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

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Across the earth's surface are scattered a large number of discrete, human-created, geo-related features belonging to many categories and associated with long historical events in the world. Here, categories and historical events are regarded as semantic attributes of the corresponding features. The spatio-temporal distribution and semantic distribution, of these features is worthy of being revisited and discussed.

This thesis proposes three 3D visualization prototypes. One of them, "space-time micro landscapes" is inspired by the classic space-time cube (STC) [1], but is capable of representing different categories of geographic data. The visual outcomes of these prototypes are presented via a multimedia story map [2].

PROTOTYPES

Space-time micro landscapes

Creation:

1. Tessellate the area where the features located at into grids and set the time step intervals; (alternative: extract "administrative units" from the feature dataset);
2. Generate space-time bins with aggregated proportional symbols (sizes: number of features per category; colors: categories);
3. Pull the aggregated symbols to the center of the bins by lambda (0 ~ 1).

Characteristics: More information is able to be visualized with fewer overplotting issues. Temporal and semantic (categorial) changes are intuitively represented in one visual representation.

The "virgin land" problem:

Creation:

1. Extract the "first-ever" feature under each category;
2. Plot the features in 3D.

Characteristics: Spatio-temporal changes are intuitively represented (more convenient than ArcGIS Time-aware maps, as no animation is acquired to demonstrate temporal factors); important semantic information (e.g., "birthplaces" of the features) is clearly indicated.

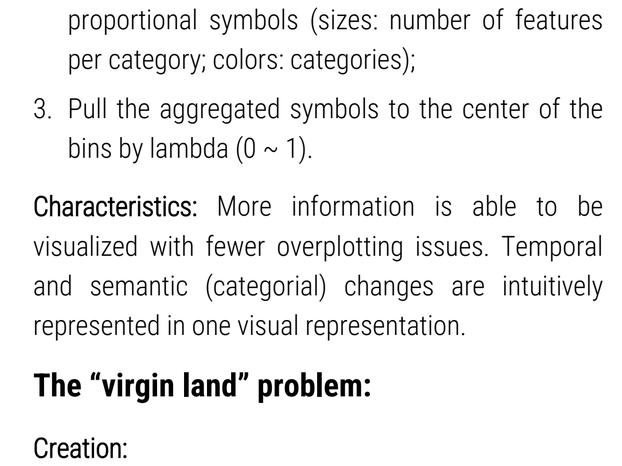

Fig.1 a) space-time bin; b) space-time micro landscapes (grids); c) space-time micro landscapes (administrative units, legend representing categories); d) space-time micro landscapes (administrative units, legend representing numbers)

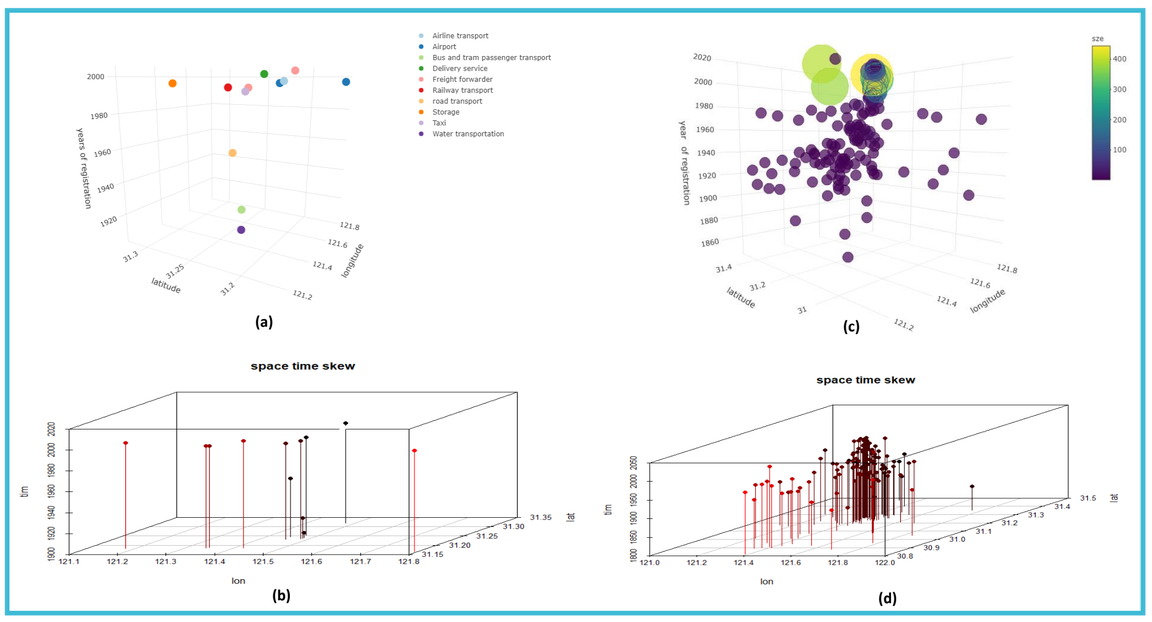

Fig. 2 a). The "virgin land" problem for companies under organization type "transportation, storage and mailing"; b) The space-time skew of the "virgin land" problem (vertical lines indicating the positions of each point on the geographic surface); c) maximal number of features per year; d) the space-time skew for "maximal number of features"

Maximal number of features (study area's expansion):

Creation:

1. Tessellate the area where the features are located at into grids (or extract "administrative units" from the feature dataset);
2. Generate space-time bins with proportional symbols (representing ONLY numbers of features, not categories) placed at their centers;
3. Plot the bins with the biggest proportional symbols representing maximal number of features for every default time step interval

Characteristics: The study area's expansion can be intuitively indicated by the aggregated symbol indicating the maximal number of features on the finest temporal granularity.

STORY MAP

Test dataset: 14510 companies, registered between 1848 and 2016 (temporal granularity: one year), belonging to 17 industrial types and 649 organizational types in Shanghai, China.

1. Background information about Shanghai and the test dataset (static; author-driven);
2. The spatio-temporal distributions of the companies that belong to different industrial types (the semantic attribute this thesis primarily focuses on) during various historical events from 1848 to 2016 in 2D maps (dynamic, interactive immersive blocks in StoryMaps allowed; reader-driven);
3. The spatio-temporal distribution and semantic distribution of the companies visualized via the 3D prototypes (currently author-driven, with screenshots and videos of the prototypes).

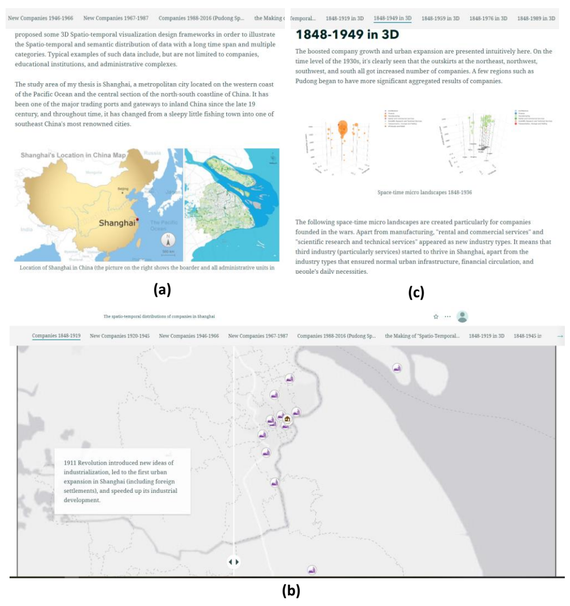

Fig. 3) Introduction of study area; b) spatio-temporal distributions of companies in 2D; c) spatio-temporal distribution of companies in 3D

CONCLUSION & OUTLOOK

Conclusion:

3D interactive geodata visualization prototypes such as the proposed ones give a simple and straightforward illustration of typical spatio-temporal and semantic patterns of geo-related features. Furthermore, The combination of the proposed 3D spatio-temporal protypes and classic ArcGIS geovisual storytelling techniques are indeed effective in conveying important information spatio-temporal and semantic distributions from various perspectives.

Outlook:

Explore more on semantic distributions of the companies using the test dataset (more than the columns of industry types and organization types) and the information beyond the dataset to be acquired.

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YEAR

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LINK OF THE STORY MAP

https://tu-muenchen.maps.arcgis.com/home/item.html?id=57e6c1bf8db4485fa311059b00e2304c

KEYWORDS

Geovisualization,
spatio-temporal distribution,
semantic distribution,
multiple categories,
long historical events,
Space-time cube,
spatial point aggregation,
3D symbol design,
geovisual storytelling

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