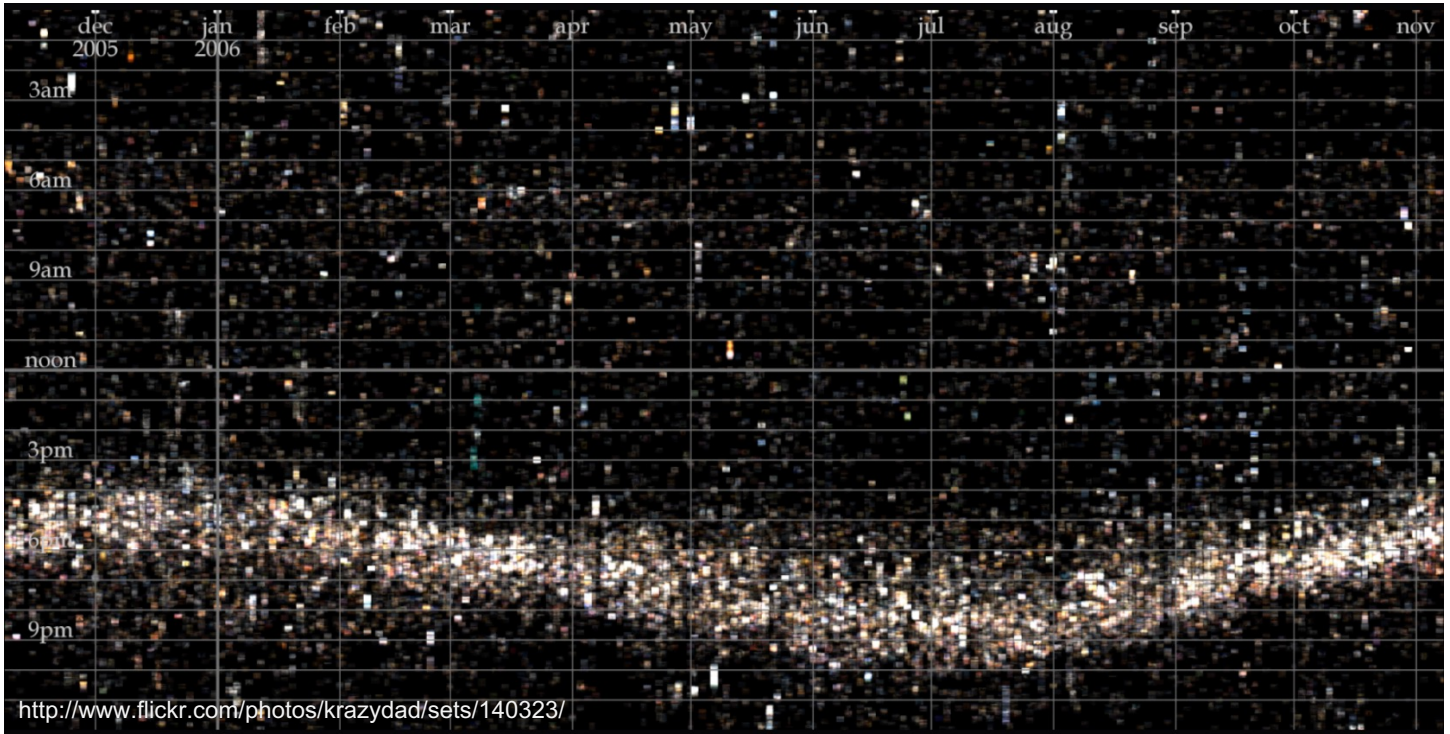
(Reference: Nelson Goodman, “Languages of Art”, 1960)

Rules in spatializing & organizing data

Use full screen 1920 x 1080 pixels for final version (use small screen during development)

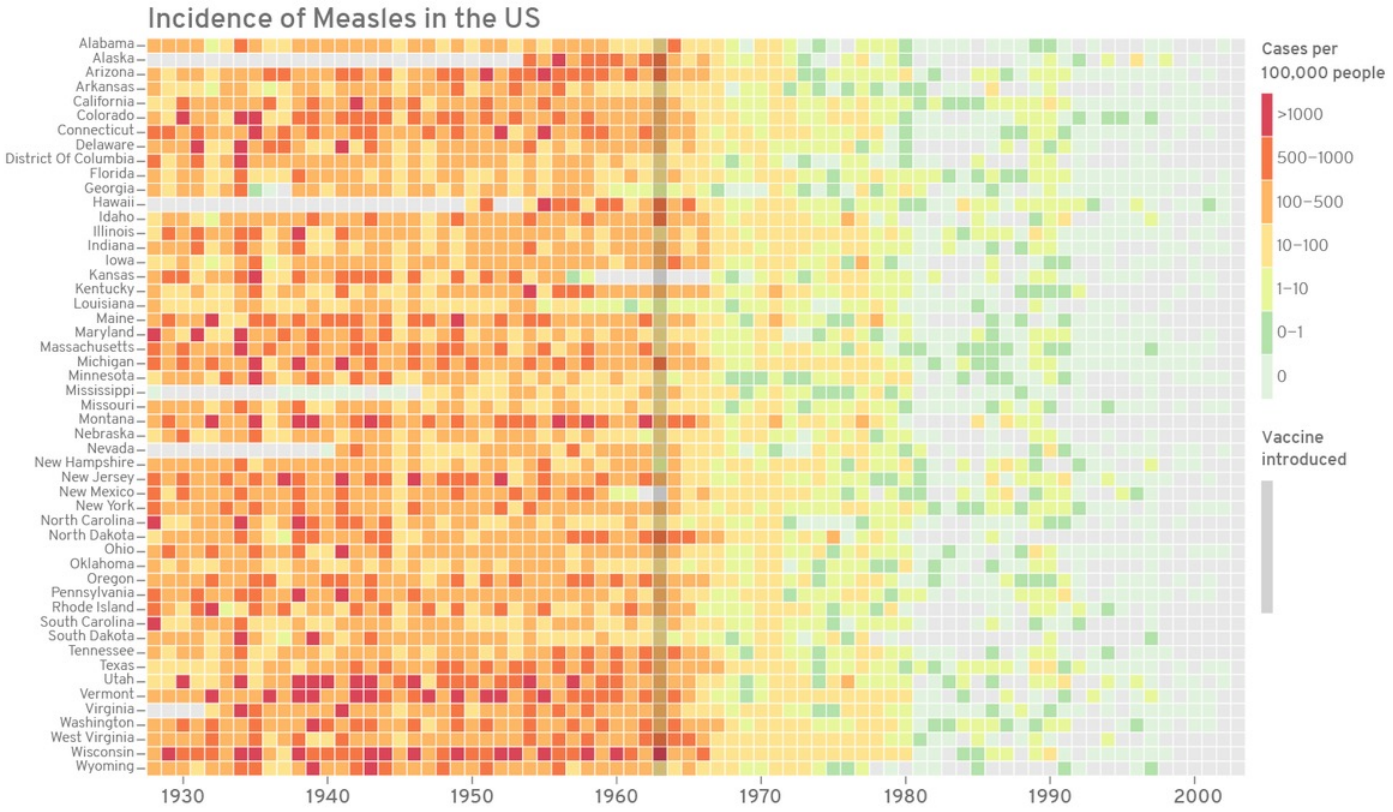
In 2D, subdivide screen (rule of thirds; or according to any set of rules)

In 3D, set of rules for x, y, z determine data location

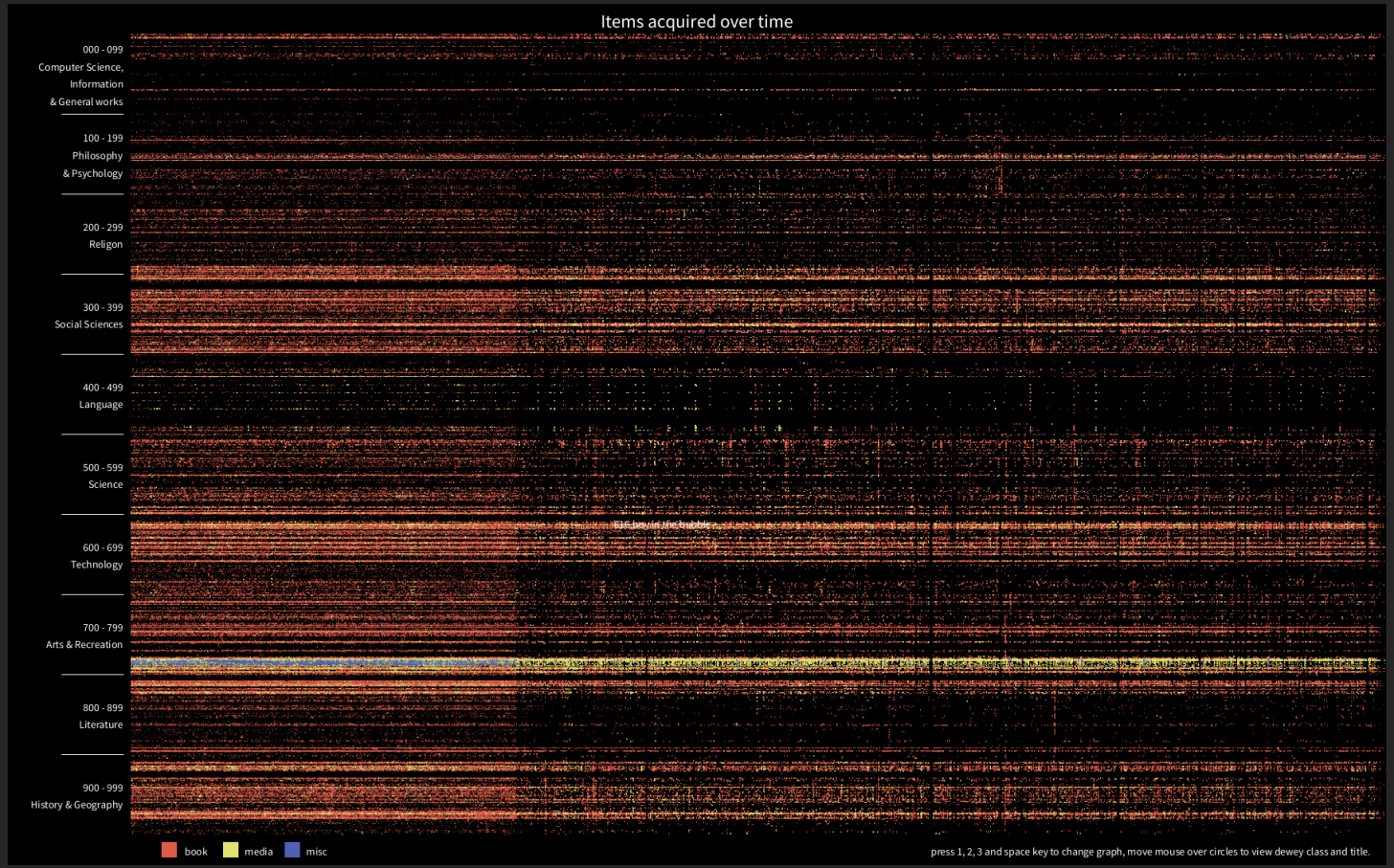


Color Coding: Example for positioning data according to a set of rules

Heatmap: Magnitude of phenomenon using color either by hue or intensity



Visualizing ItemNumber over Time



https://vislab.mat.ucsb.edu/2019/p1/Jiaheng_Tang/index.html

Fundamentals in situating data in visual space

- 3D data placement requires horizontal (**x**), vertical (**y**) and depth (**z**) positions
- Location of data in 3D space may require some indicative marker (**color, scale, shape, etc**.)
- Interaction usually requires instructions through a menu

Multi-variate data is given visual form

itemNumber	cout	collcode	itemtype	barcode	title	callNumber	deweyClass
2124890	2007-01-02 09:20:00	nacd	accd	0010053294418	tigers have spoken	CD 782.421642 C2665T	782.421642
1963406	2007-01-02 09:12:00	cafic	acbk	0010046075908	Heart on the line	FIC ARNOLD	NULL
1348064	2007-01-02 09:03:00	nalpfic	acbk	0010047150288	Too hot to handle	FIC LOWELL	NULL
264450	2007-01-02 09:13:00	canf	acbk	0010027180271	Governing public schools new times new requirements	371.2 DANZBER 1992	371.2
436074	2007-01-02 09:13:00	cs9	acbk	0010002326972	great deception the inside story of how the Kremlin took over Cuba	972.91 M741G	972.91
660741	2007-01-02 09:13:00	canf	acbk	0010041599258	Logic or The right use of reason in the inquiry after truth with a va…	160 L793W 1996	160
2225714	2007-01-02 09:12:00	cafic	acbk	0010050230746	Something about Emmaline	FIC BOYLE2005	NULL
860548	2007-01-02 09:14:00	canf	acbk	0010048238389	Understanding installation art from Duchamp to Holzer	709.04 R7277U 2003	709.04
15316	2007-01-02 09:12:00	cs9	acbk	0000103502175	Frank B Kellogg a biography	B K292 B	NULL
418329	2007-01-02 09:13:00	cs9	acbk	0010002324977	German raider Atlantis	940.953 F8517G	940.953
745716	2007-01-02 09:13:00	cafic	acbk	0010033394031	Zabelle	FIC KRICORI1998	NULL
1529347	2007-01-02 09:14:00	canf	acbk	0000102981248	Reservation narrow gauge Omak Creek railroad Bow Arrow Short Li…	385.52097 L587R	385.52097
1558007	2007-01-02 09:13:00	canf	acbk	0010004731641	place no one knew Glen Canyon on the Colorado	779 P833P2a	779
1681487	2007-01-02 09:12:00	canf	acbk	0010002691342	Buddhism in translations passages selected from the Buddhist sacr…	294 W252B	294
1688675	2007-01-02 09:14:00	canf	acbk	0010048100100	death in Washington Walter G Krivitsky and the Stalin terror	327.1247 K4592D 2003	327.1247
2424499	2007-01-02 09:13:00	canf	acbk	0010054269096	101 diseases you dont want to get	614.5 P8715o 2005	614.5
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2205408	2007-01-02 09:14:00	canf	acbk	0010050859288	fragrance of faith the enlightened heart of Islam	297 R1294F 2004	297
2631813	2007-01-02 09:14:00	nanf	acbk	0010053789672	How to reduce workplace conflict and stress how leaders and their…	658.1053 M327H 2005	658.1053
702785	2007-01-02 09:13:00	canf	acbk	0010034758416	home of the blizzard a true story of Antarctic survival	919.8904 MAWSON 1998	919.8904
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1703576	2007-01-02 09:12:00	canf	acbk	0010025511717	Lakota recollections of the Custer fight new sources of Indian milit…	973.82 LAKOTA 1991	973.82
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295289	2007-01-02 09:13:00	canf	acbk	0010041330571	Running with the Buffaloes a season inside with Mark Wetmore Ad…	796.42809 C7193L 2000	796.42809
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67201	2007-01-02 09:45:00	nchol	jcbk	0010045871109	Jothams journey a storybook for Advent	J YTREEID	NULL
1336766	2007-01-02 09:44:00	cs9o	acbk	0010001512887	Burri	B B942B	NULL
2582486	2007-01-02 09:44:00	ncnew	jcbk	0010050556819	Lady in the water a bedtime story	E SHYAMAL	NULL
1978356	2007-01-02 09:45:00	cs6ro	arbk	0010019836690	Bullard Arms	338.76834 J241B	338.76834
1404338	2007-01-02 09:44:00	canf	acbk	0010038257472	Perfect bones a six point plan to promote healthy bones	616.716 L5785P 2000	616.716
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468341	2007-01-02 09:41:00	nafic	acbk	0010022410574	Fly fishing tales literary bait by angling authors	FIC FLY FIS1994	NULL
1558499	2007-01-02 10:02:00	nanf	acbk	0010037361580	Chariots of the gods unsolved mysteries of the past	001.94 DANIKEN 1999	001.94
2064174	2007-01-02 09:41:00	canf	acbk	0010036046778	way of agape	241.4 MISSLER 1999	241.4
18430	2007-01-02 09:41:00	canf	acbk	0010026014141	Future of medicine toward a science of prevention based on ancie…	613 DUGLISS 1993	613
614085	2007-01-02 09:41:00	canf	acbk	0010045701462	Tanker operations a handbook for the person in charge PIC	623.88245 H8627T 2001	623.88245
1591175	2007-01-02 09:39:00	caesl	bcbk	0010034398809	Angliiskii iazyk prosto o slozhnom prakticheskii kurs	RUSSIAN 428.24917 L576A	428.24917
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965750	2007-01-02 09:38:00	capf	acbk	0010025431536	Kathy and Mo show parallel lives	812.54 GAFFNEY 1992	812.54
1970799	2007-01-02 09:39:00	nafic	acbk	0010046761242	revelation	FIC LITTLE	NULL
1006825	2007-01-02 10:17:00	cacd	accd	0010046200415	peaceful Christmas	CD 782.21723 P3133	782.21723
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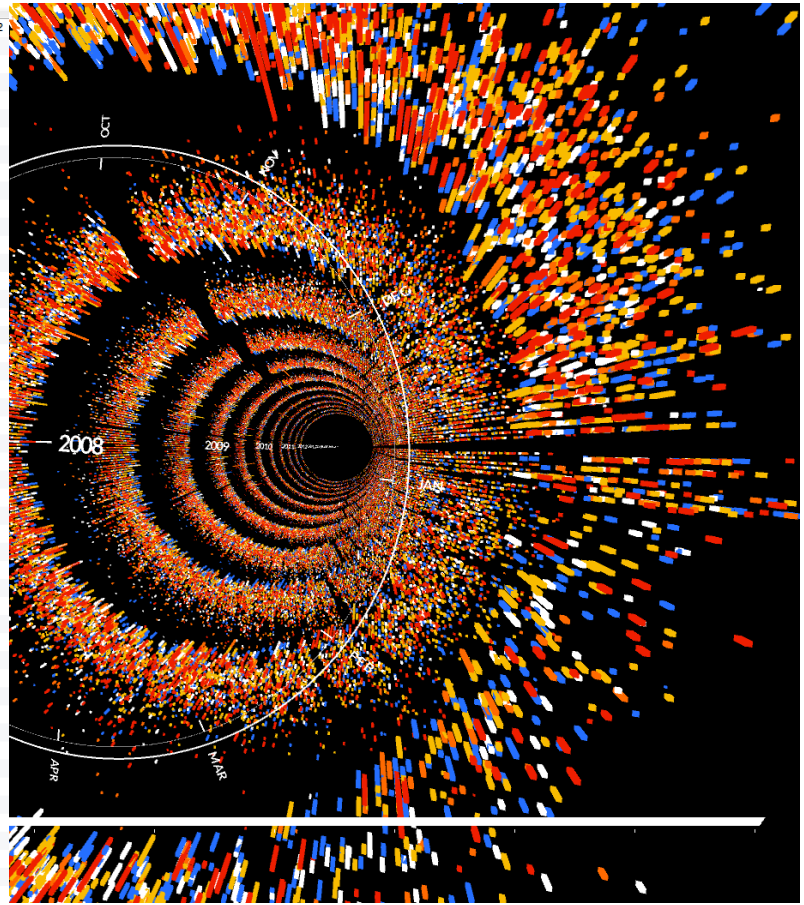

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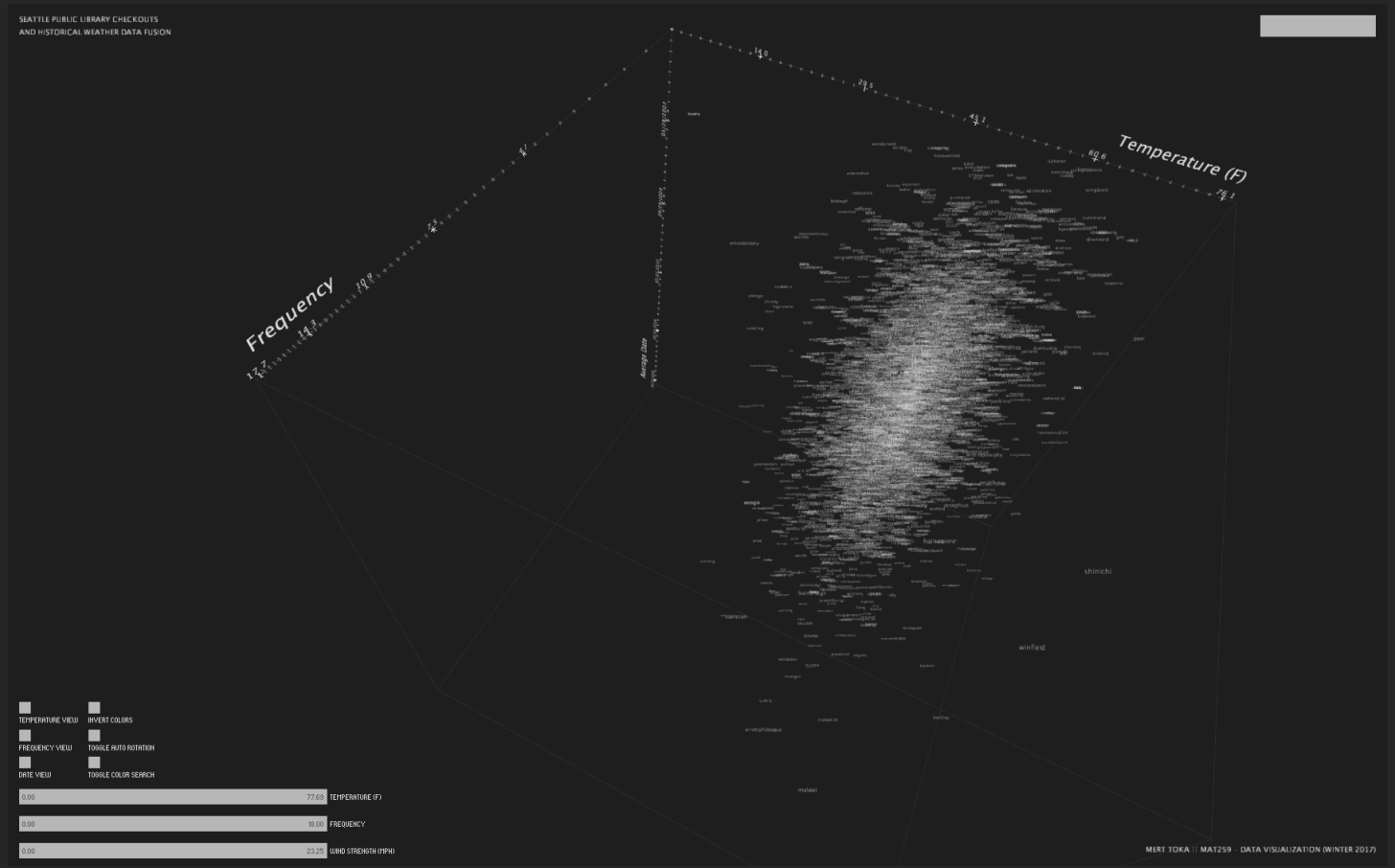
Word Temperatures



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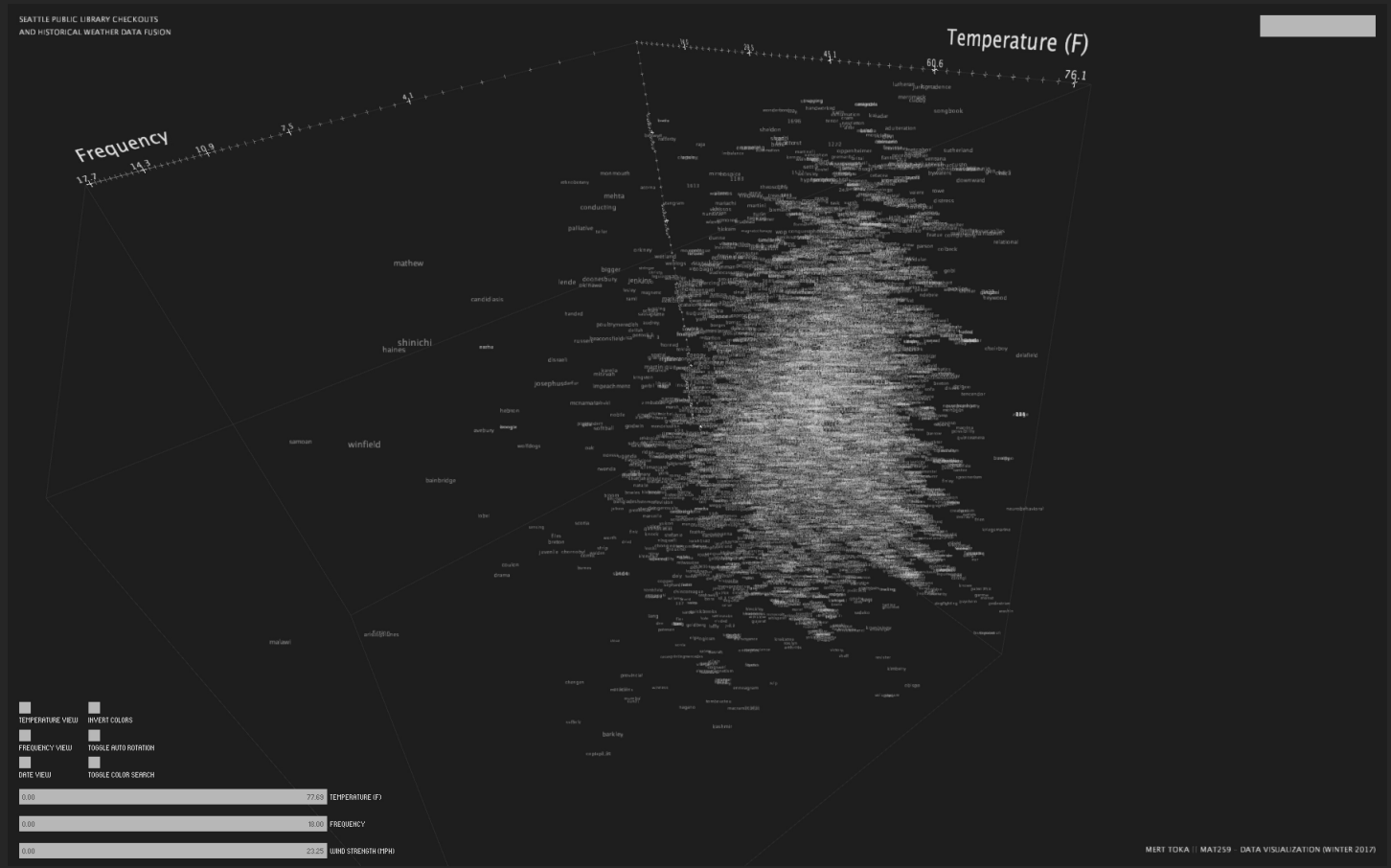

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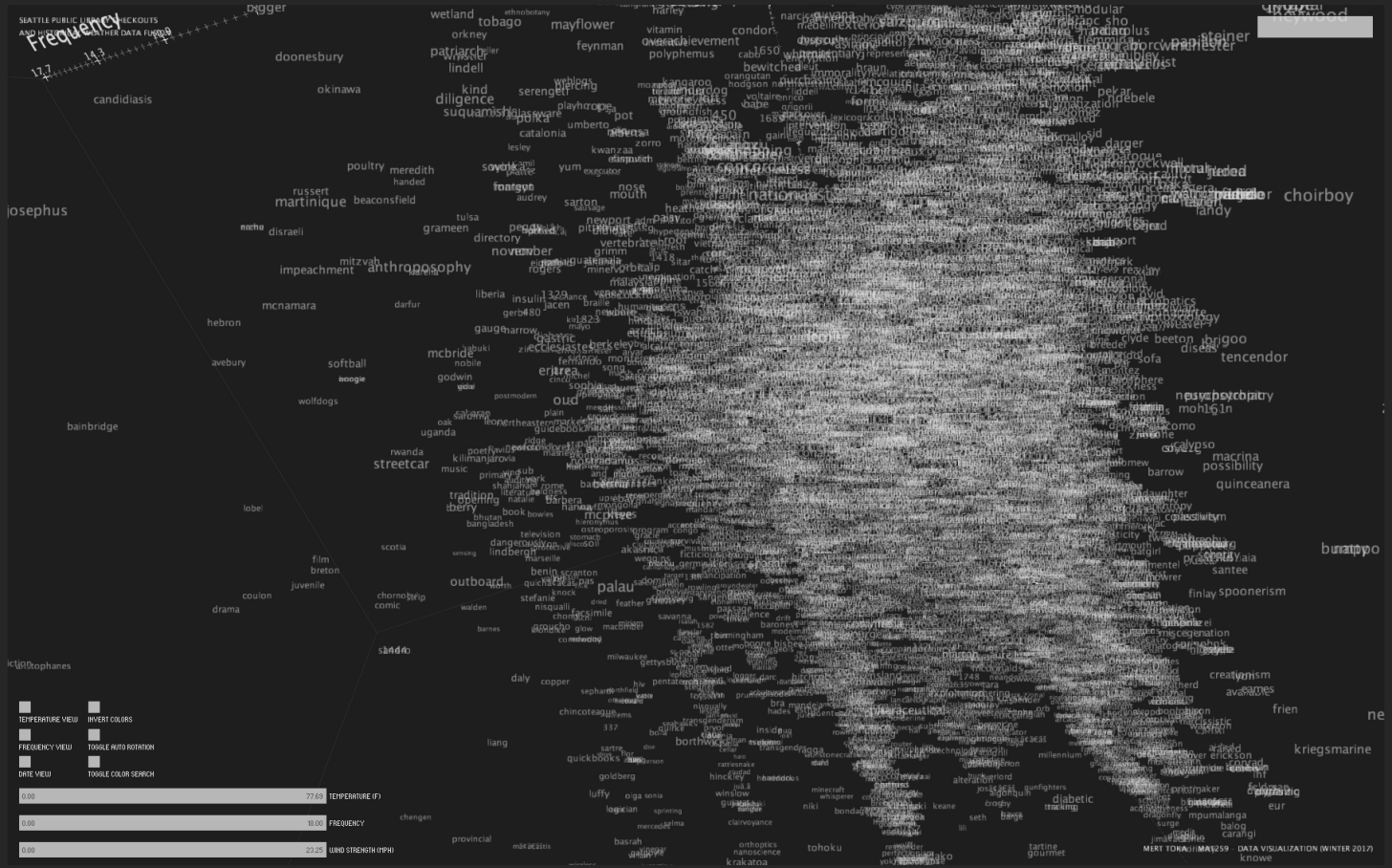

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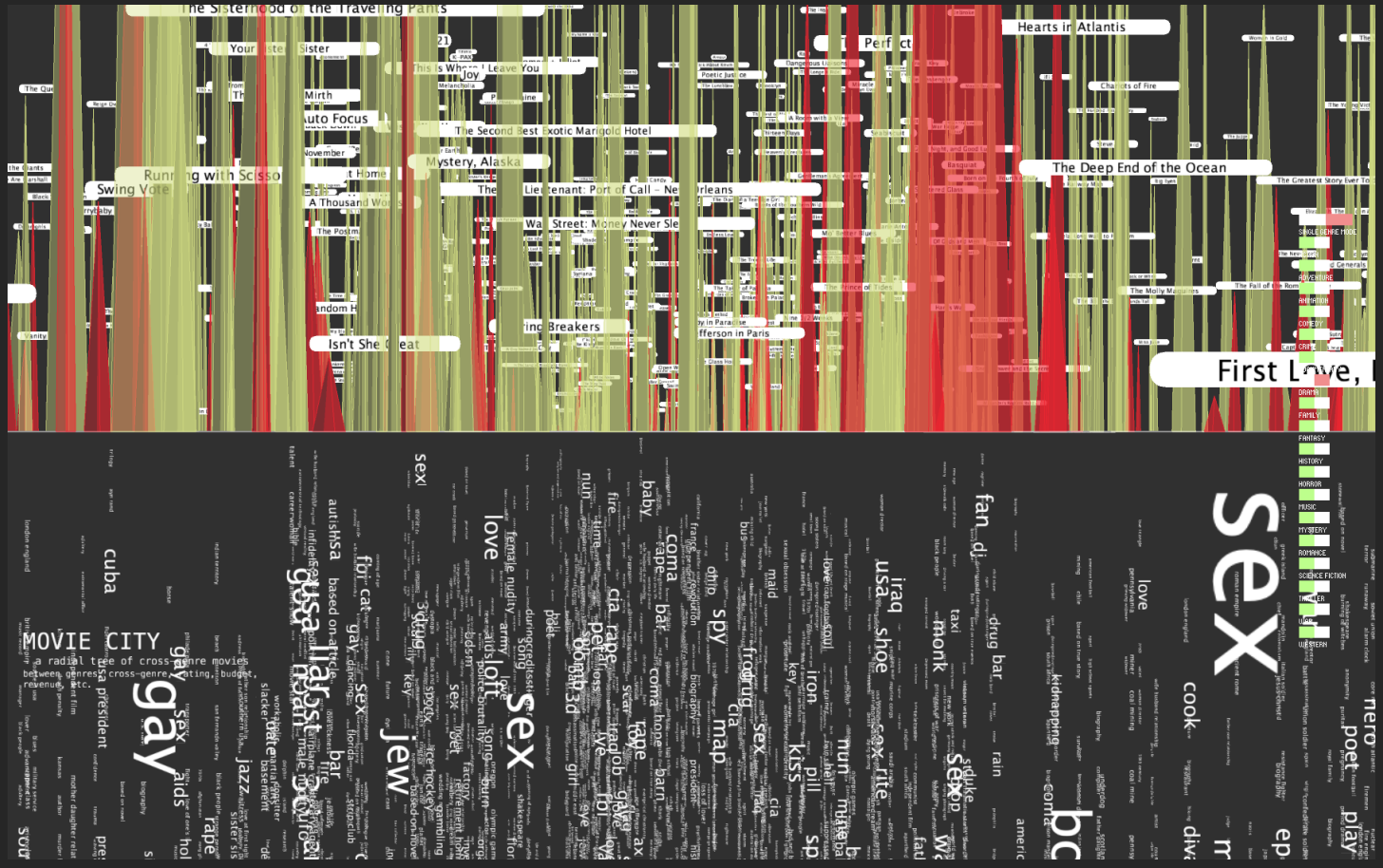
Movie City



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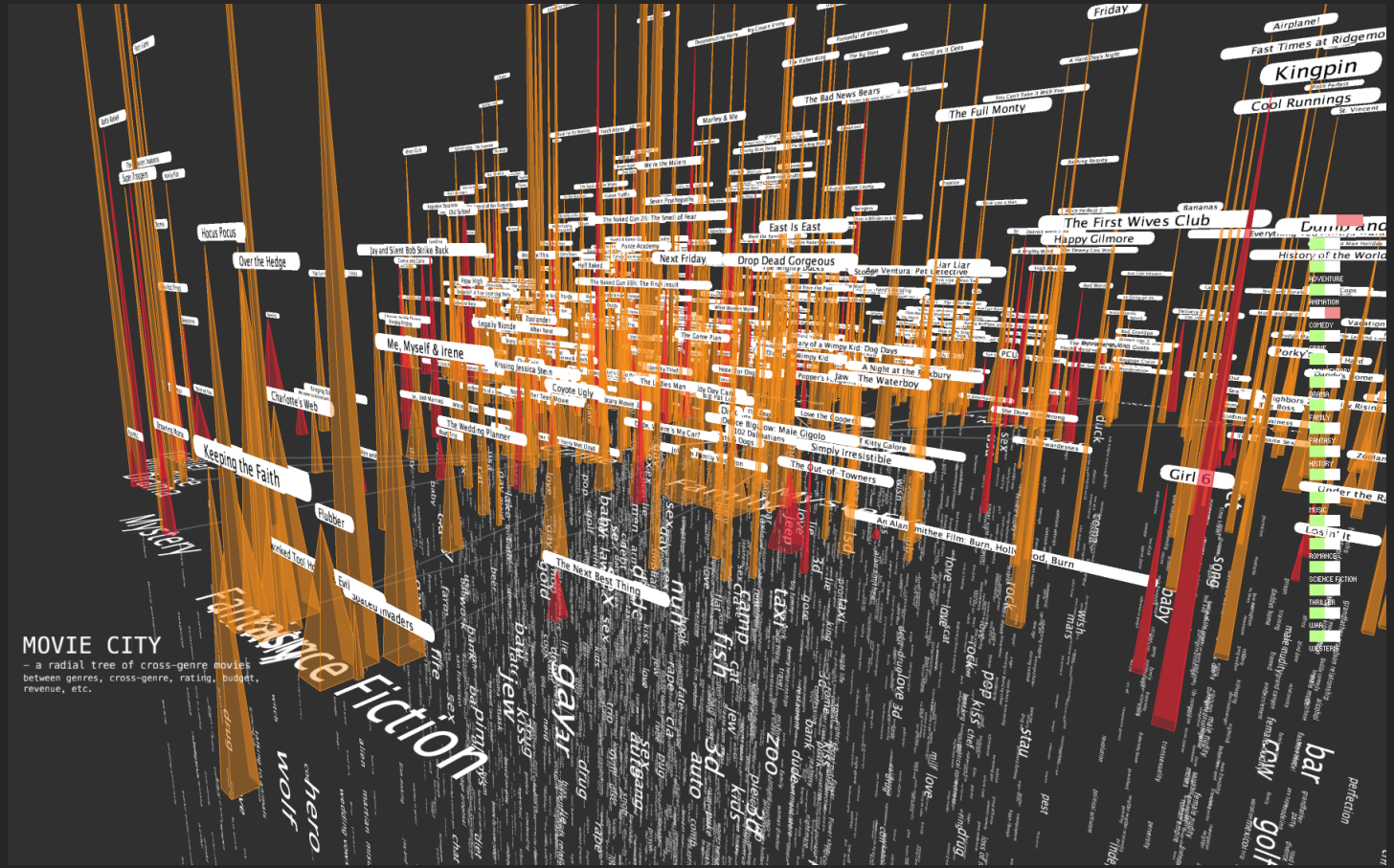

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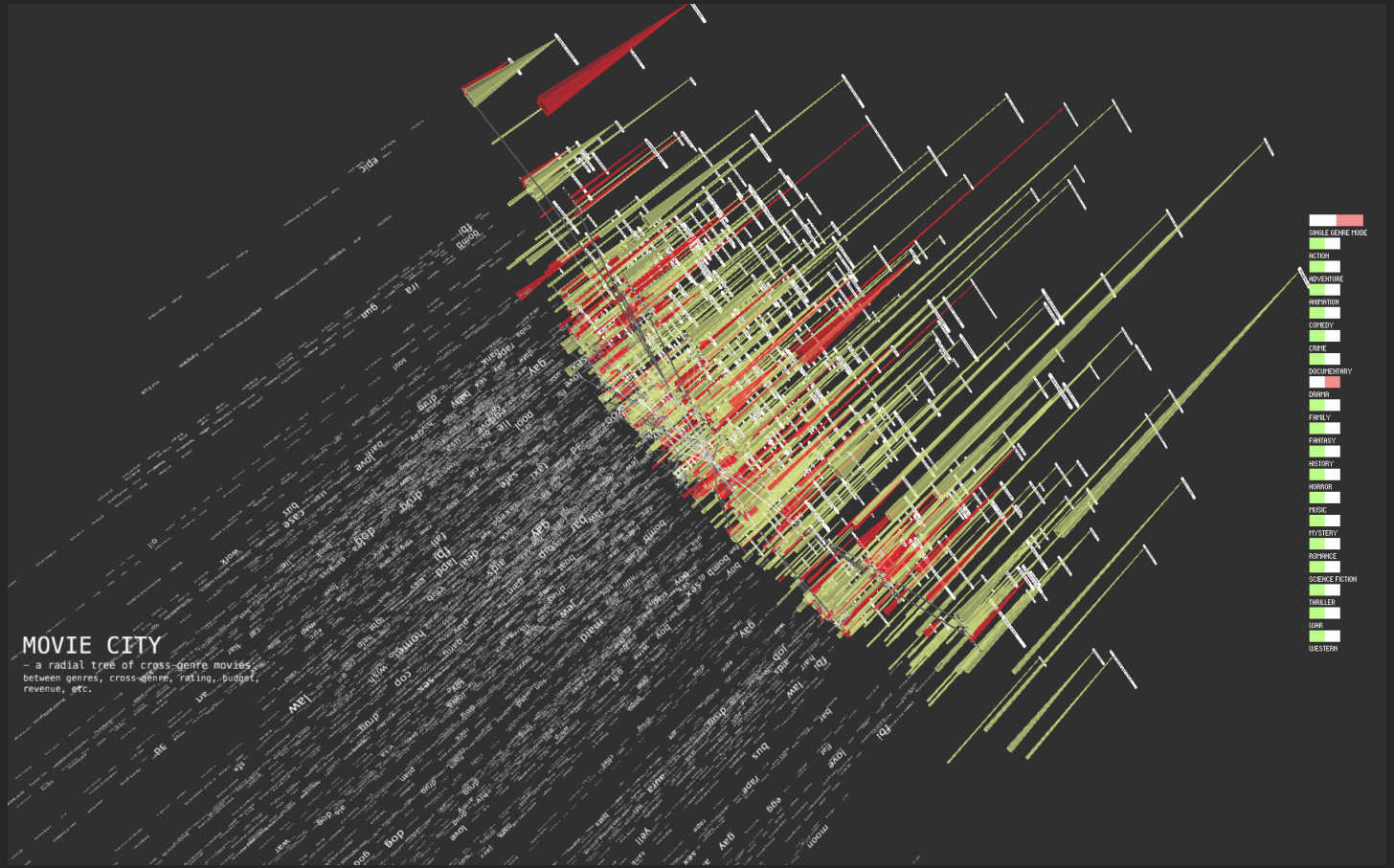

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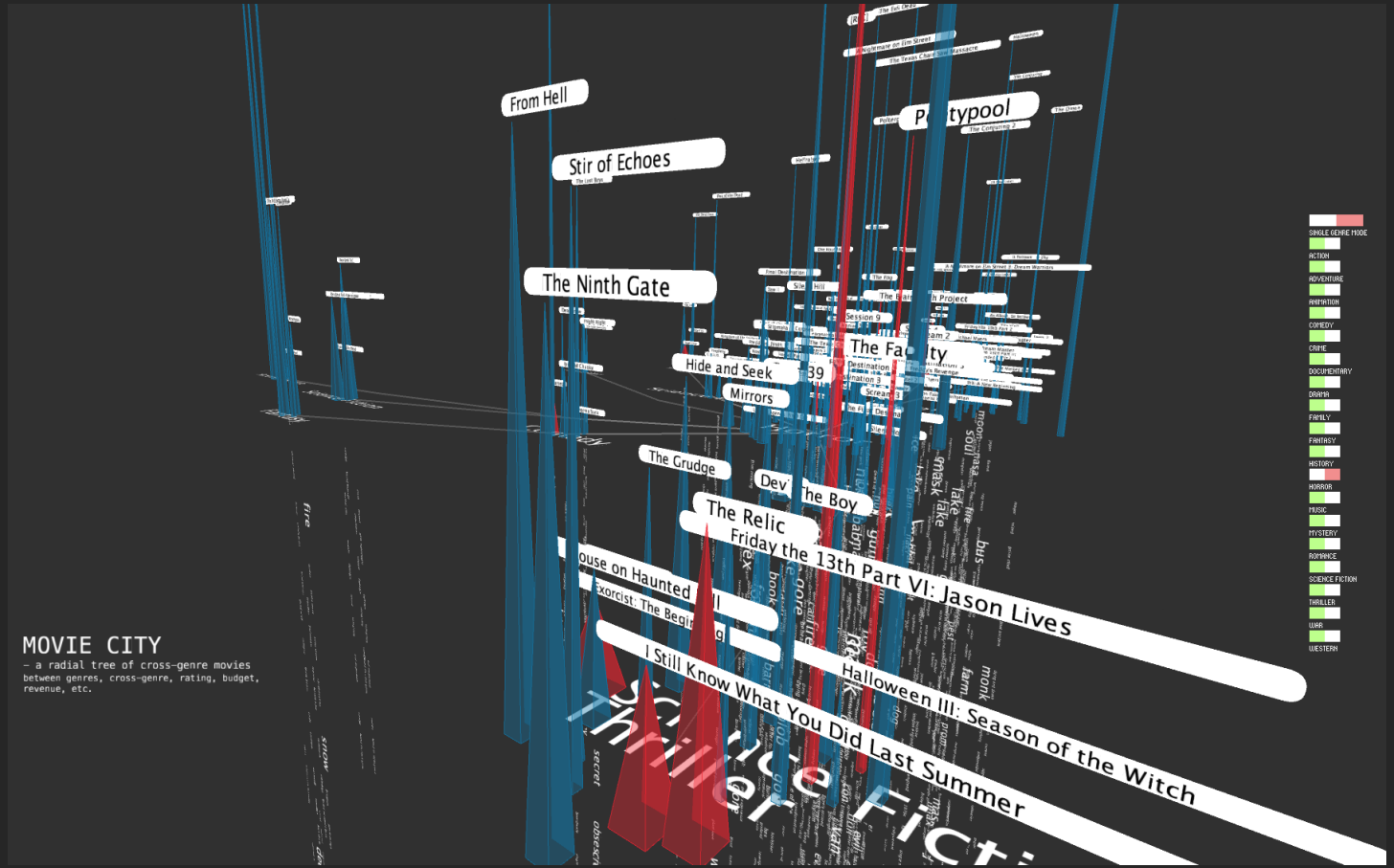

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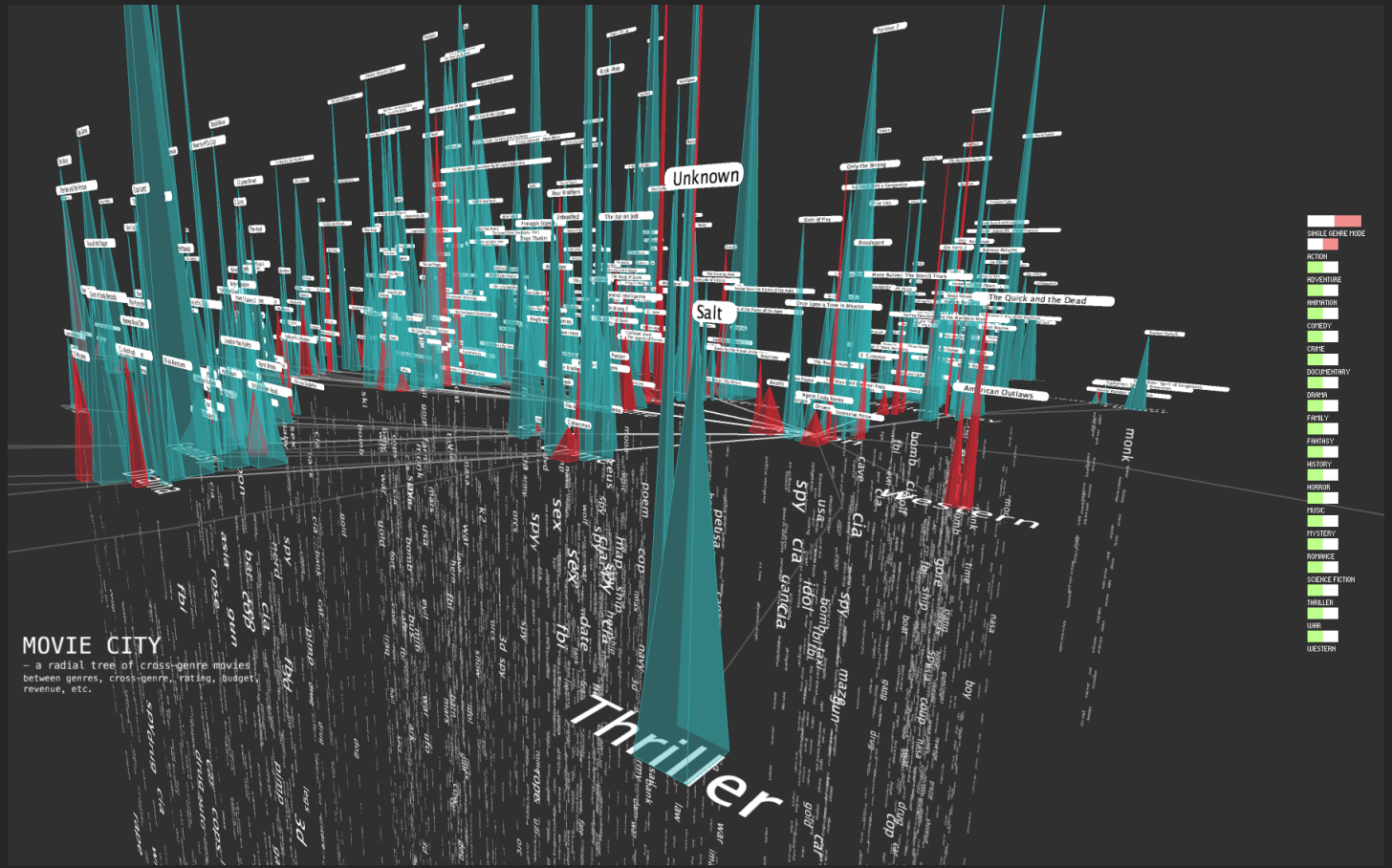
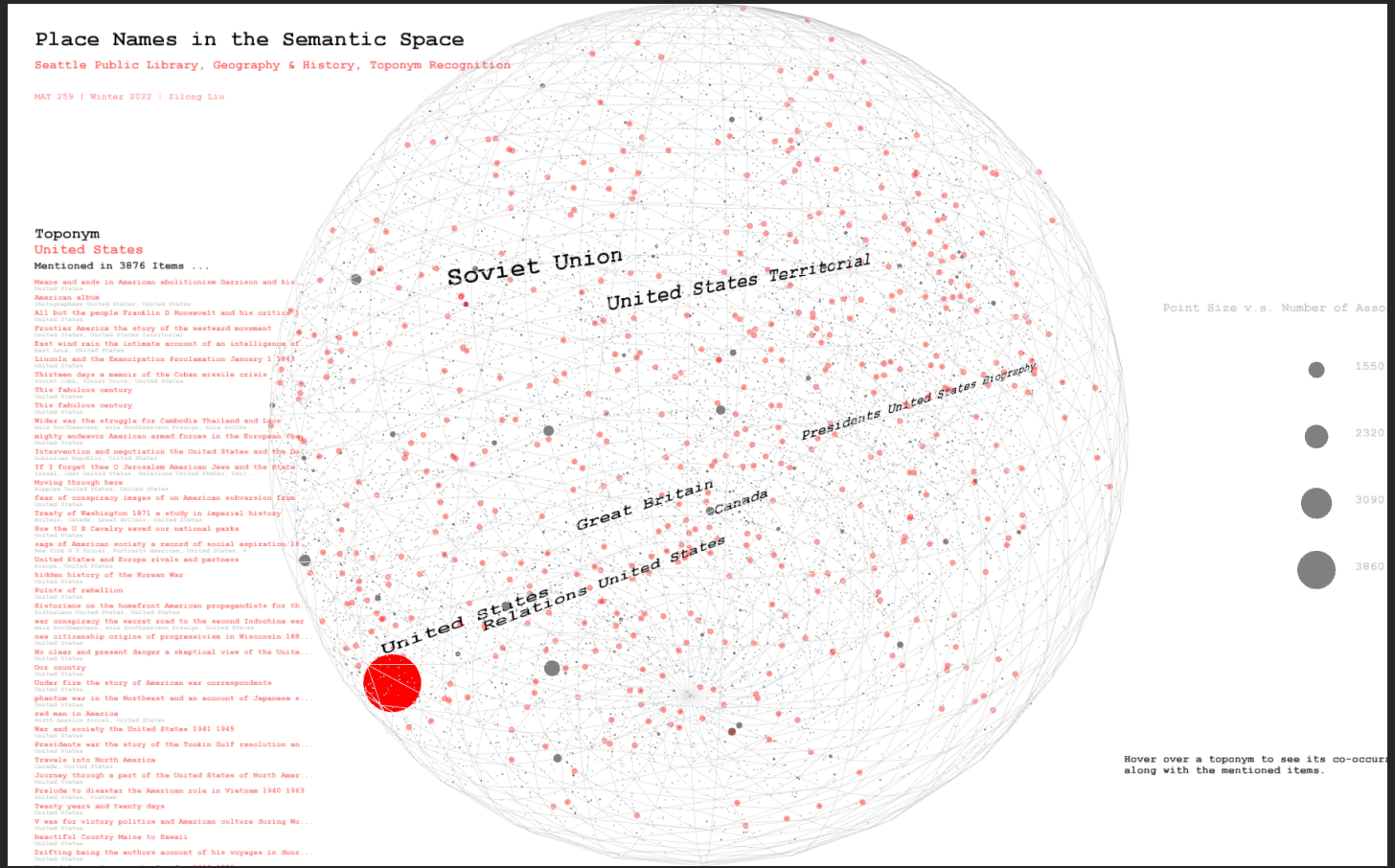


https://vislab.mat.ucsb.edu/2018/p3/Yan_Kong/index.html

Form of News

https://vislab.mat.ucsb.edu/2018/p3/Weidi_Zhang/index.html

Place Names in Semantic Space



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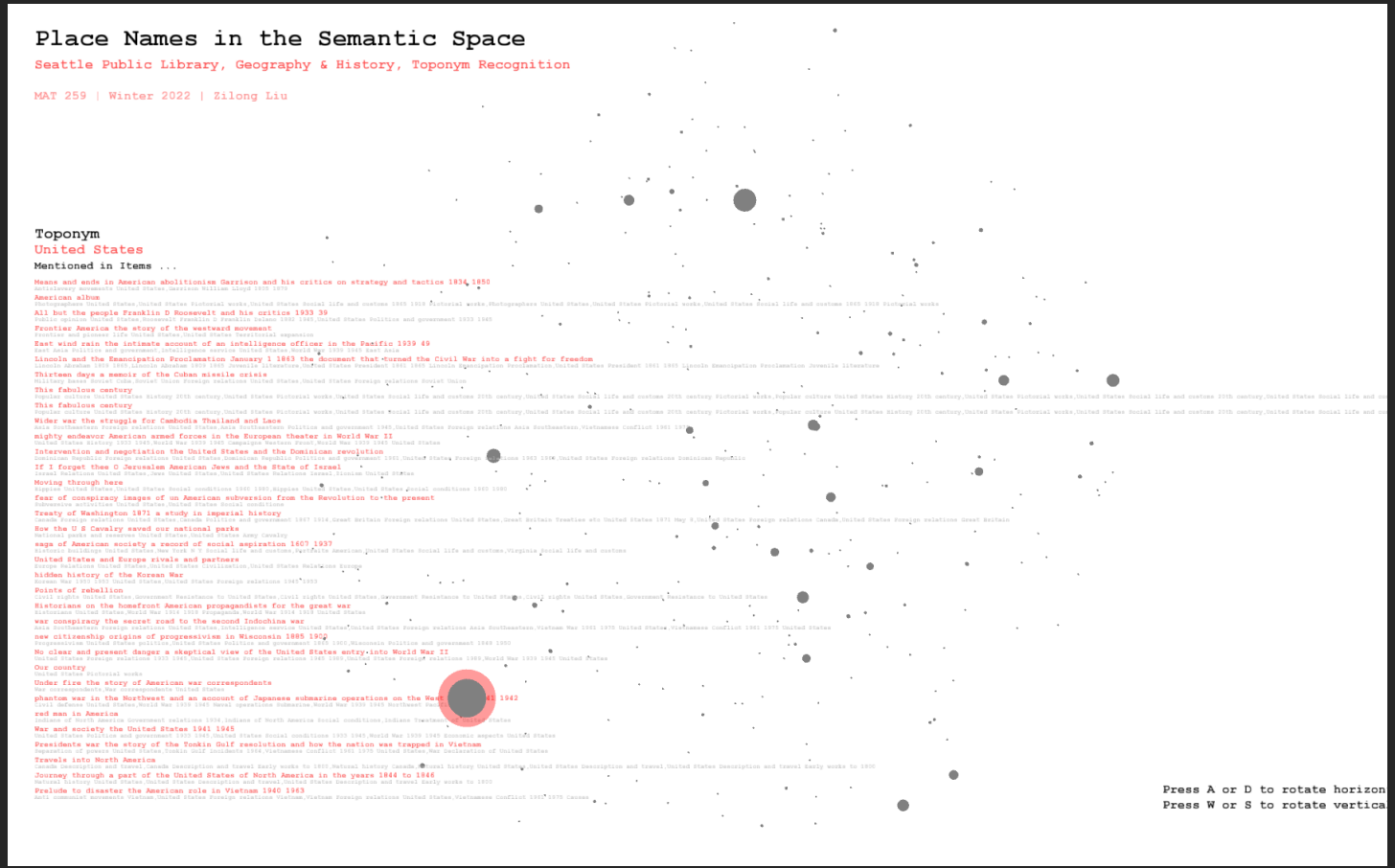
Place Names in Semantic Space



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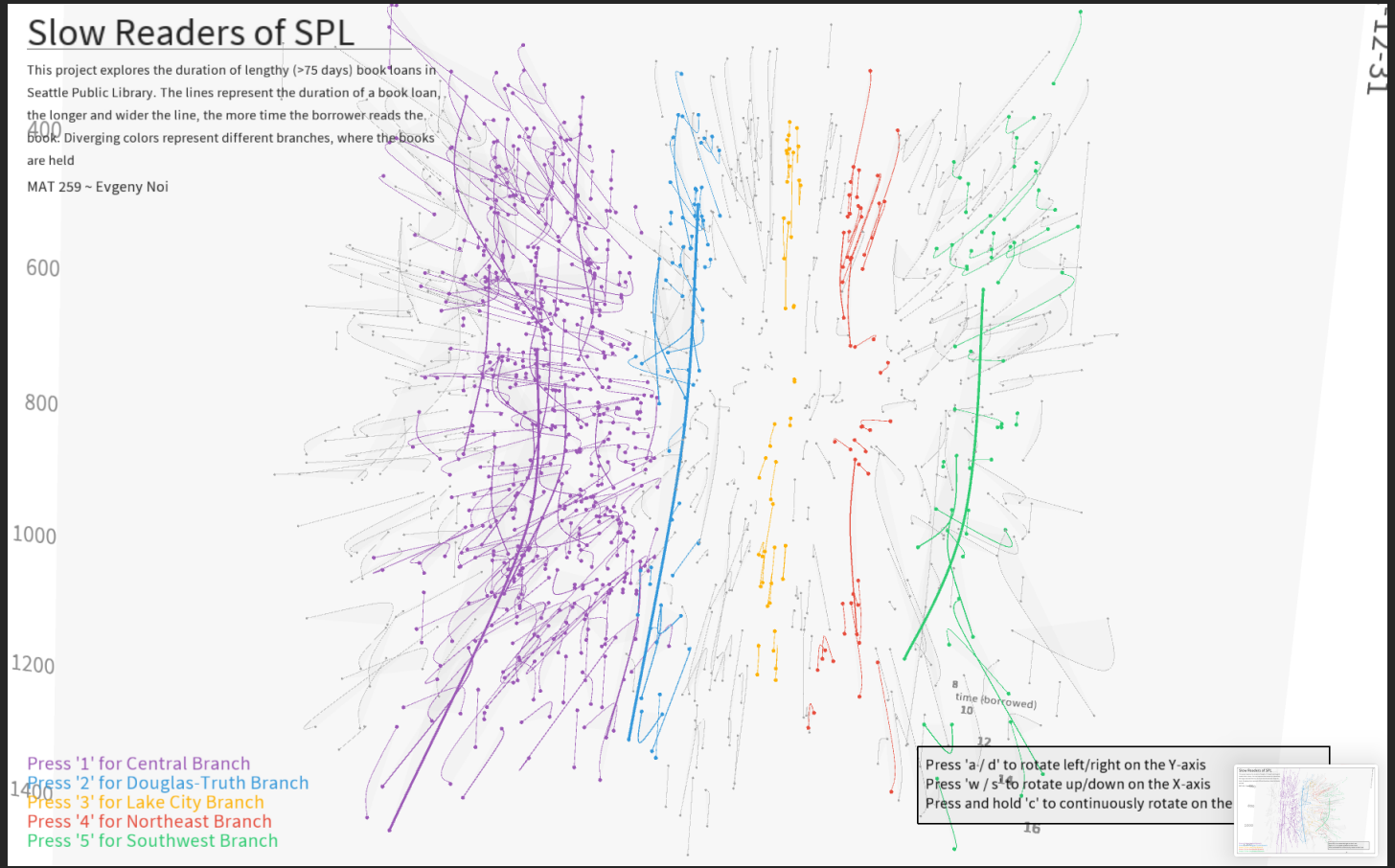
Data in 3D space based on some rules, color, connecting lines, etc.



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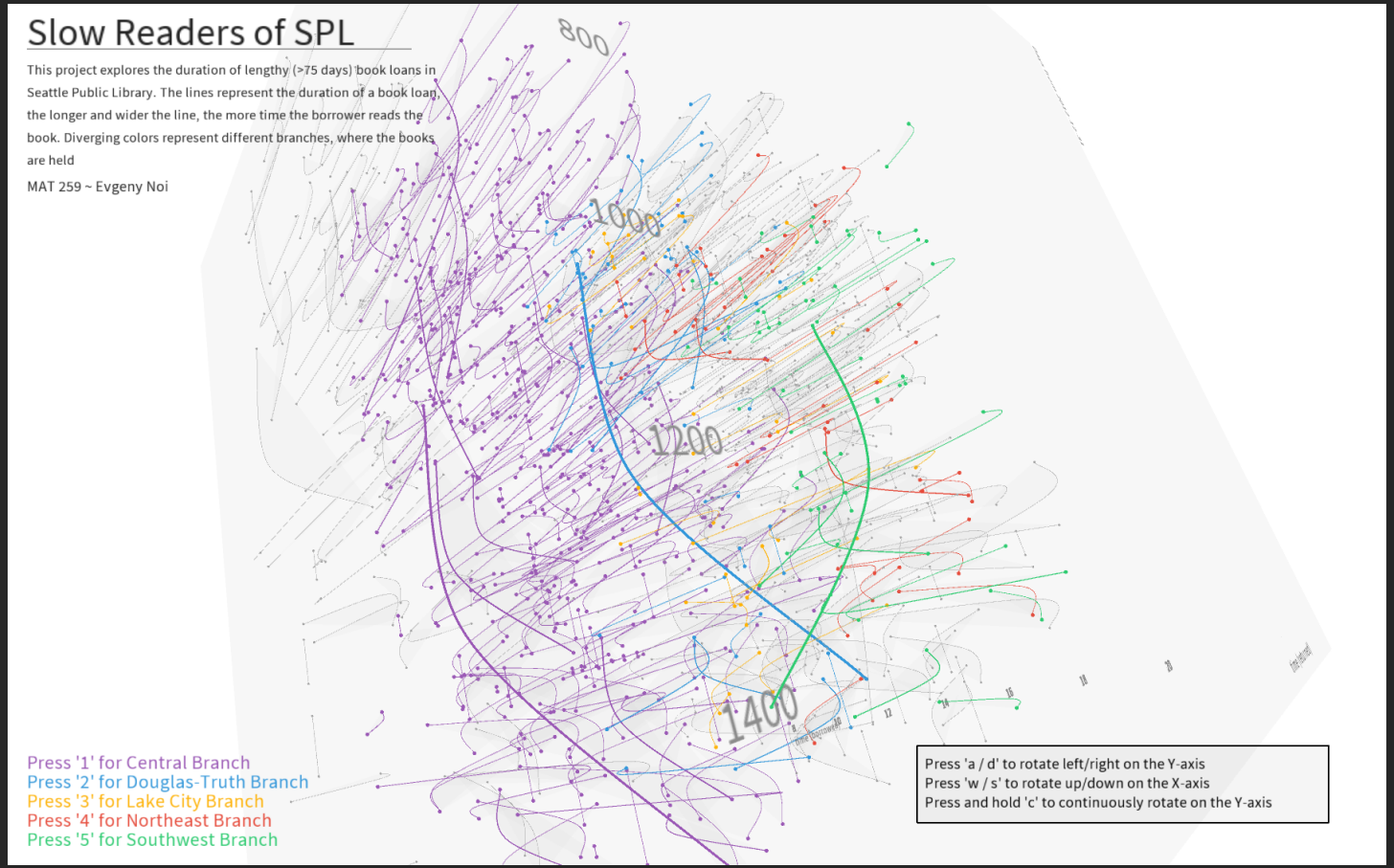
Data in 3D space based on some rules, color, connecting lines, etc.



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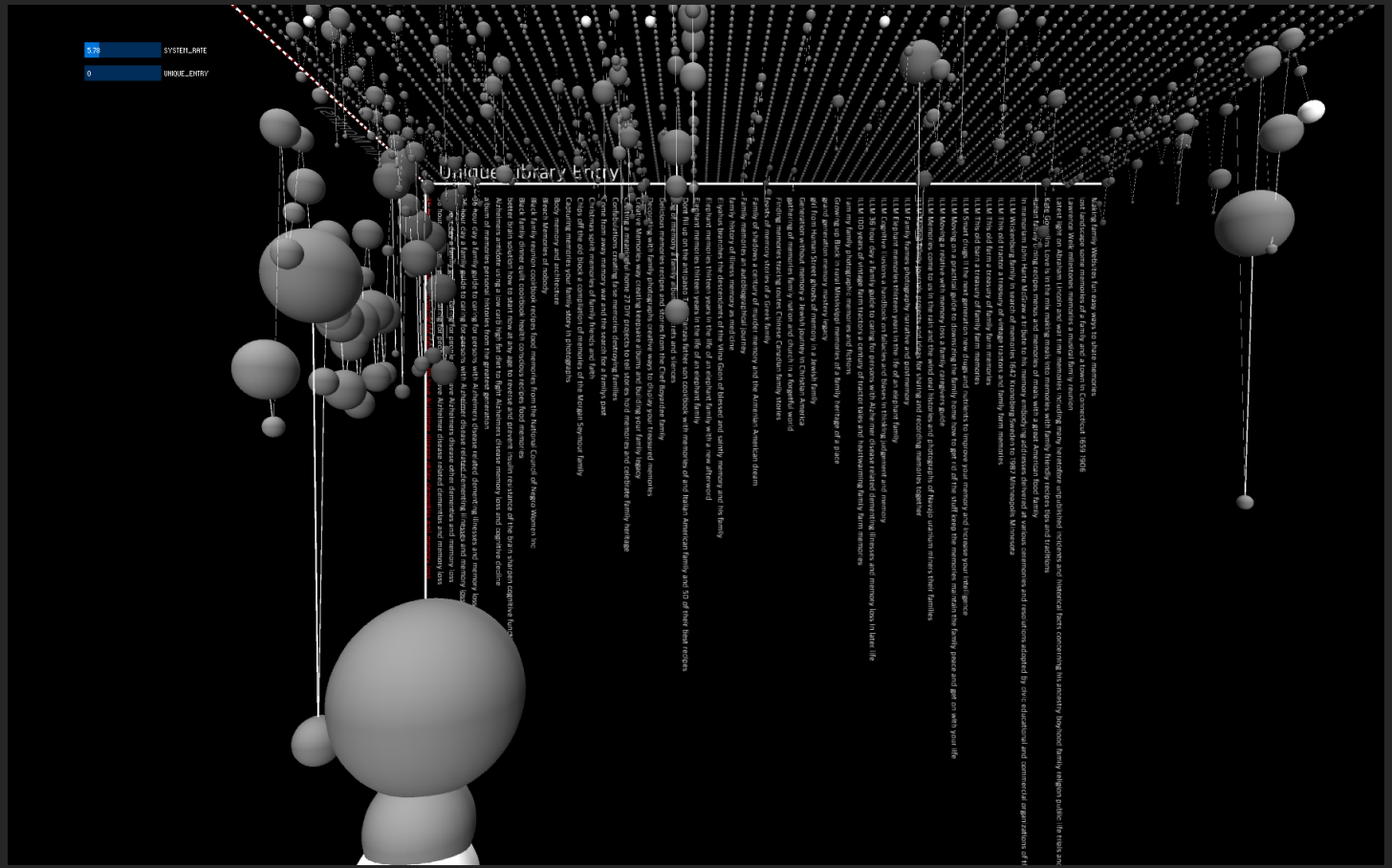
Exploring Embodied and Generational Memory…



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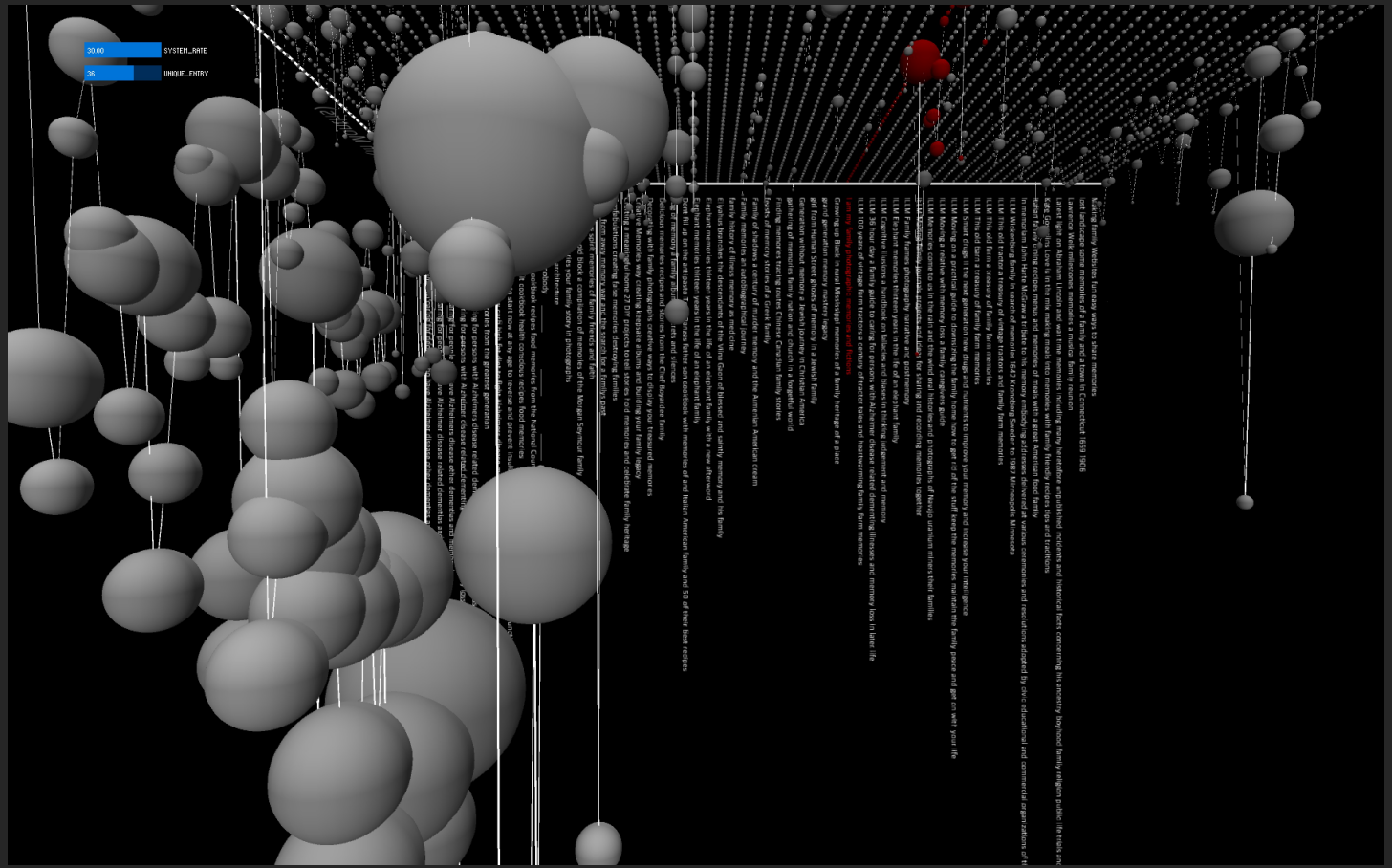

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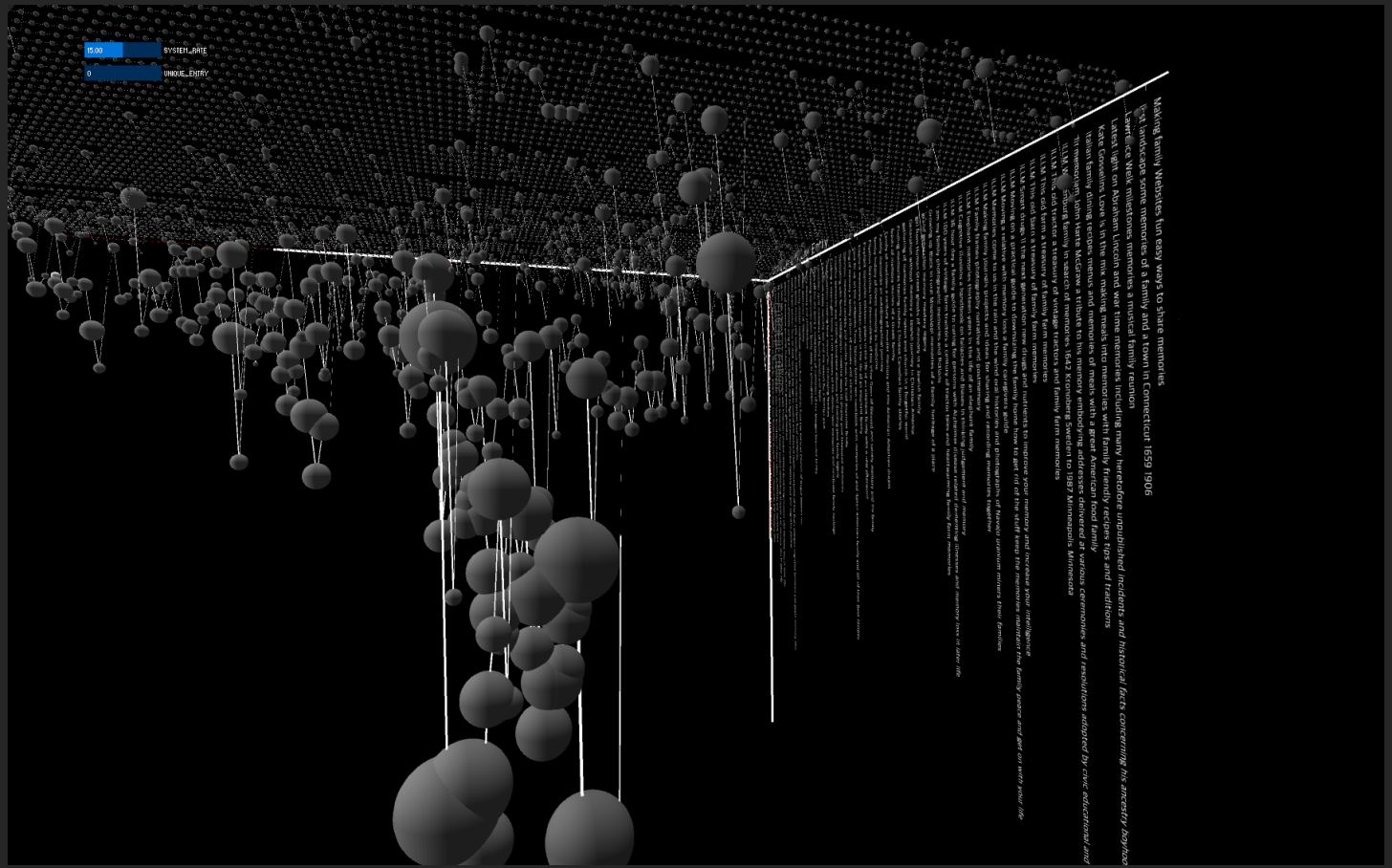
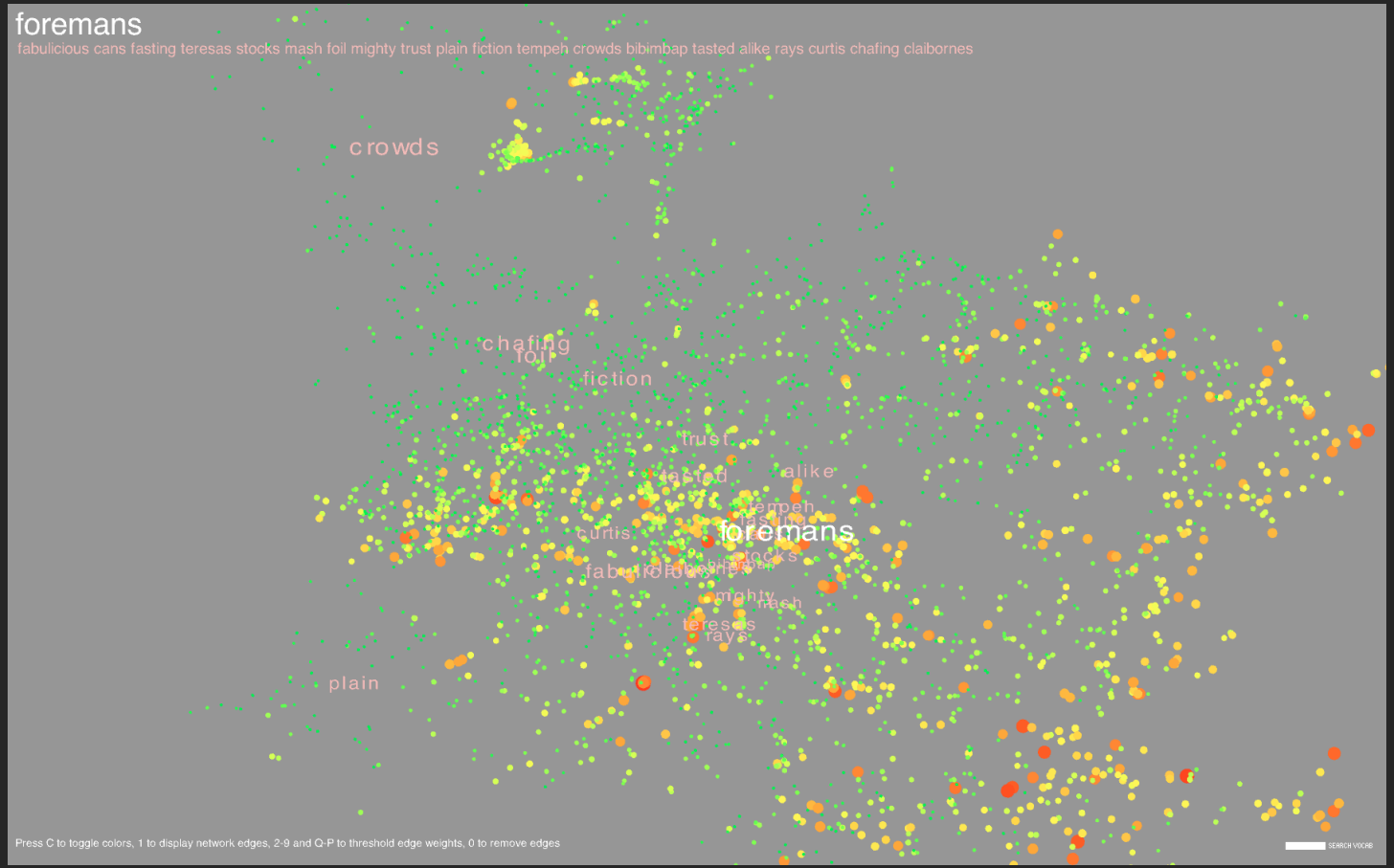
Exploring Embodied and Generational Memory…

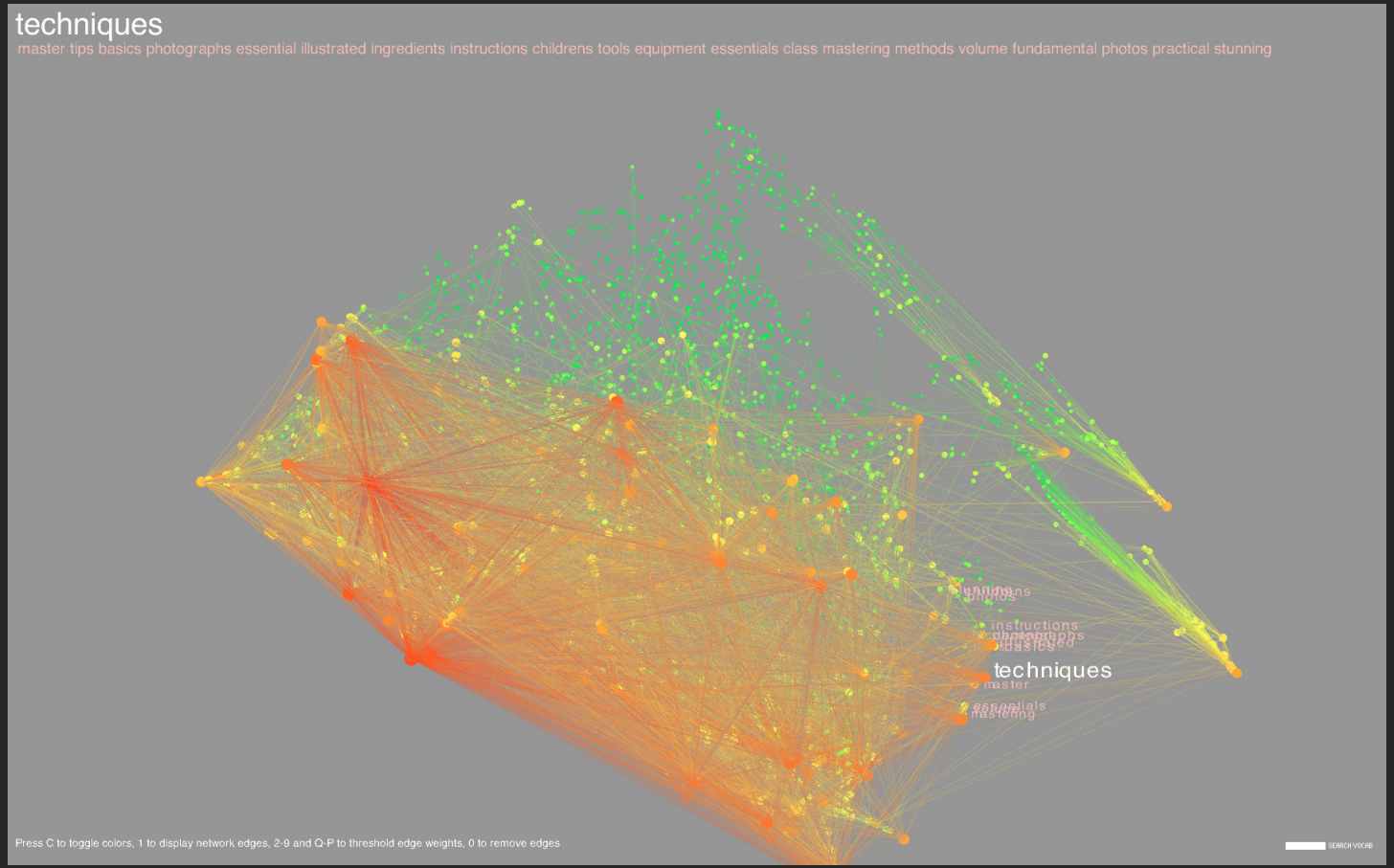

15.00
SYSTEM_RATE
0
UNIQUE_ENTRY
Making family Websites fun easy ways to share memories
Sea landscape some memories of a family and a town in Connecticut 1659 1906
Lawrence Welk milestones memories a musical family reunion
Latest light on Abraham Lincoln and some memories including many heretofore unpublished incidents and historical facts concerning his ancestry boyhood
Kate Greenaway Love is in the air and memories of meals with a great American food family
Italian family cook book Kate McGloin a tribute to his memory embodying addresses delivered at various ceremonies and resolutions adopted by civic educational and
Memories of Dad family in search of memories 1642 Kronoberg Sweden to 1987 Minneapolis Minnesota
This old tractor a treasury of vintage tractors and family farm memories
This old farm a treasury of family farm memories
This old tractor a treasury of family farm memories
Moving on a practical guide to downsizing the family home how to get rid of the stuff keep the memories maintain the family peace and get on with your life
Moving relatives with memory loss a family caregivers guide
Making family journals a step by step guide to preserving memories and passing them on
Capturing memories a handbook on history and travel for the family historian
Family stories biographies and memoirs a guide for writing and publishing memoirs
Family stories biographies and memoirs a guide for writing and publishing memoirs
Family stories biographies and memoirs a guide for writing and publishing memoirs

3D Data Clustering: Food & Drink Words



https://vislab.mat.ucsb.edu/2019/p2/Chantal_Nguyen/index.html

3D Data Clustering: Different ways by which to show clustering



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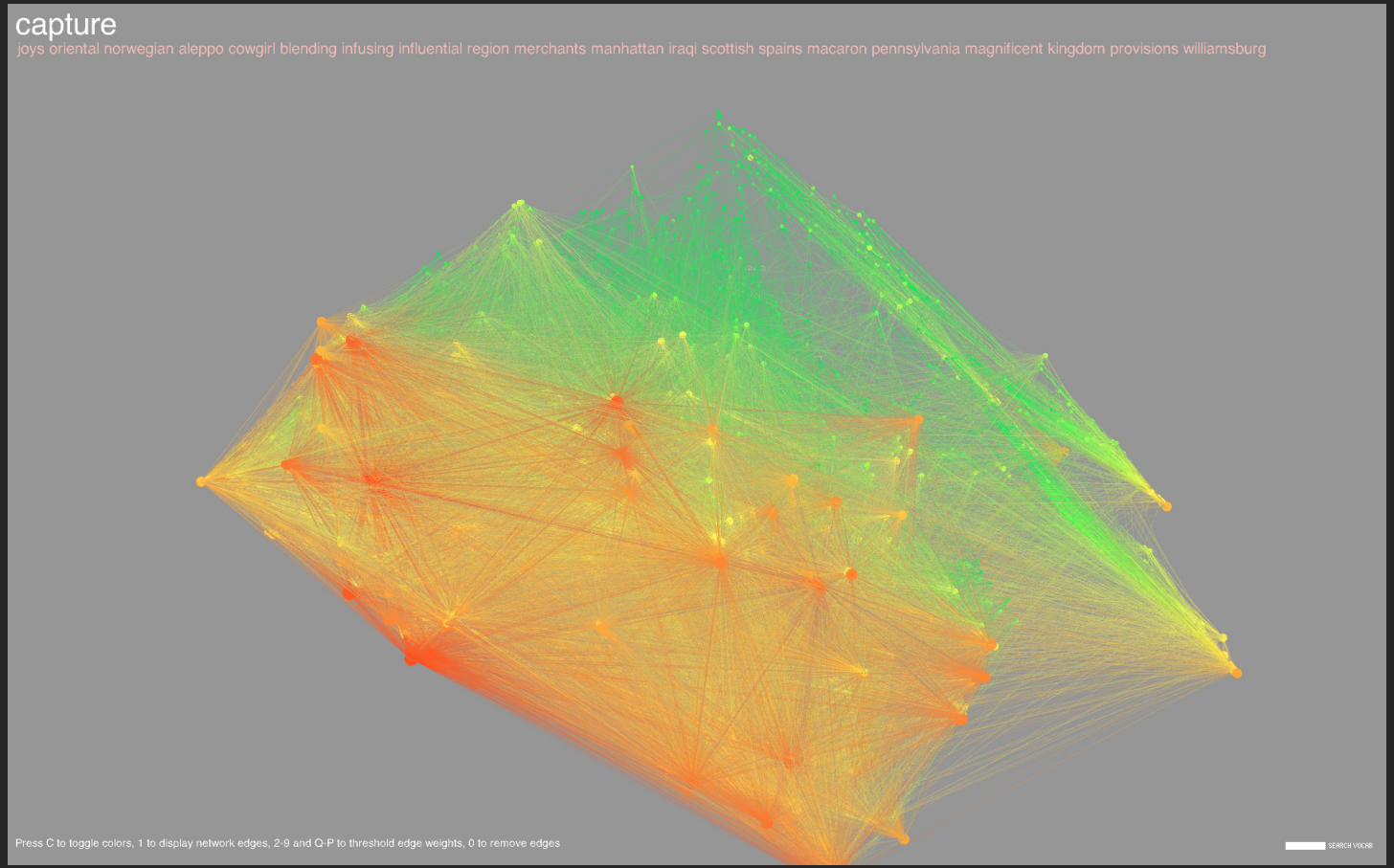
Food & Drink Words



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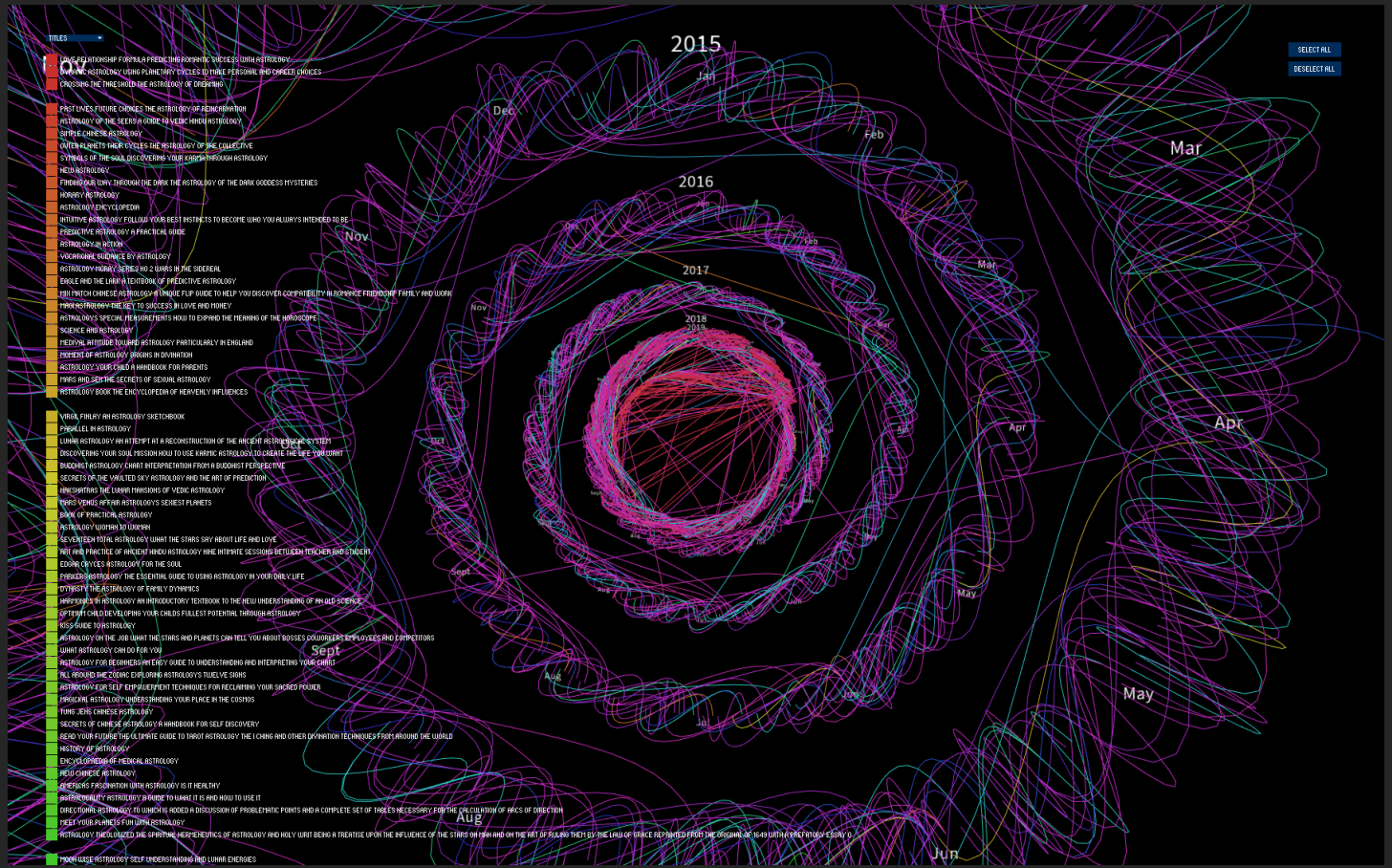
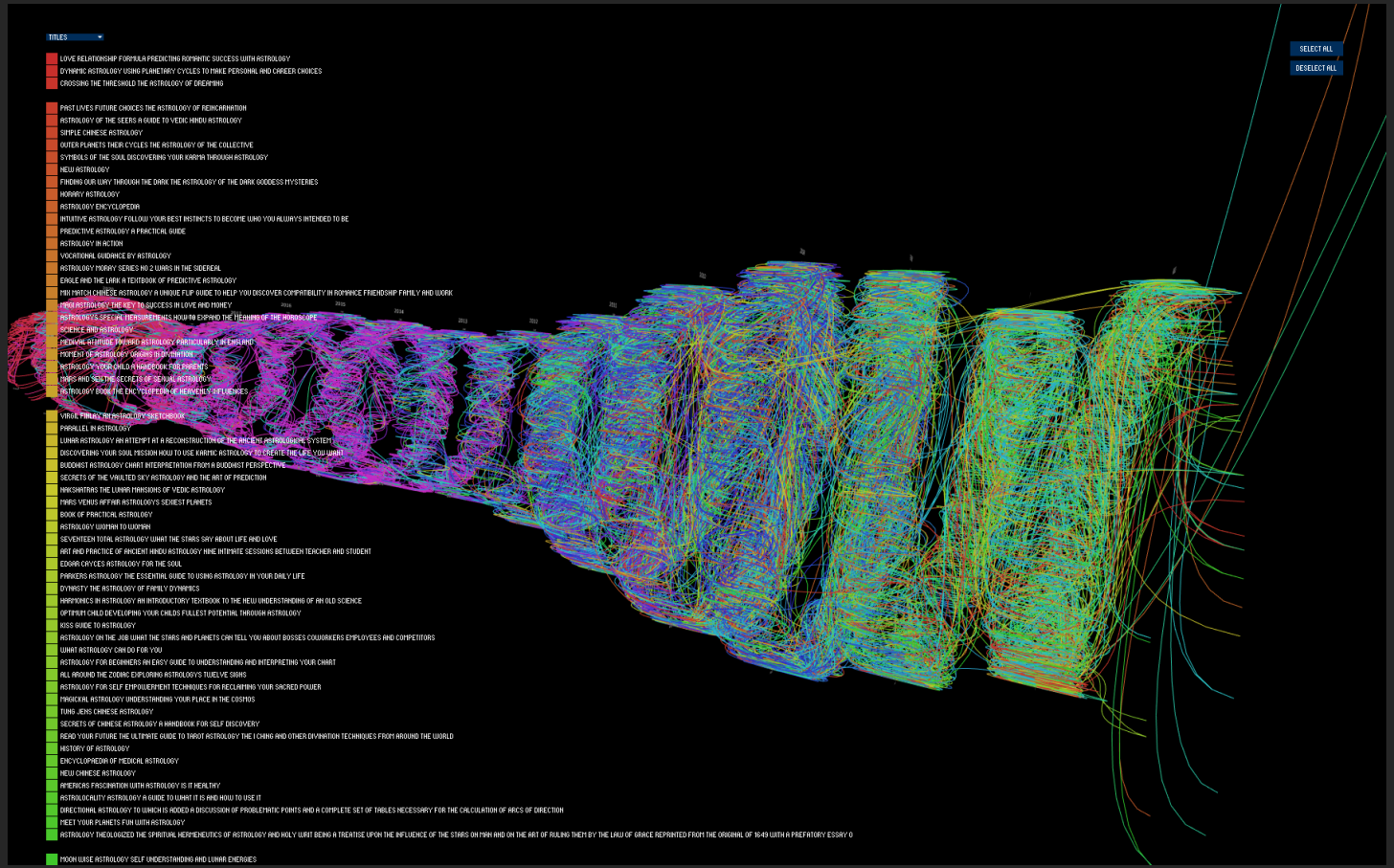
Color Encoding to give shape and form. Topic “Astrology”



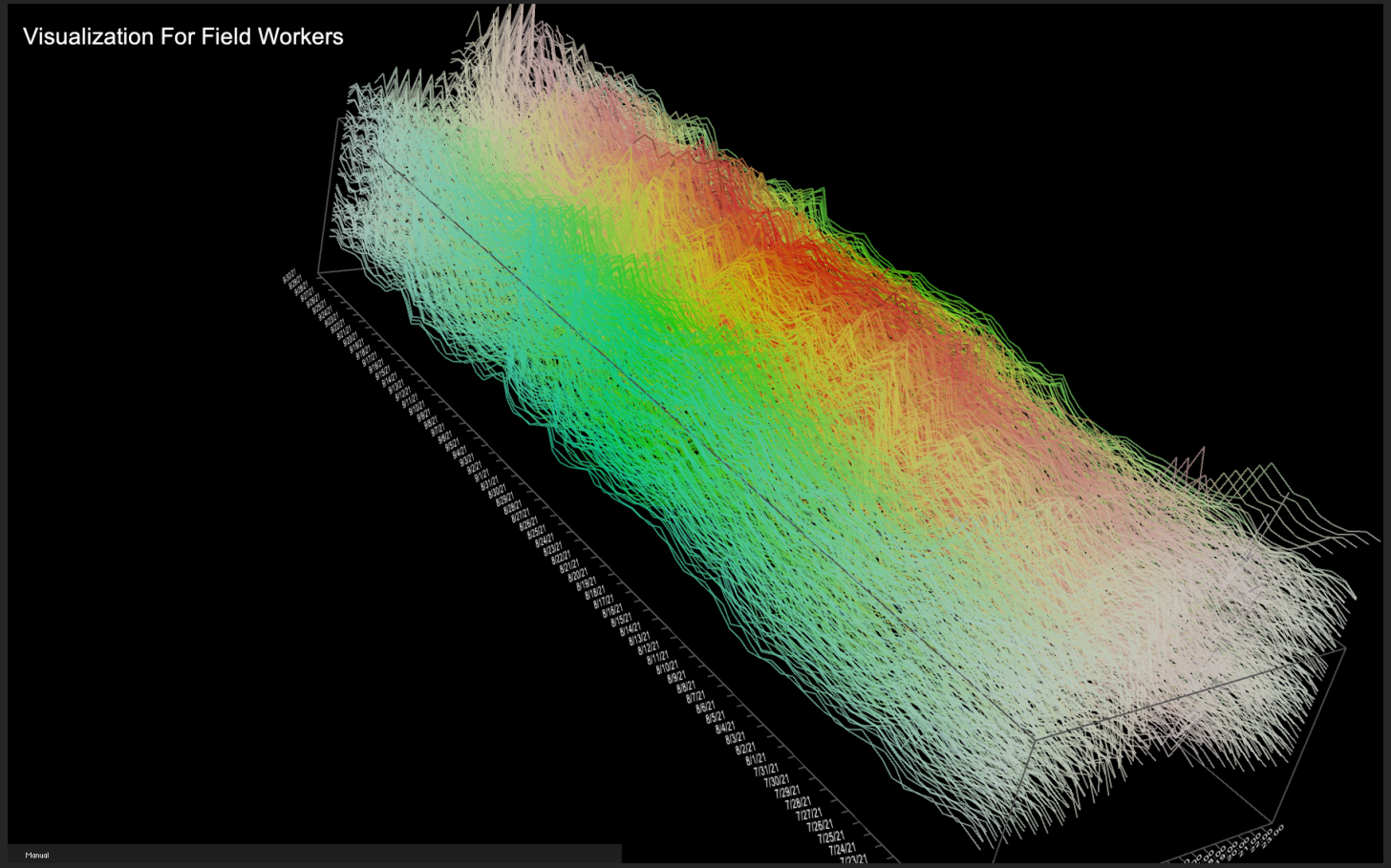
https://vislab.mat.ucsb.edu/2021/p2/Colette_Lee/Project2_Colette.html

Color Encoding to give shape and form. Topic “Astrology”



https://vislab.mat.ucsb.edu/2021/p2/Colette_Lee/Project2_Colette.html

3D Form. Topic: “Visualization of Field Workers”



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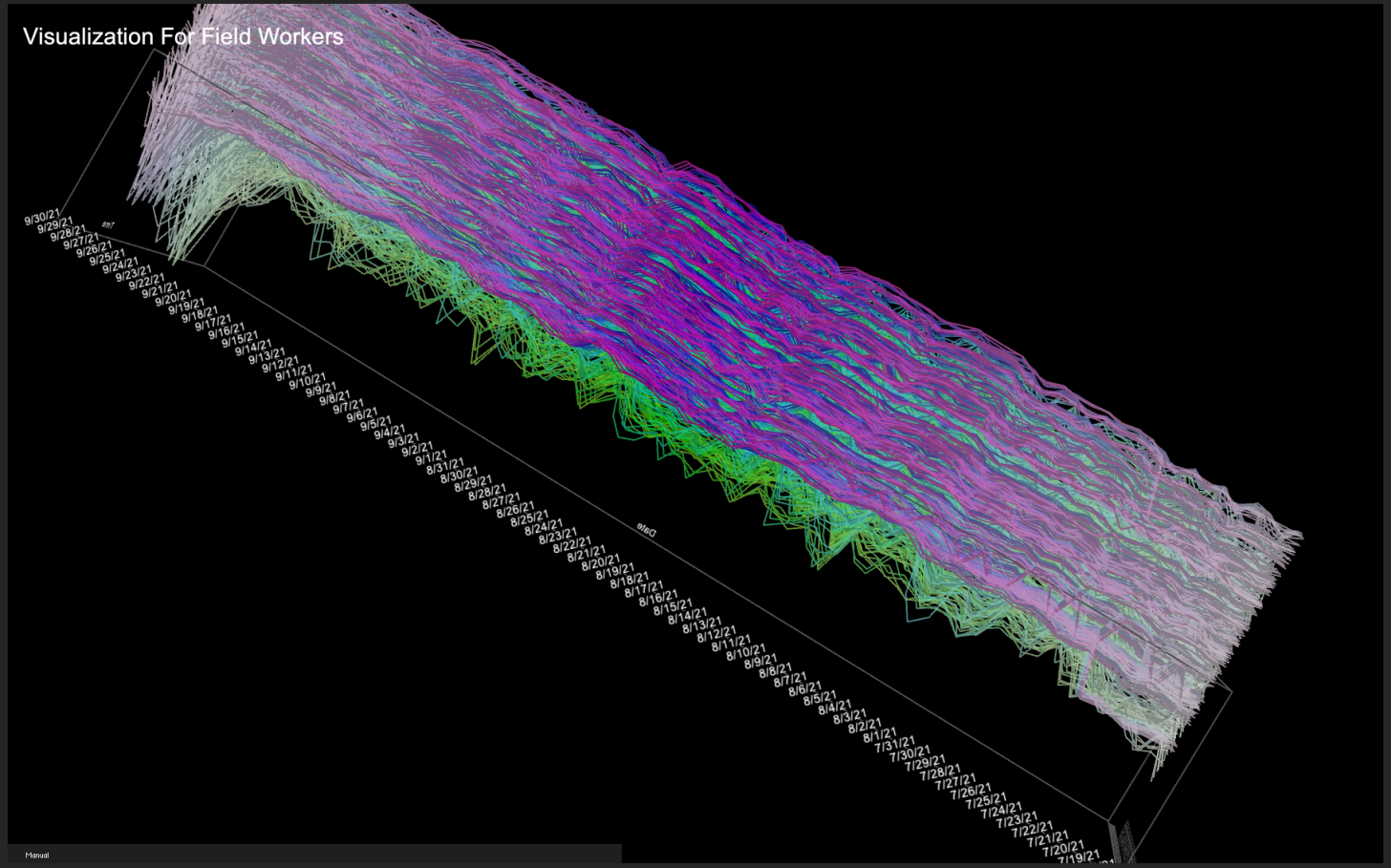
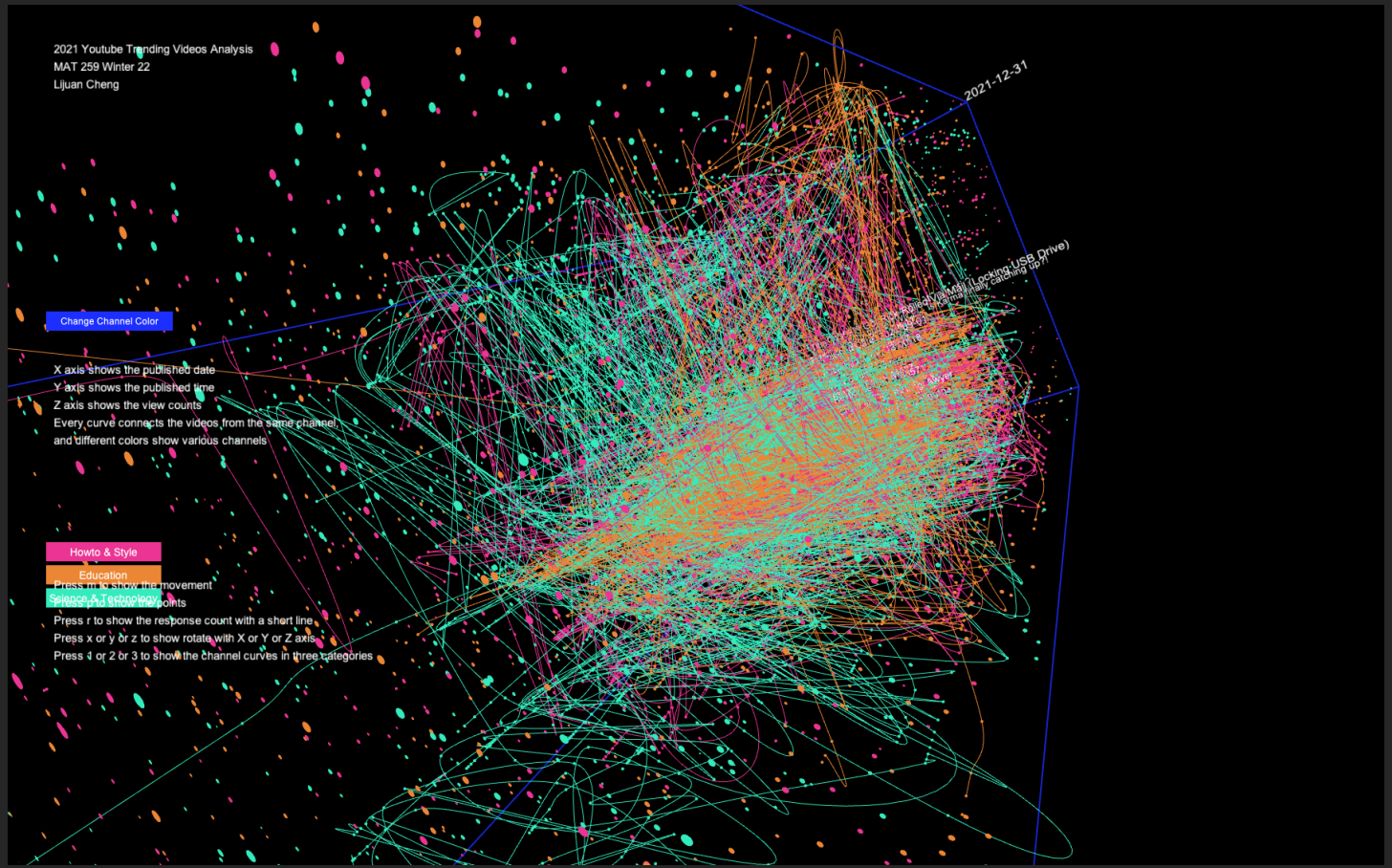


Animation in 3D: “Trending Videos in 3 Categories”



https://vislab.mat.ucsb.edu/2022/p3/LijuanCheng/Project3_LijuanCheng.html

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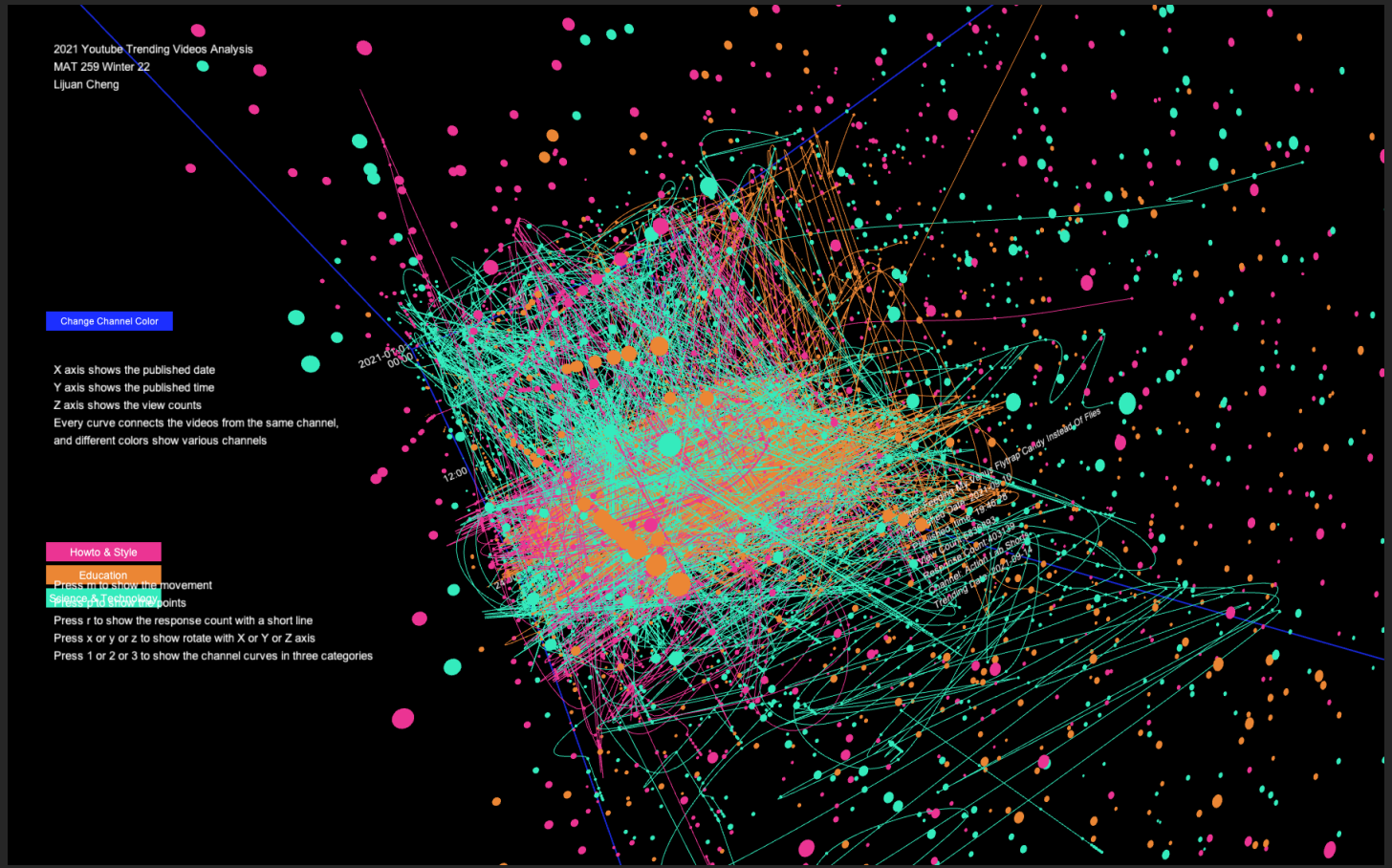
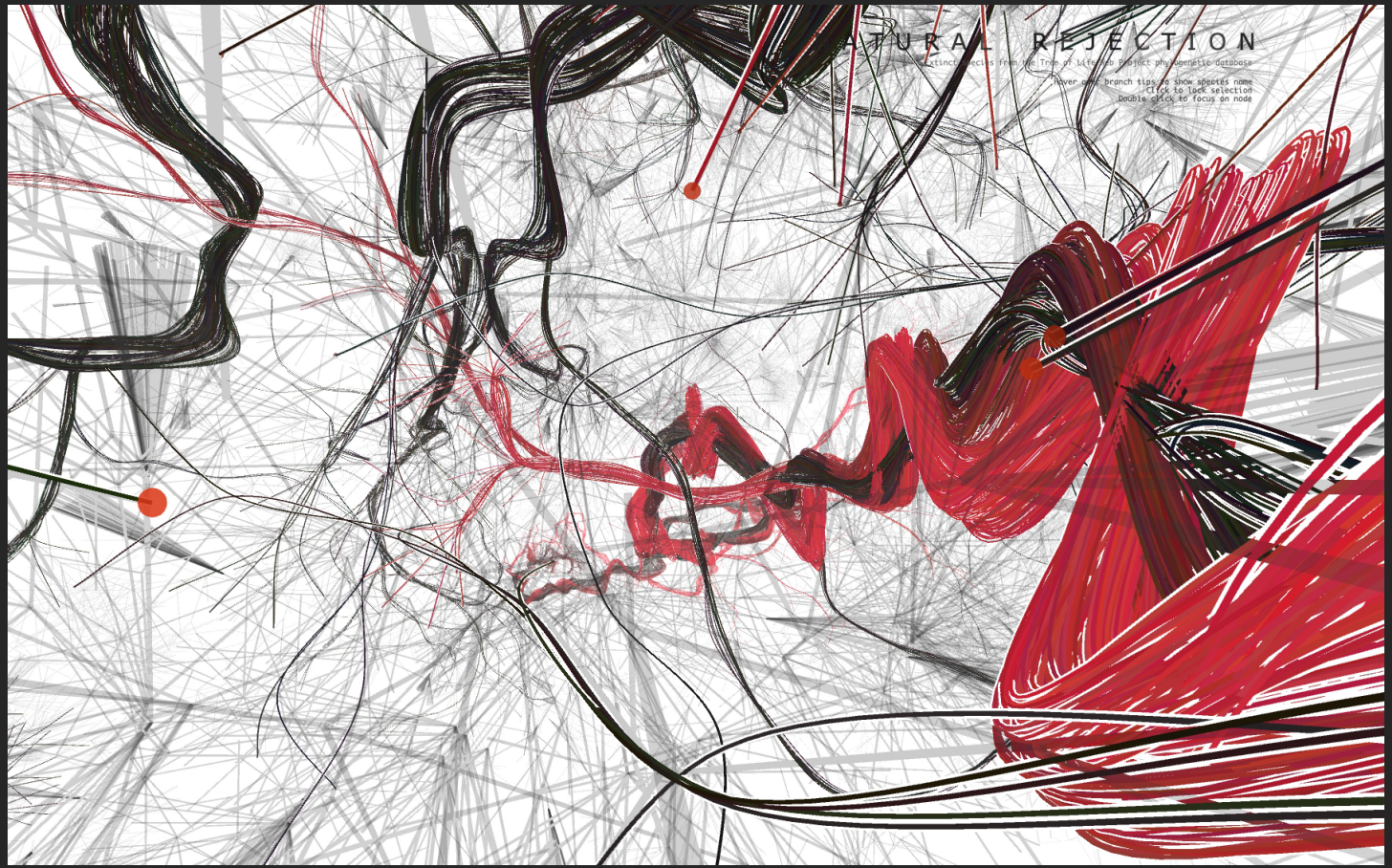
https://vislab.mat.ucsb.edu/2022/p3/LijuanCheng/Project3_LijuanCheng.html

Animation in 3D: “Trending Videos in 3 Categories”



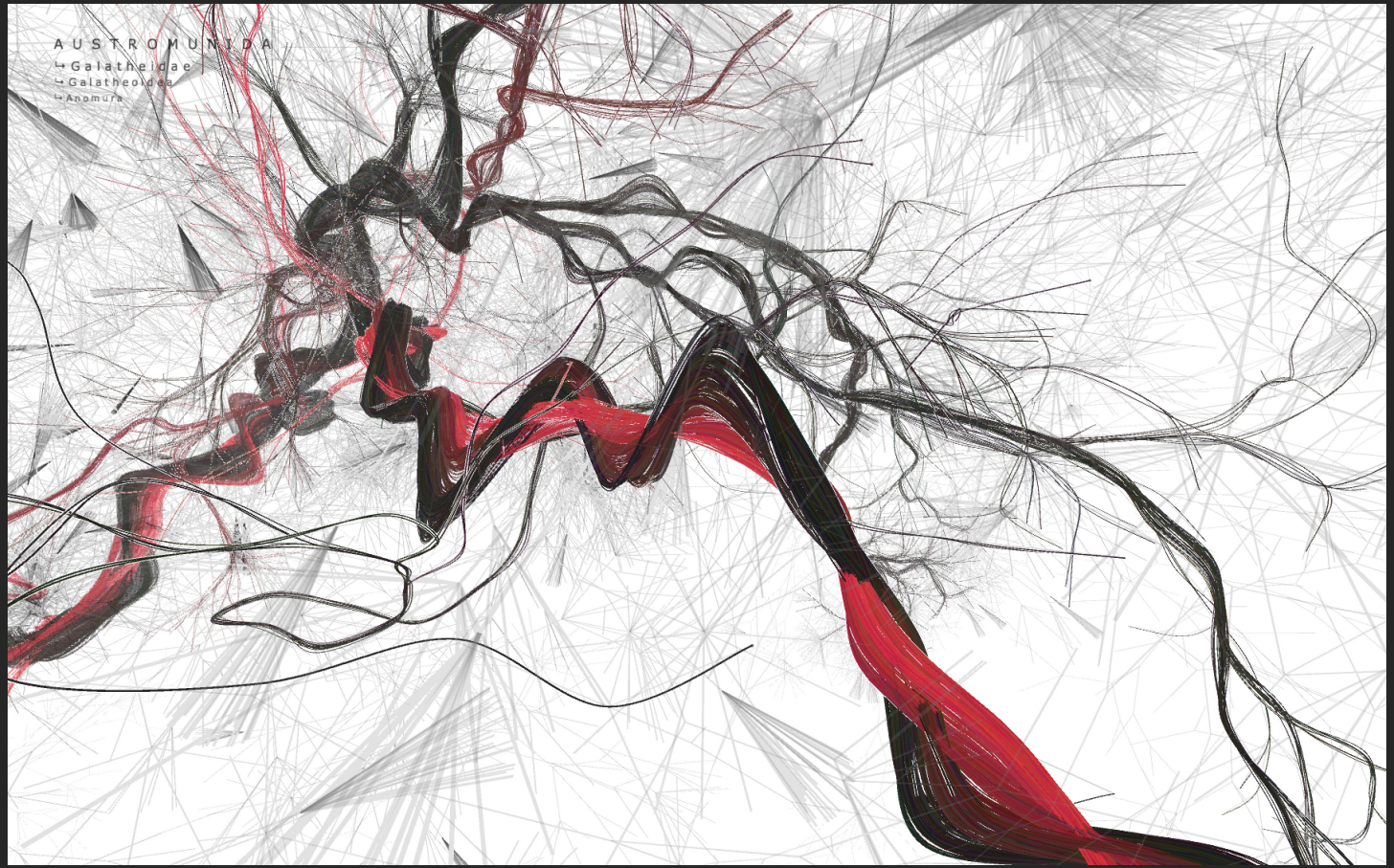
https://vislab.mat.ucsb.edu/2022/p3/LijuanCheng/Project3_LijuanCheng.html

Animation Algorithm for “Natural Rejection”



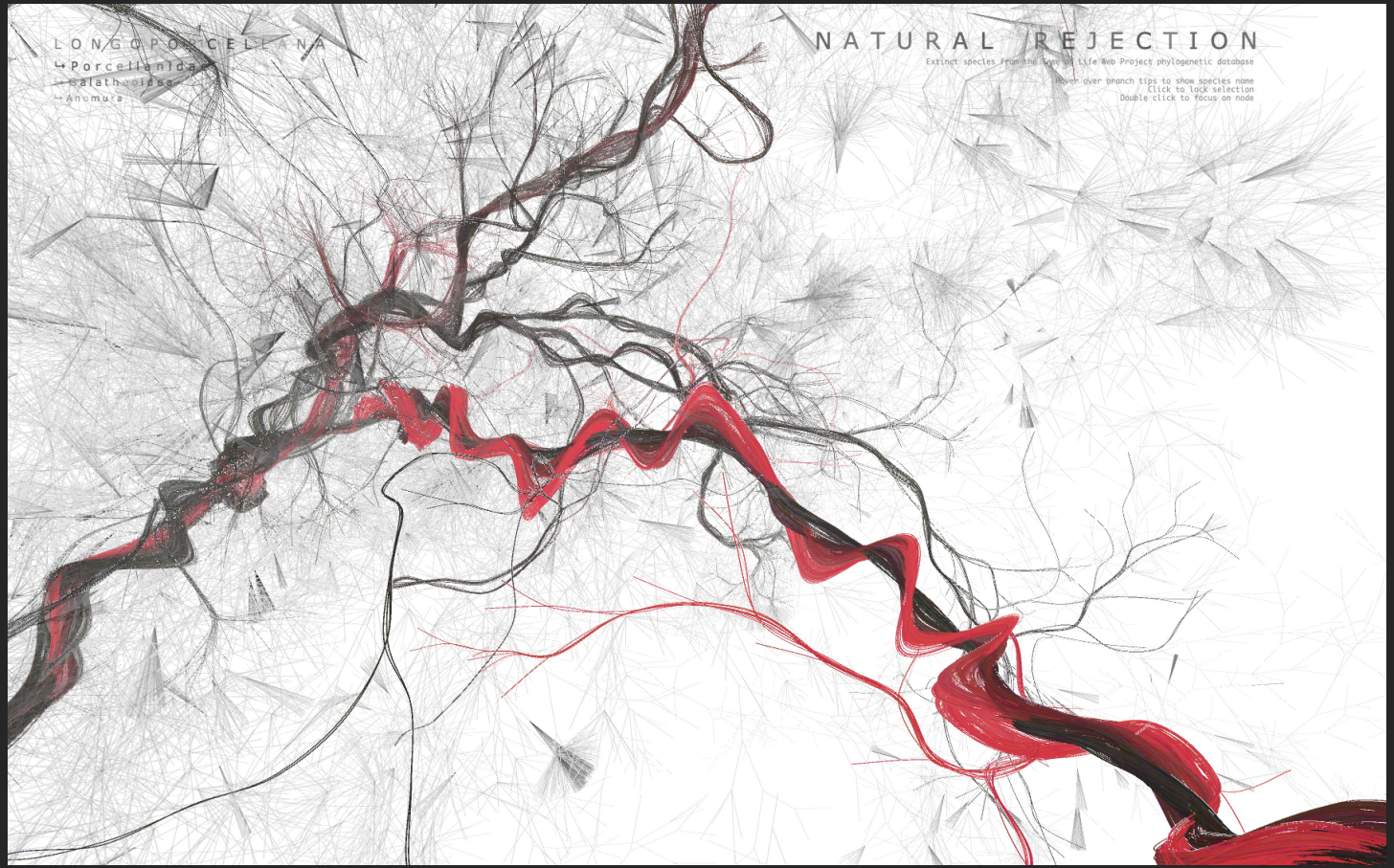
https://vislab.mat.ucsb.edu/2015/kaminski/p4/index.html

Animation Algorithm for “Natural Rejection”



https://vislab.mat.ucsb.edu/2015/kaminski/p4/index.html

Animation Algorithm for “Natural Rejection”

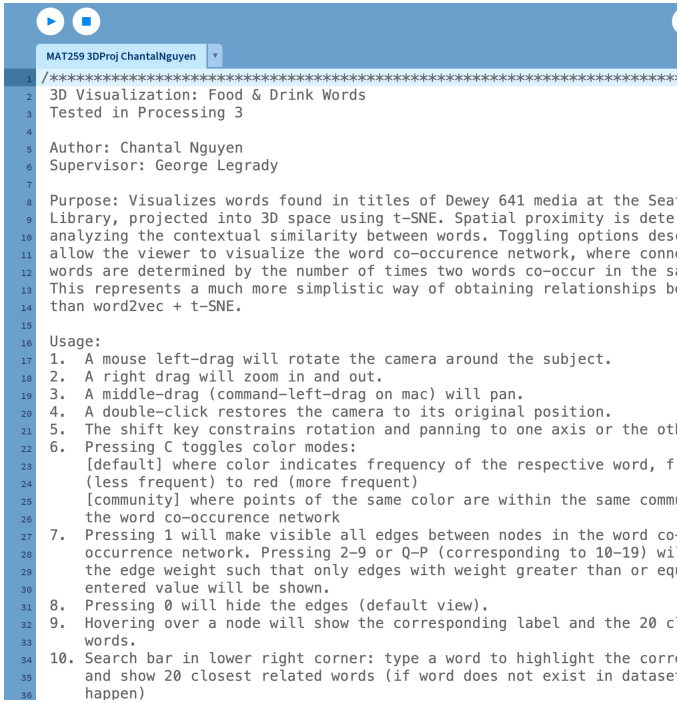


https://vislab.mat.ucsb.edu/2015/kaminski/p4/index.html

File Header provides relevant information

```
/**********************************************************************************************************************
* Li Zheng work in 2014, m259 data visualization course                                                               *
* 2018 additions by George Legrady                                                                                    *
*                                                                                                                     *
* A 3D interactive demo that uses peasycam, updated in Processing 3.3.6 - January 29, 2019                            *
*                                                                                                                     *
* It compares  two data sets a) CHina (RED),b) Japan (BLUE)                                                           *

The demo introduces:
 1) Comparing data from two csv files

 2) HSB, hue, saturation, brightness, transparency color system

 3) PeasyCam camera settings in conjunction with angle-of-view perspective()

 4) BeginShape, quad, Vertex, and EndShape functions

 5) The log()function as a way to normalize the China and Japan heights (increase or decrease the vertical scaling)    *
in this case resetting thevalues of the globalvariables chinaHeight and japanHeight, each originally set to 20

**********************************************************************************************************************/
```

Standard practices in giving credit in the code




```
// borrowed from ChantalNguyen, 3D Visualization,
// Food & Drink Words

    cam.beginHUD();
    textAlign(LEFT, TOP);
    textFont(f, 40);
    fill(255);
    text(selectedWord.label, 10, 10);
    textFont(f, 20);
    fill(242, 186, 184);
    text(associationString, 7, 50);
    cam.endHUD();
    popMatrix();
```

Selecting Colors: Best to limit to a maximum of 12 or black and white

2 modes in computing:

•**RGB** (Red, Green, Blue) Additive system

•**HSB** (Hue, Saturation, Brightness) // best to use this as you can control all colors hues (0-255), or saturation (0-255)

Color Impact greatly depends on the relationships

•**Colorpicker:** http://tristen.ca/hcl-picker/#/hlc/6/1/20313E/EFEE68

•**HCL Wizard**: http://hclwizard.org/hclcolorpicker/

•**w3Schools**: https://www.w3schools.com/colors/colors_picker.asp

Some geeky discussions: https://www.vis4.net/blog/2011/12/avoid-equidistant-hsv-colors/

Fonts Recommendation (Swiss Graphic Design)

Sans Serif ()

This is **Arial** designed for Windows but also works well on Mac

This is **Acumin** (from Adobe designed in 1989)

This is **Courier** (looks like industrial IBM typewriter)

This is **Futura**, Bauhaus aesthetic from 1927

This is **Helvetica** developed in 1957, has been adopted by industry

This is **Univers** font in bold, developed in

This is **Univers Condensed** often used in book publishing

Schneiderman's Data Visualization Design (Interaction Design)

Overview: Gain an overview of the entire collection

Zoom : Zoom in on items of interest

Filter: filter out uninteresting items

Details-on-demand: Select an item or group and get details when needed

Relate: View relationships among items

History: Keep a history of actions to support undo, replay, and progressive refinement

Extract: Allow extraction of sub-collections and of the query parameters

https://www.mat.ucsb.edu/~g.legrady/academic/courses/11w259/schneiderman.pdf

Between Function & Abstraction

PURE FUNCTION < --------- Interesting approach is somewhere between the two --------- > **TOTAL ABSTRACTION**

Exploratory Design Rules

- Study previous projects at https://vislab.mat.ucsb.edu/courses.html
- Doodles (critical quick bridge from idea to image)
- Make brief code sketches
- Plan your time schedule so that you have time to REDO. Each new version is better than the previous one!

Doodles

Miriah Meyer (https://miriah.github.io/projects/)

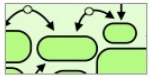
MODELS FOR VISUALIZATION DESIGN

Making Data Visual

Practical guidance for translating data into insightful visualizations.
related material: [book18]

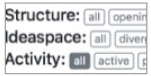
Rigor and Knowledge Construction

How visualization designers (can) construct rigorous knowledge.
related material: [infovis20] [infovis19] [cga18]



Visualization Design Research

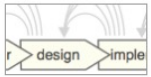
Models that describe what visualization design researchers do and the design decisions they make.
related material: [beliv16] [infovis14] [iv13] [leo13] [cga13] [beliv12] [infovis12] [visweek10]



Workshops

Participatory design workshops for discovering visualization opportunities.
related material: [beliv20] [infovis18] [methods]

DESIGN STUDIES



Projects that target specific, real-world, data analysis challenges.
related material: [Trevo] [ImplicitError] [Graffinity] [BubbleNet] [WeaVER] [Poemage] [ShotViewer] [PoemViewer] [MulteeSum] [Pathline] [Mizbee]

CRITICAL DATA VISUALIZATION

Words Matter

Critique of 'chartjunk' as misaligned and inappropriate for vis research.
related material: [altvis21]

Data Hunches

Valuing personal knowledge in visual analysis.
related material: [preprint]

VISUALIZATION OF PERSONAL DATA

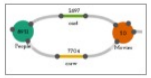
The Personal Informatics Analysis Gap

Three-year study with asthamtic families that reveals opportunities for visualization.
related material: [vis21] [ubicomp18] [lcn18]

AQ&U

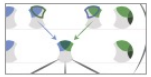
Empowering citizens to reason about air quality using networks of low-cost sensors.
related material: [enviro20] [envres20] [ubicomp18] [lcn18] [cityvis18] [website]

RAPID PROTOTYPING WITH DATA



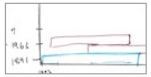
Reshaping Graphs

Tool for representing, reshaping, and reimagining data as a graph.
related material: [vast19] [software]



Iterating Between Tools

Model that describes how to bridge between generative and drawing tools, and Hanpuku, a tool that bridges D3 and Illustrator.
related material: [infovis16] [software]



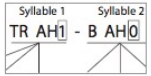
How Designers Design with Data

Results of a qualitative study that describe how designers use data and existing tools to create infographics.
related material: [avi14]

DIGITAL HUMANITIES

Visualizing Poetry

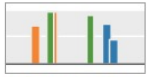
Visual encoding of poetic devices for poets.
related material: [infovis15] [eurovis13]
software: [poemage] [poemviewer]



RhymeDesign

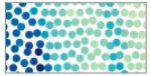
A formalism for analyzing sonic devices in poetry.
related material: [clfl15] [software]

VISUALIZATION OF BIOLOGICAL DATA



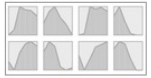
inSite

Interactive viewer for comparing patterns of binding sites across multiple genomics regions.
related material: [software]



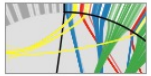
MulteeSum

Exploration tool that supports the comparison of multiple gene expression data sets defined both spatially and temporally.
related material: [infovis10] [software]



Pathline

Tool that visualizes temporal gene expression data over multiple molecular pathways and across multiple species.
related material: [eurovis10] [software]



MizBee

Browser that enables analysis of comparative genomics data through visualization across multiple scales.
related material: [infovis09] [software]

Data Visualization Topics

Visualization, exploration & analytics techniques for various data types; e.g., stream, spatial, graph
Human-in-the-loop processing
Human-centered databases
Data modeling, storage, indexing, caching, prefetching & query processing for interactive applications
Interactive & human -centered machine learning
Interactive data mining
User -oriented visualization; e.g., recommendation, assistance, personalization
Visualization & knowledge; e.g., storytelling
Progressive analytics
In-situ visual exploration & analytics
Novel interface & interaction paradigms
Visual representation techniques; e.g., aggregation, sampling, multi-level, filtering
Scalable visual operations; e.g., zooming, panning, linking, brushing
Scientific visualization; e.g., volume visualization
Analytics in the fields of scholarly data, digital libraries, multimedia, scientific data, social data, etc.
Immersive visualization
Interactive computer graphics
Setting-oriented visualization; e.g., display resolution/size, smart phones, visualization over networks
High performance, distributed & parallel techniques
Visualization hardware & acceleration techniques
Linked Data & ontologies visualization
Benchmarks for data visualization & analytics
Case & user studies
Systems & tools

3D Visualization Fundamentals

https://www.mat.ucsb.edu/~g.legrady/academic/courses/24w259/w3/vis.pdf

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Experimental Visualization Lab
Media Arts & Technology
University of California, Santa Barbara