CASA0003
Group Mini Project: Digital Visualisation
"The Living City"

Group 3: The Growing City-Cell

(5442tu, https://www.5442tu.com/fengjing/20150710/24174.html)

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Link: https://hong998.github.io/The-Growing-City-Cell/index.html

Project Output Description Table

Project Output	Output Description
Project Output Files	Zip File on Moodle
Project Website	https://hong998.github.io/The-Growing-City-Cell/index.html

Individual Contributions Outline Table 1

Components	Interactive Mapping		D3 Chart and Graph	
	Major contributors	Additional contributors	Major contributors	Additional contributors
Visualisation 1	Tommy Sin		Tommy Sin	
Visualisation 2	Minghang Hong		Yuyan Hu	
Visualisation 3	Minghang Hong	Linan Zhu	Yuyan Hu	
Visualisation 4	Minghang Hong		Yuyan Hu	Linan Zhu

Individual Contributions Outline Table 2

	Major Contributors	Additional Contributors
Concept Development	Tommy Sin	All team members
Data preparation and integration	Tommy Sin Minghang Hong	Yuyan Hu Linan Zhu
Slides Edit	Yuyan Hu	
Presentation video	All team members	
Video Edit	Linan Zhu	
Website Development	Linan Zhu	Yuyan Hu
Conclusion	Linan Zhu	All team members

The tables above show the contributions of every group member. Table 1 is specific to the visualisation outputs and Table 2 describes the other contributions, like concept development, edit parts and website development for every member. Tommy is the major contributor for the part of concept development, he explains the concept of "City as Growing City-Cell" and guides other team members to explore the related topics of this theme. The dataset is majorly prepared by Tommy and Minghang. Tommy is in charge of the part of Visualisation 1 which focuses on the content of urbanisation percentage. The Interactive Mapping part in Visualisation 2, 3, and 4 are majorly completed by Minghang. The D3 Chart and Graph part for Visualisations 2, 3, and 4 are majorly finished by Yuyan, for example, the lollipop charts. The connection of D3 Chart and Interactive Mapping is completed by Minghang. The slides edit is contributed by Yuyan. The video edit, website development, and conclusion part are majorly completed by Linan.

Chapter 1: Concept Development and Data Sources

Introduction and Motivation

Cities have often been compared to cells, both in the field of urban studies and biology (Batty, 2005; Sahtouris, 2020). The latter author, an evolutionary biologist, noted several visual similarities between biological cells and cities.

Given that cells are the most basic unit of life, and the theme of "The Living City", our group began querying characteristics common across all living organisms, to uncover these visual similarities between cells and cities. Biology informed us that all living organisms, and cells by extension, share seven traits: growth, nutrition, excretion, movement, reproduction, sensitivity, and respiration.

Upon further discussion, we noted that the first four of these traits were most clearly seen in cities, which could be used to link them to cells via digital visualisations of urban datasets. Furthermore, the first trait, growth, is useful in demonstrating that beyond exhibiting properties similar to living things (formed of cells), cities develop over time. This would allow for a dynamic time component to our visualisations, to make them more interactive and interesting.

As such, we settled on the concept of "City as Growing City-Cell", to highlight the fact that cities are analogous to cells, through the fact that they are not just living, but growing over time. This would be demonstrated through three aspects of cities: their populations, their carbon dioxide emissions, and their transport networks and systems.

Outputs and Objectives

This project thus aims, through its outputs, to highlight cities as growing city-cells through the four aspects listed below. In the next step, methods for each visualisation will be detailed in the relevant chapters subsequently.

1. The proportion of people living in cities has been growing over time, linking cities to cells by virtue of their continued growth. This can be seen on a global scale, where the proportion of populations living in urbanised areas has been increasing on average (see Figure 1.1). This will be represented by Visualisation 1 (Chapter 2).
2. Large urban agglomerations have also grown in size by population, linking cities to cells by this accumulative process similar to nutrition, where instead of nutrients, cities accumulate people. This is explored by Visualisation 2 (Chapter 3)
3. Emissions data alongside city-cell growth, analogous to the process of waste excretion from cells. This is studied in Visualisation 3 (Chapter 4).
4. Transport network data would be visualised to highlight the movement abundant in these city-cells. This is explored in Visualisation 4 (Chapter 5).

Then we will list the challenge and solution (Chapter 6) which we visualised the data of each topic and finally make a conclusion of this project (Chapter 7).

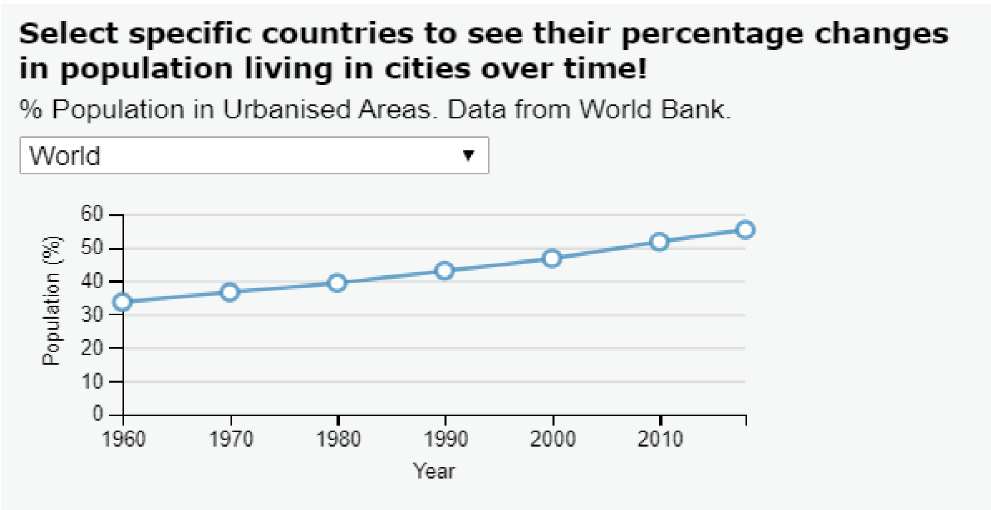

Figure 1.1

More broadly, this project aims to highlight similarities between urban studies and cellular biology, through providing a different perspective to view, and thereby understand, the city. While we are cognizant of debates over the growth of city-cells (densification and urban sprawl considerations for instance), they are beyond the scope of our project which serves to simply provide an expository take on the matter through thematic visualisations. This will provide material to spur further research or discussions on the topic.

Data Sources

In the Visualisation 1, the dataset used was the UN Population Division's World Urbanisation Prospects (2018 Revision), and this was taken from the World Bank hosting site (World Bank, 2018). It contains data on the urban population of each country as a percentage of the total national population from the years 1960 – 2018. For easier user exploration of the data, the years 1960, 1970, 1980, 1990, 2000, 2010, and 2018 were selected as datapoint years.

The dataset using in visualisation 2 is Population of Urban Agglomerations with 300,000 Inhabitants or More in 2018 from World Urbanization Prospects 2018 (United Nations, 2018). This dataset not only includes the population data of the urban agglomerations from 1950 to 2035 but also has the longitude and latitude of the cities in each country. This visualisation will specific in the data from 1960 to 2020.

The datasets used in visualisation 3 came from the website of Our World in Data (Ritchie and Roser, 2017). Consider the population issue, the country with a high total carbon emission does not mean that the country also has a high carbon emission per capita. We therefore choose the dataset of annual total carbon dioxide emissions and per capita CO2 emissions in each country to visualise the emission growth. Additionally, the data of percentage of emission in transportation is employed. The map for the total CO2 emission amount and emission per capita will specific in the data from 1960 to 2016 and the map for the percentage of emission in transportation will visualise the data from 1970 to 2015. Due to the missing value, the data of emission in transportation in 1970 was replaced with the 1971 data, 2015 replaced with 2014.

Three datasets will be used in the visualisation 4. The data of the length of railways and expressways in China from 2000 to 2018 and the data of length of urban rail transit system in China from 2006 to 2018 are employed. All the datasets were collected from the journal, named S*tatistical Yearbook of China* in different years.

Chapter 2: Visualisation 1 (Urbanisation Percentage)

Studying the urban population of a country is indicative of understanding the growth of the city-cell. Visualisation 1 hence highlights the world urbanisation percentage, on a global scale, by country.

The objectives of Visualisation 1 are to highlight the growth of the city-cell on a global scale, via visualising Spatio-temporal patterns showing change over time of the proportion of each country's population living in urban areas. Interactive elements were utilised to demonstrate this growth, as well as for statistical and analytical features for user exploration. There were four methods/features in this visualization.

Method 1: Backdrop choropleth map (Figure 2, Static Feature 1)

Firstly, a backdrop choropleth map was made of the variable of interest in 1960. The spatial join was done using QGIS, between the world countries shapefile (Natural Earth, 2020) and the .csv file containing the variable data. This was then plotted and styled using Mapbox Web, with the title and legend styled using CSS. Such a base map allows for a baseline comparison of countries' historic urbanisation percentages, highlighting the initial state of city-cells' growth before Method 2 shows the process of growth.

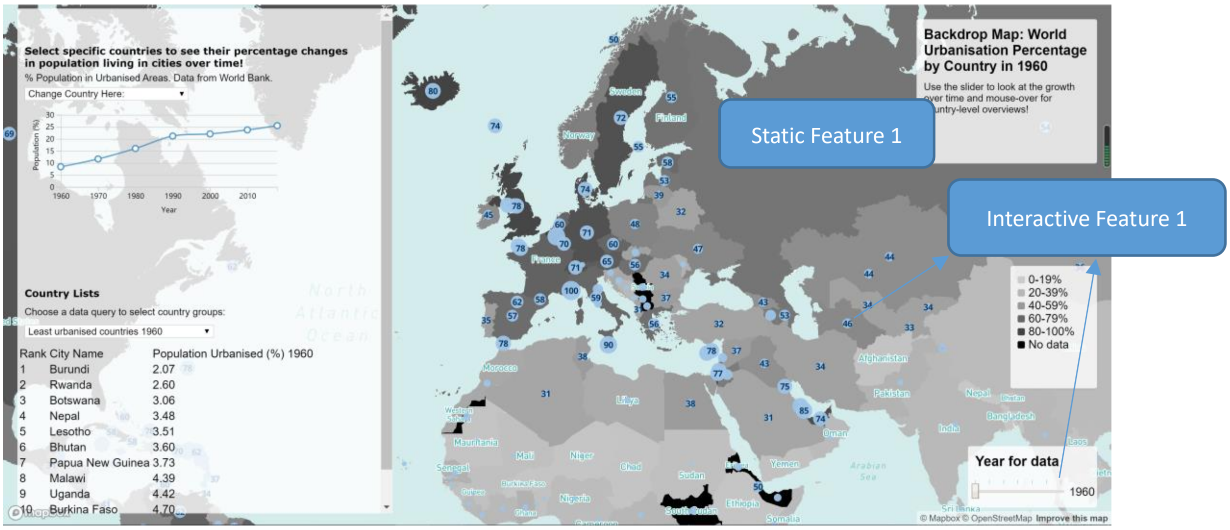

Figure 2.1

Method 2: Proportional circles layer (Interactive Feature 1, Figure 2.1)

Next, a proportional circles layer was constructed based on a shapefile with a point for each country's capital (Earth, 2020). These circles were styled by the country's percentage of population living in urban areas over time, for their radii and a label on them showing the exact percentage in the year for data. The user would then be able to select the year for data via the slider in the bottom right hand corner of the visualisation.

This allowed for the demonstration of spatio-temporal growth over time of city-cells, with generally increasing circles and larger numbers over time (with slider going from left to right). The dynamic time variable of urban growth is highlighted by this method, on a global scale.

Method 3: Mouseover popups (Interactive Feature 2, Figure 2.2)

While Method 2 allows for the trend of city-cells' growth to be seen broadly, on a global scale, it does not let the user zoom into individual countries and witness the changes over time. Method 3 was thus utilised to address this gap, by displaying a simple table of the percentage of the country population living in urban areas by the year of data, whenever the user's cursor is over a proportional circle. Thus, unlike a general picture of global urban growth, Method 3 allows for the user to understand the growth of individual city-cells over time.

Method 3 was coded using Mapbox GL's popup function, and the setHTML() method was used for coding the table within the popup, referring to the data which had earlier been joined to the shapefile and loaded into Mapbox Web.

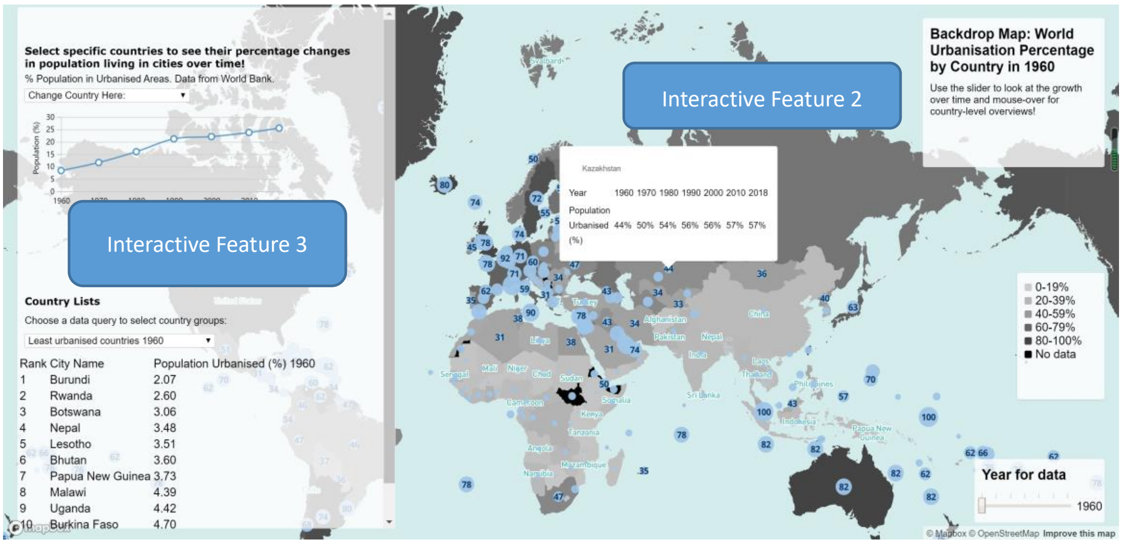

Figure 2.2

Method 4: D3 graphs/charts (Interactive Feature 3, Figure 2.2)

Building on Method 3, D3 graphs were used to visualise the growth of individual city-cells. After exploring Interactive Features 2 and 3, which allow users to understand the global and country-level growth of city-cells, they allow for visual exploration of the data by any country the user is interested in. The graph also allows for the world average to be displayed, serving as a useful benchmark to compare against. Additionally, it also lets the user explore how countries at different stages of city-cell growth (based on the backdrop choropleth map, or Static Feature 1) grew over time. Additionally, D3 tables were used to allow for groups of countries to be queried. They were coded within the same style, on the translucent panel on the left side of the screen. 5 criteria were included – highest/lowest urbanisation percentages in 1960 and 2018, as well as the highest growth in urbanisation percentage from 1960-2018 (the temporal boundaries of the dataset). This allows the user to analyse the dataset based on what features are of interest, and then explore individual countries in detail by using the graph above the tables.

Chapter 3: Visualisation 2 (Urban Agglomeration)

The growth of the urban population in urban agglomeration like the cell accumulation of nutrition. The number of urban agglomerations and the population size of urban agglomerations are increasing by the time. Fujita (1988) claimed that amenities play a critical role in attracting people to cities. Earning and productivity affect the population size of cities as well, which brings the appearance of urban agglomeration. In China, there are more than 100 cities with more than 1 million residents, this number is likely to double in the next 10 years (Hass, 2017). The development of cities is so fast that the number of cities with large population would increase rapidly.

In this chapter, we will visualise the growth pattern of urban agglomerations by both population size and the amount of urban agglomeration. There are 2 maps coded by Mapbox GL JS in this visualisation. The below shows the methods and features for this visualisation.

Method 1: Proportional Circle map

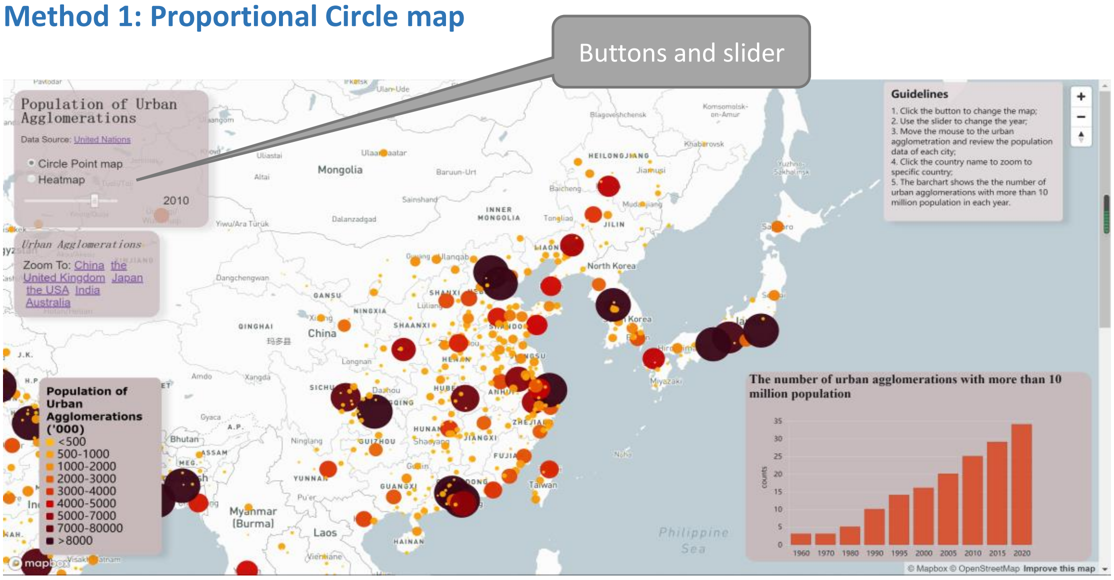

Figure 3.1 Proportional Circle map

The Proportional Circle map is used to visualise the population of each urban agglomeration. Firstly, we generated the shapefile document by using data of latitude and longitude of each city in Rstudio. In the next step, the proportional circles are used to represent each city point. From figure 3.1, the radius and color of each circle set with the different population sizes. For the urban agglomeration with a large population size, the radius of the circle will become larger and the color will become darker. The default year set in this visualisation is 2010, which indicates that the map initially shows the population in the year 2010 for each city. The time slider is employed to change the time and help users to observe the population size change. When we sliding the time slider, the size and color for the circle will be changed due to the different population sizes in different years. The combination between slider and circle can show the growth pattern of population size in urban agglomerations.

Besides, the increase in the number of circles can also reflect the increase in the number of cities. However, due to the population of the urban agglomeration is not particularly large at the initial stage of development, the radius of the circle is small and the newborn urban agglomerations are hard to be observed.

Method 2: Heatmap

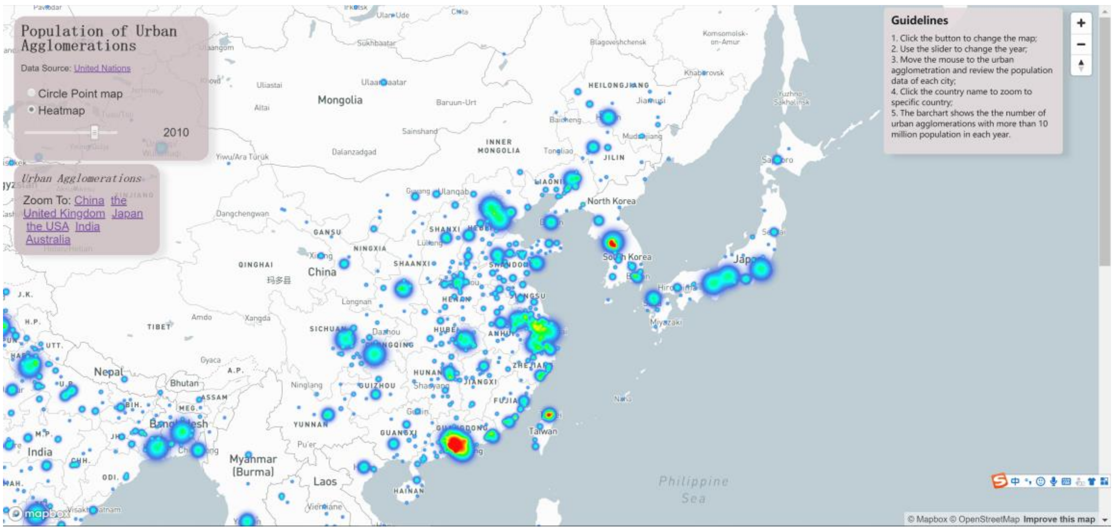

Figure 3.2 Heatmap

To deal with the above problem, the heatmap is employed to visualise the density of urban agglomeration. Users can switch the Proportional Circle map to the heatmap by click the radio button and the layer will be changed. In the heatmap (figure 3.2), cold colors represent sparse urban clustering and warm colors represent dense urban agglomeration. When we sliding the time slider, the color will be changed by the different amounts of urban agglomeration in different years. Especially, when we move the slider from 1960 to 2020, the number of regions with red color increases. Increasingly dense urban agglomeration indicates a growing trend in the number of urban agglomerations over time.

Method 3: Zoom to specific countries

The map list 7 countries in the world such as Chine, the UK, and the USA. The user can zoom to these countries and move the time slider to study the growth pattern of urban agglomerations conveniently. To achieve this, the function of 'flyTo' is employed to zoom to the country by the space coordinates.

Method 4: Barchart

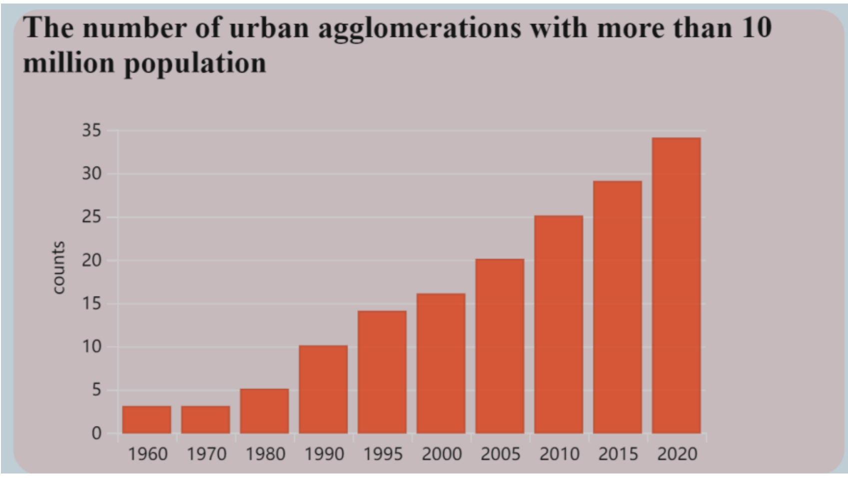

Figure 3.3 Barchart

In this chapter, we use the barchart to visualise the number of cities with a population of over 10 million. The number of cities with population exceeds million is count from each year and visualised by the D3 graph. From the barchart in figure 3.3, we can find a clear upward trend for the number of cities. This also shows a growth pattern in the amount of urban agglomeration with a large population size.

Method 5: Mouseover popups

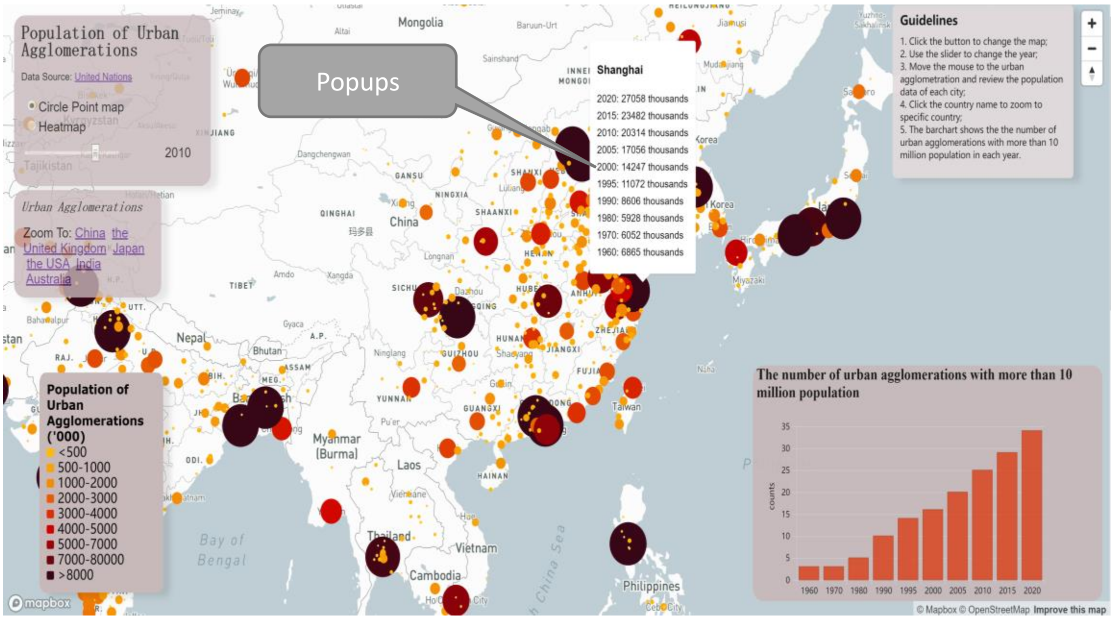

Figure 3.4 Popups in Shanghai

There are totally 1860 urban agglomerations record in the dataset. If we select a specific city by the drop-down menu and visualise the population size for this city in each year by line charts, the process will be troublesome. This because the users may spend time finding the location of the city from the drop-down menu. Therefore we use the popups to present the data of population size for the city each year. The process of add popups into each city is majorly by the function of 'setLngLat' and 'setHTML'. The 'setLngLat' identifies the location where the cursor located and the 'setHTML' add the content of the popups. The users only need to move their mouse to the circle where the city located in, the popup will show the data of this urban agglomeration.

Comparison

1960 1990 2020

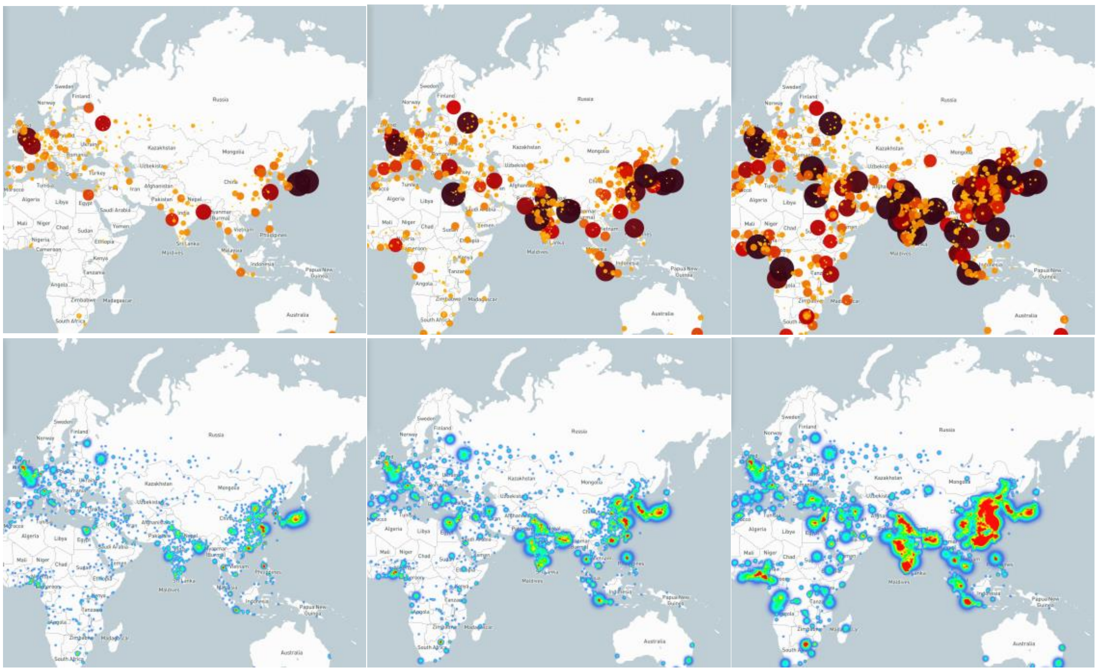

Figure 3.5 Comparison the growth of urban agglomeration

Figure 3.5 shows the patterns of urban agglomeration in 1960, 1990, and 2020. We can find that the population and number of urban agglomerations are increasing over time. From the circle map, the size and number of the circle increase over time. From the heatmap, urban agglomerations were mainly concentrated in Western Europe and Eastern Asia in 1960. After that, more and more cities have gathered with time increase and most of them show a trend of being distributed along the coastline, for example, Pacific Rim, Indian subcontinent, and Gulf of Guinea.

Chapter 4: Visualisation 3 (Carbon Dioxide Emission)

The growth of carbon dioxide emissions in the city is just like a growth cell in terms of its waste excretion. According to figure 4.1, we can find that the world‘s carbon dioxide emission amount shows an upward trend from 1960 to 2016. The maps in this visualisation are majorly coded by Mapbox GL JS.

Urbanization and industrialization have developed rapidly in recent decades, which can also lead to an increase in carbon dioxide emissions. For example, approximately 27.9% of global CO2 emissions in 2017 come from China as this country is experiencing rapid urbanization and facing huge inequality in regional development (Xiao, et. al, 2019). Besides, the emission per capita in China still shows a growing trend in the past 15 years even if the population size is large (Pettinger, 2019). Both the total CO2 emission amount and per capita emission amount are supposed to be explored. Additionally, the development of urbanization also increased the proportion of transportation carbon emission due to the higher dependency on vehicles. The transportation carbon emission is also a noteworthy direction in this growth city-cell.

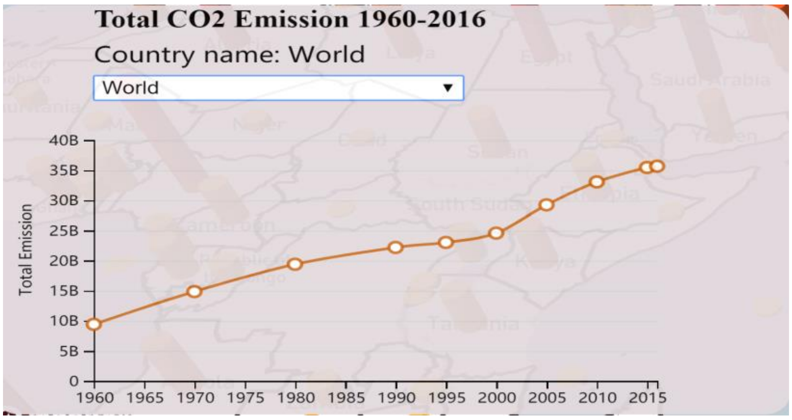

Figure 4.1 World CO2 emission

Method 1: 3D Extrusion Map

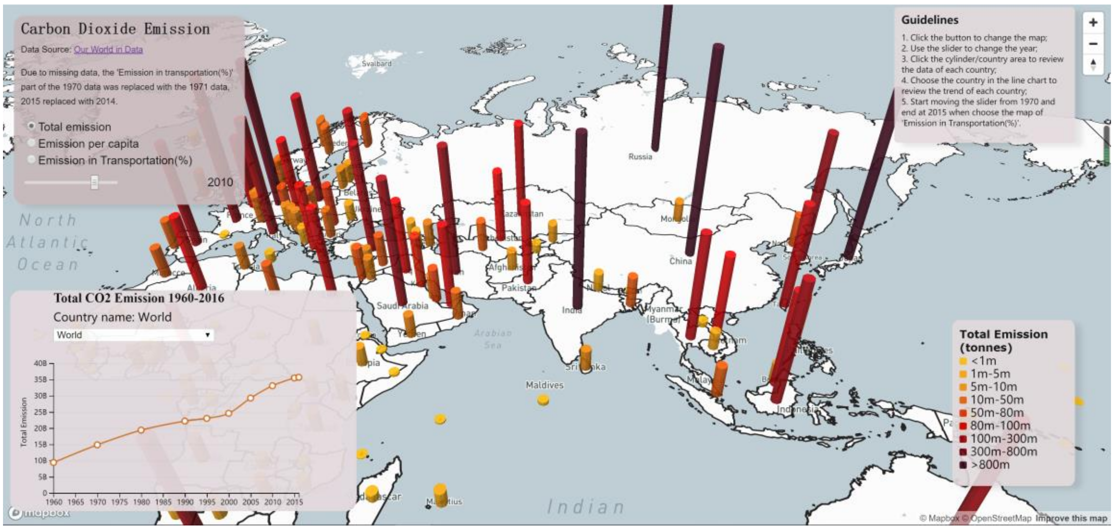

Figure 4.2 3D Extrusion Map for Total Emission

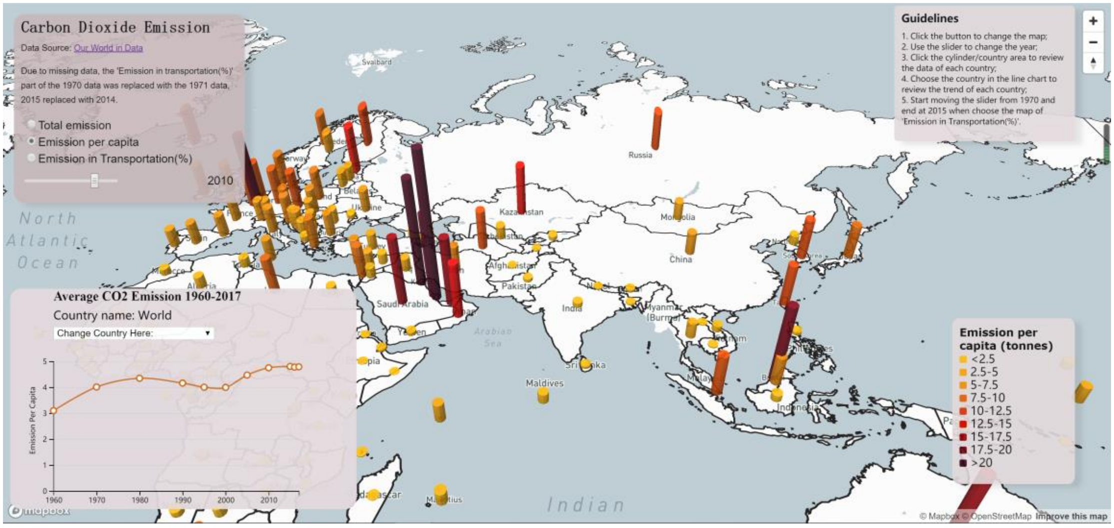

Figure 4.3 3D Extrusion Map for Emission per capita

Both total emission and emission per capita in each country are visualised by the 3D extrusion map (Figure 4.2 and Figure 4.3). The countries on the map are represented by the cylinder. The cylinders are all located in the centroid of countries. The country with a higher total emission amount or larger average emission will have higher height and darker color for the cylinder. Combining the legend and color, users can roughly estimate the emissions amount of each country when they firstly observing the map. Users can also switch these two maps by clicking the radio button and make comparisons for the total emission and per capita emission directly and conveniently. We can find that the country with a large population like China and India have a large amount of total emission while a relatively small amount of average emission. For oil-rich country like Qatar, the amount of total emission is relatively low, but the emission per capita is particularly high. Additionally, these two maps initially reflect the emission amount of each country in 2010 due to the setting of the default year. The user can move the slider to change the year and the height of each cylinder will change based on the emissions amount of the corresponding year. The combination between slider and height of the cylinder can show the growth pattern of emission amount. The increase in emissions shows that the living city-cell is growing over time.

Method 2: Choropleth

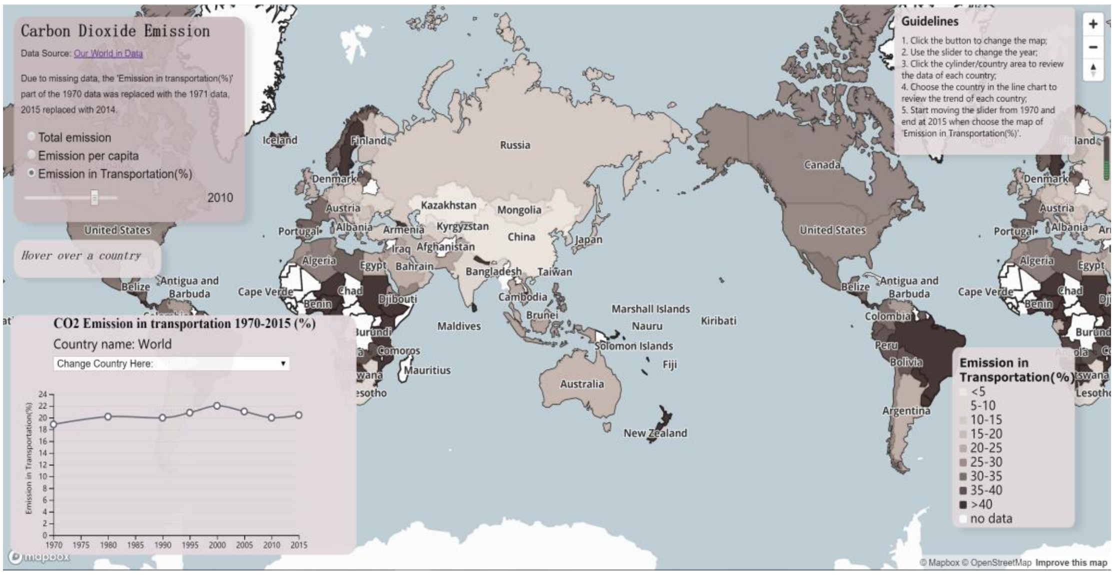

Figure 4.4 Choropleth for Emission in Transportation

The choropleth in this chapter is applied to visualise the proportion of emission in transportation. On this map, countries with a relatively large proportion of transportation carbon emissions will have a darker color for filling. The color of each country will gradually change by the percentage data of the year when moving the slider.

1970 2015

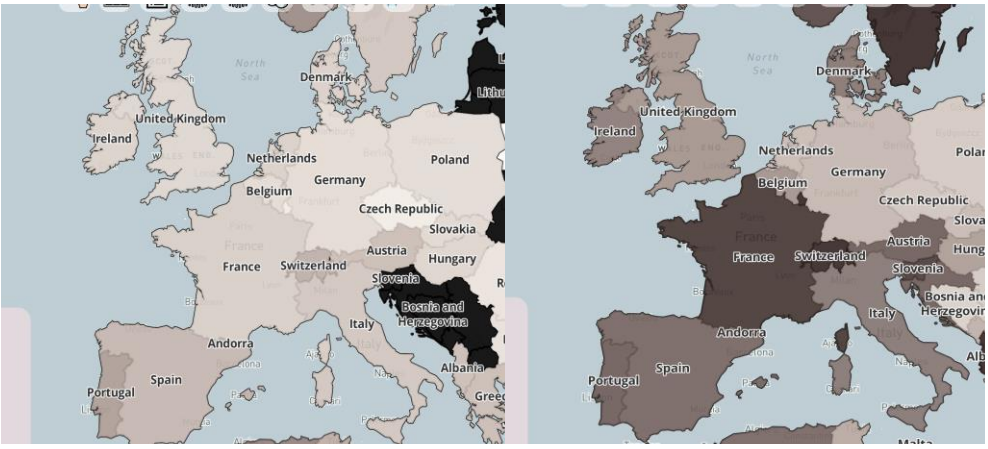

Figure 4.5 Choropleth for Emission in Transportation in Western Europe (1970 and 2015)

Western Europe is a good example to show the growth in the proportion of emissions in transportation. When sliding the slider from 1970 to 2015, we can find that the colors of these Western European countries like the UK and France are gradually deepening (Figure 4.5). This may because the development of urbanization has also risen the dependence on vehicle transportation of people, the proportion of transportation carbon emissions has also grown.

Method 3: Line chart

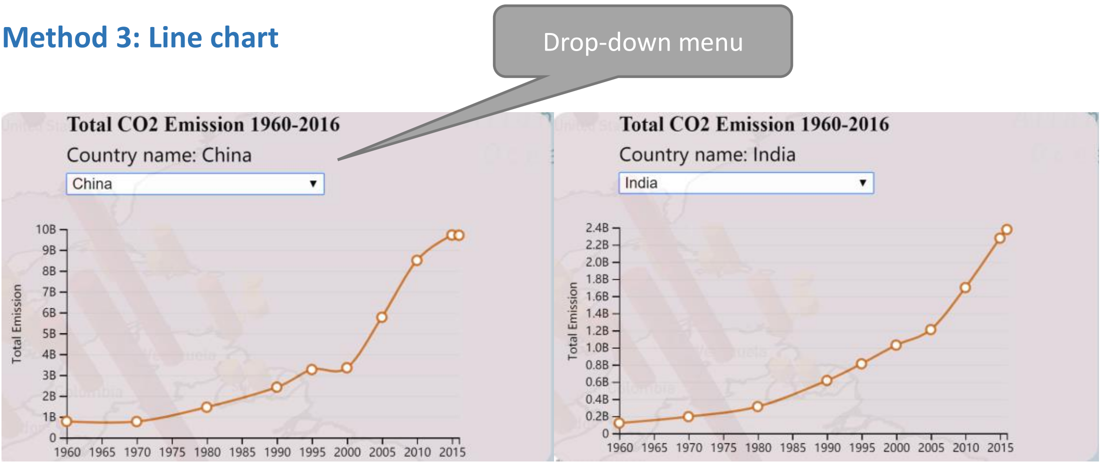

Figure 4.6 Line chart for Annual Total Emission in China and India

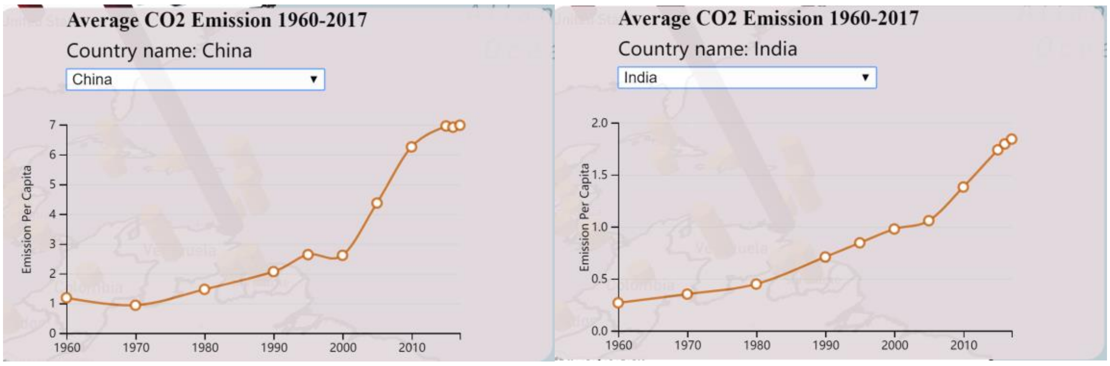

Figure 4.7 Line chart for Emission per capita in China and India

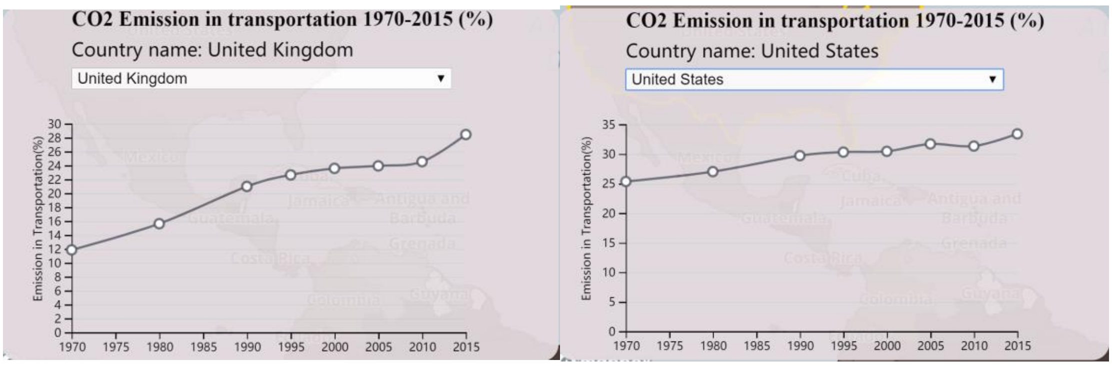

Figure 4.8 Line chart for Emission in transportation in the UK and the USA

The proportion changes in some countries are relatively small, using the color change to reflect the data changes may not be obvious especially in the world range map. Therefore, we introduced the line chart in this visualisation and users can select the country from the drop-down menu and observe the trend and data change for each country. When we switch the layer by the radio button, the content in the line chart will also change to the corresponding one. In the line chart of total emission and per capita emission (Figure 4.6 and Figure 4.7), the emission amount from populous countries like China and India are showing growth. In the line chart of emission in transportation (Figure 4.8), the proportion in developed countries like the UK and the USA are presenting an increasing trend.

Method 5: Popups

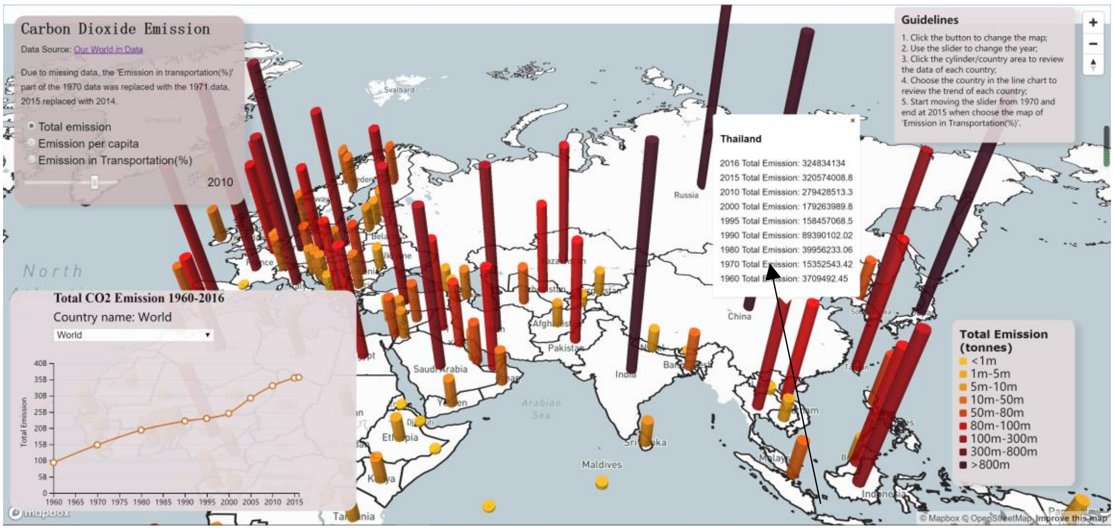

Figure 4.9 Popups for Annual Total Emission in Thailand

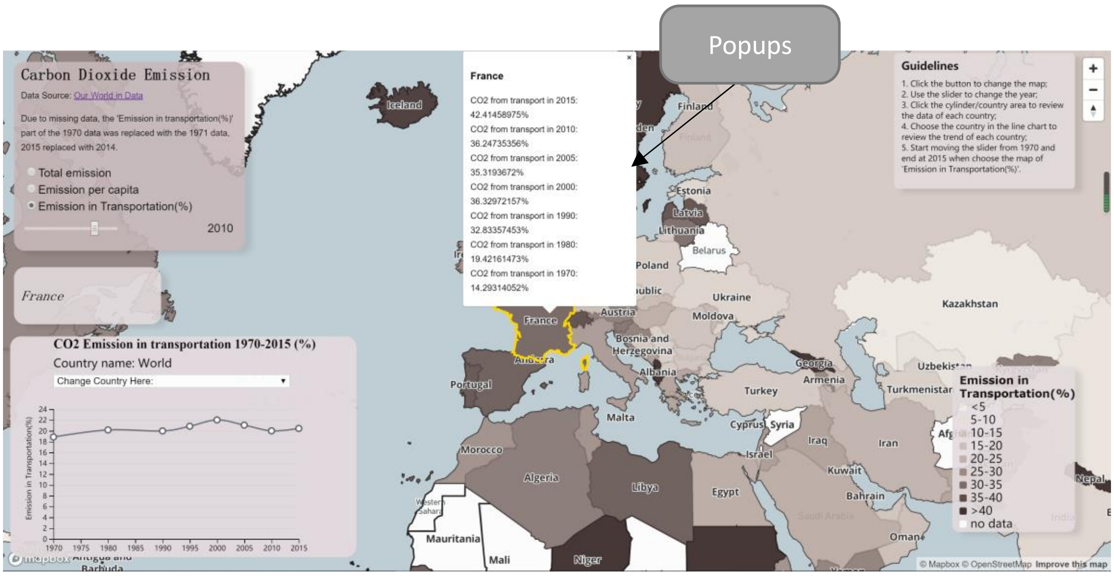

Figure 4.10 Popups for Emission in Transportation in France

In the map of total emission and emission per capita, the emission amount will present in the popups. Users can click the cylinder to review the emission amount data of each country. While for the map of emission in transportation, the country boundary will be highlighted with a gold line when users move the mouse to the country area. Additionally, the data of emission in transportation in each year will be shown in the popups when users click this area. The popups content can help users review the exact data for different country each year directly. Same with visualisation 2, the 'setLngLat' and 'setHTML' functions are used to add the content of popups in this visualisation.

Chapter 5: Visualisation 4

As mentioned in the part of Introduction and Motivation, cities are often regarded as cells, and transportation is an important factor that makes them seem 'living' (Batty, 2005). A report from CASA, UCL states as cities are developing, they have to expand in the surrounding areas, because it seems quite more difficult to increase the density of the cores (Batty, Besussi and Chin, 2003). What makes it possible is to improve the connection between the centre and the edge within one city or among different cities by extending transportation lines, like tubes, railways, expressways, and so on.

Based on our personal impression or experience, China has undergone tremendous transformation in the past few years and decades. Many aspects have been developing rapidly, especially traffic. For example, Qinghai-Tibet Railway, the highest and longest altitude railway in the world, was fully opened to traffic in 2006. There are 17 metro lines, one Pujiang line, and one maglev line in Shanghai in 2020 (ShanghaiMetro, 2020). Therefore, it is meaningful to have a case study on the development of transportation in China according to accurate data.

We will try to visualise the growth of transportation of city-cells in China at a province-level in three different parts, which are railways, expressways, and urban rail transit system. Different visualisation methods will be applied to every factor, like the interactive map, circular bar plot, lollipop chart, and so on. Moreover, we will try to compare the differences between Hubei Province and Shanghai City in the urban rail transit system part of this visualisation.

Interactive Map: Length of railways

We can use the choropleth, an interactive map, coded by Mapbox GL JS to show the lengths of railways among provinces. The features are all the data are presented in different colors and we can change the years by using the slider. Meanwhile, if we click the name of one province on the map, its lengths in different years will be shown together. The purpose to use this choropleth is to better find how the lengths of railways vary among provinces in the same year and compare how one area changes during a period. Our project also provides the choropleth maps for the length of expressways and urban rail transit system, which can be switched by clicking the radio buttons on this visualisation output.

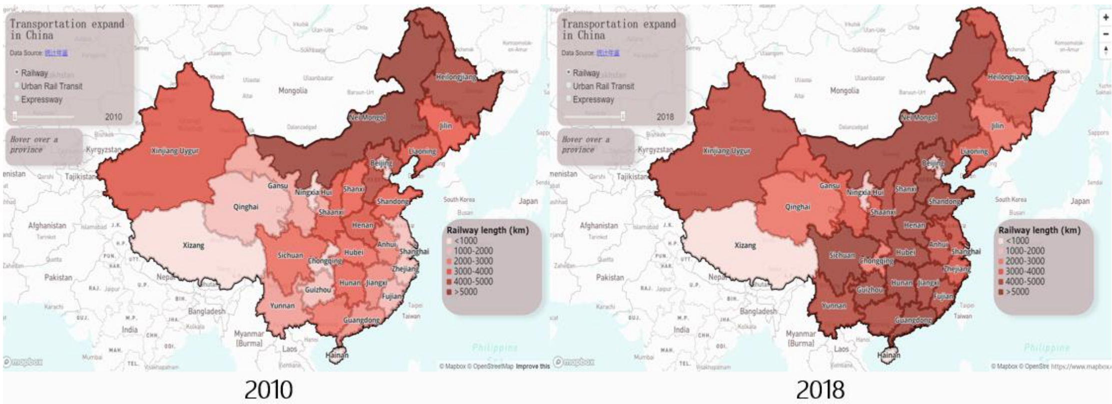

Figure 5.1 The choropleth of railways length in 2010 and 2018

If we focus on the year 2000 and 2018, we can find in 2010, the total lengths in most provinces and cities were less than 3000 kilometers. However, in 2018 most areas' total lengths became larger than 5000 kilometers. It has significantly grown.

Lollipop Chart: Length of Urban Rail Transit System

Urban Rail Transit System might include the metro and the tram. We can use the lollipop chart to visualise the system's length. The features are we can use the buttons to choose different years. The purposes are to find how provinces vary in the same year and to avoid the disadvantages of the scatterplot that it is hard to match the point with its name and the bar chart that it is difficult to present too many provinces together in a clear pattern. The code is referenced from a website, named d3 graph gallery, with the author, Yan Holtz (2018).

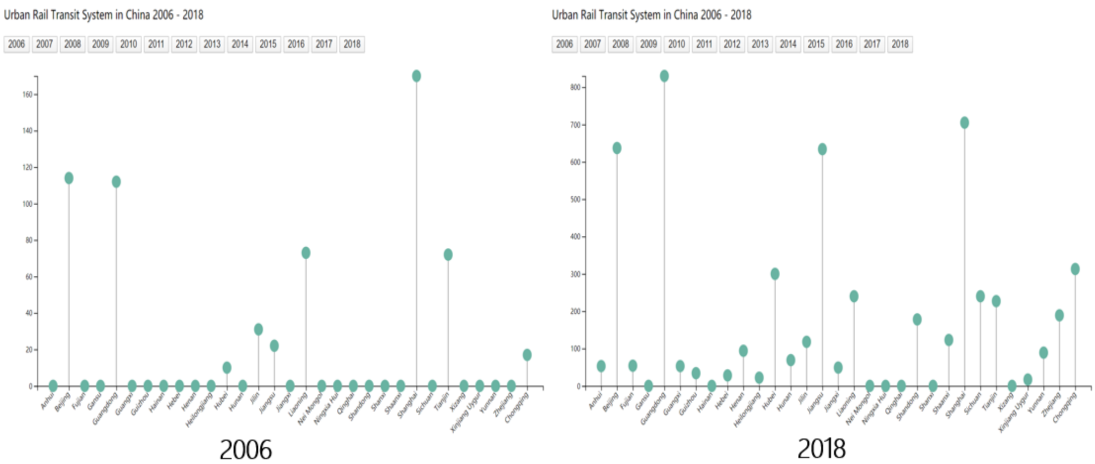

Figure 5.2 The lollipop chart of urban rail transit system in 2006 and 2018

Here are the lollipop charts in 2006 and 2018. We can find in 2006 only 9 provinces had this urban rail transit system, and the largest length was around 160 kilometers and was in Shanghai. In 2018, only 7 areas did not have this system, and the longest one was nearly 900 kilometers and was in Guangdong. There has been a great development in the whole country.

Circular bar plots: Length of expressways

We can use the circular bar chart, which is different from the traditional bar plot, and display the data in a circle to visualise the lengths of expressways among provinces to better visualise the data together when there are too many columns or rows. The code of this chart is also learned from Holtz (2018).

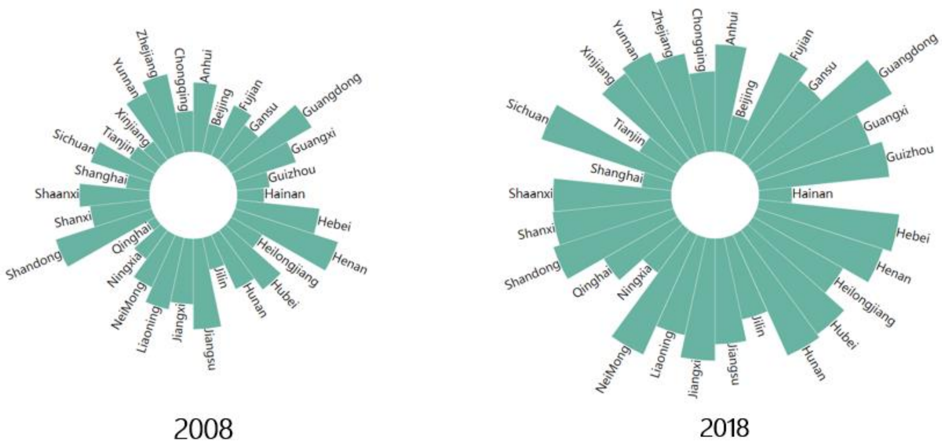

Figure 5.3 The circular bar plots of expressways in 2008 and 2018

Here are the circular bar plots in 2008 and 2018. We can find that nearly all provinces or cities extended their expressway's lines. The length in Shanghai, Hainan, Tianjin, and Beijing increased little. The reasons might be that Shanghai and Beijing had been already developed before 2008, the total land area in Tianjin is small, and Hainan is an island, which is hard to build expressways to be connected with other cities.

Case study: Compare Hubei Province with Shanghai City of Urban Rail Transit System

Hubei Province is in the middle of China, Shanghai City is one of the most international and famous cities in China. Moreover, Wuhan City, the provincial capital city of Hubei Province, became well-known in the world because of the COVID-19 (coronavirus). Therefore, it might be a choice for us to compare Hubei with Shanghai in the part of Urban Rail Transit System.

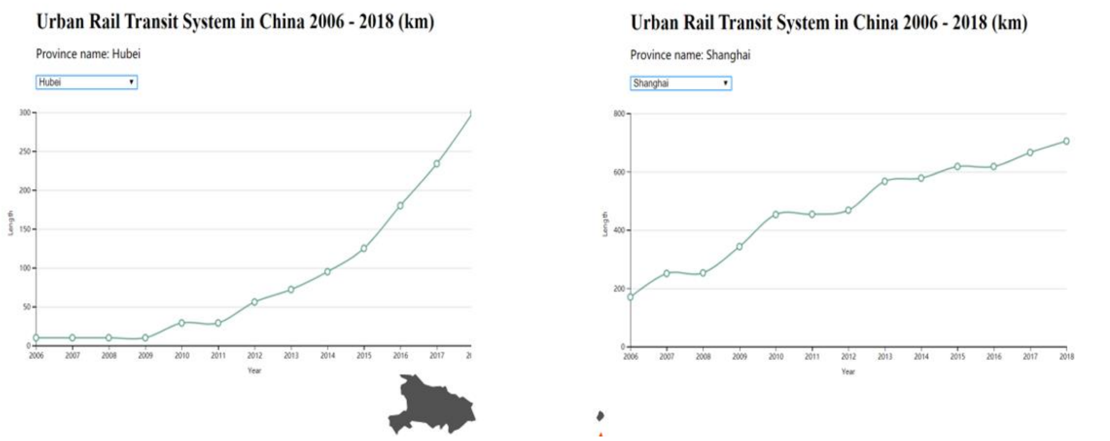

Figure 5.4 The line chart of urban rail transit system in Hubei Province and Shanghai

We can use the box in the line chart to choose different provinces or cities you want to visualise, find how one area changed in different years, and compare their lengths and development. The code of line charts is learned from the example provided in Week 4 (Duncan, 2020). Here we choose Hubei and Shanghai. We can find Hubei Province started to develop the urban rail transit system from 2009, and it has been greatly improved since 2012. In 2018, it reached about 300 kilometers. Then we can find in Shanghai, in 2006, it already had the urban rail transit system, and was significantly developed from 2008 to 2010. From then on, the total length grew slowly because the system had already developed. In general, Hubei Province covers an area nearly 30 times the size of Shanghai, but its total length of urban rail transit system is only half that of Shanghai. There is a great space for development in Hubei province for its urban traffic system.

Chapter 6: Challenge and Solution

Interactive Mapping part

Challenge 1: While conducting dataset pre-processing in visualisation 1, after doing the spatial join in QGIS of the shapefiles to the dataset, the variable field could not be read in Mapbox.

This was overcome via using the “refactor” function in QGIS to coerce the data type into “Double”, such that it could be read as numerical data in Mapbox Web.

Challenge 2: While coding the mouseover popups in visualisation 1, they initially did not allow the embedding of any text or figures.

To address this, we studied the example of luminocity 3D (Smith, 2018) and learned to apply the setHTML() method, which allowed for the calling of the variable field within the javascript chunk which was the Mapbox popup. However, embedding the D3 graph was still a challenge, so we used a separate style to display it on the left side of the visualisation 1.

Challenge 3: In visualisation 3, the 3D Extrusion Map cannot set the height to the circle point because the point is not a polygon. Therefore, using the center coordinates of each country to build the cylinder will encounter obstacles.

We can create buffer areas of the centroid circle points by using QGIS. Then the buffer area became the bottom surface of the cylinder and the height of the cylinder can be set.

Challenge 4: Switch the map by the radio button in the visualisation 2, 3 and 4.

When coding the map, using ‘setPaintProperty’ function to reset the opacity of the layers. The opacity of selected map set 1 or other value greater than 0; the opacity of other maps set 0.

Challenge 5: We need to ensure the content of legend, popups, and line charts are also changed synchronously with the corresponding maps information when the users switch the map.

a. For the legend, the solution is similar to the challenge 4, but the function used here to reset the value of opacity is ‘style.opacity’. We can use this to reset the value of opacity and hide the uncorrelated legends in the map.

b. For the line charts, in addition to setting the value of the opacity of uncorrelated charts to 0, we also need to employ the function of ‘style.zIndex’ to reset the value of z-index. The z-index of the corresponding chart should be higher so that this chart can be brought to front. Then the users can select the country by the drop-down menu correctly and the uncorrelated charts have been placed at the bottom.

c. For the content of popups, we need to avoid the popup content in other maps shows in the target map. To achieve it, we used the function of ‘setLayoutProperty’ and set the visibility of corresponding layers as ‘visible’ and the uncorrelated layers as ‘none’.

Challenge 6: In the visualisation 3, the viewing angle needs to be changed when the user switches maps.

It will be better to use an inclined visual angle when the user viewing the 3D extrusion map and use a vertical visual angle when viewing the choropleth. To reach it, we used the function of ‘setPitch’ and set the value of pitch as ‘50’ in 3D extrusion map and ‘5’ in choropleth.

D3 Chart and Graph part

Challenge 1: There were styling issues as formatting often resulted in several styles being conflated together – the legend for the choropleth map, and the D3 graphs and charts for instance.

We conducted extensive debugging, flagging, and testing repeatedly. He learned to understand and code styles as well as how to nest elements within different styles. Additionally, He learnt to apply the .innerHTML() method to code the elements of the D3 table within a Javascript “if”, adapted once again from Smith’s (2018) luminocity

3D example.

Challenge 2: In visualisation 4, we can find that if we choose to present the conditions of all provinces or cities in one year by a bar chart, it seems too crowded with 31 areas together in the same x-axis.
Then, we might prefer a similar chart pattern, the lollipop chart, which uses a line rather than a bar to visualise the data so that it can improve the overall look and feel.

Challenge 3: The columns of years in the original data are named directly by numbers in visualisation 4. If we directly use those numbers when defining the chart data in the code, the final chart will not be outputted.
Then we change the number into “length + number”, for example, 2018 into length2018, then the chart will be generated as expected.

Challenge 4: Failing to match the index number with the code that the original index numbers start from 1, however, the code was set to begin with 0.
To solve it, we need to change the first index number into 0 rather than 1, the data will be presented correctly with its province.

Chapter 7: Conclusions

To conclude, thus our project and thus have met the aims as discussed in our introduction, to highlight cities as growing city-cells, through demonstrating their accumulation of resources as nutrition, waste production as excretion and transport system as a movement. ‘City as Growing City-Cell’ interprets cities as growing cells that would enrich themselves in many aspects. Our group show growing cities through the upward growth trajectory of cities, the increasing large urban agglomeration patterns, the patterns of emissions over time alongside city-cell growth and the evolving transport networks and systems.

There are three main topics for this project. The first one, urban population, shows the visualisations of world urbanization percentage and population of urban agglomerations. Display on the growth over time of countries link cities to cells by their continued growth. World urbanization percentage shows how the proportion of people living in cities grows over time on a global scale. It contributes to demonstrating the growth of city-cells on a global scale, at a country-level, which highlights the higher proportion of people living in cities over time. Besides, visualisation of the population of urban agglomerations focuses on cities with 300,000 and more inhabitants. Circle point map distinguishes the population size of urban agglomerations in different regions and the heatmap reflects the density of urban agglomerations in different regions. The number of urban agglomerations and the population size in these cities clustering also demonstrate a global growing trend and a rapid and dense-growing trend in the coastal regions.

For carbon dioxide emission, total CO2 emission amount over time in each country, emission per capita overtime at a country-level, and the percentage of emission in transportation are visualised. These are achieved by the use of 3D map, choropleth, slider and the combination of highlight areas and popups. Generally speaking, the world total emissions show an upward trend. Populous countries such as China and India are great examples. They have both large and growing amount of total emission and emission per capita. Besides, the developed countries, the UK and the USA for example, their transportation contributes to an increasing proportion of emissions.

The emission in transportation also leads to the final topic, a case study of transportation in China, focusing on the length of railway line expressway and the urban rail transit system. It shows how the lengths of railways vary among provinces in the same year and better compare how one area changes during a period. It is found that Shanghai and Hubei province start to develop their transportation network in different years, and their speed and scale of transportation development are different. Generally speaking, transportation networks in China is in a rapidly developing stage now. Some areas are already developed while some provinces are still developing.

Further researches could focus on highlighting similarities between urban studies and cellular biology, which leads to different perspectives of understanding cities. It might provide an expository take on it through thematic visualisations and can further reveal the protentional of shared insights on cells or cities.

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