



# Cartography M.Sc.

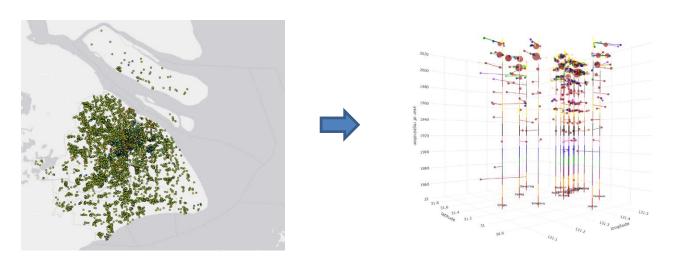
3D interactive spatio-temporal and semantic visualization for discrete data associated with multiple categories and long historical events

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### Outline



- Introduction
- Literature Review
- Methodology
- Experiments
- Discussion
- Conclusions and Outlook







### Introduction



- Motivation and problem statement
- Research objectives



# Motivation and problem statement



Chronology & Geography are commonly called the eyes of History.

Can't duration be imitated & represented as significantly, as distinctly as space, & can't intervals also be counted by degrees?

-Jacques Barbeau Dubourg

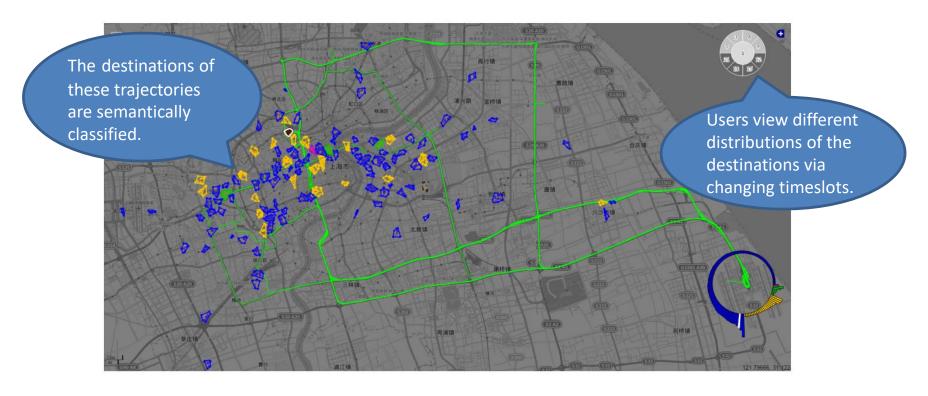




# Motivation and problem statement



What is "semantic distribution"?? Definition unknown.



For this thesis: the spatio-temporal distribution of semantic attributes.



# Research objectives



- Propose novel prototypes to visualize the spatiotemporal and semantic distribution of a geodata set over various time periods;
- Construct a "plotline" that crafts typical geospatial and semantic patterns of geodata into a story map;
- Create a multimedia story map with interactive parts to represent spatio-temporal and semantic patterns of geo-related features.



### Literature review



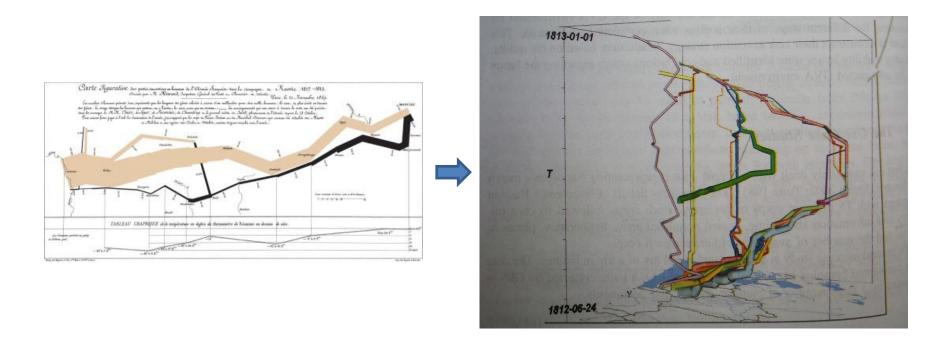
- Space-time cube (STC)
- Small multiples
- 3D aggregated symbols



# Space-time cube (STC)



 Continuous data, physical movement (Kveladze, Kraak and Elzakker, 2017)

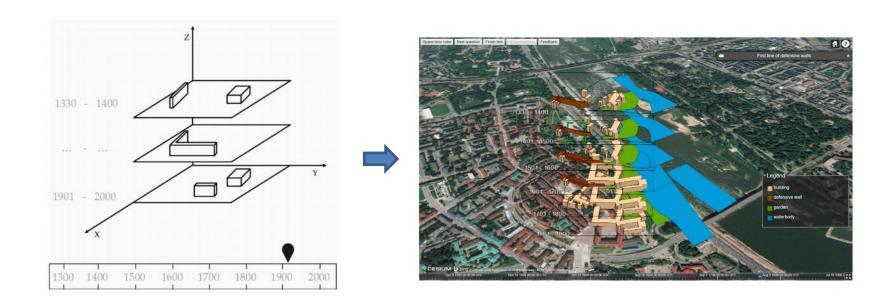




# Space-time cube (STC)



 Continuous data, temporal movement (Bogucka & Jahnke, 2018)



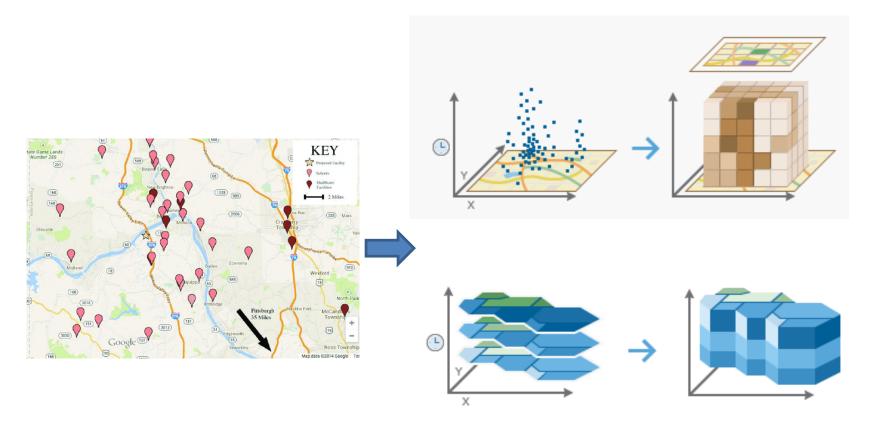
Temporal movement: the creation, destruction, reconstruction and conservation of a cultural heritage (ICOMOS)



# Space-time cube (STC)



Discrete data (ESRI, 2021)

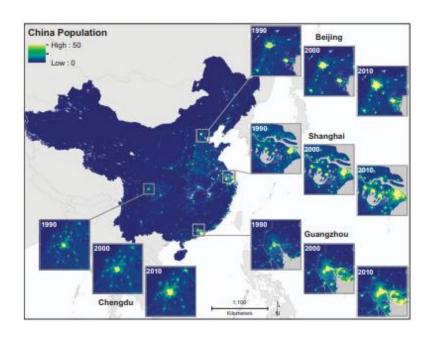


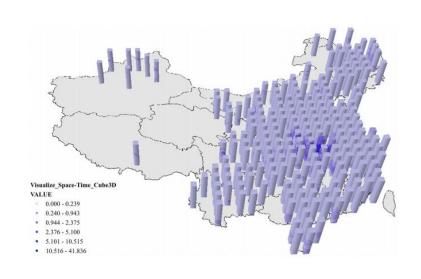


# Small multiples



Layer juxtaposition vs. STC (Mayr & Windhager, 2018)





cumbersome

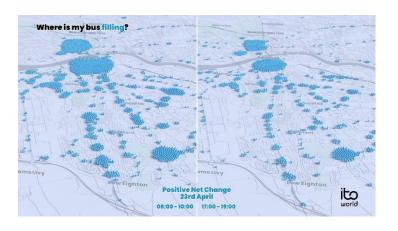
minimalistic

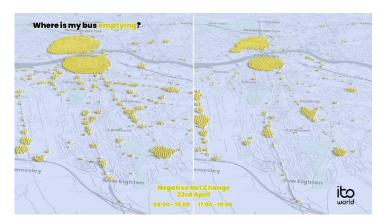


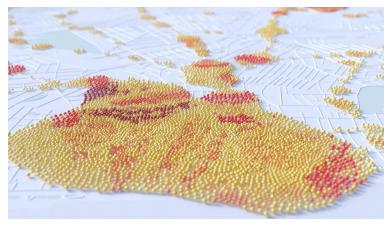
# 3D aggregated symbols



Passengers getting on/off a bus (Taylor, 2021a)





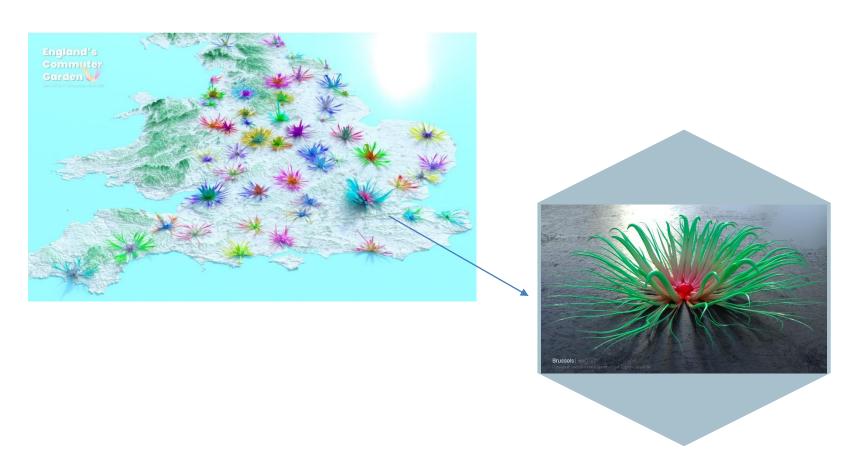




# 3D aggregated symbols



Commuters garden (Taylor, 2021)





# Methodology



- Prototype design
- Plotline for story mapping





 Time helps people to establish casual and motivational links between discrete and incoherent events in the physical space via its linearity. By emphasizing the sequential and chronological aspects of these events, it benefits people to derive spatial dynamics a great deal. An STC not only provides a direct integration of spatiotemporal coordinates, but also depicts time to space, making the temporal and geographic information of an event similarly salient. (Mayr & Windhager, 2018)

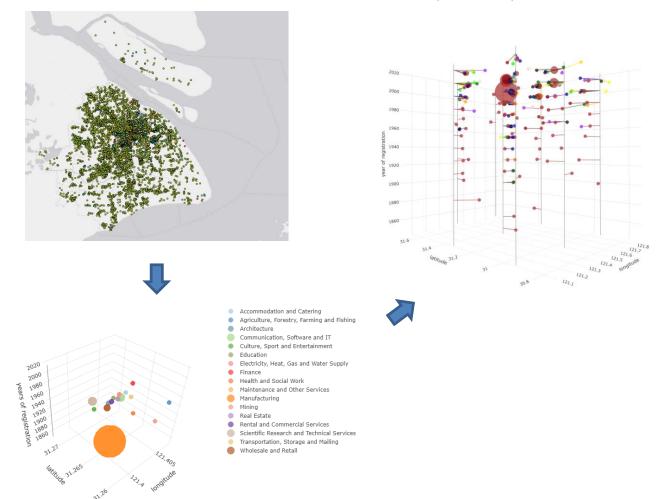


Agriculture, Forestry, Farming and Fishing Culture, Sport and Entertainment

Health and Social Work Maintenance and Other Services Manufacturing

Rental and Commercial Services Scientific Research and Technical Services Transportation, Storage and Mailing

Space-time micro landscapes (grids)

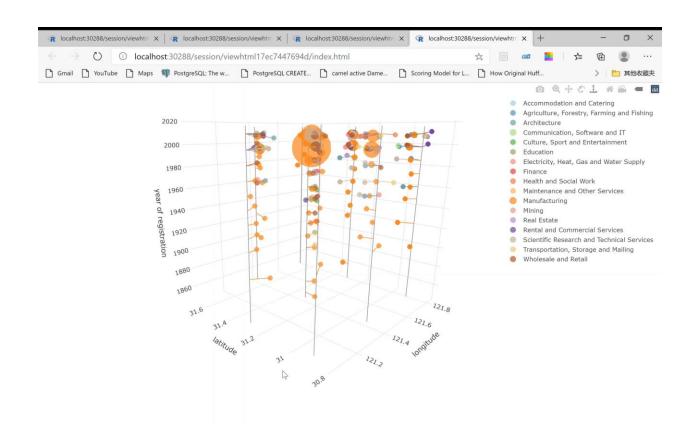








Space-time micro landscapes (grids)



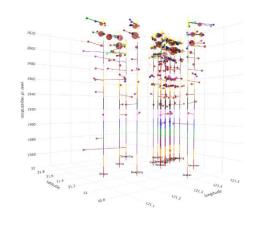




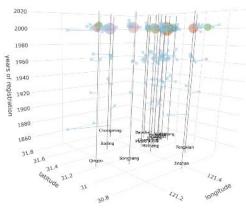
Space-time micro landscapes (administrative units)

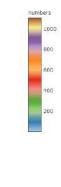
#### location

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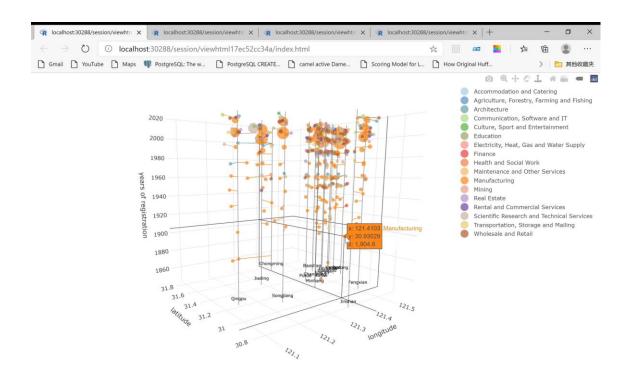








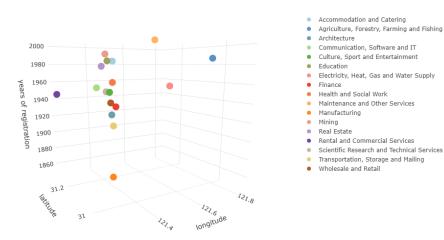
Space-time micro landscapes (administrative units)

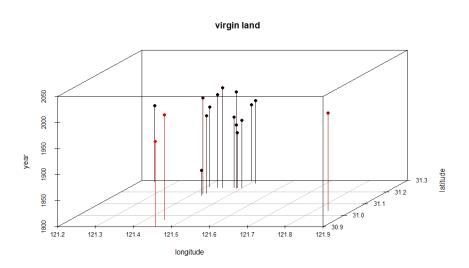






The "virgin land" problem





The appearance of first-ever features

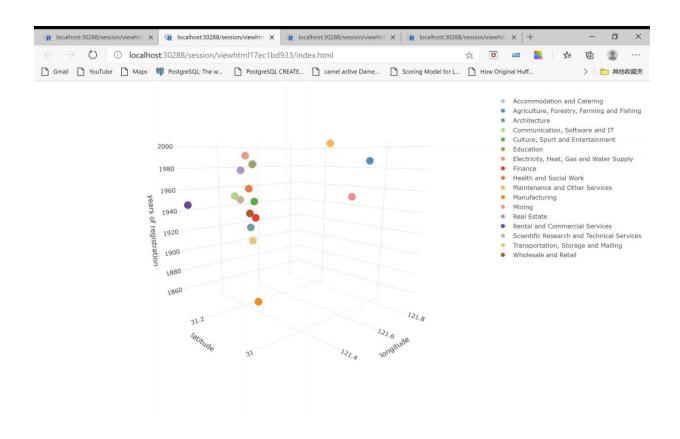


Cultivation of a new land





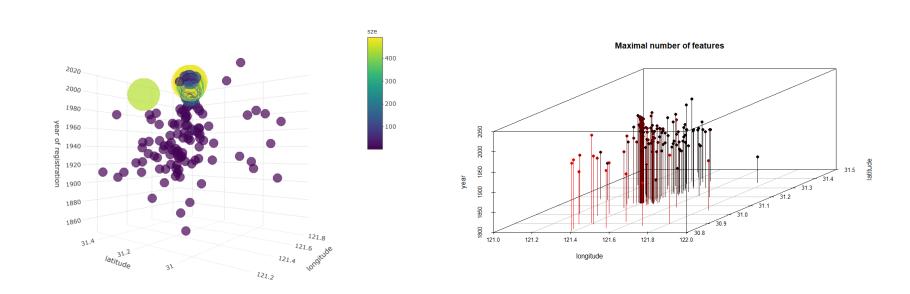
The "virgin land" problem







Maximal number of features (urban expansion)

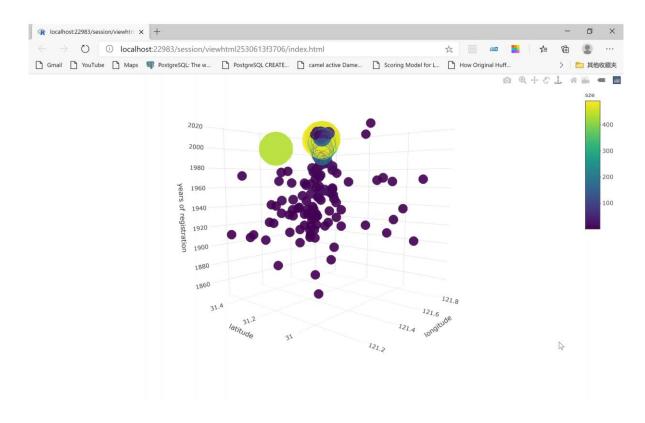


ONLY the bins with the maximal number of features per year are illustrated





Maximal number of features (urban expansion)





# Plotline for story mapping



Acts	Contents
Setup	<ul><li>1.A brief introduction of the study area;</li><li>2.A short description of the features and the associated historical backgrounds;</li></ul>
Conflicts	<ul><li>1.The positive and negative visual outcomes of geo-related features caused by the corresponding historical events or governing policies;</li><li>2.The problem of missing information in a geodataset;</li><li>3.The overplotting issue of traditional 2D mapping.</li></ul>
Resolutions	<ol> <li>The spatio-temporal distribution and semantic distribution of geo-related features is influenced by significant historical events and/or governing policies associated with the study area;</li> <li>The proposed prototypes efficiently demonstrate the change of spatial data along the temporal axis by aggregated symbols.</li> </ol>





# **Experiments**

The Spatio-temporal Distribution of Companies in Shanghai

https://storymaps.arcgis.com/stories/57e6c1bf8db4485fa311059b00e2304c



### **Discussions**



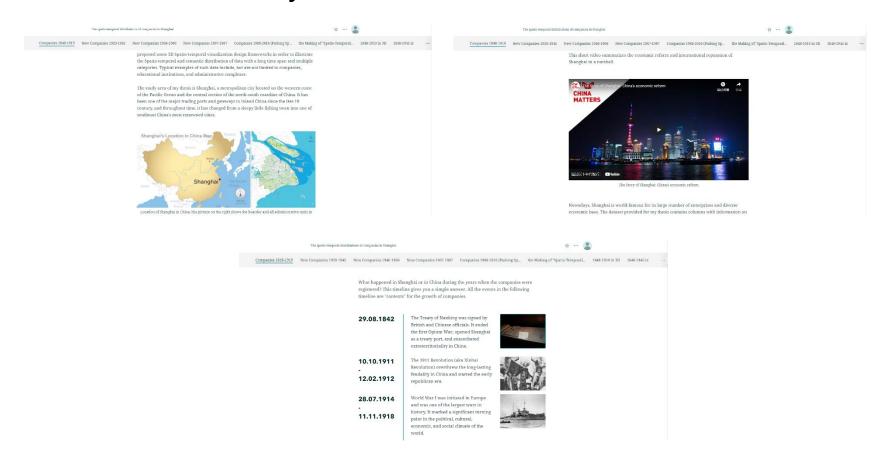
- Performances of the story map
- Performance of the prototypes
- Unusual visual outcomes
- Unexplored columns



# Performance of the story map



### Author-driven styles

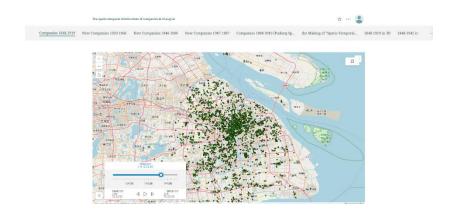




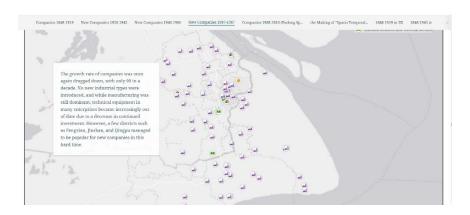
# Performance of the story map



### Reader-driven styles



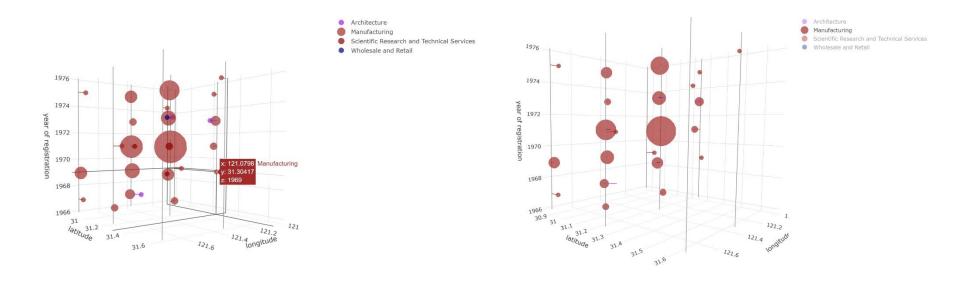






# Performance of the prototypes

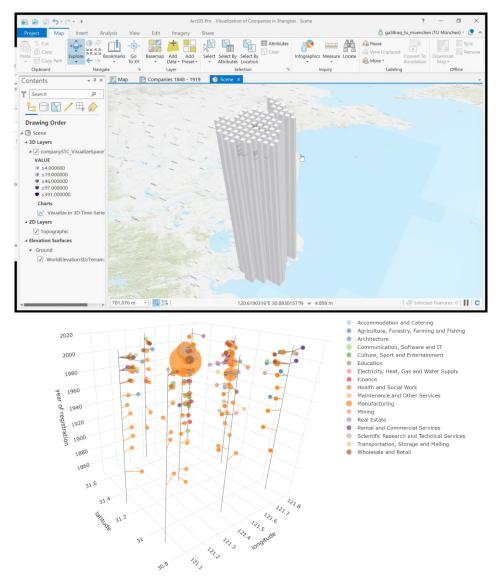






# Performance of the prototypes

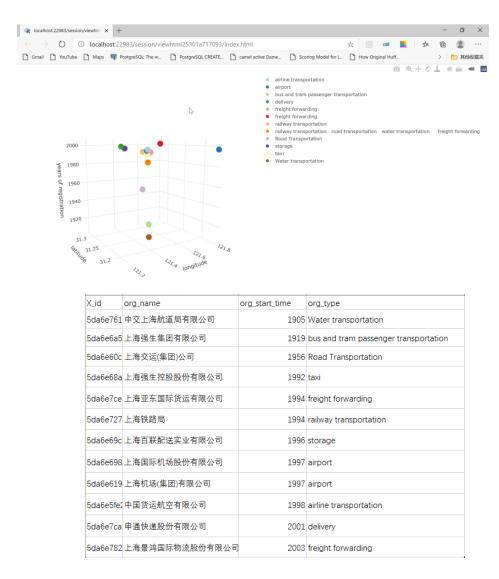






# Performance of prototypes

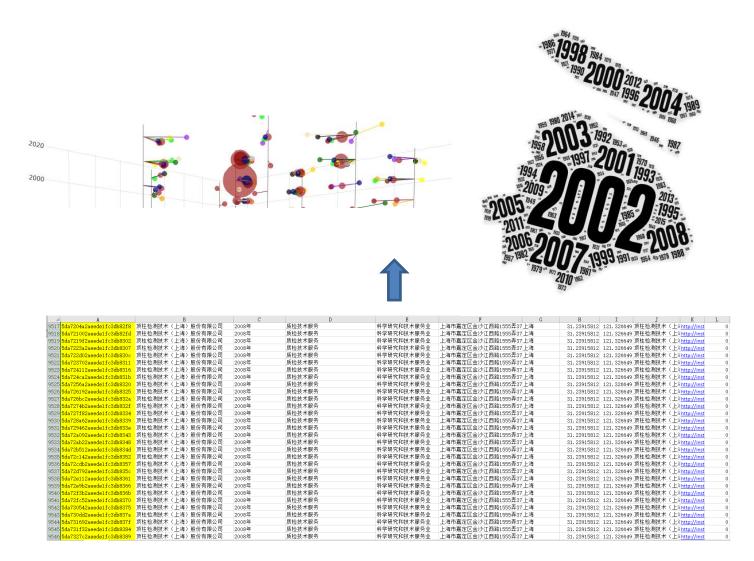






### Unusual visual outcomes







# Columns to be explored more



industry_type	no_org_type
Manufacturing	448
Transportation, Storage and Mailing	12
Architecture	15
Finance	8
Wholesale and Retail	41
Rental and Commercial Services	15
Scientific Research and Technical Services	17
Culture, Sport and Entertainment	9
Communication, Software and IT	14
Health and Social Work	3
Electricity, Heat, Gas and Water Supply	9
Real Estate	2
Education	2
Accommodation and Catering	3
Agriculture, Forestry, Farming and Fishing	11
Mining	3
Maintenance and Other Services	5



### **Conclusions and Outlook**



- Conclusions
- Outlook



#### Conclusions



- STC is advanced in representing spatio-temporal distribution of geo-related features concisely, and the overplotting issue of traditional 2D mapping is easily avoid. However, the proposed prototypes, particularly the space-time micro landscapes are capable of depicting multiple categories, hence the semantic attributes of geo-related features, via aggregated 3D symbols.
- The influences of historical events on the spatio-temporal and semantic distribution of geo-related features in a geographic area are reflected by their numbers under each category. Additionally, the categories of these features normally develop from basic to advanced. It can be a solid storyline for cases such as enterprise evolution.

### Conclusions



- In general, peaceful environments and revolutionary historical events foster the growth of geo-related features (not the case for an epidemic, though) in a geographic area, whereas wars and political chaos suppress their growth.
- The combination of 3D prototypes and classic ArcGIS StoryMaps storytelling techniques are indeed effective in conveying important spatiotemporal and semantic information from various perspectives.

### Outlook



Missing years of registration



Rough estimation: org\_start\_time and firm\_info of other data with complete information (before online & offline investigations)



### Outlook



· Dive deeper into the "city center" phenomenon



Headquarter – branch dynamic? Supply chain?



### Outlook



- A potential law about geography and chronology to propose?
  - "Things that appear more simultaneously are more related to things that appear in longer time intervals."
  - "Things that appear closer and more simultaneously are more related to things that appear distant and in longer time intervals."
- A potential law about geography and chronology to propose?



### Image credits



- Google Image Search
- Ding, L., Yang, J. & Meng, L. (2015). Visual Analytics for Understanding Traffic Flows of Transport Hubs from Movement Data. Proceedings of the 27th International Cartographic Conference, 16th General Assembly. ISBN 978-85-88783-11-9. Retrieved from <a href="https://icaci.org/files/documents/ICC\_proceedings/ICC2015/papers/2/785.html">https://icaci.org/files/documents/ICC\_proceedings/ICC2015/papers/2/785.html</a>
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- Info We Trust 2020, Stories of Space, Time and Data [video], https://www.youtube.com/watch?v=rjl6lfSQZyw&t=2523s





# Image credits

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- Taylor, C. (01., September 2021). Passengers getting on and off a bus. [Web log post] retrieved from <a href="https://twitter.com/CraigTaylorViz/status/1433020149037162498">https://twitter.com/CraigTaylorViz/status/1433020149037162498</a>



### Thanks a lot!







Two eyes of history (Info We Trust, 2020)



